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Assessment of Problem-Solving Abilities in Normal Adolescents

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ASSESSMENT OF PROBLEM-SOLVING ABILITIES
IN NORMAL ADOLESCENTS
BY
KELLEY ANN CROWNOVER

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN
SPEECH-LANGUAGE PATHOLOGY

UNIVERSITY OF RHODE ISLAND

2004

ABSTRACT

This study examined the problem-solving abilities of adolescents, using a newly designed test, RAPS (the Rapid Assessment of Problem-Solving), by Marshall & Karow (2001). The tool is a modified version of the Twenty Questions Test that measures performance based on the number of questions asked to solve each problem, the percent of constraint-seeking questions used, and the efficiency or the amount of information gained from the first four questions asked. Participants included a total of 20 children with no history of neurological or psychiatric disorders who were categorized by age groups (10-11, 12-13, 14-15, and 16-17) with five subjects in each group. ANOVA results revealed there were no statistical differences among the four age groups for any of the three RAPS measures. Although children did not solve RAPS problems optimally, where they eliminate half of the picture board with each question asked, they did primarily ask questions which targeted groups of pictures based on semantic category labels. Compared to previous RAPS studies (Marshall, Karow, Morelli, Iden, & Dixon, 2003) children performed similarly to adult normal subjects both in the efficiency with which they solved the problems and in the types of questions they asked. The youngest group of children did appear to perform differently than the other groups; however, these differences were not identified statistically, possibly due to the low number of subjects per group. Finally, normal children did not improve their performance on successive administrations, which further supports the developing methodologies and scoring system of RAPS.

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TABLE OF CONTENTS

ABSTRACT.....	ii
ACKNOWLEDGEMENTS.....	iii
TABLE OF CONTENTS.....	iv
LIST OF TABLES.....	vii
LIST OF FIGURES.....	viii
CHAPTER I. INTRODUCTION.....	1
Background of Problem-Solving.....	1
Executive Functioning and Problem-Solving.....	1
Neuroanatomy of Executive Functioning.....	2
Problem-Solving Skills.....	3
Development of Problem-Solving.....	3
Measuring Problem-Solving.....	6
Problem-Solving in Learning Disabled Children.....	7
Purpose.....	8
CHAPTER II. METHODS.....	11
Subjects.....	11
Experimental Design.....	11
Standardized Tests.....	12
Experimental Task.....	13
Scoring.....	14
Statistical Analyses.....	16
Descriptive Analyses.....	18

Types of Questions.....	18
Reliability.....	18
CHAPTER III. RESULTS.....	20
Learning Effects.....	20
Analysis of Age Effects.....	23
Number of Questions Asked Per Problem.....	23
Percent of Constraint-Seeking Questions Asked Per Problem.....	23
Question-Asking Efficiency Scores.....	25
Test-Retest Reliability.....	26
Question Type and Form.....	26
Guessing.....	28
CHAPTER IV. DISCUSSION.....	29
Future Implications.....	33
APPENDICES	
A: Telephone Screening.....	35
B: Consent Form.....	37
C: Assent Form.....	39
D: History Form.....	40
E: Description of the traditional standardized cognitive measures administered.....	44
F: Summary of differences between RAPS and the Twenty Questions Test developed by Mosher & Hornsby (1966).....	46
G: Picture of RAPS-Game Board 1.....	47

H: Sample RAPS Score Sheet.....	48
BIBLIOGRAPHY.....	49

LIST OF TABLES

TABLE	PAGE
1. Subject demographic data (i.e. age, gender, mean years of education).....	11
2. The mean scores of the standardized cognitive tests (i.e. the Visual Paired Associates I and II, and the Verbal Paired Associates I and II from the Weschler Memory Scale-Revised (Weschler, 1987), and the Coloured Progressive Matrices (Raven, Raven, & Court, 1998)).....	12
3a. RAPS raw scores for administrations of problems 1, 2, and 3 for 10 and 11 year- olds.....	21
3b. RAPS raw scores for administrations of problems 1, 2, and 3 for 12 and 13 year-olds.....	21
3c. RAPS raw scores for administrations of problems 1, 2, and 3 for 14 and 15 year-olds.....	22
3d. RAPS raw scores for administrations of problems 1, 2, and 3 for 16 and 17 year-olds.....	22
4. Total number of questions asked, percentage of CS questions asked, and question-asking efficiency scores to solve RAPS problems 1, 2, and 3.....	22
5. Total number of questions asked, the percent of CS questions asked, and question-asking efficiency scores per age group.....	25

LIST OF FIGURES

FIGURE	PAGE
1. Number of questions asked on RAPS across age groups.....	24
2. Percentage of CS questions on RAPS across age groups.....	24
3. Mean question-asking efficiency scores on RAPS across age groups.....	25
4. Number of types of questions asked by participants for 60 RAPS problems. Total number of questions asked = 291	27

CHAPTER I. INTRODUCTION

Background of Problem-Solving

Problem-solving encompasses a vast range of normal cognitive activity. At its most basic, the ability to "problem solve" requires the modulation and control of more fundamental or routine cognitive skills (McCarthy & Warrington, 1990). The right skill has to be harnessed at the right time and changing between skills has to be flexible. Cognitive skills have to be integrated and adapted so that they comply with situational constraints and yet are optimally coordinated so that goals are achieved as efficiently as possible. Luria (1973) stated:

Man not only reacts passively to incoming information but creates intentions, forms plans and programmes of his actions, inspects their performance and regulates his behaviour so that it conforms to these plans and programmes, finally he verifies his conscious activity comparing the effects of his actions with the original intentions and correcting any mistakes he has made. (p. 79)

Problem-solving includes the ability to draw higher order inferences that require the individual to abstract the necessary information from the elements of the problem and to analyze how its properties may be related to those of others. The formulation of strategies is a necessary component of successful problem-solving and allows the individual to plan an action (McCarthy & Warrington, 1990). These processes develop through childhood and adolescence, and play an important role in a child's cognitive functioning, behavior, and social interaction.

Executive Functioning and Problem-Solving

Executive function is comprised of a range of cognitive abilities that facilitate

intentional, goal-directed, problem-solving (Gioia, Isquith, Retzlaff, & Espy, 2002). Executive function is considered to be an umbrella term “that includes all supervisory or self-regulatory functions, which organize and direct cognitive activity” (Gioia, Isquith, Kenworthy, & Barton, 2002). While some authors regard executive functioning as a unitary system, most support the idea that the subdomains are separable (Diamond & Goldman-Rakie, 1989; Welsh, Pennington, & Grossier, 1991). Commonly agreed upon executive subdomains include the ability to initiate and maintain behavior, select goals, strategize, and monitor and evaluate one’s own behavior.

Executive function has been hard to define, however one component consistently included is problem-solving skills. Gioia et al. (2002) suggested that the problem-solving process requires interaction between components of executive function to achieve efficient multi-step performance. Certain executive functions (e.g., inhibition) may be more important and allow for sustained strategic problem-solving.

Neuroanatomy of Executive Functioning

Anderson (2002) proposes that the anterior regions of the brain mediate executive functioning. It is well established that the frontal lobes, and in particular the prefrontal cortex, is involved in the cognitive aspects of executive function. There are complex circuits that contain extensive connections to and from the frontal lobes providing an ideal system to allow information processing, which is necessary to higher level cognitive functioning, such as executive function. The prefrontal region is an association region with extension connections to all areas of the neocortex via

cortico-cortical projections, in addition to links with limbic and subcortical structures such as the cingulate gyrus, hippocampus, basal ganglia, and thalamus. Damage to any of these areas may affect the efferent and/or afferent connections of the prefrontal cortex, and in turn, influence executive functioning. Therefore, executive dysfunction is not always associated with prefrontal pathology directly, but may be related to network disconnections such as white matter damage or impairment to other brain regions that interact with the frontal lobes. Hughes and Graham (2002) report executive impairments in a number of neurological disorders, including autism, attention-deficit/hyperactivity disorder (ADHD), head injury, epilepsy, Gilles de la Tourette's syndrome and conduct disorder; although autism and ADHD are the two disorders in which impaired executive function is most evident.

