INDIVIDUAL DIFFERENCES IN CHILDREN'S REASONING

by

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A thesis submitted in conformity with the requirements for the degree of Doctor of Education
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Abstract
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A long history of developmental theory suggests that children's reasoning becomes more analytical, complex, and abstract with age. This history is embodied in more recent two-process theories of reasoning (Evans & Over, 1996; Sloman, 1996; Stanovich, 1999) that distinguish analytic from heuristic processing. However, contrary to some traditional developmental theories and to the two-process theories, some previous research into the development of inductive reasoning ability has suggested the counterintuitive finding that analytic processing ability may well decline with age from early childhood to early adulthood (e.g. Jacobs & Potenza, 1991; Davidson, 1995). In the present study the development of analytic and heuristic processing in children in grades five, six, and eight was examined using an inductive and a deductive reasoning task. The inductive task was designed to be analogous to the scenarios used by Jacobs and Potenza (1991) pitting individuating information against base rate information and was adapted for use by children. The deductive task was an experimental measure consisting of syllogisms taken from Markovits and Nantel (1989) and again, was adapted for use with children. Data from one hundred and eight students were examined. Results indicated that analytic processing improved with age. Further, cognitive ability was positively associated with analytic reasoning performance. Importantly, measures of thinking dispositions – specifically, the Actively Open-minded Thinking composite – predicted unique
variance in reasoning performance after cognitive ability was partialled out. Overall, the results support the notion that analytic reasoning performance improves developmentally. Possible reasons for divergence from the results of Jacobs and Potenza (1991) are discussed.
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Children's Reasoning

Introduction

It is well known that children's cognitive capacities and cognitive structures increase in efficiency and complexity with age (Case, 1985; Inhelder & Piaget, 1958). These developing cognitive structures should support more complex reasoning performance; thus, it would be paradoxical to find that reasoning performance does not improve as children age. Nevertheless, certain researchers have claimed just that. Some of the research literature on children's reasoning seemingly reports such counterintuitive results (Davidson, 1995; Jacobs & Potenza, 1991; Klaczynski, Fauth & Gordon, 1997; Leevers & Harris, 2000). In particular, these studies suggest that younger children demonstrate better reasoning than older children or adults. Such findings have counterintuitive theoretical implications – for example, implying that children's reasoning should become more heuristic with age rather than becoming more analytic. This would contradict many two-process theories of reasoning that suggest a stronger alliance of analytic processing with age (Evans & Over, 1996; Sloman, 1996; Stanovich, 1999).

The first purpose of this study was to test the claims made in the literature that children's thinking and reasoning performance do not improve with age. The second purpose of this study was to examine the correlates and predictors of children's reasoning performance. This was done by using an individual differences framework based on the work of Stanovich and West (1998, 2000; Stanovich, 1999). One important correlate that was examined was cognitive ability. The relationship of cognitive ability and reasoning was examined within groups of typical students but also within a sub-sample of students in a gifted program who had been identified by scoring in the 99th percentile on a cognitive ability test (WISC-III). This study addressed the following questions when we consider a sample of children, “Who does well on reasoning problems?” and “Does high cognitive ability guarantee good reasoning?”
Children's Reasoning

Development and Reasoning

As children progress developmentally, they gain in experience and knowledge. According to Piagetians, as children’s computational capacity increases, their reasoning proficiency should increase (Inhelder & Piaget, 1958). This relationship has been examined in a variety of studies (Case, 1985; Kuhn, Amsel, & O'Loughlin, 1988; Siegler & Jenkins, 1989). Thus, from the Piagetian perspective, children’s reasoning should become more complex, abstract, and analytical as they get older (Inhelder & Piaget, 1958).

Dual-process theorists (for example, Epstein, 1994; Evans & Over, 1996; Levinson, 1995; Sloman, 1996; Stanovich, 1999) postulate a model of reasoning that consists of two systems. In his synthesis of several two-process frameworks, Stanovich (1999) applies the generic terms, System 1 and System 2, to describe these two systems of reasoning. System 1 describes thinking that is sometimes referred to as the default system. It occurs automatically and very rapidly. This type of processing is largely unconscious, highly contextualized, that is, personalized and socialized. It is characterized by heuristic processing. On the other hand, System 2 processes are controlled, relatively slow and analytic. Prior beliefs and knowledge are decoupled from the details of reasoning problems resulting in tasks that are abstract problems decontextualized from personal experience. System 2 processes are relatively capacity dependent.

In the present study, analytic processing which is a property of System 2 reasoning, was defined as the type of controlled reasoning processes that are engaged during deductive, inductive, and statistical reasoning. This type of controlled processing is discussed by many two-process theorists such as Evans and Over (1996) and Sloman (1996). For example, Sloman defines the analytic system of reasoning as one that is conscious, “...rule-based and tries to describe the world by capturing different kinds of structure, structure that is logical, hierarchical, and
causal-mechanical” (p.6). In contrast, heuristic processing which is a characteristic of System 1 reasoning, is rapid and automatic. It operates in a highly contextualized and interactional manner (Evans, 1984; Stanovich, 1999). Quick and inflexible responding is based on tendencies to contextualize information and impose pattern on even random situations (Levinson, 1995). Most everyday thinking is driven by System 1 servicing the need for quick and frequently repetitive responses. In certain circumstances such as complex decision-making or in the solution of difficult reasoning problems, System 2 reasoning is required to decouple contextual features supplied by System 1 and to act as an override system to System 1 so that the problem features can be analyzed abstractly to arrive at the best solution.

From many developmental perspectives, not only the Piagetian perspective, analytic thinking is presumed to increase with age through to adulthood. For example, Overton, Byrnes and O’Brien (1985) examined reasoning performance in eighth, tenth, and twelfth graders on an inference task and an evaluation task. Overall, they found that grade 12 students performed significantly better than both grade 8 and grade 10 students on the inference task. Also, grade 12 students benefited significantly from contradiction training on the evaluation task, but neither grade 8 nor grade 10 students benefited from this training. In another study conducted with children in grades one to six, Janveau-Brennan and Markovits (1999) found a steady age-related increase in accurate reasoning performance on a conditional inference task. The developmental literature has additional empirical evidence that displays this trend (Kuhn & Pearsall, 2000; Markovits, 1993; Schaubule, 1990).

Although the trend in the developmental literature has typically supported increases in reasoning performance with age, some research has made alternative claims. Jacobs and Potenza (1991) studied decision making using first, third, and
sixth grade students. The children were presented with 13 different scenarios developed to model the Kahneman and Tversky (1972) judgment tasks. Two task conditions (baserate-information-only, baserate plus individuating information) and two domains (object, social) were created (2 tasks by 2 domains). In the baserate information only task (BR), participants chose whether to use the baserate information or not. The scenarios varied by two domains - object or social. Scenarios in the object domain contained content about objects such as socks. For example, they might be told that Mike's drawer contains three pairs of white socks and six pairs of coloured socks. Scenarios in the social domain contained content requiring judgments about social decisions. For example, Julie takes piano lessons or swimming lessons during the summer given the baserate information that four girls took piano and two took swimming. Participants chose between using or not using the baserate information provided to decide the likely outcome of the object (socks) and the social (lessons) scenarios.

In the other task condition, baserate plus individuating information (BRIN) were given in the scenarios. Scenarios in both the object and social domains were presented. An example of a BRIN object domain task is a scenario about buying a bicycle. The aggregated baserate information given is that a bicycle magazine says that most of their readers say the Zippo bike is best. The individuating information given is that Jim's neighbour says the Whammo bike is the best. The BRIN social domain task included problems containing content requiring social judgments. In an example of a BRIN social domain item, the individuating information given was that Juanita is popular and pretty. The baserate information given is that 10 girls are trying out for cheerleading while 20 are trying out for the band. The question is whether Juanita is likely trying out to be in the band or a cheerleader. Participants decided between using baserate information or individuating information to make
decisions about Jim's and Juanita's actions. Sole reliance on individuating information when its diagnosticity is low and the reliability of the base rate is high, is not normative (Stanovich, 1999). Normative in this sense means optimal reasoning resulting in the effective and efficient achievement of one's goals. Jacobs and Potenza (1991) found that base rate information in the social domain was used significantly less often by older students than by the younger students, and that older students tended to use the individuating information more frequently. These findings were taken by Jacobs and Potenza to indicate a decrease in normative thinking with advancing age, at least in the social domain involving judgments about people. These results, however, were not replicated in the object domain. In the object domain, decreases in the use of the representativeness heuristic and increases in the use of base rates were observed in older children. Tasks analogous to those used by Jacobs and Potenza (1991) were used in the present study.

Another study by Davidson (1995) reported similar results to those of Jacobs and Potenza (1991). Davidson (1995) conducted a study examining the use of base rates and the representativeness heuristic by second, fourth, and sixth grade children. The representativeness heuristic is used when people rely on individuating information, that is, information about a particular case, instead of base rate information to make decisions. The children were given scenarios about people (elders and children). Some of the scenarios included individuating information that cued stereotypic knowledge and some included neutral information. The following is an example of a scenario that cues stereotypic knowledge: “Seventy year-old Mrs. Smith is going out with her friends for a bike ride or a walk. Four of them go for a bike ride and two of them go for a walk. Does Mrs. Smith go biking or walking?” An example of neutral or non-stereotypic problem information follows: “Seventy-two year-old Mr. Arnold chooses from four pairs of blue socks and eight pairs of black
socks." The children were required to decide the most likely outcome based on the information given and to justify their responses. They were also given conjunction effect problems about elderly and younger adults. A conjunction fallacy is demonstrated in problems when subjects rate the occurrence of conjoined events A and B as more probable than event A alone. An example follows:

Younger adult character

Mrs. Kelley is a pretty woman, with black hair and brown eyes. She likes to do many things, but her favorite thing to do is spend time with children. Mrs. Kelley really likes children. Mrs. Kelley is a smart person. Do you think that Mrs. Kelley is:
A teacher in a grade school?
An old person who has grandchildren?
A dancer with the city ballet?
A waitress at a local restaurant?
A teacher in a grade school and a waitress at a local restaurant?

Selection of the final possibility as most likely, is an example of committing the conjunction fallacy. Davidson found that older (grade 6) children were more likely to commit the conjunction fallacy more frequently than younger (grade 2) children, presumably because of reliance on the representativeness heuristic. Ignoring the fact that two conjoined events/cases are less likely than one, the older children chose the response with two events/cases because the two cases (pretty, child-likeing teacher and/or waitress) were familiar.

Thus, the Jacobs and Potenza (1991) and Davidson (1995) studies help to
create an important controversy about the developmental trajectory of children's reasoning. The classic literature (Case, 1985; Piaget & Inhelder, 1958) has argued that children's reasoning becomes increasingly analytic as they get older, a position shared by many dual process theorists (Evans, 1989; Evans & Over, 1996; Reber, 1993; Sloman, 1996). However, as the previous review has indicated, some developmental studies have suggested that children's thinking becomes more heuristic as they get older providing empirical evidence for alternate theories of reasoning such as, fuzzy trace theory (Reyna, 2000) that posits that quantitative computational strategies decrease and use of intuition increases in reasoning with development. Thus, the developmental course of heuristic and analytical reasoning remains a contentious issue theoretically. As a result, one of the aims of the present study was to explore both inductive and deductive thinking tasks to assist in clarifying whether children become more heuristic or analytic in their reasoning as they develop.

In their study, Jacobs and Potenza (1991) attempted to follow Kahneman and Tversky's (1972) model of pitting baserate and individuating information against each other to test the developmental trajectory of heuristic and analytic reasoning. They presented thirteen scenarios to grade one, three, six, and college-age students. Within two task conditions (Baserate only or Baserate plus individuating information), the students were required to make decisions about either objects or social situations. Four types of scenarios were created: baserate information alone for judgments in the object domain, baserate information alone for subjects in the social domain, baserate plus individuating information for judgments in the object domain and baserate plus individuating information for judgments in the social domain. Overall, they found that both the use of baserates and the use of individuating information increased with advancing age. Their interpretation of these
findings was that heuristic processing increases as children develop into adults. In order to examine the claims made by Jacobs and Potenza, other tasks were developed for use with children in the current study. A number of concerns with the stimuli from Jacobs and Potenza (1991) and Davidson (1995) are outlined next.

**Methodological Issues in Developmental Reasoning Studies**

From examination of the methodology, specifically the stimuli, four possible confounds are noted. They are: inequity of prior knowledge demands in the domains (object versus social) within the same task (for example, individuating plus baserate), lack of control for the conflict or support of baserates with individuating information (stereotypes), lack of clear differentiation between the object and social domain scenarios and differences in processing demands between the object and social domains.

Firstly, the scenarios (object and social) within the same task condition are not equivalent in their demands on prior knowledge. Scenarios in the social domain include individuating information but the content of the scenarios also cues the use of additional prior knowledge of stereotypes. In the Baserate (BR) task - social domain, gender stereotypes are invoked by cuing the question - Do girls like piano lessons or swimming lessons better? In the Baserate plus Individuating (BRIN) task - social domain, vocational stereotypes are invoked by cuing the question - Are cheerleaders or musicians in a school band more likely to be pretty and popular girls? Whereas, the object domain scenarios in both task conditions do not cue stereotypic information, for example, in the BRIN task - object domain, the participant is to decide if “Jim” chooses a “Zippo” or a “Whammo” bicycle. These brands of bicycles are fictional and are not actual brands. This scenario does not invoke prior social knowledge of the kind that the participants have about cheerleaders or school band musicians because there is none. This makes the bicycle decision hypothetical versus the cheerleader
decision which is based on prior knowledge of social stereotypes gained through personal experience or enculturation. Grade one students and college students are equally ignorant about the types of people that ride Zippos or Whammos or the benefits (real or perceived) of either of these bicycles. In other words, the content (hypothetical versus stereotypical) of the scenarios of the object and the social domains although considered to be the same task is clearly not equivalent. As such, judgments made about the scenarios in the two domains would be affected. As a result, the finding that heuristic reasoning increases with age becomes suspect. Perhaps, the result is due solely to the increase in social knowledge of stereotypes with increasing age which is likely to confound reasoning, at least in the social domain problems discussed by Jacobs and Potenza. The scenarios developed for the current study do not use stereotypic information in the object or social domains in either of the two task conditions (BR or BRIN). As a result, the social and object domain problems are balanced in their demands on prior knowledge.