Problem-Solving Skills

Development of Problem-Solving

The development of different components of problem-solving in children is related to the development of the frontal systems in the brain. The frontal cortex is relatively slow to develop with some anatomical changes extending into adulthood (Anderson, 2002). Not surprisingly, problem-solving appears to have a prolonged developmental course, with evidence that some basic problem-solving skills emerge in the first year of life, and that various components of problem-solving continue to develop into adolescence.

Some researchers have employed Piagetian techniques to investigate early cognitive development and its relationship with cerebral development. Diamond and Goldman-Rakie (1989) used the classic Piagetian object permanence paradigm, as

well as an object retrieval task, to investigate goal-directed behaviors in infants.

Object permanence and object retrieval are important aspects of problem-solving in which the infant demonstrates the ability to plan means-ends sequences. The understanding that objects continue to exist even when they are out of site for a period of time is apparent in children as young as 12 months of age. On object retrieval tasks, human infants showed age-related improvements in planning and self-control.

Maturation of the dorsolateral prefrontal cortex is necessary to intentionality, and has been demonstrated through animal research. Diamond and Goldman-Rakie (1989) found that adult rhesus monkeys exhibit object permanence by successfully locating hidden objects even when delays of ten seconds were in place. They tested two groups of adult rhesus monkeys, one with bilateral lesions to the prefrontal cortex and another with bilateral lesions to the parietal lobes on tests of object permanence. Although the group with parietal lesions continued to demonstrate intact object permanence, the prefrontal lesioned group performed like human infants that could only locate hidden objects as long as there was no delay between covering the object and allowing for retrieval of it. The ability to locate a hidden object without a delay is present in infants between 7.5 and 9 months of age (Diamond & Goldman-Rakie, 1989). Because of these findings the authors reported object permanence begins to develop around 7.5 months in the infant and is dependent on maturation of the dorsolateral prefrontal cortex.

Other studies have attempted to map developmental paths for aspects of problem-solving skills in older children. Passler, Isaac, and Hynd (1985) have shown that children as young as 6 years are able to exhibit strategic and planful behavior on

tasks of frontal lobe function. Their results suggest that the emergence of frontal-lobe function in children represents a multi-stage process with the period of greatest development occurring at the 6-8 year-old level, with mastery of behaviors associated with frontal lobe function occurring around the age of 12.

Standardized tests of executive function designed to measure problem-solving have been used to determine developmental levels in children. Levin et al. (1991) evaluated 52 normal children and adolescents in three age bands, 7-8 years, 9-12 years, and 13-15 years. They administered a range of measures and identified developmental gains, reflecting progress in concept formation, mental flexibility, and problem-solving through childhood. Specifically, they found major gains in mental flexibility between the 7-8 and 9-12 year-old groups on the Wisconsin Card Sorting Test and further advances were evident on concept formation and problem solving in the 13-15 year-old age range on the Twenty Questions and Tower of London Test. Likewise, Welsh et al. (1991) studied a sample of normal children, aged 3-12 years, using a series of executive function measures. Consistent with previous findings, they provide evidence for stage-like development in problem-solving skills. They argue for three distinct developmental stages, the first commencing around age 6, a second about age 10, and final spurt in early adolescence. They suggest that speeded responding (i.e. verbal fluency, visual search, and motor sequencing skills) is the first skill to mature at around age 6, hypothesis testing and impulse control reach adult levels around age 10, and planning ability does not reach adult levels until age 12.

There are varying findings regarding what age children are achieving adult level performance on problem-solving. Young children do appear to have skills in

problem-solving which reach adult level around 10-12 years of age. However, all of these studies suggest continued significant improvement in performance through middle childhood, indicating ongoing gains in problem-solving abilities.

Measuring Problem-Solving

Executive functioning skills, such as organization, planning, goal formulations, and plan follow-through, are necessary for the execution of daily tasks and solving problems that arise in everyday life across the lifespan. Deficits in any of these skills can have significant implications on an individual's ability to function in his/her home, community, and workplace. There are many tests available to measure different components of executive function and problem-solving skills, however, most of these tests are difficult or take long to administer, only address specific components of problem-solving, have little ecological validity, and are not normed across the lifespan.

The Twenty Questions (20Qs) Test (Mosher & Hornsby, 1966) assesses a child's ability to utilize feedback and reevaluate goals to reach a correct response. The child is shown a card with 42 hand-drawn pictures, which may be grouped into various categories (e.g. animals, plants, utensils). The child is asked to identify which picture the examiner has in mind, and is able to ask 20 questions to do so. Only questions necessitating a yes or no response are allowed. Unfortunately, developmental norms are not available for this task, and administration protocols vary considerably.

The Wisconsin Card Sorting Test (WCST) (Chelune & Baer, 1986) is considered to tap the ability to form abstract concepts and shift and maintain set. The child is presented with four stimulus cards, a red triangle, two green stars, three yellow

crosses, and four blue circles. The child is then directed to match each of the response cards, each with configurations similar to those on the stimulus cards, to one of the four stimulus cards and informed that they will be told whether or not each response is correct. Chelune and Baer (1986) provide normative data for children aged between 6-12 years on the WCST, indicating improvements in performance throughout childhood, reflecting increasing abilities in concept formation.

The Tower of London (TOL) (Culberson, & Zilimer, 1999) measures problem-solving aspects of executive functioning. The task involves 12 items, with each requiring children to rearrange three colored balls to a configuration presented on a stimulus card, and in a prescribed number of moves. When a child fails to complete an item correctly, the balls are replaced in their original configuration, and the child has the opportunity to try again. This test taps planning speed, impulsivity, and flexibility, however, its clinical use has been restricted because it lacks standardized administration protocols and normative data.

Traditional measures typically use specially formulated problems and tasks that are unfamiliar to the client. Some researchers have questioned the accuracy of such unnatural tasks and their assessments of executive functioning, indicating a need for ecologically valid tests (Anderson, 2002; Gioia et al., 2002; Marshall et al., 2003).

Problem-Solving in Learning Disabled Children

Learning to ask questions effectively is an important achievement with considerable practical application. Such information seeking enables a child to acquire knowledge, to clarify ambiguity, and to solve problems. It is also an important aspect of children's developing communicative ability.

Recent studies have shown that many of the academic problems of students with learning disabilities are tied to problem-solving difficulties (Norris & Foxcroft, 1996). Researchers suggest that difficulties in the application of efficient task strategies may be characteristic of some students with learning disabilities, and that poor academic performance is in part due to the lack of, or failure to utilize specific goal-directed strategies. Norris and Foxcroft (1996) found that boys with learning disabilities were as adept as their normally achieving peers in the induction of equivalence concepts, but were unable to utilize these concepts "as the basis for the development of an effective questioning strategy." As a result, they were less able than their normally achieving peers to formulate effective questioning strategies for an information-seeking task.

Purpose

Although executive skills appear to be crucial to successful functioning of children in school and in society at large, there is a lack of measures that (a) are designed for use with children and adolescents and (b) yield information that accurately reflects their day-to-day behavior. Most clinical measures of problem-solving have been designed primarily for adult populations. As a result, many assessment tools are irrelevant for children and possess limited supporting normative data.

Present research using RAPS, a modified version of the 20Qs Test, focused solely on the problem-solving abilities of adults, both young and old (Marshall et al., 2003). However, past research has been conducted not only on the decline of problem-solving in the elderly, but also on the overall development of the executive

functioning skills beginning in childhood (Denny, 1985). Mosher and Hornsby (1966) examined six to eleven year-old children and determined that older children perform better than younger children on the 20Qs Test. Likewise, Levin et al. (1991) utilized the 20Qs Test in their study of executive function, and found that older children needed to ask fewer questions to identify target pictures, suggesting better capacity to form concepts and utilize feedback. Garth, Anderson, and Wrennall (1997) employed the 20Qs Test to investigate the problem-solving skills of children who had sustained frontal lobe damage. They found no differences between a clinical group and controls on summary measures of total questions asked and time to complete the task. Using a qualitative analysis of the nature of questions posed, they identified less efficient performance by children with frontal lesions. This group exhibited higher frequencies in guessing and less frequency in more efficient ways of solving problems such as constraining a large number of items by the formulated question.

There is a need to devise valid and well-standardized assessment measures for children that are based on current understanding of the nature of both cerebral and cognitive development through childhood. Most available or commonly utilized tests purported to measure executive function in children have been developed for use with adults. These tests may be of little interest or relevance to young children, and frequently lack normative information with respect to developmental expectations. The purpose of this study is to evaluate how normal children solve RAPS problems and to determine if this measure can be used to successfully evaluate problem-solving skills. It is predicted that children's performance will improve as they increase in age and overall they will be less efficient than adults reported in previous studies. This

study is the first to obtain information on how children complete RAPS problems and will contribute to the growing normative database on performance across the lifespan.

CHAPTER II. METHODS

Subjects

Twenty children between the ages of 10 and 17 participated in the study. Subjects were assigned to each of four age groups (10-11, 12-13, 14-15, and 16-17) with five participants per group. Groups were not balanced for gender, however, every attempt was made to include both males and females (see Table 1 for subject demographics). The purpose of the study was to investigate normally developing problem-solving skills in children, therefore, any potential subject with a history of poor academic performance, psychiatric or neurological disorders was excluded (see Appendix A for screening criteria).

Table 1. Subject demographic data (i.e. age, gender, mean years of education).

Age		Gender		Education
Range	Mean	Male	Female	Mean Grade
10-11	10.86	1	4	6.0
12-13	12.65	3	2	7.4
14-15	14.86	2	3	9.8
16-17	16.24	1	4	11.0

Following approval by the University of Rhode Island's Institutional Review Board (IRB), all subjects were recruited from the University of Rhode Island Speech and Hearing Center. An initial screening process via telephone was conducted with a parent in order to obtain information regarding the exclusion criteria. No subjects were excluded on the basis of race or ethnic background. Written informed consent was obtained from one parent of all subjects (see Appendix B), and written informed assent was obtained from all subjects (see Appendix C).

Experimental Design

Prior to participation in the study, each subject was screened to test whether

they met the inclusion criterion via a telephone screening. Once the screening was passed, each subject participated in a single, individual session that lasted between 90 to 120 minutes in length. Testing took place in quiet, private rooms located at the subject's home or in the Department of Communicative Disorders. During the session, only the subject and the investigator were present.

Standardized Tests:

All participants completed a battery of standardized cognitive tests prior to the experimental task on problem-solving. Each testing session was initiated by the completion of a case history interview to gather data on the subject's educational background, medical history, and social behavior (see Appendix D). This was followed by four subtests from the *Wechsler Memory Scale-Revised* (Wechsler, 1987) including the Visual Paired Associates I and II, and the Verbal Paired Associates I and II, and the 36-item *Raven Coloured Progressive Matrices* (Raven, Raven, & Court, 1998). Complete descriptions of each measure of cognitive ability is available in Appendix E. Mean scores for each test are reported in Table 2.

Table 2. The mean scores of the standardized cognitive tests (i.e. the Visual Paired Associates I and II, and the Verbal Paired Associates I and II from the Wechsler Memory Scale-Revised (Wechsler, 1987), and the Coloured Progressive Matrices (Raven, Raven, & Court, 1998).

Age Groups	Tests									
	Visual Paired Associates I		Visual Paired Associates II		Verbal Paired Associates I		Verbal Paired Associates II		CPM*	
	M	SD	M	SD	M	SD	M	SD	M	SD
10-11	16.0	1.22	6.0	0.0	21.4	1.67	7.8	0.45	31.0	4.58
12-13	16.8	2.49	6.0	0.0	22.0	1.22	8.0	0.00	32.8	0.84
14-15	16.8	2.39	6.0	0.0	20.8	3.96	7.8	0.45	33.8	1.64
16-17	17.0	0.71	6.0	0.0	21.6	1.82	7.8	0.45	34.2	2.05

* Coloured Progressive Matrices

Experimental Task:

Following the administration of the standardized tests, each subject completed three problems of RAPS (Marshall & Karow, 2001) in succession. RAPS is a clinical measure of verbal problem-solving based on the Twenty Questions (20Qs) Test (Mosher & Hornsby, 1966).

RAPS differs from the 20Qs Test in several dimensions (see Appendix F). RAPS has nine problem-solving boards (see sample game board in Appendix G); a different board is used for each administration of the test. RAPS uses fewer pictures on each board than the 20Qs Test; 32 instead of 42. The new measure also includes 16 colored and 16 black and white pictures versus all black and white drawings, and all pictures are arranged in a grid of columns and rows. RAPS also controls the number of pictures belonging to specific categories (groups of 8, 6, and 4) in order to enable problem-solvers to develop strategies for asking questions; for example to eliminate larger than smaller numbers of pictures. As pictures are eliminated by the test-taker, the examiner covers the targeted stimuli to reduce demands on memory.

The following instructions were read by the examiner preceding the initial game and were only repeated prior to games two and three if requested by the subject:

"We are going to play a question-asking game. I am thinking of one of these pictures (gesturing to the board) and your job is to figure out which one it is. You can ask any question you want so long as I can answer it "yes" or "no." Try to ask as FEW questions as possible. When you are ready, go ahead and ask your first question. There is no time limit for this test."

As subjects asked each question, the examiner responded "yes" or "no" accordingly. Each time one or multiple pictures were eliminated, the examiner covered the targeted pictures with small black cards. For example, if the target picture was the chair and the question was "Is it a living thing?," the examiner would respond "No" and cover all the pictures of live objects. Conversely, if the target picture was the grasshopper, and the same question was asked, the examiner would respond "Yes" and cover all the pictures of inanimate objects. If a question was asked that could not be answered "yes" or "no," the examiner informed the subject to rephrase the question and be sure it can be answered "yes" or "no." Additionally, if the examiner was unsure which pictures were targeted by a specific question, the subject was prompted to identify the intended picture(s). The subject was allowed to correct the examiner at any time if a picture was covered or not covered correctly. If during the administration of RAPS a subject asked only questions that were guesses (e.g., "Is it the cat?"), a maximum of 10 questions was permitted before the examiner responded "Yes" to the final guess in order to end the problem. Throughout the administration of RAPS, the examiner recorded all questions and eliminated pictures.

Scoring

The problem-solving skills required to solve RAPS are calculated based on three separate scores: 1. the total number of questions needed to solve the problem; 2. the percentage of constraint-seeking questions used; and 3. the question-asking efficiency scores for questions 1 to 4. Each scoring procedure is described below. See sample score sheet in Appendix H.

Total number of questions- Each problem was considered solved when the game board was reduced to two pictures. It was from this point that the number of questions asked was tallied. Only questions that could be answered "yes" or "no" were calculated in the total.

Percentage of constraint-seeking (CS) questions- Each question asked was coded as a constraint-seeking question (CS), or a guess. CS questions refer to those that eliminate more than one picture and target categories or groups of pictures on the game board (e.g., "Is it an instrument?" or "Is it a living thing?"). CS questions are considered to be more efficient than guesses. There are two type of guesses, frank guesses (G), and pseudo-constraint seeking questions (PC). PC questions are questions that only eliminate one picture, but are phrased like CS questions (e.g., "Does it have a long neck and eat leaves from the top of trees?"). The number of constraint-seeking questions were totaled for the given problem and divided by the total number of questions asked to calculate the percentage of CS questions score.

Question-asking efficiency scores- The efficiency of questions asked refers to how well subjects asked questions that target large categories of items. Specifically, this procedure looked at the percent of figures eliminated by each question asked. The most efficient questions target and eliminate 50 percent of the remaining pictures on the game board. For example, each board contains 32 pictures; therefore question 1 should eliminate 16 items, question 2 should eliminate 8 items, question 3 should eliminate 4 items, and question 4 should eliminate 2 items to solve the problem.