The second problem lies with the effect of the base rate supporting or conflicting with the stereotype in the social domain scenarios. For example, in the BR task (social domain) scenario where Julie is deciding between piano lessons or swimming lessons, the likely stereotype invoked is that girls like music better than sports. The base rate information supports the stereotypic answer, piano lessons. Conversely, in the BRIN task (social domain) scenario where the participant has to decide if girls who are pretty and popular are more likely to try out for cheerleading or the school band, the base rate information conflicts with the stereotypic answer, cheerleading. The pattern of results when base rate information conflicted with stereotypes versus when it supported the prevailing stereotype could reveal interesting trends. However, this data was not analyzed in Jacobs and Potenza's study. Lack of analysis of the pattern of heuristic or analytic processing when
baserate supported or conflicted with stereotype is a possible confound of their results. And in fact, they do not address the issue of using stereotypes as a form of individuating information at all. This issue did not occur in the current study since the individuating information provided in the scenarios was not stereotypic.

Thirdly, although Jacobs and Potenza state the difference between the object and the social domains, in the actual examples of scenarios the content cannot be clearly differentiated. The object domain scenarios involve events and people making decisions about purchases. In the social domain scenarios people make decisions about recreational activities. It is not clear why making decisions about recreational activities is social and making shopping decisions is not. In the current study, all the scenarios where baserate information was pitted against individuating information involved people making decisions about purchases or prospective actions thereby avoiding problematic divisions between object and social domains.

Finally, in the object domain problems, the participant has to decide whether “Jim” should rely on the individuating advice of a neighbour or the baserate information in the bike magazine report about whether to buy a Zippo or a Whammo bicycle. In the social problems, the participant has to decide to consider the information that 10 girls tried out for cheerleading versus 20 for band and his personal knowledge of whether pretty, popular, fun girls would more likely try out for cheerleading or the band in order to decide what “Juanita” is going to do. In the first problem, the participant has no personal knowledge or experience to draw upon because it is a hypothetical product whereas in the second he has personal knowledge of a pattern that cheerleaders are pretty and popular girls through first hand or arm’s length experience. To correctly solve the object domain problem, which bicycle Jim should buy, requires statistical knowledge of probability which will suffice in discounting the hypothetical neighbour’s information. To solve the social domain
problem, in addition to statistical knowledge, the participant must also have a
measure of "metalogical" (Bara, Bucciarelli & Johnson-Laird, 1995) knowledge –
conscious and explicit thinking about solving problems of logical reasoning – to
recognize that knowledge of stereotypes is being invoked by the individuating
information in the problem and that they should discount their personal "knowledge"
in considering the information given. Participants need to be able to recognize that
the individuating information "pretty and popular" is irrelevant to the outcome. The
process of deriving a solution to this problem can be understood by invoking the two
process framework discussed by Stanovich (1999, 2000). According to this
framework, default mode to the pattern (or the stereotype) recognized is a System 1
heuristic response. A System 2 response, however, can be cued invoking statistical
reasoning and overriding the pattern-recognition function of System 1. In the object
domain problem, System 2 needs only to invoke statistical reasoning. Jacobs' and
Potenza's object and social scenarios invoke different sub-component steps in the
reasoning process and are not equivalent in their processing demands. However,
based on the results of this study, Jacobs and Potenza imply that heuristic and
analytic reasoning are separate processes and develop in domain-specific
trajectories. In the object domain, they suggest that the increase in use of baserates
is normative while the increase in heuristic processing may be specific to the social
domain and based on the development of social schemas. Considering that the
processing demands of the scenarios are so different, it seems premature to accept
their interpretation that the developmental increase in heuristic processing is based
on normal development. In the current study, all the scenarios where baserate
information was pitted against individuating information involved people making
decisions about purchases or prospective actions that involved hypothetical products
and objects and as a result, were equivalent in their processing demands.
Methodological problems stemming from the nature of the stimuli exist with Davidson's research study as well. Replicating the results of Jacobs and Potenza, Davidson (1995) found that "...with age, there was greater use of individuating information consistent with stereotypes." (p.341). In her study, problems were constructed where baserate information conflicted with individuating information, as well. The individuating information was based on the assumption that the participating children held specific stereotypes of elderly and younger adults and children, and that these stereotypes conformed to the stereotypes held or known by the experimenter. Stereotypes, presented as the individuating information, could lead to the use of the representativeness heuristic. However, individuating information can be non-stereotypic as well. Stereotypes are cultural artifacts and are learned through experience. Someone with a lack of experience due to developmental stage or lack of familiarity with a specific culture may not be aware of the culturally predominant stereotypes but may still use individuating information over the analytic choice of baserate information. Thus, responses would be the same but it would not be clear if the response was due to individuating information based on knowledge of stereotypes or lack of knowledge of stereotypes. What Davidson's problems might actually measure is knowledge of stereotypes rather than use of individuating information over baserates. As a result, the problems in our study were carefully constructed to control for stereotypes in both the individuating and the baserate choices. Vivid information, such as names of famous people or brand names, was avoided. The problems used in the current study still involved people making decisions about actions and purchases. Baserate information was contrasted with individuating information of low vividness in order to increase diagnosticity of the participants' responses. An example from the present study follows:
Ms. Owen is going to take her class to a food court for lunch and they need to get served fast. The food court manager says the shortest lunch line-ups are almost always at Restaurant 123. Last time Ms. Owen went to the food court, the shortest lunch line-up was at Restaurant 456. Where do you think Ms. Owen is most likely to take her class?

a) Ms. Owen will definitely take the class to Restaurant 456.
b) Ms. Owen will probably take the class to Restaurant 456.
c) Ms. Owen will probably take the class to Restaurant 123.
d) Ms. Owen will definitely take the class to Restaurant 123.

The information from the food court manager is the optimal choice that presumably includes baserate information. Ms. Owen's personal experience is the response choice with the individuating information. Both choices are relatively equivalent. Ms. Owen's visit to Restaurant 456 would not invoke the kind of response that her visit to “Taco Bell” would have. The participant's response was therefore a more direct test of whether the heuristic of using individuating information was preferred over the analytic choice using baserate information. Therefore, the use of individuating information was not confounded with stereotypic information, providing a more direct test of heuristic and analytic reasoning. This problem provides a measure of reasoning rather than current knowledge of the prevailing cultural stereotype.

A second problem with Davidson's study is similar to one in the Jacobs and Potenza study. Again problems lie with the lack of control for the effect of the baserate supporting or conflicting with the stereotype in the social domain scenarios. One of Davidson’s scenarios asks the participants to decide if 72 year-old Mrs. Smith goes for a walk or a bicycle ride with her friends, given the information that four go for a bike ride and two go for a walk. Believability supports the walk choice. The
baserate choice indicating analytic thinking supports the bicycle ride choice. In the current study, the scenarios were controlled for effects of believability.

Finally, it was unfortunate that raw data for responses to the scenarios were not reported by Davidson (1995). Only data for verbal justifications of responses are provided in their research report. In other words, the actual responses of the children to the scenarios are not available to permit making more specific comparisons with the data of the current study.

The Present Study: Developmental Differences, Individual Differences, and Reasoning

Reasoning tasks similar to those used by Jacobs and Potenza (1991) and Davidson (1995) were employed in the present study. These tasks have come from the inductive reasoning literature of the type extensively investigated by Nisbett and colleagues (Nisbett, Krantz, Jepson, & Kunda, 1982; Nisbett & Ross, 1980). Inductive reasoning involves making judgments about problems of familiar content. Another task came from the deductive reasoning literature. Formal deductive reasoning involves identifying the relationship between statements that include premises and conclusions. The relationship may be valid or invalid. This study used the quintessential deductive reasoning task – syllogistic reasoning. Syllogisms are commonly used with children and adolescents (Galotti, Baron, & Sabini, 1986; Hawkins, Pea, Glick, & Scribner, 1984; Klaczynski & Narasimham, 1998; Leevers & Harris, 2000) as well as adults (Stanovich & West, 1998) to explore the domain of deductive reasoning. The syllogisms used in the present study were taken from an investigation by Markovits and Nantel (1989) and adapted for use with children (Siddiqui, West & Stanovich, 1998; Stanovich, West, & Harrison, 1995). Thus in the present study, tasks similar to those used in previous empirical studies by Jacobs and Potenza and Davidson were employed. This enabled a direct comparison with
their pattern of results. However, in the present investigation a deductive reasoning task as well as an inductive reasoning task was used in order to sample a range of tasks and to speak to the larger theoretical issue of whether children's reasoning becomes less or more heuristic with age.

The second primary purpose of this study was to examine the correlates and predictors of reasoning performance from an individual differences perspective. One pervasive issue in the literature on critical thinking is whether individual differences in reasoning performance are associated with cognitive capacities or thinking dispositions (Baron, 1991). Overton, Byrnes, and O'Brien (1985) suggest that reasoning performance “...is a function of both the individual's level of logical competence and various moderator variables...which may include organismic factors (e.g. motivation, memory, attention) and situational factors (e.g. task structure and demands, contextual factors).” (p.639)

Baron (1985) has argued that cognitive capacities and thinking dispositions are conceptually separate from each other and that each can explain unique variance in performance. The latter empirical conjecture has been supported by some previous research (Klaczynski, Gordon & Fauth, 1997; Stanovich, 1999; Stanovich & West, 1997, 2000). Cognitive capacities include abilities such as processing speed, speed of retrieval, and working memory capacity. Cognitive capacities tend to be relatively fixed at a given point in time in an individual, and Baron (1995) argues that they are likely to be determined by genetic and physiological factors rather than by learning. It is often argued that these types of abilities constitute and explain a large component of intelligence (Baron, 1995). Cognitive capacities are often used to explain reasoning performance where those who are faster and have a greater capacity tend to perform better on reasoning problems (Johnson-Laird & Byrne, 1990; Mynatt, Doherty, & Dragan, 1993;

In contrast, thinking dispositions are "learned tendencies to behave in certain ways" (Baron, 1991, p. 118). The terms, thinking disposition, and cognitive style, are frequently used interchangeably. In this study, the term, thinking disposition, is used. Thinking dispositions are not fixed and can be somewhat altered with practice and across different situations (Baron, 1991). For example, it has been shown that training in the cognitive style or thinking disposition of reflectivity improved children's performance on school tasks (Baron, Badgio, & Gaskins, 1986), and adolescent's performance on conditional reasoning (Overton, Byrnes, & O'Brien, 1985). Many different cognitive styles or thinking dispositions have been discussed in the literature, for example, the need for cognition style (Cacioppo, Petty, Feinstein, & Jarvis, 1996), the reflectivity-impulsivity style (Kagan, Rosman, Day, Albert, & Phillips, 1964) and the contextualization-decontextualization style (Denny, 1991). Some of these were explored in the present study.

The distinction between cognitive capacity and dispositional explanations has many additional complexities (Baron, 1985, 1991; Perkins, 1995; Perkins, Jay & Tishman, 1993). Several empirical studies have demonstrated that variance in reasoning performance can be explained by thinking dispositions once the variance due to cognitive capacity has been partialled out (Klaczynski, Gordon & Fauth, 1997; Sá, West & Stanovich, 1999; Stanovich & West, 1997, 2000). For example, Stanovich and West (1997, 2000) found that thinking dispositions predicted further variation on performance of an argument evaluation task after cognitive capacities were partialled out. They explained this additional contribution of thinking dispositions by suggesting that reasoning is not only explainable by cognitive capacities at the algorithmic level of explanation (Anderson, 1990; Stanovich, 1999), but also by the intentional level of analysis (see Dennett, 1987). For example,
Stanovich and West (1997) argue, "we must know something about the epistemic goals of the reasoners" (p. 352) to understand reasoning performance.

Other researchers have reported similar results. Cacioppo, Petty, Kao, and Rodriguez (1986) found that both a dispositional variable (need for cognition) and verbal intelligence significantly predicted the number of arguments participants could recall after being presented with a persuasive message. After verbal intelligence was statistically controlled, the dispositional variable accounted for significant additional variance in the number of arguments recalled. Klaczynski, Gordon and Fauth (1997) examined individual differences in cognitive ability and the rational/intuitive thinking disposition (as defined in the work of Epstein, 1991, 1994) as predictors of the following tasks: a task involving sensitivity to the the law of large numbers, an analysis of covariance task, and a task involving evaluation of experimental evidence. They found that reasoning performance was predicted by thinking styles and not by cognitive ability.

What these studies indicated is that individual difference measures have been found to predict performance on reasoning tasks. Most importantly, however, is the finding that thinking dispositions (Stanovich & West, 1997; Cacioppo, Petty, Kao, & Rodriguez, 1986; Klaczynski, Gordon & Fauth, 1997) are independent predictors after differences in cognitive capacity have been controlled. These unique contributions of cognitive ability and thinking dispositions have been implicated in adult reasoning performance and this provides a rationale for exploring the roles of cognitive ability and thinking dispositions in children's reasoning performance.