Question-asking efficiency (QE) was calculated by dividing either the number of pictures targeted by a question or the number of pictures eliminated by the question

(the smaller amount) by the number of pictures remaining under consideration when the question was asked, and multiplying the number by 2. (The smaller of the two numbers was used in order to compensate for guesses that were not representative of the subject's true performance.) For example, if there are 16 pictures on the board and a person asked a question (such as, "Is it an animal?") that targeted 12 of the 16 pictures, the number 4 was used to calculate the QE score. It did not matter if the answer was "yes" (which would eliminate only 4 pictures) or "no" (which would be lucky and eliminate 12 pictures), the smaller of the two numbers was used. In this example, the QE score would be calculated by the following equation: $(4/16) \times 2 = 50\%$. The most efficient question asked would have resulted in a QE score of 100% (e.g., if the question targeted 8 of the 16 pictures, the QE score would be $(8/16) \times 2 = 100\%$).

In previous normative studies using RAPS, an intra-scorer and inter-scorer reliability testing for RAPS was conducted on 53 solved RAPS problems. Reliability on the scoring of the number of questions asked, question clarification, percent of CS questions, and question-asking efficiency was considered. Intra-scorer and inter-scorer reliability ranged from 95.2-99% (Marshall et al., 2003) for all of the measures.

Statistical Analyses

To determine if there are differences in performance between the three administrations of RAPS, the data was analyzed on a problem-by-problem basis. If subjects performed differently between administrations (e.g., improved in performance between the first problem and the third problem), then this may indicate that a learning effect has occurred across the administrations and the test itself may not be a stable indicator of the skills (i.e. problem-solving) it is proposed to measure. Therefore, a

one-way analyses of variance (ANOVA) was conducted between each administration of the RAPS to determine if there were learning effects for the total number of questions used to solve the problem, the percentage of questions that are constraint-seeking, and the question-asking efficiency. Since there were no learning effects (which was predicted based on the Marshall et al. study), all three administrations of RAPS was used to analyze performance. Performance was analyzed as follows:

Total number of questions- The total number of questions asked for each administration of RAPS was summed. Therefore, the score used for analyses ranged from 3 (if the subject guessed the correct answer on the first try for each of the three problems administered) to 30 (if the subject asked 10 questions and the problem was ended on all three administrations).

Percentage of constraint-seeking questions- The percentage of constraint-seeking questions was obtained by dividing the total number of questions asked across the three problems by the total number of CS questions across the three problems. The range of scores was 0% (if the subject did not ask any CS questions for each of the test administrations) to 100% (if the subject asked all CS questions for each of the test administrations).

Question-asking efficiency- The question asking-efficiency scores for the first four questions of each RAPS administration was averaged. If any subject solved a problem (i.e. the RAPS game) with less than four questions, then the remaining questions (from the remaining problems) was used for analyses.

After completing these calculations, a series of ANOVAs were conducted for each measure across the age groups to determine if subjects demonstrated differences in problem-solving ability as a function of age.

Descriptive Analyses

Types of Questions:

To further analyze the RAPS problems, each question was analyzed according to the type of question asked. Category-focused questions are questions that targeted an entire category on the board, part of a category, more than one entire category, or those that narrowed the field after a category was targeted. Each category-focused question was labeled as a multi-category, whole-category, part-category, or narrowing question. Narrowing questions occurred after a question identified the category containing the target picture or when there was only one category of pictures remaining. Each non-category focused question was coded as color-based (those that asked if the items were black and white or colored), idiosyncratic (those that were non-categorical, targeting a large number of pictures such as “Is it bigger than a bread box?” or “Does it move?”), or novel (those that pull together items based on descriptors rather than labels such as “Is it round?” or “Is it furry?”). Each guess was labeled as a frank guess (e.g., “Is it the cow?”) or a pseudo-constraint question, which sounded like it would constrain more than one item, but ultimately only targeted or eliminated one item, therefore it was a guess (e.g., “Is it an instrument that you beat on?”).

Reliability

Interexaminer reliability checks were completed on 15 of 60 solved problems

(70 questions) to determine measurement repeatability for the number of questions asked metric and the calculated QE scores. Two members of the research team counted the number of questions needed to solve the problem and calculated question-asking efficiency scores for each of the first four questions approximately 2 months apart. Interexaminer reliability checks were made by comparing point-to-point agreement for question counts and for the calculated QE scores for the two examiners. The percent of interexaminer agreement was 98.57% and 97% respectively.

CHAPTER III. RESULTS

Learning Effects

To examine if learning occurred across administrations of the three RAPS problems, the data was first analyzed on a problem-by-problem basis. Table 3a-d shows the total number of questions asked, percentage of constraint-seeking questions and question-asking efficiency (QE) scores for each age group, respectively. Separate one-way analysis of variance (ANOVA) were conducted on each of the three RAPS measures (total number of questions asked per problem, percent of constraint-seeking questions asked per problem, and question-asking efficiency scores) to determine if performance improved across administrations. Subjects posed an average of 5.2, 4.4, and 4.95 questions for problems 1, 2, and 3, respectively (see Table 4). ANOVA calculations determined that there was no significant differences in the number of questions asked for each of the three problems [$F(2,57) = 1.249$, $p = 0.295$]. The mean percent of CS questions asked across problems 1, 2, and 3 were 92%, 88.5%, and 87.51%, respectively (see Table 4). ANOVA results revealed that there was no significant differences for percent of CS questions across the problems [$F(2,57) = 0.333$, $p = 0.718$]. The QE scores were calculated for subjects for the first four questions asked for each of the three problems. Mean QE scores for problems 1, 2, and 3 were 58.83%, 60.20%, and 60.24%, respectively (see Table 4). A single factor ANOVA for the four questions for problems 1, 2, and 3 was conducted to examine differences in QE scores across problems. A total of eleven subjects solved at least one of the problems with fewer than four questions. In these instances, the QE score used for analysis was calculated by averaging the remaining data points. ANOVA

results revealed no significant difference in QE scores across games [$F(2,57) = 0.041$, $p = 0.960$].

Table 3a. RAPS raw scores for administrations of problems 1, 2, and 3 for 10 and 11 year-olds.

Age Group	ID	Problem Number	Mean QE Score	Total # Of Q	%CS
10-11 year-olds	1	1	61.01	4	1.00
		2	61.11	6	1.00
		3	56.68	5	1.00
	2	1	40.12	5	0.60
		2	61.64	5	0.40
		3	25.97	8	0.25
	3	1	58.49	4	1.00
		2	66.67	4	1.00
		3	57.26	6	0.67
	4	1	56.96	6	1.00
		2	68.75	2	1.00
		3	61.19	5	1.00
	5	1	13.65	9	0.67
		2	39.42	3	0.67
		3	46.10	7	0.86

Table 3b. RAPS raw scores for administrations of problems 1, 2, and 3 for 12 and 13 year-olds.

Age Group	ID	Problem Number	Mean QE Scores	Total # Of Q	%CS
12-13 year-olds	6	1	93.30	4	1.00
		2	57.54	6	1.00
		3	50.11	3	1.00
	7	1	78.33	3	1.00
		2	43.33	4	0.50
		3	50.11	3	1.00
	8	1	45.72	4	1.00
		2	58.34	6	0.83
		3	58.34	6	1.00
	9	1	78.75	5	1.00
		2	50.45	2	1.00
		3	91.07	3	1.00
	10	1	28.80	10	0.70
		2	55.90	6	0.83
		3	51.39	3	1.00

Table 3c. RAPS raw scores for administrations of problems 1, 2, and 3 for 14 and 15 year-olds.

Age Group	ID	Problem Number	Mean QE Scores	Total # Of Q	%CS
14-15 year-olds	11	1	79.41	5	1.00
		2	74.12	4	1.00
		3	91.07	3	1.00
	12	1	50.40	6	0.83
		2	56.96	6	0.83
		3	38.39	7	0.57
	13	1	73.04	5	1.00
		2	66.67	3	1.00
		3	91.07	3	1.00
	14	1	79.76	5	1.00
		2	54.05	6	.083
		3	60.00	6	0.50
	15	1	79.17	5	1.00
		2	38.54	3	1.00
		3	53.97	5	1.00

Table 3d. RAPS raw scores for administrations of problems 1, 2, and 3 for 16 and 17 year-olds.

Age Group	ID	Problem Number	Mean QE Scores	Total # Of Q	%CS
16-17 year-olds	16	1	19.72	2	1.00
		2	58.10	4	1.00
		3	58.34	5	0.80
	17	1	39.53	7	1.00
		2	93.30	4	1.00
		3	78.88	4	1.00
	18	1	79.76	5	1.00
		2	61.22	3	1.00
		3	80.70	4	1.00
	19	1	67.22	5	1.00
		2	66.67	6	1.00
		3	60.83	6	1.00
	20	1	53.51	5	0.60
		2	58.34	5	0.80
		3	43.45	7	0.86

Table 4. Total number of questions asked, percentage of CS questions asked, and question-asking efficiency scores to solve RAPS problems 1, 2, and 3.

Problem	Number of Questions			Percent of CS Questions			QE Scores	
	M	Range	SD	M	Range	SD	M	SD
1	5.20	2-10	3.33	92.0	60-100	0.02	58.83	496.10
2	4.40	2-6	2.04	88.5	40-100	0.03	60.20	129.80
3	4.95	3-8	2.68	87.5	25-100	0.05	60.24	321.31

In summary, results for all measures obtained across the three administrations of RAPS revealed no significant differences, suggesting that subjects did not improve in their performance with the repeated trials. Therefore, each of the RAPS measures were analyzed for all three problems to determine if differences occurred between age groups.

Analysis of Age Effects

Number of Questions Asked Per Problem

The total number of questions asked for each of the four age groups (10-11, 12-13, 14-15, and 16-17) were summed across the three RAPS administrations. Mean scores were 15.8, 13.6, 14.4, and 14.4 for each age group, respectively (see Table 5). A single factor ANOVA comparing groups by number of questions asked, revealed that there were no significant differences between the total number of questions asked across the four age groups [$F(3,16) = 0.402, p = 0.753$]. Figure 1 shows the mean scores for each group noting that subjects aged 12-13 asked the fewest number of questions while subjects in the 10-11 year-old age group asked the greatest number of questions to solve RAPS problems.

Percent of Constraint-Seeking Questions Asked Per Problem

The total number of constraint-seeking questions asked per problem were calculated by dividing the total number of questions asked across the three problems by the total number of CS questions across the three problems. Mean scores were 79.66%, 90.54%, 90.03%, and 93.48% for each of the four age groups, respectively (see Table 5). A single factor ANOVA revealed no significant differences between age groups and the percentage of CS questions asked [$F(3,16) = 0.700, p = 0.566$].

Although the percent of CS questions did not increase incrementally as the children got older, the 16-17 year-olds had the highest percentage (93.48%), while the 10-11 year-olds had the lowest percentage (79.66%). CS percentages across age groups are illustrated in Figure 2.

Figure 1. Number of questions asked on RAPS across age groups.

Figure 2. Percent of CS questions on RAPS across age groups.

Question-Asking Efficiency Scores

The question-asking efficiency scores were calculated for each of the age groups by averaging all the QE scores together for the first four questions of each RAPS administration. Mean QE scores were 51.29%, 59.98%, 66.56%, and 62.56%, respectively (see Table 5). Again, a single factor ANOVA on QE scores found no differences between age groups [$F(3,16)= 1.369$, $p= 0.288$]. Figure 3 shows the total QE scores for each age group.

Table 5. Total number of questions asked, the percent of CS questions asked, and question-asking efficiency scores per age group.

Age Groups	N	Number of Questions		Percent of CS Questions		QE Scores	
		Mean	SD	Mean	SD	Mean	SD
10-11	5	15.8	2.59	79.66	25	51.29	13.08
12-13	5	13.6	3.91	90.54	10	59.98	12.54
14-15	5	14.4	3.44	90.03	14	66.56	12.67
16-17	5	14.4	2.79	93.48	10	62.56	11.04
Total	20	14.6	3.07	88.00	16	60.10	12.71

Figure 3. Mean question-asking efficiency scores on RAPS across age groups.

In conclusion, the main findings from this study were: 1. Subjects do not learn the task during repeated administrations, therefore there is no difference in performance on the first trial of RAPS compared to subsequent trials; 2. There were no differences in performance as a function of age, and 3. There were no significant differences in the efficiency of questions asked as subjects proceed through the task; performance did not improve in a linear fashion. This suggests that the mean amount of information gained (i.e. the efficiency of questions asked) did not improve as subjects increase in age.

Test-Retest Reliability

Ten subjects participated in a repeat administration of three RAPS problems two weeks after the initial administration. A paired two sample for means t-test was conducted between the first and second administration of RAPS on the total number of questions asked, percentage of constraint-seeking questions, and QE scores to determine if performance improved between the test and the retest administration. These tests revealed no differences between the test and retest measures for the total number of questions asked [$t(9) = 0.343, p > .05$], percentage of constraint-seeking questions [$t(9) = 0.344, p > .05$], and QE scores [$t(9) = 0.424, p > .05$] for each of the subjects.

Question Type and Form

All of the questions from the participants were yes/no questions and no re-instruction was required. In solving 60 RAPS problems, participants asked a total of 291 questions. Each of the questions were identified as category-focused (CF), non-category focused (NCF), or a guess. CF questions included those that targeted an

entire category on the board, part of a category, more than one entire category, or those that narrowed the field after a category was targeted. NCF questions included those that asked if the items were black and white or colored, were idiosyncratic, or were novel (meaning those that pull together items based on descriptors rather than labels such as “Is it round or Is it furry?”). Of the 291 questions, 175 (60.14 %) were classified as CF questions, 75 (25.77 %) as NCF questions, and 41 (14.09 %) as guesses (see Figure 4).

Figure 4. Number of types of questions asked by participants for 60 RAPS problems. Total number of questions asked = 291.

The 75 NCF questions often incorporated pictures from more than one category. There were 37 (49.33 %) novel questions which are questions that target a group of items by describing a characteristic (e.g., “Is it round?” or “Is it furry?”), location (e.g., “Is it found outside?”), or movement (e.g., “Does it fly?” or “Does it spin?”). There were 22 (29.33 %) NCF questions based on color (e.g., “Is it black and white?”).

Finally, there were 16 (21.33 %) NCF questions that were idiosyncratic (“Is it alive?” or “Is it bigger than a breadbox?”).

Guessing

Figure 4 shows that 41 of the 291 (14.09 %) questions asked were guesses. Although guessing accounted for a relatively small portion of all the questions, the point in the question-asking sequences where guessing occurs appears to be important. The reason that is most participants used a CF strategy to solve RAPS problems. In such cases, the participant will ultimately receive a “yes” answer that will inform him or her of the target picture’s category (e.g., “Is it an animal?”). In these instances, the participant has two choices. The more efficient strategy is to ask a narrowing question to further reduce the number of pictures under consideration (e.g., “Does it live on the farm?”). The less efficient strategy is to try to guess the target picture by asking a frank question or a pseudo constraint-seeking question (a question that sounds like it will constrain more than one item, but ultimately only targets or eliminates one item; therefore, it is a guess). It appears that when there is a choice to make between asking a narrowing question and guessing, the likelihood of a participant asking a narrowing question (69.57 %) was higher than that of guessing (30.43 %).

CHAPTER IV. DISCUSSION

This study was designed to assess the problem-solving abilities of adolescents, ages 10-17, by measuring performance using the newly designed RAPS (the Rapid Assessment of Problem Solving, Marshall and Karow, 2001). The tool is a modified version of the 20Qs Test (Mosher and Hornsby, 1966) and requires subjects to determine a pre-selected target picture from a total of 32 pictures by only asking questions that can be answered “yes” or “no.” Examinees are instructed to use as *few* questions as possible in order to solve each problem. The test design and format restrict individuals in such a way that the task is one of problem-solving, a component of executive functioning, placing demands on skills such as organization, goal formulation, and working memory.