A series of cognitive styles or thinking dispositions that have been used in the literature previously were selected based on how well they match or describe processes involved in children's epistemic reasoning about inductive and deductive reasoning problems. Stanovich (1999) has suggested a set of dispositions that are
associated with epistemic regulation and cognitive decontextualization. These dispositions include: flexible thinking, need for cognition, dogmatism, the absolutism thinking style, belief identification, and categorical thinking. Additionally, a related disposition called the impulsivity/reflectivity style (Kagan, Rosman, Day, Albert, & Phillips, 1964) was added to the thinking disposition battery because it is theoretically linked to measures of epistemic regulation and it has a history of use with children. Individual differences in these thinking dispositions and their relationship to reasoning performance were examined in this study.

Summary of Research Questions

To summarize, this investigation examined a variety of questions in the domain of children's reasoning:

1. As children develop, does their heuristic processing increase or decrease?
2. On the reasoning tasks investigated in this study (drawn from both the inductive and deductive reasoning domains) can it be demonstrated that thinking dispositions in participant children predict their reasoning performance over and above their cognitive ability?
3. If so, do these individual difference analyses parallel those in the adult literature?
4. Finally, are any of these individual differences moderated by developmental level (as characterized by the two age groups being investigated)?

Hypotheses

Contrary to the findings of Jacobs and Potenza (1991) and Davidson (1995), it was predicted that:
1. Analytic thinking would increase (and heuristic thinking would decrease) as children develop.

In regard to the individual difference analyses, contrary to the findings in
Klaczynski, Gordon, and Fauth (1997), it was predicted that:

2. Cognitive ability would account for independent variance on reasoning problems.

And that:

3. Thinking dispositions would account for independent variance in both the inductive and deductive domains after cognitive ability was partialled out.

Method

Participants

The participants were 112 students (50 females and 62 males) in grades 5, 6 and 8, placed in general (n=61) and in gifted (n=51) classes in one urban (K to 8) elementary school. All grade 5, 6, and 8 students in the school were invited to participate in the study and given an information/permission form to take home for their parents to read. Students who returned signed forms indicating parental consent participated in the study by completing the battery of tasks. Grade 5 and 6 students were collapsed into one group and served as the developmental contrast with grade 8 students.

Table 1 displays differences in the participant sample. The participants were divided into four groups distinguished by differences in grade and program. Between and within group differences in age (months), pro-rated IQ and a measure of cognitive ability (both discussed later in the Method) are noted. Gender differences were non-significant on most measures but when it was, the difference was due to the imbalance of males and females in the gifted program. Gender differences are not analyzed further.

Age

The mean age in months of each group was compared. Age (months) was significantly different ($F(1,104) = 522.6, p<.001$) when the two grade groups were
compared. There was no age difference within the grades whether the students were in the gifted program or the general program. (See Table 1)

Outliers

Outliers were identified using the Mahalanobis statistic as calculated by the JMP Software Program (SAS) version 2.5 on the cognitive ability measures. Data from four participants (2 males and 2 females in the general program) were excluded. Two outliers were recently-arrived English as a Second Language speakers. They were doing schoolwork in English in Canada for less than two years. The other two had pro-rated IQ scores of less than 80, which is below the average range of performance (as measured by the Vocabulary and Block Design Subtests of the WISC-III). These four outliers were removed from the analyses (Tabachnick & Fidell, 1989, p.64).

Missing Data

The unsystematic missing data (less than 1% of the cells) was filled with the rounded mean (Tabachnick & Fidell; 1989, p. 64).
Table 1

Participants: Grade and Program by Mean Age (in Months), Pro-rated IQ, and Cognitive Ability

<table>
<thead>
<tr>
<th>Program:</th>
<th>General (n=31)</th>
<th>Gifted (n=26)</th>
<th>General (n=26)</th>
<th>Gifted (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Age (months)</td>
<td>132.5</td>
<td>9.5</td>
<td>127.5</td>
<td>8.5</td>
</tr>
<tr>
<td>Pro-Rated IQ</td>
<td>94.4</td>
<td>11.2</td>
<td>128.8</td>
<td>10.4</td>
</tr>
<tr>
<td>Cognitive Ability</td>
<td>-1.91</td>
<td>1.14</td>
<td>.68</td>
<td>.92</td>
</tr>
</tbody>
</table>

Note. Cognitive Ability = ZBlock Design + ZVocabulary
Reasoning Problems

The inductive and deductive reasoning problems used are described below.

Inductive reasoning.

The inductive reasoning problems were taken from Fong, Krantz and Nisbett (1986) and adapted for use by children. Students read 15 reasoning problems about everyday matters. The instructions directed them to choose an answer from a series of response options. The key problems pit baserate information against individuating information of low diagnosticity. An example follows:

Kyle wants to buy a dog that is a good swimmer. After checking with the Kennel Club, the Humane Society, and several dog breeding books, he decides to buy a Labrador because they are rated as the best swimmers. However, his neighbour has a Labrador who is a terrible swimmer. What type of dog is Kyle most likely to buy?

a.) Definitely a Labrador
b.) Probably a Labrador
c.) Probably another type of dog
d.) Definitely another type of dog

Selection of the c.) or d.) option indicates that the participants are using the low diagnostic individuating information rather than the baserate information to make their decision. Seven of the problems involved the accurate use of baserate information only. Responses for all groups were close to ceiling on these problems and thus they were not analyzed. The eight problems analyzed were those where baserate information conflicted with individuating information. (The problem above is an example of such a problem.) Problems were scored in the direction of higher scores
indicating more baserate usage (baserate responding represents the analytic response on these problems). In the problem example, a response of a.) would be scored 4 and a response of d.) would be scored 1, with the remaining two responses falling in between. For each problem, the scale ranged from 1- 4 with higher scores indicating the analytic response. Total scores for each participant ranged between 8 and 32 on this task. The total raw score was used in analyses. (See Appendix A for the complete problem set.)

**Deductive reasoning with syllogisms.**

The syllogism task is an experimental measure adapted for use with children (Siddiqui, West & Stanovich, 1998; Stanovich, West, & Harrison, 1995). The items were taken from Markovits and Nantel (1989). Students were read a script asking them to pretend that an alien from another planet had landed on Earth. The script read, “The alien’s thought processes are very logical, but it knows nothing about Earth. The alien will be told a number of things about Earth but some of the information might be false.” The students were then instructed to give their opinion about what the logical alien would conclude based on what it had been told. Two premises and a conclusion were read. Then, the students circled “Yes” or “No” to indicate that they agreed or disagreed that the stated conclusion was made by the alien. Two practice problems were completed first. The practice problems were constructed using imaginary (neutral) content, for example:

*The logical alien is told...* All tumpers lay eggs.

*The alien is also told...* Sampets are tumpers.

*The logical alien would conclude...* Sampets lay eggs.
For each problem, the scale ranged from 0-1 with the higher score indicating the analytic response. One of the practice problems was logically valid (as is the problem above) while the other was logically invalid. Each student was provided feedback from a script articulating the reasoning upon which the correct response was based, whether they made the correct conclusion or not. Upon completion of the practice problems, as they followed along with the written text, students were read eight syllogistic reasoning problems. For four of the problems believability and validity were in the same direction. For example, a believable conclusion was valid or an unbelievable conclusion was invalid. These were termed "consistent" problems. Students from all groups performed close to ceiling on these problems and thus, they were not analyzed. For the remaining four problems, the valid solution required conclusions that conflicted with the believability of the content. For example, a believable conclusion was invalid or an unbelievable conclusion was valid. These were termed "inconsistent". Responses on each item were coded 1 for correct or 0 for incorrect. Higher scores indicated the analytic response. Scores ranged from 0 to 4. The total raw score for each student was used in the analyses. An example of problem with a valid conclusion consisting of unbelievable content follows:

_The logical alien is told..._All mammals walk.
_The alien is also told..._Whales are mammals.
_The logical alien would conclude..._Whales walk.

See Appendix B for the complete problem set.
Thinking Dispositions

Thinking dispositions were measured using two tasks. One task, the Thinking Dispositions Questionnaire, required the completion of a rating scale tapping epistemological thinking styles. The other task, the Matching Familiar Figures Test, involved matching figures to tap into the impulsivity/reflectivity thinking disposition.

On the Thinking Dispositions Questionnaire, students read a series of statements about thinking. Then, they were asked to rate the statements on a four point scale (1. strongly agree 2. agree 3. disagree 4. strongly disagree). These statements are based on existing thinking scales that have been used with adults and were modified for use with children for this study. Ten different thinking dispositions were tapped through 53 items. Items from the different subscales were randomly intermixed. A brief description with some examples of these subscales follow. Some of these subscales were combined to form two thinking disposition composites: the actively-openminded thinking composite and the luck composite. The need for cognition scale and the MFFT remained as stand-alone scales. These four scales were used in later statistical analyses. See Appendix D for a complete listing of all of the items.

Actively-Openminded Thinking Composite.

The actively-openminded thinking composite was created by combining the following five scales: flexible thinking, Cederbloom’s belief identification scale, the absolutism scale, the dogmatism scale and the categorical thinking scale. On the first scale, flexible thinking, high scores indicate openness while high scores on the other four scales indicate lack of openness. Therefore, flexible thinking was reflected so that the scores of all four subscales were in the same direction. Next, responses for each of the items for all of the subscales were summed and transformed into standard scores. Then the standard score was multiplied by -1 so that an positive
score indicated increasing openness and a negative score indicated lack of openness. The actively-openminded thinking composite consists of a total of 30 items. The Spearman-Brown coefficient for the 30 items in this composite was .79.

The flexible thinking style developed by Stanovich and West (1997) was influenced by a variety of sources from the critical thinking literature (e.g., Facione, 1992; Ennis, 1987; Lipman, 1991; Nickerson, 1987; Norris & Ennis, 1989; Perkins et al., 1993; Zechmeister, & Johnson, 1992) especially by the work of Baron (1985, 1988, 1993). This scale was included in the present study because it taps an individual's inclination to decontextualize a problem or issue in order to be able to examine it from multiple perspectives rather than just a self-serving one demonstrating "myside" bias. Also, it has never been used with children.

In the thinking disposition scale in this study, there are 10 items from the Flexible Thinking scale, some tapping the disposition toward reflectivity (e.g. "If I think longer about a problem I will be more likely to solve it."), willingness to consider evidence contradictory to beliefs (e.g. "People should always consider evidence that goes against their beliefs."), willingness to consider alternative opinions and explanations (e.g. "A person should always consider new possibilities."), and a tolerance for ambiguity combined with a willingness to postpone closure (e.g. "Changing your mind is a sign of weakness." - which is reverse scored). The split-half reliability (Spearman-Brown corrected) was .61.

The belief identification thinking disposition was inspired by a theoretical paper by Cederbloom (1989), in which he argues that a potentially important dimension for explaining how willing people are to reason about issues involves how closely they identify their beliefs with their concept of "self". At one extreme of this dimension are people who closely identify their beliefs with their own sense of self. These people may, consequently, be less inclined to revise or change beliefs since they view them
as an intimate part of who they are. At the other end of the spectrum are those who see themselves simply as a belief forming-process. These people do not identify their beliefs with their sense of self and simply view beliefs as external entities that may be evaluated, revised or discarded without impacting on their own persona. Kuhn (1992), referring to this dimension under the rubric of “belief ownership”, makes the case that having a sense of “ownership” in your beliefs and thus creating a sort of vested interest in their continued existence, can be detrimental to an impartial evaluation of their objective validity. A person who scores high on this scale is indicating that the stability of their belief system is an important epistemic goal to them. High scores on this scale would also indicate a lack of openness and presumably would hinder reasoning performance of children on the inductive and deductive thinking problems in this study.

A six item scale distilled from the ideas expressed in Cederbloom (1989) was administered. An example of an item is “I never change what I believe in – even when someone shows me that my beliefs are wrong.” The split-half reliability (.33, Spearman-Brown corrected) was of course quite low given that the scale is composed of only six items.

The Absolutism/Dualism scale was adapted from the Scale of Intellectual Development (SID) developed by Erwin (1981, 1983) and consists of five items. The SID represents an attempt to develop a multiple-choice scale to measure Perry’s (1970) hypothesized stages of epistemological development in young adulthood. Perry’s early stages are characterized by an absolutist orientation and are characterized by cognitive rigidity, by belief that issues can be couched in either/or terms, that there is one right answer to every complex problem, and by reliance on authority for belief justification. It is similar to related work in the literature (King & Kitchener, 1994; Kramer, Kahlbaugh, & Goldston, 1992; Schommer, 1990, 1993,
1994). This orientation is captured by items such as “A good person usually does what they are told to do.” These items should be sensitive to the developmental and cognitive ability contrast of the sample of children in this study. It is at this age (adolescence) that some children start to question authority and attempt to make their own decisions.

The dogmatism thinking style is based on Rokeach’s (1960) development of the Dogmatism Scale. Consisting of six statements, some sample items are: “If everybody in a group has too many different ideas, the group will break up.”; and “It really makes me angry when someone can't say they are wrong.” The split-half reliability (Spearman-Brown corrected) was .44.

The categorical thinking disposition is based on Epstein and Meier’s (1989) scale, the Constructive Thinking Inventory (CTI) and reflects the tendency to place ideas, events, objects, and people in exclusive categories based on specific characteristics. Three items were administered: “There are basically two kinds of people in this world, good and bad.”; ” There is one right way and lots of wrong ways to do most things.”; and “ I think people are either with me or against me.”

The need for cognition thinking scale (NC).

The need for cognition (NC) disposition is described as follows:

Individuals high in need for cognition were proposed to naturally tend to seek, acquire, think about, and reflect back on information to make sense of stimuli, relationships, and events in their world. Individuals low in need for cognition, in contrast, were characterized as more likely to rely on others (e.g., celebrities and experts), cognitive heuristics, or social comparison processes to provide this structure. (Cacioppo, Petty, Feinstein, & Jarvis, 1996, p. 198)
Petty and Cacioppo (1986) examined whether those who have a high need for cognition would generate thoughts that better reflect the quality of an argument presented than those who have a low need for cognition. They examined this question by presenting college participants with a message about raising tuition. What they found is that "the profile of thoughts generated by individuals high in need for cognition is more likely to reflect the quality of the arguments in a message than is the profile of thoughts generated by individuals low in need for cognition." (Cacioppo et al., 1996) It seems that the need for cognition style captures a more in-depth approach to problem solving, and a lower susceptibility to being captured by superficial cues such as the expertise or attractiveness of the message source (Petty, Cacioppo, & Goldman, 1981) or the number of arguments in the message (Petty & Cacioppo, 1984). These characteristics are important in inductive reasoning problems about everyday matters. The need for cognition style has never been examined in children.

The NC scale consists of nine items. In the measurement of the NC thinking style, participants are asked to respond to whether a series of statements are true of themselves, such as: "I like hard problems instead of easy ones." (Cacioppo et al., 1996). Raw scores of the nine items of the NC scale were summed for analysis. The split-half reliability as measured by the Spearman-Brown statistic was .67.

**Luck composite.**

The Luck Composite is made by combining three similar scales, the Concept of Luck Scale, the Paranormal Scale, and the Superstitious Thinking Scale, which tap into the belief that external events beyond an individual's control affect goal achievement. This composite consists of eight items. The Spearman-Brown coefficient for the eight items in the luck composite was .59.

The Concept of Luck scale consists of five items. These items reflecting
conceptions of luck are taken from previous work by Stanovich and West (1998). Sample items include: “I have things that bring me luck.” and “The number 13 is unlucky.”

The Paranormal Belief Scale consists of two items. These two items are concerned with belief in astrology: “It's a good idea to consult your horoscope every day.” The items were adapted from the paranormal belief scale validated by Jones, Russell, and Nickel (1977).

The Superstitious Thinking Scale consists of one item taken from the Superstitious Thinking subscale of Epstein and Meier's (1989) Constructive Thinking Inventory (CTI). The item included is “I do not believe in any superstitions.” and is reverse scored.

Other dispositions.

Five items reflecting social desirability response bias were taken from Paulhus, (1991). Some examples of these items are: “I always obey rules, even if I probably won't get caught.”; and “I sometimes tell lies if I have to.” The latter was reverse scored.

One check item (Birds have feathers.) was also included in the rating scale for a total of 53 items.

Reflectivity and impulsivity.

The reflectivity-impulsivity dimension has mainly been studied in children, where “reflective children are those who choose to be careful at the expense of speed”, while “impulsive children do things quickly but make many errors” (Baron, 1995, p. 112). The classic task used to measure this dimension is the Matching Familiar Figures Test (MFFT), which was developed by Kagan, Rosman, Day, Albert, and Phillips (1964). In this task, participants need to match a target picture with one of six other pictures. This task effectively captures a trade-off between speed and
accuracy (Baron, Badgio, & Gaskins, 1986). The dimension of reflectivity and impulsivity has been described as a disposition, as people have some control over how quickly they get through a task (Baron et al., 1986). The idea that spending more time on a task to think through the problem is likely to be an important process in reasoning.

Participants were presented with one target picture and a set of six pictures which included an exact match of the target picture. The participant was instructed to point to the correct match of the target. When the participant made an incorrect selection, they were asked to select again - this procedure was repeated up to a maximum of six attempts or until the participant pointed to the correct match whichever came first. There were 14 items altogether in the MFFT.

The total time taken to complete an item and the total number of errors were measured in this task. Also recorded were the number of items with incorrect responses and the response latency of the first attempt for each item. The mean time to the first response for all items and the total number of items with incorrect responses were standardized for each participant. The standardized metric for reaction time was called MFFT_RT and the standardized error metric was called MFFT_Errors. The difference between these standard scores was taken to create a variable which took into account both response time and number of items with errors. This variable was called MFFT_RT-Errors. See Appendix D for a sample item of the MFFT.

Pro-rated IQ and Cognitive Ability

Two cognitive ability metrics were calculated. Participants completed a short form of the Wechsler Intelligence Scale for Children-III (WISC-III, Wechsler, 1991). The short form consisted of the Vocabulary and the Block Design Subtests. This particular dyad of subtests is reported (Sattler, 1992) to have the highest internal
consistency subtest reliabilities (Vocabulary subtest, r=.86; Block Design subtest, r=.85) compared to all of the other subtests in the WISC-III. Second, the combined Vocabulary and Block Design subtests provide the most valid estimate of Full Scale IQ (r=.906) compared to all other dyad short forms in the WISC-III (Sattler, 1992). These two subtests were prorated to give an estimated Full-scale IQ score. The Full-scale IQ estimate score was 104.5 (SD=16.51).

An IQ score is an age-relativized measure. Models of computational capacity in the cognitive science literature concern absolute computational capacity. Thus, an additional measure of absolute cognitive ability, Cognitive Ability (CAb), was created. For this variable, the raw scores on the subtests (Vocabulary and Block Design) were standardized and summed. The mean is zero and therefore a negative number indicates that the score is below the mean. This new score represents absolute computing power without any correction for age. Both metrics, Pro-rated IQ and Cognitive Ability, were used in the statistical analyses.

Table 1 (p. 21) displays the mean pro-rated IQ scores of each group. There was no difference in pro-rated IQ between grade 5/6 students or grade 8 students within programs. This means that the grade 5/6 students in general classes and the students in grade 8 general classes were from the same population when Pro-rated IQ was used to describe them. The same was true for the grade 5/6 and grade 8 students in gifted classes. Comparisons of pro-rated IQ measures between the gifted program and the general program yielded significant differences (F(1,104) = 172.63, p<.001). The interaction of grade by program was significant (F(1,104) = 4.72 p < .05). The interaction occurs because the program difference in IQ is larger in the Grade 5/6 group than in the Grade 8 group.

Table 1 also displays the mean cognitive ability scores of each group. The between grade difference in the means of the cognitive ability scores was significant
(F (1,104) = 55.62, p<.001). Differences in the participants were also noted by program. Students in the gifted program had significantly higher scores than students in the general program (F (1,104) = 154.35, p<.001). The cognitive ability scores reflected the expected pattern that the grade 8 students in the gifted program had the greatest computational power while grade 5/6 students in the general program had the lowest computational power.

As can be seen in the table, interestingly, grade 5/6 students in the gifted program scored higher both in the pro-rated IQ score and the cognitive ability score than the Grade 8 students in the general program. However to summarize the overall differences, Grade 8 students had greater computing power than grade 5/6 students and students in the gifted program more than students in the general program.

**Statistical Knowledge**

A measure of statistical knowledge was created by adapting questions with statistical content from the 1997 Grade Three Assessment of Reading, Writing and Mathematics (EQAO, 1997). Four questions assessing the ability to apply knowledge of frequency and probability were included. Basic knowledge of statistics and probability is required in order to use given base rate information when making decisions or judgments. If statistical knowledge competency is demonstrated then decision-making performance on scenarios will provide results with greater diagnosticity. That is, one of the sources of variance, basic statistical knowledge, will be largely eliminated. Variance in performance will be influenced by individual differences in cognitive ability and/or thinking dispositional styles rather than statistical knowledge competency. The response format was multiple choice. A correct answer was scored one and an incorrect answer was scored zero. Scores ranged from zero to four. The raw scores of the four questions were summed and used in the statistical analyses.
Ethical approval to conduct this study was gained from the University of Toronto in March 2000 and from the participating school board in May 2000. See Appendix E and F for consent and demographic data forms.

Data was collected during October and November of 2000. Upon consent from parents of each participating child and teachers of each participating classroom, students were taken from their classrooms during class hours in order to complete the battery of tasks. All testing took place in a quiet room at their school. Before participation began, a child assent form was read to each participant by the experimenter. Students were reminded that the research tasks had nothing to do with their classroom program and were provided with a general overview of the assessment. The students were advised that they did not have to answer any questions if they did not wish to, and that they could stop participating at any time. They were also told that a research report detailing the results of the study would be made available to them at the school office upon the completion of the study. Participants were then asked to provide their assent. Demographic data was collected and the battery of standardized measures, experimental measures, and rating scales were administered. Participants were tested individually by one of two experimenters. All participants received the common test battery in the same sequential order. The entire battery took between 45-90 minutes in total. A nominal food "treat" was provided to all participants upon completion of the assessment as thanks for their participation. Table 2 lists the order of Task Administration.
Table 2

**Order of Task Administration**

1. Child Assent
2. Demographic Data
3. Inductive Problems
4. Deductive: Syllogisms
5. Thinking Dispositions Scale
6. WISC-III Block Design subtest
7. WISC-III Vocabulary subtest
8. Matching Familiar Figures Test (MFFT)
9. Statistical Knowledge

The tasks were balanced between independent work and work with the experimenter to assist in maintaining interest and attention. An offer of verbal debriefing of the study and its tasks was made when the participants completed the battery of tasks. Other tasks not discussed here were administered to the children.
Children’s Reasoning

Results

The goal of this study was to examine analytic and heuristic thinking in children. This study attempted to determine 1. whether older students (grade 8) performed better than younger students (grade 5/6) on reasoning problems, 2. whether performance of students in the gifted program differed from students in the general program and finally, 3. the relationship between thinking dispositions and performance on the reasoning tasks.

Reasoning and Development

Inductive reasoning.

The inductive reasoning task consisted of 15 problems. The optimal choice on seven of the problems involved the accurate use of base rate information. Responses for all groups were close to ceiling and thus, were not analyzed. The eight problems analyzed were those where base rate information conflicted with individuating information. The scale ranged from 8-32, with higher scores indicating the analytic response (choosing the base rate information over the individuating information). The ceiling score was 32 (8 x 4).

A 2 (grade) by 2 (program) analysis of variance was conducted on the inductive reasoning scores. The means of the four subgroups are presented in Table 3. As indicated in Table 3, the means for both grade ($F(1, 104) = 9.58, p < .01$) and program ($F(1, 104) = 14.51, p < .001$) were significantly different. The interaction was not significant ($F(1, 104) = 0.49, ns$). Grade 8 students performed significantly better than grade 5/6 students. Students in the gifted program performed better than students in the general program. As indicated in the table, the mean scores of the grade 5/6 students in the gifted program were quite similar to the mean scores of the grade 8 students in the general program.
Eight syllogism problems were presented. For four of the problems, believability and validity were in the same direction. Students from all groups performed close to ceiling on these problems and thus, they were not analyzed. For the remaining four problems, the valid solution required conclusions that conflicted with the believability of the content. These were termed "inconsistent". Responses were coded 1 for correct or 0 for incorrect. Higher scores indicate the analytic response. Ceiling was (4x1=) 4.

A two (grade) by two (program) analysis of variance was conducted on the deductive reasoning scores. The means of the four subgroups are presented in Table 4. Both grade and program showed significant differences in performance means, $F(1, 104) = 7.58, p < .01$, and $F(1, 104) = 13.16, p < .001$, respectively. The interaction
effect was not significant ($F (1, 104) = 1.21, p = .27$). Grade 8 students performed significantly better than grade 5/6 students. Students in the gifted program performed better than students in the general program. As on the inductive reasoning task, grade 5/6 students in the gifted program performed better than the grade 8 students in the general program but this was not statistically significant.

Table 4
Mean Performance on Deductive Problems (Inconsistent Syllogisms)

<table>
<thead>
<tr>
<th>Program</th>
<th>Grade 5/6</th>
<th>Grade 8</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gifted</td>
<td>M: 1.96</td>
<td>SD: .92</td>
<td>M: 2.64</td>
</tr>
<tr>
<td>General</td>
<td>M: 1.52</td>
<td>SD: .96</td>
<td>M: 1.81</td>
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<tr>
<td>Totals</td>
<td>M: 1.72</td>
<td>SD: .95</td>
<td>M: 2.22</td>
</tr>
</tbody>
</table>

Predictors of Performance on the Reasoning Tasks

Table 5 displays all the correlations among the major variables in the study. As is clear from the table, the two reasoning tasks displayed a significant but modest correlation. In terms of participant characteristics, subject age was correlated with performance on both tasks as was the statistical knowledge measure (.25 to .30). However, cognitive ability was even more strongly associated with reasoning performance than the age of the subjects (correlations of .49 and .43, respectively). Several of the thinking disposition measures displayed significant associations with
performance on the reasoning tasks, but most of these correlations were fairly low. The exception to this trend was the actively-openminded thinking composite which displayed moderate correlations with each of the reasoning tasks (.43 and .40, respectively). Like cognitive ability, the actively-openminded thinking disposition scale displayed a larger association with analytic responding than did the age of the participant.

Correlations between cognitive ability and thinking dispositions largely replicated associations found in previous work with adult participants (Stanovich & West, 1997; Sá et al., 1999). The cognitive ability composite displayed a moderate correlation (.48) with the actively-openminded thinking composite and significant correlations with the luck composite scale and MFFT\textsuperscript{Errors}. Within the thinking dispositions measures, actively-openminded thinking displayed a significant negative correlation (-.34) with the luck subscale and a significant negative correlation (-.23) with MFFT\textsuperscript{Errors} and a significant positive correlation with the MFFT composite (.22).