Normal children between the ages of 10 and 17 solved RAPS problems with approximately 4.86 questions per problem. Approximately 60% of the questions asked were category-focused. Children do not solve RAPS problems optimally, where they eliminate half of the picture board with each question asked. However, they do perform similarly to adult normal subjects and eliminate on average a little less than one-third of the remaining pictures with each subsequent question. The RAPS QE measure has quantified this skill and the subjects from this study were considered 60% efficient in completing RAPS problems. The efficiency of solving a RAPS problem can also be measured by determining the percentage of questions that target more than one picture. The children in this study asked constraint-seeking questions approximately 88% of the time. This is somewhat higher than adults in previous RAPS studies (Marshall et al., 2003) that asked CS questions only 80% of the time.

Finally, children do guess while completing a RAPS problem; however, this occurs infrequently, approximately 14% of the time.

An important finding to support the methodology and scoring of RAPS is that normal children do not improve their performance on successive administrations. The results demonstrating no learning effects were similar to previous studies (Marshall et al., 2003), and therefore data from all three administrations of RAPS could be analyzed collectively.

Compared to previous research that found age related differences in the performance of children completing the 20Qs Test, this study found no differences among the four age groups for any of the RAPS measures. This finding may be interpreted in a number of ways. The first possibility is that there are differences between age groups that were not identified because the number of subjects per group was small ($n=5$). There was a tendency for the youngest group to have less similar scores on RAPS compared to the other three groups collectively, particularly for the number of questions asked and the percent of constraint-seeking questions. Perhaps, performance was reflective of the fact that most of the children had reached adult level performance on the skills necessary to complete the task. Problem-solving skills are dependent on executive functions. Welsh et al. (1991) reported speeded responding developed by age 6, hypothesis testing and impulse control reaching adult levels by age 10, and planning ability by age 12. Additionally, Chelune and Baer (1986) reported concept formation to improve significantly between the ages of 6 and 12. Passler et al. (1985) reported that strategic and planful behavior is mastered by age 12. Therefore, RAPS performance may mirror these skill levels and most of the adolescent

subjects may already have developed them, accounting for the lack of differences in the groups.

Another possible interpretation is that RAPS differs from the 20Qs Test in several dimensions, which could lead to the different findings. Half of the RAPS pictures are colored and half are black and white, rather than strictly black and white line drawn pictures used by the 20Qs Test. This change improves the saliency of the picture stimuli and allows the individual to adopt a color strategy. Also, the Mosher and Hornsby test does not control for the number of pictures in specific semantic categories. The number of pictures belonging to specific categories is semantically controlled in RAPS (i.e. boards contain categories of 8, 6, and 4 pictures) enabling the individual to use a strategy of asking questions that target larger then smaller numbers of categories. Another important change for RAPS is that the examiner covers those pictures eliminated for each question asked by the participant. The covering of the pictures eliminated by each question reduces the demands on memory for the participant by making it unnecessary for the person to remember the questions he or she has already asked.

The manner in which the subjects went about solving the RAPS problems provided was analyzed descriptively. Although children were not “optimally” efficient (i.e. eliminating half of the pictures on the game board- rated as 100%), eight of the 20 subjects tested eliminated 16 out of the possible 32 pictures with the first question asked. It was also noted that 3 of the questions asked were multi-category labeled questions that targeted 2 or more categories (e.g., “Is it an animal or a bird?”) and six targeted multiple items without labeling the categories in the question, for

example “Is it used for entertainment?” or “Can you play with it?”, which included all the sports and all the musical instruments. Perhaps this question strategy was rarely used because it involved identifying the existence of more than one category of pictures at the same time, requiring more complex cognitive skills.

Further examination of the types of questions children asked revealed several other findings. There were two factors that appeared to influence question-asking efficiency scores of many of the participants. The first was to initiate problem-solving effort by asking an optimal question, namely one that would eliminate half of the pictures from consideration. To do this, the individual needed to use information available from the problem-solving board in planning. This could involve recognizing that the pictures are arranged in rows and columns and that half of the pictures are colored and half are not. Moreover, initial question-asking efficiency could be improved by asking a multiple category question (e.g., “Is it an animal, clothing, or dessert?”). As mentioned, participants rarely targeted more than a single category (only 9 of 291 questions). Another important piece of information available to the participants is that the problem-solving boards contain more pictures of some categories than others. Thus, efficiency can be improved by first asking questions targeting the larger categories. Thirty-seven percent of the questions asked targeted more than 8 items. Twenty-six percent targeted eight items, 23% six items, and 6% four items. This demonstrated that many of the questions did target larger categories with 73% of the questions targeting eight or more items. This ability to ask “efficient questions” can be attributed to the manner in which participants use information from the problem-solving board to plan how to solve a RAPS problem.

Participants asked primarily constraint-seeking questions in solving RAPS problems and most of these were category-focused. Ultimately, a CF approach will identify the target picture's category. Once this occurs, the individual needs to make a strategy shift and ask a narrowing question to avoid using extra questions. Normal participants varied in their ability to shift to a narrowing question. Two possible reasons for this come to mind. One is that once the target picture category is known, the participant becomes impulsive and is prone to gamble with a guess. A second is that the individual is unable to shift to a question that focuses on features common to members of a category and render a guess. Examination on where guessing occurred in the question-asking sequence revealed that 41 guesses were made and only 10 occurred after the category was known. This result differed from performance for adults completing RAPS and suggests that children were better able to make a strategy shift, thereby narrowing the targeted category.

Future Implications

There are few clinical measures available to assess problem-solving skills in children. Anderson (2002) reports that there are both theoretical and practical challenges in evaluating executive functions. One problem is the lack of normative data on commonly used tests, which were developed for adults. Second, many assessment measures are very structured tests and do not allow for flexibility and evaluation of outcomes that are foundation skills in problem-solving. RAPS has been found useful for assessment of clinical populations in adults. It is fast, easy to administer and motivating to the examinee because of its “game-like” structure (Marshall et al., 2003). Because it appears that adolescents demonstrate adult-like

performance on RAPS, it is possible that this tool may be useful for examining clinical populations. Children with neurological disorders such as ADHD, childhood TBI, and Asperger's syndrome are known to have difficulty with skills dependent on frontal lobe function. However, they often are difficult populations to test. Future research should include assessment of children with and without neurological disorders to determine performance on RAPS.

Because no differences were found between age groups, future research should include evaluation of RAPS performance in younger children to determine if age differences are found in 6-12 year olds. Additionally, a larger sample should be obtained to improve statistical power. If a large enough sample is obtained it may be instructive to conduct a different type of analysis that does not artificially place children in specific age groupings. Also, other possible factors such as gender and years of education may have had an influence on results. Early findings do suggest some stability in performance, such that RAPS may be instrumental in comparing normal and clinical populations.

Appendix A

TELEPHONE SCREENING

The University of Rhode Island
Department of Communicative Disorders
Independence Square II
25 West Independence Way, Suite I
Kingston, RI 02881

"Assessment of Problem-Solving Abilities in Normal Adolescents"

<i>Question</i>	<i>Response</i>	<i>Criteria</i>	<i>+/-</i>
1) How old is your child?		10 to 17 years of age	
2) Has your child ever been treated for a brain injury or been hit in the head and knocked out for more than a brief period of time?		No	
3) Does your child take any medication to assist him/her with learning?		No	
4) Is your child's academic performance average or above average?		Yes	
5) Is your child in a regular classroom?		Yes	

Appendix A Continued

6) Does your child receive any special education services?		No	
7) Does your child have any documented neurological problems (strokes, seizures, head injuries, etc.)?		No	

Appendix B

CONSENT FORM

**The University of Rhode Island
Department of Communicative Disorders
Independence Square II
25 West Independence Way, Suite I
Kingston, RI 02881**

"Assessment of Problem-Solving Abilities in Normal Adolescents"

You are invited to take part in a research project that is described to you in detail below. My name is Kelley Crownover, and I am a graduate student at the University of Rhode Island enrolled in a master's degree program for speech-language pathology. I am conducting this research project under the supervision of Colleen Karow, Ph.D., SLP-CCC. If you have any questions, please feel free to ask them at this time. If you have any questions, please feel free to ask them at this time. If you have more questions later, Dr. Colleen Karow (401) 874-2490 or I (508) 880-9435 will discuss them with you.