Thus, to summarize the relationships in the correlation matrix, there were indications that analytic responding in both the deductive and inductive tasks is related to both cognitive ability and to some of the thinking dispositions measures included in the study. A set of regression analyses were conducted in order to explore the extent to which cognitive ability and thinking dispositions measures were independent predictors of analytic reasoning. Table 6 presents the results of these regressions conducted on performance on the inductive reasoning problems.
Table 5

Intercorrelations Among the Primary Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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</thead>
<tbody>
<tr>
<td>Reasoning task</td>
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<td></td>
</tr>
<tr>
<td>1 Inductive</td>
<td>–</td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>2 Deductive</td>
<td>.25**</td>
<td>–</td>
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<td></td>
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<td>Participant Characteristics</td>
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<tr>
<td>3 Age</td>
<td>.30**</td>
<td>.25**</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 CAb</td>
<td>.49***</td>
<td>.43***</td>
<td>.41***</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 SK</td>
<td>.30**</td>
<td>.30**</td>
<td>.13</td>
<td>.40***</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinking Dispositions</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 AOT</td>
<td>.43***</td>
<td>.40***</td>
<td>.22*</td>
<td>.48***</td>
<td>.38***</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 NC</td>
<td>.02</td>
<td>-.08</td>
<td>-.24*</td>
<td>.09</td>
<td>.05</td>
<td>.16</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Luck</td>
<td>-.10</td>
<td>-.25**</td>
<td>-.12</td>
<td>-.30**</td>
<td>-.36***</td>
<td>-.34***</td>
<td>-.14*</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 MFFT&lt;sub&gt;Err&lt;/sub&gt;</td>
<td>-.23**</td>
<td>-.06</td>
<td>-.05</td>
<td>-.24**</td>
<td>-.08</td>
<td>-.23*</td>
<td>-.20*</td>
<td>.23*</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>10 MFFT&lt;sub&gt;RT&lt;/sub&gt;</td>
<td>.19*</td>
<td>.03</td>
<td>-.10</td>
<td>.07</td>
<td>.02</td>
<td>.17</td>
<td>.18</td>
<td>-.05</td>
<td>-.61***</td>
<td>–</td>
</tr>
<tr>
<td>11 MFFT&lt;sub&gt;RT-Err&lt;/sub&gt;</td>
<td>.24*</td>
<td>.05</td>
<td>-.03</td>
<td>.17</td>
<td>.05</td>
<td>.22*</td>
<td>.21*</td>
<td>-.15</td>
<td>-.90***</td>
<td>.90***</td>
</tr>
</tbody>
</table>

Note. CAb = cognitive ability, SK = statistical knowledge, AOT = actively-openminded thinking composite (standard scores of flexible thinking scale + Cederbloom's belief identification scale + absolutism scale + dogmatism scale + categorical thinking scale x -1); NC = need for cognition scale; luck composite = concept of luck scale + paranormal subscale + superstitious thinking subscale; MFFT<sub>Err</sub> = number of items where errors were made on the Matching Familiar Figures Test; MFFT<sub>RT</sub> = Length of time taken to make the initial response; MFFT<sub>RT-Err</sub> = standard score of response time minus the standard score of the number of items where errors were made. 

* = p < .05, ** = p < .01, *** = p < .001, all two-tailed.
The first analysis in Table 6 indicates that when cognitive ability and actively-openminded thinking are entered into a regression equation predicting performance on the inductive reasoning problems both predict significant independent variance. Cognitive ability is the most potent predictor (10.9% unique variance explained), but actively-openminded thinking does predict a statistically significant 4.8% unique variance once the variance in cognitive ability has been partialled out. The two variables commonly predict 13.5% of the variance in inductive reasoning performance.

The remaining three regression analyses indicate that when cognitive ability is entered into a regression equation predicting performance on inductive reasoning along with each of three thinking disposition measures (need for cognition, luck, MFFTErrors), only cognitive ability is a significant unique predictor. Specifically, when cognitive ability and need for cognition are entered into the the regression equation, cognitive ability predicts all of the variance (24.5%). Similarly cognitive ability predicts most of the variance when cognitive ability (24% unique variance) and luck (1% unique variance) are entered into the regression equation. For the latter two regressions, there is no shared common variance. Finally, when cognitive ability and MFFTErrors are entered into the regression equation, cognitive ability predicts 21% unique variance while MFFTErrors predict 2% unique variance. The two variables commonly predict 2.7% of the variance in inductive reasoning performance.
Table 6
Simultaneous Regression Analyses for Inductive Problems

<table>
<thead>
<tr>
<th>Criterion Variable = Inductive Problems</th>
<th>beta weight (standardized)</th>
<th>t-value</th>
<th>Unique Variance Explained</th>
<th>Partial r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Ability</td>
<td>.376</td>
<td>4.018***</td>
<td>.109</td>
<td>.365</td>
</tr>
<tr>
<td>AOT</td>
<td>.248</td>
<td>2.648**</td>
<td>.048</td>
<td>.250</td>
</tr>
<tr>
<td>Overall Regression: F = 21.612 ***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R = .54</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R-squared = .292</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criterion Variable = Inductive Problems</th>
<th>beta weight (standardized)</th>
<th>t-value</th>
<th>Unique Variance Explained</th>
<th>Partial r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Ability</td>
<td>.497</td>
<td>5.836***</td>
<td>.245</td>
<td>.495</td>
</tr>
<tr>
<td>Need for Cognition</td>
<td>-.029</td>
<td>.339</td>
<td>.001</td>
<td>-.033</td>
</tr>
<tr>
<td>Overall Regression: F = 17.048 ***</td>
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<tr>
<td>Multiple R = .495</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R-squared = .245</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criterion Variable = Inductive Problems</th>
<th>beta weight (standardized)</th>
<th>t-value</th>
<th>Unique Variance Explained</th>
<th>Partial r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Ability</td>
<td>.511</td>
<td>5.763***</td>
<td>.240</td>
<td>.490</td>
</tr>
<tr>
<td>Luck</td>
<td>.057</td>
<td>.640</td>
<td>.010</td>
<td>.060</td>
</tr>
<tr>
<td>Overall Regression: F = 17.243 ***</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R = .497</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R-squared = .247</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criterion Variable = Inductive Problems</th>
<th>beta weight (standardized)</th>
<th>t-value</th>
<th>Unique Variance Explained</th>
<th>Partial r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Ability</td>
<td>.466</td>
<td>5.376***</td>
<td>.210</td>
<td>.460</td>
</tr>
<tr>
<td>MFFT Errors</td>
<td>-.116</td>
<td>1.333</td>
<td>.020</td>
<td>-.130</td>
</tr>
<tr>
<td>Overall Regression: F = 18.147 ***</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R = .507</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R-squared = .257</td>
<td></td>
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</tr>
</tbody>
</table>

Note. AOT = actively-openminded thinking composite (standard scores of flexible thinking scale + Cederbloom's belief identification scale + absolutism scale + dogmatism scale + categorical thinking scale x -1); luck = composite of concept of luck scale + paranormal subscale + superstitious thinking subscale; MFFT Errors = number of items where errors were made on the Matching Familiar Figures Test.

* = p < .05, ** = p < .01, *** = p < .001
Table 7 indicates that exactly the same pattern that was displayed when regression analyzes were conducted on performance on the deductive reasoning problems. The actively-openminded thinking composite was a significant unique predictor of analytic responding on the deductive task after the variance accounted for by cognitive ability had been partialled. Cognitive ability is the most potent predictor (8% unique variance explained), but actively-openminded thinking does predict a statistically significant 5% unique variance once the variance in cognitive ability has been partialled out. The two variables commonly predict 10.6% of the variance in inductive reasoning performance.

However, none of the other thinking dispositions measures (need for cognition, luck, MFFT Errors) were significant unique predictors. Cognitive ability was a unique predictor of deductive reasoning skill in every case. Specifically, when cognitive ability and need for cognition are entered into the regression equation, cognitive ability predicts most of the variance (19% unique variance) while need for cognition predicts 1% of the variance uniquely. Similarly cognitive ability predicts most of the variance when cognitive ability (14% unique variance) and luck (1% unique variance) and cognitive ability (18.6% unique variance) and MFFT Errors (0% unique variance) are entered into the regression equations. Cognitive ability and luck share common variance of 5.3% while the other the variables in the other two equations do not share any common variance.
## Table 7

**Simultaneous Regression Analyses for Deductive Problems**

<table>
<thead>
<tr>
<th>Criterion Variable = Deductive Problems</th>
<th>beta weight (standardized)</th>
<th>t-value</th>
<th>Unique Variance Explained</th>
<th>Partial r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Ability</td>
<td>0.313</td>
<td>3.219**</td>
<td>0.080</td>
<td>0.300</td>
</tr>
<tr>
<td>AOT</td>
<td>0.251</td>
<td>2.579*</td>
<td>0.050</td>
<td>0.240</td>
</tr>
<tr>
<td>Overall Regression: F = 16.176***</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R = .485</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R-squared = .236</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Criterion Variable = Deductive Problems</th>
<th>beta weight (standardized)</th>
<th>t-value</th>
<th>Unique Variance Explained</th>
<th>Partial r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Ability</td>
<td>.444</td>
<td>5.070***</td>
<td>0.190</td>
<td>0.440</td>
</tr>
<tr>
<td>Need for Cognition</td>
<td>-.124</td>
<td>1.412</td>
<td>0.010</td>
<td>-.140</td>
</tr>
<tr>
<td>Overall Regression: F = 13.309***</td>
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<td></td>
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<tr>
<td>Multiple R = .45</td>
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</tr>
<tr>
<td>Multiple R-squared = .202</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Criterion Variable = Deductive Problems</th>
<th>beta weight (standardized)</th>
<th>t-value</th>
<th>Unique Variance Explained</th>
<th>Partial r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Ability</td>
<td>.394</td>
<td>4.312***</td>
<td>.140</td>
<td>.390</td>
</tr>
<tr>
<td>Luck</td>
<td>-.130</td>
<td>1.425</td>
<td>.010</td>
<td>-.140</td>
</tr>
<tr>
<td>Overall Regression: F = 13.332***</td>
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<td></td>
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</tr>
<tr>
<td>Multiple R = .45</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R-squared = .203</td>
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</table>

<table>
<thead>
<tr>
<th>Criterion Variable = Deductive Problems</th>
<th>beta weight (standardized)</th>
<th>t-value</th>
<th>Unique Variance Explained</th>
<th>Partial r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Ability</td>
<td>.444</td>
<td>4.896***</td>
<td>.180</td>
<td>.430</td>
</tr>
<tr>
<td>MFFTErrors</td>
<td>.045</td>
<td>.500</td>
<td>.000</td>
<td>.050</td>
</tr>
<tr>
<td>Overall Regression: F = 12.237***</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Multiple R = .435</td>
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<td></td>
</tr>
<tr>
<td>Multiple R-squared = .189</td>
<td></td>
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</tbody>
</table>

*Note.* AOT = actively-openminded thinking composite (standard scores of flexible thinking scale + Cederbloom's belief identification scale + absolutism scale + dogmatism scale + categorical thinking scale x -1); luck = composite of concept of luck scale + paranormal subscale + superstitious thinking subscale; MFFTErrors = number items where errors where made on the Matching Familiar Figures Test

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

This investigation examined a variety of questions about children's reasoning. Contrary to the findings of Jacobs and Potenza (1991) and Davidson (1995), it was predicted that as children develop, analytic thinking would increase and heuristic thinking would decrease. That is, it was expected that older students would perform better, and again contrary to the findings in Klaczynski, Gordon, and Fauth (1997), that cognitive ability would account for independent variance on reasoning problems. In addition, it was predicted that thinking dispositions would also account for independent variance in both the inductive and deductive domains.

The first set of major research questions were, “How does reasoning change developmentally?” and “As children develop, does heuristic processing increase or decrease?” Results indicated that reasoning does improve with age. The scores on the reasoning problems of the older students (grade 8) were higher than the scores of the younger students (grade 5/6). Furthermore, since the inductive reasoning problems pit baserate versus individuating information and the deductive problems include syllogisms where validity contrasts with believability, the conclusion that heuristic processing declines and that analytic processing increases with age can be made.

The second major research question concerned the explanatory power of individual differences on reasoning performance: “Do thinking dispositions predict inductive and deductive reasoning performance over and above cognitive ability in children?”. The individual difference analyses revealed results paralleling those in the adult literature (Klaczynski, Gordon & Fauth, 1997; Sá, West & Stanovich, 1999, Stanovich & West, 1997, 1998). Regression analyses demonstrated that in addition to cognitive ability, the thinking disposition, actively-openminded thinking, predicted performance on the reasoning tasks. For example, Table 5 indicates that cognitive ability, statistical knowledge, and the thinking disposition, actively-openminded thinking, increased with age while the reliance on luck decreased. Surprisingly, scores
on the need for cognition thinking disposition declined with age.

As Children Develop, Does Heuristic Processing Increase or Decrease?

In the two reasoning tasks examined in this study, it was found that grade 8 children outperformed grade 5/6 children suggesting that analytic processing increases and that heuristic processing decreases developmentally. These results are consistent with reasoning models investigated in the adult literature – namely, the two process framework (Sloman, 1996; Stanovich, 1999). They are also consistent with the findings of Bara, Bucciarelli, and Johnson-Laird (1995) in the domain of syllogisms. In their study examining the development of syllogistic reasoning among three groups of participants (9-10 year-olds, 14-15 year-olds and 21 year-olds), Bara, Bucciarelli, and Johnson-Laird (1995) found that as age increased performance on tasks employing a variety of syllogistic forms improved. Bara et al. (1995) found that age was the best predictor of performance, accounting for 35% of the variance, overriding effects of working memory. In the current study, similarly, an increase in age demonstrated corresponding increases in performance on syllogisms where believability conflicted with validity although cognitive ability was a strong predictor. More recently, Leevers and Harris (2000) working with children as young as 4 years old found that some of them could solve syllogistic problems accurately. However, they did not find evidence that these young children reasoned deductively better than older children. The findings of Leevers and Harris and the findings of the current study contradict the results reported by Jacobs and Potenza (1991) and Davidson (1995) investigating reasoning in the inductive domain.

In these studies (Davidson, 1995; Jacobs & Potenza, 1991) it was claimed that in the inductive reasoning domain younger children performed better than older children. Jacobs and Potenza suggest that the representativeness heuristic is used in the social domain more often as people age often leading to errors in judgment. They
suggest that this may be due to the development of social categories. As people age, they use social categories more frequently to make social judgments when bare rate information is difficult to collect and integrate. Jacobs and Potenza continue by suggesting that instead of being two independent reasoning strategies – use of baserates and use of indicant information, they may be dependent on each other. As baserate information is collected, stereotypes are formed. Stereotypes become social categories which may still be changed with the collection of additional baserate information. Reference to social categories cues use of the representativeness heuristic. As indicated in the Introduction of the present study, methodological concerns characterize both of these studies.

Examination of the stimuli in the Jacobs and Potenza study reveals four possible explanations for the inconsistency between Jacobs and Potenza’s results and the results of the current study arise. They are: inequity of prior knowledge demands in the domains (object versus social) within the same task, lack of control for the conflict or support of baserates with individuating information, lack of clear differentiation between the object and social domains and differences in processing demands between the object and social domains. The stimuli used in the Davidson study also lead to methodological concerns. Stereotypes were used as individuating information. It was assumed that the participants had knowledge of the specific stereotypes implied in the scenarios. The conflict or support of the baserate with the stereotype was not controlled. And importantly, the raw data of participant responses to the scenarios was not reported. Rather, data describing the justifications for the responses was reported.

Nevertheless, Jacobs and Potenza’s results in the object domain are consistent with those of the current research study indicating that baserate use increases with age thereby, increasing confidence that it is in fact analytic processing
that increases with age. Divergence occurs in the results of the social domain scenarios. From Jacobs' and Potenza's (1991) and Davidson's (1995) studies, it appears that social domain reasoning is dominated by reliance on individuating information at the cost of baserate information. Accordingly since use of individuating information is a characteristic of heuristic reasoning, this increasing reliance leads Jacobs and Potenza and Davidson to surmise that an increase in heuristic reasoning occurs with development. Contrary to the findings of Jacobs and Potenza (1991) and Davidson (1995), the current study shows that reliance on individuating information declines as children get older, and that the use of baserates increases indicating a decline in heuristic reasoning and an increase in analytic reasoning. Possible reasons for this divergence of results lies in the tasks. For individuating information, Jacobs and Potenza and Davidson use social stereotypes, and the current study uses problems that pit baserate information versus individuating information of low vividness – avoiding the invocation of stereotypes. Although, they attempted to replicate Kahneman and Tversky's famous engineer problem, it was perhaps a misguided attempt. Kahneman and Tversky asked subjects to predict whether an individual was an engineer or a lawyer based on a brief personality sketch and information concerning baserates. Participants paid little attention to the baserate information in making their prediction. The engineer problem varies from the ones created by Jacobs and Potenza by the fact that characteristics common to engineers are known by all of the participants because they were adults. It was shared common knowledge. In the scenarios of Jacobs and Potenza, this sharing of the common knowledge does not exist because the participants are children aged: six, eight, and eleven. What Jacobs and Potenza do in their research study is provide evidence of the developmental trajectory of stereotypic knowledge in children, that is, stereotypic knowledge increases with age.
Do Individual Differences Explain Reasoning Performance?

Does cognitive ability predict reasoning performance?

Contrary to the findings (Jacobs & Potenza, 1991; Davidson, 1995) discussed above, regarding the effect of age on the development of reasoning, Means and Voss (1996) in their study on the development of informal reasoning in students in grades 5, 7, 9, and 11 found little evidence that grade/age was related to reasoning performance. In fact, cognitive ability was the determining variable in performance on the reasoning tasks. Fifth-grade high-ability students sometimes performed better than eleventh-grade average or below average students. In our study, although reasoning improved with increasing age, performance improvement was better explained by cognitive ability (CAb). Older students (grade 8) had greater computing power than younger students (grade 5/6) and this was subsequently reflected in their performance. In addition, remaining consistent with the CAb data, is the noteworthy trend (not significant) that grade 5/6 students in the gifted program scored higher than the Grade 8 students in the general program on the reasoning problems, as in the Means and Voss (1996) study.

Do thinking dispositions predict reasoning performance?

Klaczynski, Gordon and Fauth (1997) reported a series of experiments conducted with college-age students investigating the predictive power of intellectual ability and thinking styles on problems involving the law of large numbers, the intuitive analysis of covariance and the ability to detect flaws in experimental designs. The law-of-large-number problems pitted baserate information against individuating information, thereby, sharing the key characteristics of the inductive reasoning problems used in this study. Verbal ability (measured by the Shipley Institute of Living Scale, SOILS) was related to overall performance on the law-of-large-number and the experiment-evaluation problems. However, bias scores were
computed for the rating (persuasiveness and evidence evaluation) scores and for the reasoning scores by subtracting scores on problems containing goal enhancing information from scores on problems containing goal threatening information for each of the types of problems. These bias scores were not related to cognitive ability scores. Klaczynski, Gordon, and Fauth (1997) interpreted this to mean that cognitive ability does not translate into the ability to decontextualize. In the Klaczynski et al. study, measures of the thinking disposition called rationality were taken by administering the Rational Versus Experiential Inventory (Epstein, Pacini & Heier, 1996), a self-report questionnaire. Scores on the rationality measure were related to the bias scores but not to the cognitive ability scores. Klaczynski et al. interpreted this to mean that decontextualization is a result of the rationality thinking disposition and not cognitive ability. To summarize their findings, cognitive ability was not related to bias scores; the rationality disposition was related to the bias scores; cognitive ability was not related to the rationality disposition. Based on this argument, Klaczynski et al. state that rationality (which is related to reasoning as indexed by bias scores) is independent of cognitive ability.

In the current study, students with greater cognitive ability performed more successfully on reasoning problems than students with less cognitive ability. Through correlational analyses, cognitive ability was shown to be related to two of our thinking disposition composites, actively-openminded thinking and (negatively to) luck. As well, performance on both of the reasoning measures (inductive and deductive problems) was related to the thinking disposition composite, actively-openminded thinking. Inductive reasoning performance was also negatively related to the thinking disposition composite, luck. In the regression analyses, cognitive ability was the major predictor of success on reasoning problems, however the thinking disposition, actively-openminded thinking, did emerge as a predictor of performance
on both types of reasoning problems. The predictive power of actively-openminded thinking was independent of cognitive ability. In this respect, the results of the current study supports the findings of Klaczynski et al., that thinking styles or dispositions do predict reasoning performance. However, the results of the current study regarding the influence of cognitive ability are contrary to those of Klaczynski. Specifically, the current study of children’s reasoning has demonstrated that, unlike the Klaczynski work, cognitive ability predicts children’s performance on inductive and deductive reasoning problems. Additionally, cognitive ability predicted performance independent of the variance accounted for by the thinking dispositions variables. Finally, it has also been demonstrated that thinking dispositions in children of this age (grade 5/6 and grade 8) predict reasoning performance over and above their cognitive ability on the reasoning tasks investigated in this study of individual differences in children’s reasoning.

Do these individual difference analyses of children parallel those in the adult literature?

In a series of studies using college-age participants, Stanovich and colleagues (Stanovich & West, 1997, 1998; Sá, West & Stanovich, 1999) have demonstrated that individual differences in cognitive ability and thinking dispositions independently predict performance on a variety of reasoning tasks. Stanovich and West’s (1997) study of the effects of cognitive ability and thinking dispositions on an argument evaluation task found that both variables predicted performance. Through regression analyses, it was determined that each variable was an independent predictor. The 1998 study involved a series of four experiments using the following reasoning tasks: syllogisms, argument evaluation, base-rate use, covariation detection, hypothesis testing, outcome bias, if-only thinking, knowledge calibration, hindsight bias, and the false consensus bias paradigm. Cognitive ability was a significant unique predictor of
performance on each of the tasks (Stanovich & West, 2000). The thinking disposition composite was also a unique predictor of performance on the base-rate task. In 1999, Sá, West and Stanovich studied belief bias in young adults (mean age 21.8) using a height judgment task and a syllogism task. They found that the actively-open-minded thinking disposition composite predicted belief bias in the syllogism task even after differences in cognitive ability were partialled out. In all of these studies with adults, cognitive ability predicted performance and a thinking disposition measure also contributed a degree of predictability independent of cognitive ability. In our study with children it was found that cognitive ability predicted performance on both of our reasoning tasks and the thinking disposition composite, actively-openminded thinking, independently predicted performance on both tasks as well. Thus, the results with children in grade 5/6 and grade 8 of the current study parallel the results in the adult studies.

Limitations

In considering limitations of the current study, one must consider the age range of the participant sample of this research study and our claims of providing data about the developmental trajectory of reasoning. Implications arise for extending the age range of the participants and for use of the Thinking Dispositions Questionnaire with children. Firstly, extending the age range of the participant population to include younger children might provide additional data about the development of analytic and heuristic reasoning in children. But using children who vary considerably in age requires adapting the stimuli or modifying the administrative procedures of the research protocol. For example, while nine-year-old participants can read syllogistic reasoning problems the experimenter must read the problems to six-year-old participants. Perhaps, accompanying pictures would be
required to equalize the memory load between the nine- and six-year-old participants since the nine-year-olds could refer to the written text while the six-year-old would have to remember the spoken information. Consistency of stimuli and administrative procedures for all participants in the current study was an important consideration as the wording of the reasoning problems, thinking disposition scales and the written instructions were adapted. Careful evaluation of each item for semantic difficulty and consistency with the original items from the scales and tasks used by adults ensured that all of the children in the current study would understand all items and that the administration of the tasks would be consistent reducing threats to internal validity. However, the developmental range of the children participating in this study does remain truncated. Secondly, the self-report thinking disposition scales adapted for use in this study were completed by children for the first time. Previously, the thinking disposition scales have been used only with adults. As a result, vocabulary and grammatical structure of the items were simplified to ensure comprehension by typical ten year-olds. Further testing is required in order to claim reliability of the use of this scale with children.

Directions for Future Research

The current study provokes a number of interesting questions for consideration regarding directions for future research. Possibilities range from comparison of the subcomponent processes of inductive reasoning in the object and social domains, to investigation of the nature and development of stereotypic knowledge, to training studies. It is noted that, in the studies reported by Jacobs and Potenza and Davidson, participants of all ages used baserates far less when considering scenarios in the social domain. This is an important observation, as much of the daily business of people involves reasoning in the social domain. An extension
of this line of research, would be to investigate if different types of thinking such as statistical reasoning, decision-making, and problem-solving in the social domain are also biased by reliance on individuating information and whether individuating information that is stereotypic has the greatest influence. Future studies might also include the examination of stereotypic individuating information in the object domain contrasted with non-stereotypic individuating information in the social domain. Hypothetically, this might reveal a pattern of results that are opposite to Jacobs and Potenza’s results. That is, stereotypic individuating information in the object domain might invoke the same kind of prior knowledge that children seem to draw upon when making choices in the social domain. This type of data might lead to the teasing apart of the relationships of stereotypes as individuating information in the social and object domains with reasoning performance. Given a clearly delineated definition of the social and object domains, such as, social behaviour includes the activities of people and the object domain does not include people but relations between inanimate objects. A possible object scenario might be:

Of the eight vehicles parked outside the house, two are foot-propelled scooters and six are skateboards. Only one gets damaged when there is car accident nearby. Is it more likely that the damaged vehicle is a scooter or a skateboard?

Currently scooters are very popular items for personal travel. From a question like this, potential information specifically about the development and prevalence of the use of stereotypic individuating information in the object domain as opposed to other types of individuating information could be gained.

Investigating developmental changes in stereotypic knowledge, rigidity and flexibility of held stereotypes and the nature of revision of held stereotypes is another
potential area of research. A question might be, “As social categories develop, are stereotypes a finer grain of categorization?” In other words, are stereotypes used as highly elaborated and specified sub-groupings of broad social categories? People use social categories and the finer grained stereotype to speed reasoning and responding. If people treated each occurrence as a new event, response would be very slow. Stereotypes are an important procedural shortcut. However, when stereotypes are too finely grained and rigid, they will lead to errors. Many current stereotypes are learned by exposure to mass media. While the bases of mass media stereotypes are not necessarily grounded in occurrence in reality but often created to meet economic agendas, they will lead to errors in reasoning. In order to improve reasoning and decision-making and to reduce susceptibility to erroneous reasoning, it would be useful to review the social psychology literature on the nature of stereotypic knowledge and the process of stereotype revision; that is, whether stereotypes remain as fixed knowledge once they are acquired, for the purpose of leading to an investigation to determine whether capacities or dispositions that lead people to revise their stereotypes be identified and predicted? Can a cuing system to begin revision of stereotypic knowledge be identified? Can this cuing system be employed independently on an individual level? Perhaps revision of stereotypes is a metacognitive skill or perhaps a dispositional tendency, related to flexible thinking and the actively-openminded thinking dispositions.