Your child has been invited to take part in a study that will examine his or her use of problem-solving strategies when presented with a "game-like" activity that is very similar to the Twenty Questions game. The purpose of this study is to learn more about how children solve problems.

If you decide that your child will take part in this study, here is what will happen: your child will be asked to participate in one or two individual sessions that will last for approximately one hour. During the sessions, your child will be presented with four different activities that include looking at pictures, sorting cards and designs, remembering words, and answering brief questions.

There is no foreseeable risk to your child. However, if your child experiences any discomfort during any part of the study, he or she should let the researcher know immediately.

Although there will be no direct benefit to your child for taking part in this study, the researcher hopes to learn more about cognitive functions that are related to problem-solving skills. By helping the researcher learn more about problem-solving, a better understanding of this cognitive function may lead to the development of better assessment tools of problem-solving ability for adolescents. If interested, the results of your child's performance will be shared with you, and any publications generated from this study will be available at your request.

Your child's participation in this study is confidential. None of the information will identify him or her by name. All records of your child's participation will be kept with a number or letter code, and any publications resulting from this study will identify your child only with this code. All paper records will be stored in locked cabinets.

The decision for your child to take part in this study is up to you. Your child does not have to participate. If you decide that your child will take part in the study, he or she may quit at any time without any penalty. If your child wishes to quit, you or your child can simply inform Dr. Colleen Karow (401) 874-2490 or Kelley Crownover (508) 880-9435 of that decision. All children who participate in the study will receive a \$10 gift certificate that can be used to purchase a movie ticket or snacks at the theatre.

If you are not satisfied with the way this study is performed, you may discuss your complaints anonymously, if you choose, with either Dr. Colleen Karow (401) 874-2490 or Kelley Crownover (508) 880-9435. In addition, you may contact the office of the Vice Provost for Graduate Studies, Research and Outreach, 70 Lower College Road, Suite 2, University of Rhode Island, Kingston, Rhode Island, telephone: (401) 874-4328.

You have read the Consent Form. Your questions have been answered. Your signature on this form means that you understand the information and you agree to allow your child to participate in this study.

Signature of Parent/Guardian

Signature of Researcher

Typed/Printed Name

Typed/Printed Name

Date

Date

Appendix C

ASSENT FORM

**The University of Rhode Island
Department of Communicative Disorders
Independence Square II
25 West Independence Way, Suite I
Kingston, RI 02881**

"Assessment of Problem-Solving Abilities in Normal Adolescents"

Hi! My name is Kelley. I am doing a special project on problem solving with Dr. Colleen Karow. If your mom or dad has said it is okay and if you want to help me, then this is what you will need to do.

You will come to help me with my project two times. There are four things I will ask you to do. You will look at some pictures and think up some questions to ask me about what you see. You will sort cards and pictures of designs. You will listen to words and have to try and remember them. You will also answer some brief questions. After you participate in these activities, you will get a \$10 gift certificate that you can use to purchase a movie ticket or snacks at the theatre.

Helping me with this project should be easy and comfortable. If you don't feel comfortable, then you should let Dr. Karow or me know right away.

Everything that you tell me will be kept a secret. Your answers for my project will be on a piece of paper that does not have your name. Instead, I will use a special number code to tell me who you are. Whenever I talk about your answers, I will not use your name. I will only use the special number code.

You do not have to help me if you do not want. If you start to help me, but then do not want to finish, that is okay too. All you have to do is tell Dr. Karow or me that you want to stop helping.

If you want to help me with my project and your mom or dad has said it is okay, then you need to write your name on the line at the bottom of this paper. If you write your name on this paper, then you want to help me with my project. If you ever have any questions, you should ask Dr. Karow or me whenever you want.

Signature of Participant

Signature of Researcher

Typed/Printed Name

Typed/Printed Name

Date

Date

Appendix D

HISTORY FORM

The University of Rhode Island
Department of Communicative Disorders
Independence Square II
25 West Independence Way, Suite I
Kingston, RI 02881

"Assessment of Problem-Solving Abilities in Normal Adolescents"

Personal History

Name _____ Date _____

Address _____ Phone _____ - _____ - _____

How did you hear about this project?

Date of Birth _____ Age _____ Gender ☐ Male ☐ Female

Race ☐ Caucasian ☐ Black ☐ Native American
☐ Hispanic ☐ Asian ☐ Other

Native Language _____ Primary Language _____

Handedness ☐ Right ☐ Left ☐ Mixed

Pediatrician _____ Neurologist _____
Psychologist _____ Other Specialist _____

Mother's Name _____

Mother's Education _____

Mother's Occupation _____

Father's Name _____

Father's Education _____

Father's Occupation _____

Parents' Marital Status ☐ Married ☐ Single ☐ Divorced ☐ Widowed

Social History

Who does the child live with?

How many people are in the child's household? _____

Child's Siblings (first names and ages)

What type of hobbies/activities does the child participate in?

What type of physical activities does the child participate in?

Prenatal and Birth History

Briefly describe mother's general health during pregnancy (illness, accidents, medications, etc.)

Length of Pregnancy _____ Length of Labor _____
General Condition _____ Birth Weight _____
Type of Delivery ☐ Head First ☐ Feet First ☐ Breech ☐ Cicerian Section

Were there any unusual conditions during pregnancy or birth? ☐ Yes ☐ No
If yes, please describe.

Developmental History

Provide the approximate age at which the child began to do the following:

Crawl	_____	Walk	_____
Sit	_____	Stand	_____
Feed Self	_____	Dress Self	_____
Single Words	_____	Combine Words	_____

Briefly describe the child's speech and language skills

Briefly describe the child's motor skills (gross and fine motor skills)

Briefly describe the child's social skills

Educational History

School _____ Grade _____

Briefly describe the child's academic performance (grades, level of coursework, etc.) _____

Does the child receive special services? ☐ Yes ☐ No

If yes, please

describe. _____

Medical History

Indicate which of the following illnesses or conditions the child has demonstrated:

☐ Allergies	☐ Head aches	☐ Chicken pox
☐ Dizziness	☐ Measles	☐ German measles
☐ Asthma	☐ Pneumonia	☐ Ear infection
☐ Mumps	☐ Tonsillitis	☐ Encephalitis
☐ Sinusitis	☐ Croup	☐ High Fever
☐ Colds	☐ Influenza	☐ Meningitis
☐ Seizures	☐ Convulsions	☐ Other _____

Describe any family history of serious illness/neurological disease.

Describe any previous hospitalizations/surgeries.

Describe any previous head injuries.

Has the child ever been knocked unconscious? ☐ Yes ☐ No

If yes, describe the event, including how long you were unconscious.

Name any medications the child is currently taking:

Name	Dose	Date Started	Reason	Changes
<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
<hr/>	<hr/>	<hr/>	<hr/>	<hr/>

Does the child have any history of depression? ☐ Yes ☐ No

If yes, please describe.

Does your child have any emotional or psychiatric disorders? ☐ Yes ☐ No

If yes, please indicate the diagnosis.

Date of diagnosis

Hearing: Date of last screening

 Results

Vision: ☐ Normal ☐ Near-sighted ☐ Far-sighted ☐ Glasses

Name of person filling out this form

Relationship to child

APPENDIX E

Description of the traditional standardized cognitive measures administered

1. Wechsler Memory Scale-Revised (WMS-R)- by David Wechsler (1987)

The WMS is a comprehensive test of cognition that was designed as a diagnostic and screening measure to be used as part of a neuropsychological examination. This test looks at short-term learning and delayed recall of verbal and figural information or items. Four sub-tests will be used:

- a) Visual Paired Associates I- Subjects are first presented with six line figures with associated colors. The figures are then presented without the colors and subjects are asked to respond by pointing to the associated color from a folder of all six possible colors. The process is repeated until all six figures and associated colors are selected, but will not exceed six presentations.
- b) Visual Paired Associates II- After an interval of 30 minutes, subjects are presented with the same six line figures and are asked to recall the associated colors by pointing to the colors.
- c) Verbal Paired Associates I- Eight word pairs (4 easy and 4 hard) are administered orally by the clinician. Subjects are then presented with the first word and are asked to recall the associated word. The paired words and trials are repeated up to six times or until the subject recalls all eight word pairs correctly.
- d) Verbal Paired Associates II- After an interval of 30 minutes, the clinician reads the same eight words without their paired associates, and subjects are asked to recall the pairs.