Implications for Education
Improving critical thinking which presumably would lead to improved decision-making is a goal of an enlightened society. Education is a vehicle for the implementation of this goal. Curricula aimed towards improving the understanding of probability and statistics, critical thinking skills and the disposition toward open-
minded thinking have been designed.

Within the last five years in Ontario, Canada, data management and probability have been delineated as specific areas of study in the elementary school mathematics curriculum. From the results of the Grade Three Assessment of Reading, Writing, and Mathematics compiled by the Evaluation, Quality and Accountability Office, an agency of the Ministry of Education of Ontario, a slight increase in student performance (from 36% to 38%) at levels three and four (top two levels of four) has been noted when comparing the results from 1997 to the results from 2000 (EQAO, 1997, 2000). In 1997, grade three teachers relied on their existing resources to teach data management and probability. In 1999, text books became available to support such instruction. In the future, as preservice teachers trained in the pedagogy of the new mathematics curriculum strand of data management and probability enter the elementary educational system, student performance will presumably improve. Future studies should be concerned with investigating whether instructional programs designed to develop statistical knowledge would be reflected in performance on reasoning problems, extending some the issues addressed in this study.

Critical thinking skill programs have demonstrated effects in magnitude and retention (Perkins & Grotzer, 1997) of improved critical thinking skills but data remains sparse regarding generalizability over time and subject area. Stand-alone thinking skills programs require additional time in an already crowded curriculum further decreasing attractiveness to classroom practitioners. On the other hand, embedding critical thinking skills in subject instruction frequently results in a lack of explicitness which is required to support transfer to other subject areas. But if society, collectively and individually, is to continue to strive to create a safe world and to improve the quality of life for all of its citizens, reasoning and decision-making
must improve. The data and probability strand of the mathematics curriculum and critical thinking skills programs aim to train students in the skills of good thinking thereby improving reasoning and decision-making as an consequence. Some researchers (Baron, Badgio, & Gaskins, 1986; Baron, 1993; Perkins & Grotzer, 1997) investigating reasoning have suggested that in addition to the skills of critical thinking, individuals must demonstrate the inclination or the disposition to be a good reasoner or thinking abilities and skills will not be employed.

Perkins, Jay, and Tishman (1993) take the notion of thinking dispositions a step further by suggesting that there are three components to the disposition to be a good reasoner: 1.) ability – meaning capability and knowledge needed to employ the techniques of good reasoning, 2.) inclination and 3.) sensitivity. Sensitivity describes the state when the reasoner’s inclination to reason and his reasoning skills are cued to a potential decision-making situation, an event that requires judgment or a problem that requires solving. Without sensitivity, many opportunities to employ one’s disposition to be a good reasoner and to use one’s critical thinking skills will be missed. Sensitivity may be the key to transferability and long-term retention. An instructional program focusing on developing sensitivity could be subject embedded thereby not requiring additional time in the instructional day. It would focus on the steps prior to identifying the problem – which is where most thinking skill programs begin. Instead of training students to start with, “What is the problem?” a prior question to be repeated frequently would be, “Is this a situation or event where a decision or judgment can be made?” If the answer is yes, then the next question is asked, “Is this decision or judgment worth the expenditure of attention and effort?” If the answer is yes, then a decision-tree can be developed based on the details of the situation outlining the possible outcomes. In the process of developing and editing the decision tree, extraneous and non-relevant information which frequently turns out to
be individuating information can be discarded. Making the decision-tree is an example of the skill of good reasoning; deciding to spend attention and time is an example of the inclination to be a good reasoner; and, asking if this an occasion where a decision or judgment can be made is an example of sensitivity to situations or events with potential for benefiting from good reasoning. Subject matter curricula, posed in the form of problems holds potential for the development of the skills, inclinations and sensitivity needed for good reasoning. Development, implementation and evaluation of the effects of such curricula could provide an opportunity to translate research findings into practice and in return as a consequence, to meet the goals of an enlightened society in the development of improved reasoners and decision-makers.

Conclusions

This study has contributed to the empirical data on the developmental gradient in reasoning by comparing the performance of younger with older children. Also, this study has contributed to explication of the incongruous findings that younger children have performed better than older children on some reasoning problems.

The second purpose of this research study was to demonstrate that individual differences analyses can contribute to understanding children's performance on reasoning tasks. In the process, this study has supported the findings in the literature using adult participants (Stanovich & West, 1998) that variance on reasoning problems is due to individual differences in thinking dispositions uniquely as well as cognitive capacity.
References


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Inductive Reasoning Problems
1. Nisbett Problems

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1. Principal
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Appendix F

Demographic Data
1. Questionnaire
Appendix A

Inductive Reasoning Problems
1. Nisbett Problems
Thinking Problems

Please read the following problems and choose one of the possible answers that follow each problem. Circle the one that you think is the best choice.

*correct solutions are bolded

1. The grade 6 class is organizing a raffle at school. The winning ticket will be chosen from 20 blue tickets and 10 red tickets. The colour of the winning ticket most likely is.....
   a) Red
   b) Blue

2. The Smith's are going to buy a home computer. Most computer magazines and web sites rate ABC computers as the best home computer. While at the computer store, the Smith family spoke to another customer who said he owned both types of computers and the 724 computer is a much better computer than the ABC computer. Which computer are the Smith's most likely to buy?
   a) Definitely a 724 computer
   b) Probably a 724 computer
   c) Probably an ABC computer
   d) Definitely an ABC computer

3. There are 60 pieces of gum in a gumball machine. There are 40 pieces of cherry and 20 pieces are grape. The flavour of gum that comes out when someone turns the handle of the gumball machine most likely is...
   a) Cherry
   b) Grape
4. There are 30 cabs waiting in a row at the airport for the next passenger. "Jiffy Taxi" company owns 20 of the cabs and "Speedy Taxi" company owns 10 cabs. The cab company that picks up the next passenger most likely is...
   a) Jiffy Taxi
   b) Speedy Taxi

5. Tishawn wants to ride the scariest roller coaster at the amusement park. A survey of hundreds of kids in "Roller Coaster Review" said that the LizardLoop is scarier than the TurboFlip. While Tishawn is having lunch, he hears the person at the next table say that he has ridden the LizardLoop and the TurboFlip, and that the TurboFlip is much scarier. Which roller coaster is Tishawn most likely going to ride?
   a) Definitely the LizardLoop
   b) Probably the LizardLoop
   c) Probably the TurboFlip
   d) Definitely the TurboFlip

6. Kyle wants to buy a dog that is a good swimmer. After checking with the Kennel Club, the Humane Society, and several dog breeding books, he decides to buy a Labrador because they are rated as the best swimmers. However, his neighbour has a Labrador who is a terrible swimmer. What type of dog is Kyle most likely to buy?
   a) Definitely a Labrador
   b) Probably a Labrador
   c) Probably another type of dog
   d) Definitely another type of dog
7. There are 12 cars parked side by side in the parking lot. Driver and passenger air bags are in 8 of the cars and 4 cars have a driver air bag only. A big snowstorm covers every car but one. The car that was not covered in snow most likely has...

a) A driver air bag only  
b) A driver and passenger air bag

8. Ms. Owen is going to take her class to a food court for lunch and they need to get served fast. The food court manager says the shortest lunch line-ups are almost always at Restaurant 123. Last time Ms. Owen went to the food court, the shortest lunch line-up was at Restaurant 456. Where do you think Ms. Owen is most likely to take her class?

a) Ms. Owen will definitely take the class to Restaurant 456  
b) Ms. Owen will probably take the class to Restaurant 456  
c) Ms. Owen will probably take the class to Restaurant 123  
d) Ms. Owen will definitely take the class to Restaurant 123

9. There are 30 cards in a stack. Of these cards 20 have diamonds on them and 10 have hearts on them. The card on the top of the stack most likely has...

a) Hearts on it  
b) Diamonds on it
10. Erica wants to go to a baseball game to try to catch a fly ball. She calls the main office and learns that almost all fly balls have been caught in section 43. Just before she chooses her seats, she learns that her friend Jimmy caught 2 fly balls last week sitting in section 10. Which section is most likely to give Erica the best chance to catch a fly ball?

a) Definitely section 43  
b) Probably section 43  
c) Probably section 10  
d) Definitely section 10

11. Sheldon wants to buy his Dad some golf balls as a birthday present. Based on testing, experts from the "All Golf" channel recommend "MegaFly" golf balls. Sheldon hears a couple golfers say that "PowerShot" golf balls are better than "MegaFly" golf balls. Which brand of golf balls is Sheldon most likely to buy his Dad?

a) Sheldon will definitely buy his Dad "PowerShot" golf balls  
b) Sheldon will probably buy his Dad "PowerShot" golf balls  
c) Sheldon will probably buy his Dad "MegaFly" golf balls  
d) Sheldon will definitely buy his Dad "MegaFly" golf balls

12. The school was holding a rubber duckie race to raise money for a school trip. There were 90 rubber duckies were released into a river at the same time. 60 were blue and 30 were brown. The colour of the duckie crossing the finish line first most likely was...

a) Blue  
b) Brown
13. Jason lives in a mountain area with no access to the Internet. When Jason goes to visit his cousins in the city, he wants to check out the coolest snowboarding web site. Many snowboard magazines recommend "www.snowzone.com" as the coolest snowboard web site. While he is at his local sports store, he overhears someone saying that "www.outthere.com" is a way cooler snowboard web site. Jason only has enough time to check one web site. Which one is he most likely to check?

a) Jason will definitely check out "www.outthere.com" first
b) Jason will probably check out "www.outthere.com" first
c) Jason will probably check out "www.snowzone.com" first
d) Jason will definitely check out "www.snowzone.com" first

14. Keisha wants to work part-time. All job counselors say surveys show that Big Depot treats student workers the best. Keisha's classmate works at JumboStore and says they treat student workers even better. Keisha only has time to apply to one store. Which store is Keisha most likely to apply to?

a) Keisha will definitely apply to Big Depot
b) Keisha will probably apply to Big Depot
c) Keisha will probably apply to JumboStore
d) Keisha will definitely apply to JumboStore

15. There were 8 canoes from Camp Running Water and 4 canoes from Camp Big Sky resting on the beach. A strong wind came up and blew one of the canoes into the water. The canoe that blew away was most likely from...

a) Camp Big Sky
b) Camp Running Water
Appendix B

Formal Deductive Reasoning Problems

1. Syllogisms
Children’s Reasoning

Syllogisms

Pretend that an alien from another planet has just landed on Earth. The alien's thought processes are very logical, but it knows nothing about Earth. Although the alien will be told about a number of things here on Earth, what it is told may be false or untrue. We are interested in your opinion about what the logical alien would conclude based on what it has been told. Let's do two practice problems first.

*Yes*  

or  

*No*

Try these ones by yourself.
1. \[ [p \rightarrow q] \rightarrow q \] \textbf{MP}

\textit{The alien is told...All birds have feathers.}

\textit{The alien is also told...Robins are birds.}

\textit{The logical alien would conclude...Robins have feathers.}

*Yes or No
(Circle one.)

2. \[ [p \rightarrow q] \rightarrow q \] \textbf{MT}

\textit{The alien is told...All animals love water.}

\textit{The alien is also told...Cats do not like water.}

\textit{The logical alien would conclude...Cats are not animals.}

*Yes or No
(Circle one.)

3. \[ [p \rightarrow q] \rightarrow q \] \textbf{MT}

\textit{The alien is told...All nuts can be eaten.}

\textit{The alien is also told...Rocks cannot be eaten.}

\textit{The logical alien would conclude...Rocks are not nuts.}

*Yes or No
(Circle one)
4.  \([p\rightarrow q/p/q]\)  DA

The alien is told...All southern countries are hot.
The alien is also told...Canada is not a southern country.
The logical alien would conclude...Canada is not hot.

Yes  or  *No
(Circle one.)

5.  \([p\rightarrow q/q/p]\)  AC

The alien is told...All insects need oxygen.
The alien is also told...Dogs need oxygen.
The logical alien would conclude...Dogs are insects.

Yes  or  *No
(Circle one.)

6.  \([p\rightarrow q/p/q]\)  DA

The alien is told...All bats have wings.
The alien is also told...Hawks are not bats.
The logical alien would conclude...Hawks do not have wings.

Yes  or  *No
(Circle one.)
7. \[p \rightarrow q \land q \rightarrow p\] MP

*The alien is told...*All mammals walk.

*The alien is also told...*Whales are mammals.

*The logical alien would conclude...*Whales walk.

*Yes* or *No*  
(Circle one.)

8. \[p \rightarrow q \land q \rightarrow p\] AC

*The alien is told...*All flowers have petals.

*The alien is also told...*Roses have petals.

*The logical alien would conclude...*Roses are flowers.

*Yes* or *No*  
(Circle one.)
Appendix C

Statistical Knowledge

1. Questionnaire
**Statistical Knowledge Questionnaire**

1. i) If you spin 100 times, how many times will the spinner likely land in the blue?

   Circle your answer.

   a) 50  b) 75  c) 10  d) 25

ii) Are you more likely to get red or blue when you spin?

   Circle your answer.

   a) red  b) blue
You are playing a game with a friend. If you draw an even numbered card from the bag (without peeking) you get a point. If your friend draws an odd numbered card she gets a point.

i) What are your chances of drawing an even-numbered card?