2: Coloured Progressive Matrices (CPM)- by J. Raven, J.C. Raven, and J.H. Court, (1998)

The CPM is a test of problem-solving abilities. It was developed to measure eductive ability, which involves the ability to make meaning out of confusion and going beyond the given to perceive that which is not immediately obvious. Subjects are presented with three sets of 12 patterns with missing pieces. For each pattern, subjects are to select the matching piece from six options shown below the pattern. Each set involves different types of patterns: “Set A” uses continuous patterns, “Set Ab” requires subjects to distinguish discrete figures as spatially related wholes to complete the pattern, and “Set B” uses figural analogies.

APPENDIX F

Summary of differences between RAPS and the Twenty Questions Test developed by Mosher and Hornsby (1966). Printed with author permission.

Feature	Twenty Questions Task	Raps
Picture stimuli	42 pictures in a 7 x 6 matrix	32 pictures in a 4 x 8 matrix
Picture features	Black and white line drawings	16 colored and 16 black and white pictures; slightly larger pictures
Picture categories	No control of number of pictures specified	Number of pictures in categories is controlled
Instructions	No modifications for brain injured	Contains modifications for brain injured; direct attention to problem-solving board; stress on the word few
Screening	No screening for oral naming or picture recognition deficits; no practice on task	Screening for oral naming and picture recognition deficits; practice in yes/no questions
Procedures	Does not cover pictures eliminated by questions	Covers questions eliminated by questions
Repeat administration	Uses same 42-item picture repeatedly	Nine problem-solving boards
Scoring score	Number of questions needed to solve problem; % of constraint seeking questions	Adds question-asking efficiency scores

APPENDIX G

Picture of RAPS-Game Board 1

APPENDIX H

Sample RAPS Score Sheet

Name: _____

Date of Testing: _____

D.O.B.: _____

Target: chair

Shirt-2	Cat-1	Pants-2	Daisy-3	Table-5	Drum-3	Sox-2	Lion-1
Rose-3	French Fries-3	Elephant-1	Hotdog-3	Deer-1	Tie-2	Tree-3	Lamp
Steak-3	Giraffe-1	Chair-5	Leaves-3	Cheese-3	Trumpet-3	Eggs-3	Guitar-3
Zebra-1	Bed-4	Piano	Shoe-2	Horse-1	Jacket-2	Pig-1	Hamburger-3

Problem: 1 2 3	A	B1	B2	B/A (use B1 or B2 smaller) x 2
Question	Total Pictures Considered	#m Pictures Targeted by Q	# Pictures Eliminated by Q	% Information Gained
1. Is it an animal? N	32	8	8	50
2. Is it clothing? N	24	6	6	50
3. Is it furniture? Y	18	6	12	66
4. Is it the bed? N	6	1	1	17
5. Made of wood? Y				
6.				
7.				
8.				
9.				
10.				

Comments: _____

# ITEMS	CATEGORY	BLACK & WHITE	COLOR
4	Food	Hotdog, Eggs	Steak, Hamburger
4	Plants	Daisy, Tree	Rose, Leaves
4	Musical Inst.	Piano, Trumpet	Drum, Guitar
6	Clothing	Pants, Jacket, Tie	Socks, Shoe, Shirt
6	Furniture	Table, Couch, Piano	Bed, Chair, Lamp
8	Animals	Zebra, Giraffe, Elephant, Lion	Cat, Pig, Horse, Deer

BIBLIOGRAPHY

- Anderson, V. (2002). Executive function in children: Introduction. *Child Neuropsychology*, 8(2), 69-70.
- Chelune, G. J., & Baer, R. A., (1986). Developmental norms for the Wisconsin Card Sorting Test. *Journal of Experimental Neuropsychology*, 8, 219-228.
- Culbertson, W., & Zilimer, F. (1999). *Tower of London: Research version*. North Tonawanda, NY: Multi-Health Systems.
- Denney, D. R., Denney, N. W., & Ziobrowski, M. J. (1973). Alterations in the information-processing strategies of young children following observations of adult models. *Developmental Psychology*, 8(2), 202-208.
- Denny, N. W. (1985). A Review of life span research with the Twenty Questions Task: A study of problem-solving ability. *International Journal of Aging and Human Development*, 21(3), 161-173.
- Diamond, A., & Goldman-Rakie, P. S. (1989). Comparison of human infants and rhesus monkeys on Piaget's AB task: Evidence for dependence on dorsolateral prefrontal cortex. *Experimental Brain Research*, 74, 24-40.
- Garth, J., Anderson, V., & Wrennall, J. (1997). Executive functions following moderate to severe frontal lobe injury: Impact of injury and age at injury. *Pediatric Rehabilitation*, 1, 99-108.
- Gioia, G. A., Isquith, P. K., Kenworthy, L., & Barton, R. M. (2002). Profiles of Everyday executive function in acquired and developmental disorders. *Child Neuropsychology*, 8(2), 121-137.
- Gioia, G. A., Isquith, P. K., Retzlaff, P. D., & Espy, K. A. (2002). Confirmatory factor analysis of the Behavior Rating Inventory of Executive Function (BRIEF) in a clinical sample. *Child Neuropsychology*, 8(4), 249-257.
- Hughes, C., & Graham, A. (2002). Measuring executive functions in childhood: Problems and solutions? *Child and Adolescent Mental Health Volume*, 7(3), 131-142.
- Levin, H. S., Culhane, K. A., Hartmann, J., Evankovich, K., Mattson, A. J., Harward, H. et al. (1991). Developmental changes in performance on tests of purported frontal lobe functioning. *Developmental Neuropsychology*, 7(3), 377-395.

- Levin, H. S., Song, J., Scheibel, R. S., Fletcher, J. M., Harward, H., Lilly, M., et al. (1997). Concept formation and problem-solving following closed head injury in children. *Journal of the International Neuropsychological Society*, 3, 598-607.
- Luria, A. R. (1973). *The working Brain*. New York: Basic Books.
- Marshall, R. C., & Karow, C. M. (2001, November). *Rapid Assessment of Problem-solving*. Paper presented at the annual convention of the American Speech-Language-Hearing Association, New Orleans, LA.
- Marshall, R. C., Karow, C. M., Morelli, C. A., Iden, K. K., & Dixon, J. (2003). A clinical measure for the assessment of problem-solving in brain-injured adults. *American Journal of Speech-Language Pathology*, 12, 333-348.
- McCarthy, R. A., & Warrington, E. K. (1990). *Cognitive neuropsychology: A clinical Introduction*. San Diego: Academic Press, Inc.
- Mosher, F. A., & Hornsby, J. R. (1966). On asking questions. In J. S. Bruner, R. Oliver, P. M. Greenfield, J. R. Hornsby, H. J. Kenney, M. Maccoby, N. Modiano, F. A. Mosher, D. R. Olson, M. C. Potter, L. C. Reich, & A. Sonstroem (Eds.), *Studies in Cognitive Growth*. (pp. 86-102). New York: Wiley.
- Norris, C. J., & Foxcroft, C. D. (1996). Cognitive maturity and the questioning strategies used by learning disabled and normal subjects: A comparative study. *South African Journal of Psychology*, 26(4), 243-247.
- Passler, M. A., Isaac, W., & Hynd, G. W. (1985). Neuropsychological development of behavior attributed to frontal lobe functioning in children. *Developmental Neuropsychology*, 1, 349-370.
- Raven, J., Raven, J. C., & Court, J. H. *Raven's Progressive Matrices and Vocabulary Scales*. Oxford, England: Oxford Psychologists Press, Ltd; 1998.
- Wechsler, D. *Wechsler Memory Scale-Revised*. San Antonio, TX: Psychological Corporation; 1987.
- Welsh, M., Pennington, B., & Groisser, D. (1991). A normative-developmental study of executive function: A window on prefrontal function in children. *Developmental Neuropsychology*, 7, 131-149.