Circle your answer.

a) 1 out of 10  b) 4 out of 8  c) 3 out of 8  d) 3 out of 10

ii) Is this a fair game?

Circle your answer.

a) yes  b) no
Appendix D

1. Thinking Dispositions Scales.
2. Impulsivity/Reflectivity (MFFT)
1. Thinking Dispositions Scales (Adapted for Use with Children - July 5, 2000)

   Actively-Openminded Thinking Composite

i. Flexible Thinking Scale

1. Changing your mind is a sign of weakness. (R)
2. A person should always consider new possibilities.
3. Feelings are the best guide in making decisions. (R)
4. If I think longer about a problem I will be more likely to solve it.
5. Mostly, I know everything I need to know. (R)
6. People make bad choices when they listen to lots of different opinions. (R)
7. People should always consider evidence that goes against their beliefs.
8. The way to fix a problem is to think about the best answer - not stand around and wait for the problem to fix itself.
9. It's ok to be undecided about some things.
10. Wise people make fast decisions. (R)

ii. Cederbloom Scale

1. The things you believe in come from inside you rather than from what has happened to you.
2. It's really good when kids believe in the same things as their parents.
3. I never change what I believe in - even when someone shows me that my beliefs are wrong.
4. Changing your beliefs shows that you are a strong person. (R)
5. It's important to change what you believe after you learn new information. (R)
6. It's fantastic when someone famous believes in the same things as me.
iii. Absolutism
1. It's better to just believe in a religion than to ask lots of questions about it.
2. Right and wrong never change.
3. A good person usually does what they are told to do.
4. It's ok to hang out with people who don't share my values.\(^{(R)}\)
5. It's better to learn about useful things instead of ideas.

iv. Dogmatism
1. Often, people who criticize me don't know what they are talking about.
2. Nobody can change my mind if I know I am right.
3. If everybody in a group has too many different ideas, the group will break up.
4. I really hate some people because of the things they stand for.
5. It really makes me angry when someone can't say they are wrong.
6. Most people just don't know what's good for them.

v. Categorical Thinking
1. There are basically two kinds of people in this world, good and bad.
2. There is one right way and lots of wrong ways to do most things.
3. I think people are either with me or against me.

\textbf{Need for Cognition Scale}
1. I like hard problems instead of easy ones.
2. I like to be in charge of a problem that needs lots of thinking.
3. I try to avoid problems that I have to think about a lot.\(^{(R)}\)
4. I like to spend a lot of time and energy thinking about something.
5. I like to do things that I've learned well over and over, so that I don't have to think about it anymore. (R)
6. It's really cool to figure out a new way to do something.
7. I'm not interested in learning new ways to think. (R)
8. I like to do jobs that make me think hard.
9. I like to do jobs where I don't have to think at all. (R)

**Luck Composite**

i. Concept of Luck
1. I have things that bring me luck.
2. The number 13 is unlucky.
3. It is bad luck to have a black cat cross your path.
4. Opening an umbrella inside can bring you bad luck.
5. I don't believe in luck.

ii. Paranormal Scale
1. It's a good idea to look at your horoscope every day.
2. Horoscopes can be useful in making personality judgments.

iii. Superstitious Thinking
1. I do not believe in superstitions. (R)
Other Dispositions

i. Impression Management aka Social Desirability Subscale

1. I always obey rules even if I probably won't get caught.
2. I sometimes tell lies if I have to. (R)
3. There are times I have taken advantage of someone. (R)
4. I have said something bad about a friend behind his or her back. (R)
5. I like everyone I meet.

ii. Check item

1. Birds have feathers.

2. Impulsivity/Reflectivity Thinking Style

Matching Familiar Figures Test (MFFT)

See sample below.
Matching Familiar Figures Test (MFFT)

Target Item

Six Possible Options
Appendix E

1. Principal Consent Form
2. Teacher Information Form
3. Parent Consent Form
4. Student Assent Form
PRINCIPAL CONSENT FORM

Study Title: Individual Differences in Children’s Reasoning

Dear Principal:

Recently, there has been a growing interest in how children reason. I am a teacher with the Halton District School Board and a graduate student at the University of Toronto who is studying how thinking processes develop in children. The intention of this study is to clarify the relationship between performance on a set of reasoning tasks, intellectual ability, and thinking styles. Specifically, I am trying to find out what types of cognitive processes predict critical thinking in children. We would like to include students from your school in this study.

This research will take place in the Fall of 2000. Students will complete a set of activities and tasks related to critical thinking at the school during regular school hours. For example, students will be asked to read stories and to then answer questions about these stories. Total participation will be between 60 and 90 minutes at most, but could be shorter. There are no effects on the students’ programme if either parents or students decline to participate or withdraw. While there are no direct risks or benefits to participation in this study, most students find it to be an interesting experience.

The study has received ethical approval by the Research Advisory Committee of the Halton District School Board. Participation in the research project is not required. The student may stop participating at any time and they can choose not to answer any questions. Student names will not appear on any of the research materials. I and my research advisor, Dr. Keith Stanovich, Professor in the Human Development and Applied Psychology department of the Ontario Institute for Studies in Education of the University of Toronto (OISE/UT), will have access to the information. The research materials will be kept confidential, except as required by law (e.g., a disclosure of child abuse must be reported to a child welfare agency). The research materials will be kept in a secure filing cabinet at OISE/UT. The data will be pooled for statistical analyses and reporting in scholarly journal articles. Please contact me at the number below if you are interested in obtaining a copy of the study results. As required by the American Psychological Association (Publication Manual, p. 283), the data will be stored for at least 5 years after the final publication of the results. After that period, it may be destroyed.

If you have any questions, please call (905 844-9619) or email (jkokis@oise.utoronto.ca) Judi Kokis. To indicate whether you will allow your school to participate in the study, please fill in and return the form that is attached to this letter. Thank you very much for taking the time to consider participating in this study!

Yours truly,

Judi Kokis, Ed.D Candidate, University of Toronto (jkokis@oise.utoronto.ca)
Halton District School Board, co: W.H.Morden P.S. (905 844-9616)

Please indicate below whether or not you agree to allow your school to participate in the study, and return this original form to J.Kokis. Please keep a copy of this form.

_____ I give permission for my school ___________________________ to participate in the University of Toronto study on individual differences in children's reasoning.

(please print name of school)

_____ I do NOT give permission for my school ___________________________ to participate in the University of Toronto study on individual differences in children's reasoning.

(please print name of school)

Name of School Principal ___________________________ Signature of School Principal ___________________________ Date __________
Dear Teacher:

Recently, there has been a growing interest in how children reason. I am a teacher with the Halton District School Board and a graduate student at the University of Toronto who is studying how thinking processes develop in children. The intention of this study is to clarify the relationship between performance on a set of reasoning tasks, intellectual ability, and thinking styles. Specifically, I am trying to find out what types of cognitive processes predict critical thinking in children. We would like to include your students in this study.

This research will take place in the Fall of 2000. Students will complete a set of activities and tasks related to critical thinking at the school during regular school hours. For example, students will be asked to read stories and to then answer questions about these stories. Total participation will be between 60 and 90 minutes at most, but could be shorter. There are no effects on the students’ programme if either parents or students decline to participate or withdraw. While there are no direct risks or benefits to participation in this study, most students find it to be an interesting experience.

The study has received ethical approval by the Research Advisory Committee of the Halton District School Board. Participation in the research project is not required. The student may stop participating at any time and they can choose not to answer any questions. Student names will not appear on any of the research materials. I and my research advisor, Dr. Keith Stanovich, Professor in the Human Development and Applied Psychology department of the Ontario Institute for Studies in Education of the University of Toronto (OISE/UT), will have access to the information. The research materials will be kept confidential, except as required by law (e.g., a disclosure of child abuse must be reported to a child welfare agency). The research materials will be kept in a secure filing cabinet at OISE/UT. As required by the American Psychological Association (Publication Manual, p. 283), the data will be stored for at least 5 years after the final publication of the results. After that period, it may be destroyed.

The data will be pooled for statistical analyses and reporting in scholarly journal articles. Please contact me at the number below if you are interested in obtaining a copy of the study results.

If you have any questions, please call (905 844-9619) or email (jkokis@oise.utoronto.ca) Judi Kokis. Thank you very much for taking the time to become informed about this study and for your assistance in facilitating student participation!

Yours truly,

Judi Kokis, Ed.D Candidate, University of Toronto
(jkokis@oise.utoronto.ca)
Halton District School Board
co: W.H.Morden P.S. (905 844-9616)
Dear Parent/Guardian:

Recently, there has been a growing interest in how children reason. I am a teacher with the Halton District School Board and a graduate student at the University of Toronto who is studying how thinking processes develop in children. The intention of this study is to clarify the relationship between performance on a set of reasoning tasks, intellectual ability, and thinking styles. Specifically, I am trying to find out what types of cognitive processes predict critical thinking in children. We would like to include your son/daughter in this study.

This research will take place in the Fall of 2000. Students will complete a set of activities and tasks related to thinking at the school during regular school hours. For example, students will be asked to read stories and to answer questions about these stories. Total participation will be between 60 and 90 minutes at most, but could be shorter. There are no effects on the students' programme if either parents or students decline to participate or withdraw. While there are no direct risks or benefits to participation in this study, most students find it to be an interesting experience.

The study has received ethical approval by the Research Advisory Committee of the Halton District School Board and the school principal. Participation in the research project is not required. The student may stop participating at any time and they can choose not to answer any questions. Student names will not appear on any of the research materials. I and my research advisor, Dr. Keith Stanovich, Professor in the Human Development and Applied Psychology department of the Ontario Institute for Studies in Education of the University of Toronto (OISE/UT), will have access to the information. The research materials will be kept confidential, except as required by law (e.g., a disclosure of child abuse must be reported to a child welfare agency). The research materials will be kept in a secure filing cabinet at OISE/UT. As required by the American Psychological Association (Publication Manual, p. 283), the data will be stored for at least 5 years after the final publication of the results. After that period, it may be destroyed.

The data will be pooled for statistical analyses and reporting in scholarly journal articles. Please contact me at the number below if you are interested in obtaining a copy of the study results.

If you have any questions, please call (905 844-9619) or email (jkokus@oise.utoronto.ca)

Judi Kokis. To indicate whether you will allow your son/daughter to participate in the study, please fill in and return the form that is attached to this letter. Thank you very much for taking the time to consider participating in this study!

Yours truly,

Judi Kokis, Ed.D Candidate, University of Toronto (jkokus@oise.utoronto.ca)
Halton District School Board
c/o: W.H.Morden P.S. (905 844-9616)

Please contact me at this number or address for a copy of the results once the study is completed. Please indicate below whether or not you agree to allow your son/daughter to participate in the study, and return the original copy of this form to your son’s/daughter’s classroom teacher.

___ I give permission for my son/daughter ____________________________ to
participate in the University of Toronto study on individual differences in children's reasoning.

___ I do NOT give permission for my son/daughter ____________________________ to
participate in the University of Toronto study on individual differences in children's reasoning.

Name of Parent ___________________________________ Signature of Parent ____________________________ Date ____________________________
**ASSENT**

*Why are we doing this study?*
I am a teacher in your school, and I am also a researcher who studies thinking at the University of Toronto. I am doing a study looking at student’s thinking. The intention of this study is to clarify the relationship between performance on a set of reasoning tasks, intellectual ability, and thinking styles.

*What will happen during the study?*
There are nine different activities in the study. These activities include reading about how someone solves a problem and telling how much you agree with them, solving everyday problems, solving word riddles, matching figures, reading and answering questions. All of this will take between 60 and 90 minutes at most, but could be shorter. We have found that students who participate in the study enjoy it and learn something from it. It is also important to remember that there are no right or wrong answers to any of the questions I will be asking you during this study.

*Can I decide if I want to be in the study?*
You do not have to participate in the study if you don’t want to, and if you do decide to participate, you can decide not to answer any questions that you don’t want to. You can also stop participating at any time.

*Who will know what I did in this study?*
I will write down your answers to the questions that I ask, and you will be writing down your answers for some of the activities. When you have finished all of the tasks in this study, we can talk about the different activities you did and why you did them. This study will not influence your grades. The information we get from this study will be used in research studies to find out more about how student’s think about some types of thinking problems. Names will be kept on the questionnaires only until you are finished the activities. After that, we will cut the names off to protect your privacy. The information will be stored in a locked room at the University of Toronto until we have finished with the research, and then it will be kept in the University of Toronto archives. Only the researchers involved in the study will see your answers, except as required by law (e.g., if you tell us about a case of child abuse it must be reported to a child welfare agency). As required by the American Psychological Association (Publication Manual, p. 283), the data will be stored for at least 5 years after the final publication of the results. After that period, it may be destroyed.

If you do not understand a question or a word or need something explained better, you can ask me any time during the interview. If you or your parents want information about the results of the study when it is completed, they will be sent to your school and you can ask at the office to look at the report.

*Do you have any questions? Would you like to participate?*

**Assent**

I was present when ___________________________ read/was read this form and gave verbal assent.

Name of person who obtained verbal assent (for children < 14) ___________________________ Signature ___________________________ Date ___________________________
Appendix F

Demographic Data
1. Questionnaire
DEMографIC InФОmmATION

Тоdау's Date: ____________________________

Sex:  M____  F____

Birthday: ____________________________
(dау, month and year)

Grade:  5/6____  8____

Program:  Gifted______  Regular______

Is English your first language?  Yes____  No____

If English is not your first language, how old were you when you started doing your schoolwork in English in Canada? Age________

List of any tasks that were read to child:

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________