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RAPS—Measuring Problem Solving in Children With and Without Autism

Haley Jones
Western Kentucky University, haley.jones483@topper.wku.edu

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RAPS-MEASURING PROBLEM SOLVING IN CHILDREN WITH AND WITHOUT AUTISM

A Thesis Project Presented in Partial Fulfillment of the Requirements for the Degree Bachelor of Science with Honors College Graduate Distinction at Western Kentucky University

By
Haley E. Jones

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Western Kentucky University

2018

CE/T Committee:
Dr. Janice Carter Smith, Chair
Dr. Leigh Anne Roden-Carrier
Mrs. Leisa Hutchison
ABSTRACT

This thesis discusses a study conducted that compared the Rapid Assessment of Problem Solving (RAPS) with the Ravens Progressive Matrices (RPM) in assessing the problem solving of children with and without autism. While the effectiveness of the RAPS had been evaluated for neurotypical children and adults, and adults with traumatic brain injuries, severe mental illness, and Alzheimer’s disease, no studies had yet been conducted with children with autism. The RAPS and the RPM were administered to twelve adolescents with autism and fifteen neurotypical, ages 10:0-17:11. To assess problem solving abilities, questions were analyzed in terms of inefficient constraint questions, frank guesses, pseudo constraint guesses, narrowing questions, novel questions and category focused questions. Understanding of pattern completion was also assessed through the RPM. Findings expanded the normative database of the RAPS to include adolescents with autism, thus providing rehabilitation professionals with critical psychometric information needed to use the test in the clinical setting. Results also provided a foundation for a larger study that will likely lead to production of the RAPS as a product for broader use in the clinical assessment of both typically developing children and children with cognitive disorders such as autism.

Keywords: RAPS, Autism, Problem solving, honors, CSD
I dedicate this thesis to my family and friends, who unconditionally love and encourage me to pursue wherever my dreams may take me.
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VITA

EDUCATION

Western Kentucky University, Bowling Green, KY  May 2018
  B.S. in Communication Sciences and Disorders – Mahurin Honors College
  Graduate

Elizabethtown High School, Elizabethtown, KY  May 2014

PROFESSIONAL EXPERIENCE

Community Living Supports Worker  August 2017-
  Bowling Green, KY  Present

Kelly Autism Program, WKU  Aug. 2016-
  Student Worker  July 2017

AWARDS & HONORS

Summa Cum Laude, WKU. May 2018
Faculty Undergraduate Student Engagement Grant Recipient, Spring 2017
1906 Founders Scholarship, WKU, 2014-2018

PROFESSIONAL MEMBERSHIPS

National Student Speech Language Hearing Association (NSSLHA)
Golden Key Honors Society

INTERNATIONAL EXPERIENCE

WKU in England: Harlaxton College  Jan. 2016-
  April 2016

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CHAPTER 1

Introduction

Problem solving is a constant in everyday life. Inevitably, situations occur that require an individual to evaluate ways to respond and choose how to proceed. For most neurotypical children and adults, the ability to problem solve is taken for granted, and this gift is realized when an unexpected circumstance compromises one’s ability to make independent, efficient decisions. In some cases, a traumatic brain injury can injure areas of the brain that pertain to the brain’s executive functioning ability. A wide range of problem solving assessments have been developed to evaluate such problem solving in adults, especially with a particular cognitive diagnosis or traumatic event that impedes this ability. Problem solving assessments for children, however, are not as common, and are difficult for evaluative purposes unless a specific scenario is employed. A gap in literature exists for an independent, yet efficient, problem solving assessment for children with and without autism. However, this research focuses on using two particular assessments to measure neurotypical children and children with autism. The assessments are commonly used when adults have experienced certain traumatic brain injuries that result in executive functioning impairment, and the cognitive effects are comparable to symptoms and mental tendencies sometimes experienced by children with autism who may experience executive function impairment in conjunction with their diagnosis.

This research project used two assessments to assess problem solving in children with and without autism: the Rapid Assessment of Problem Solving (RAPS) (Marshall, Karow, Morelli, Iden, & Dixon, 2003; Marshall & Karow, 2008) and the Raven’s Progressive Matrices (RPM) (Hetherington, 1998). The research study originated due to
a desire to gain a more informed understanding of problem solving in children. The RAPS, typically paired with the RPM to verify its results, was developed to assess adults who had experienced a traumatic brain injury (TBI). Other problem solving assessments exist to evaluate how children solve problems, but this study was the first instance of these two assessments being used to assess this particular audience. Problem solving measurement assessments, before the use of the RAPS and RPM, were not user-friendly for children due to their “complexity of instructions, expressive language demands, motor skill requirements, and the fact that they present problems for solving that are not engaging to children” (Smith, 2015, p. 3). However, the RAPS facilitates similar question-asking encounters that normally occur between children and their parents and other caregivers, making it an appealing problem solving assessment for children with and without autism.

This study sought to determine whether typically developing children perform differently on two problem solving measures in comparison to children with a diagnosis of autism spectrum disorder, as well as to assess if typically developing children use different strategies to solve problems than children with autism. Using the RAPS provided a quantitative measurement of verbal problem solving abilities, and the RPM provided a quantitative measurement of nonverbal problem solving abilities. The goal of this study, in addition to targeting the research questions above, was to determine whether the RAPS can serve as an accurate and efficient instrument to evaluate pediatric problem solving.
CHAPTER 2

Literature Review

*Autism Spectrum Disorder*

Autism spectrum disorder, often referred to as ASD, may sometimes result in individuals experiencing difficulties with communication and socializing. This being said, autism can directly impact language in children. In certain cases where language is impacted, these difficulties can be sourced in the executive function of the children’s brains, and several theories and studies have emerged in an attempt to reduce the enigma surrounding ASD and its cognitive effects. As a result, children with autism sometimes have difficulty using language to solve problems, and this problem is also experienced by adults who have suffered from brain injuries. This similarity is rooted in the executive function processing of each group, and both experience language difficulties as a result. Numerous studies are available to assess problem solving capabilities of adults with brain injuries, but why have these assessments never served as an indicator for children with and without autism?

*Problem solving and the theory of executive dysfunction*

According to Alderson-Day, “Children with autism spectrum disorders show a range of problems with executive function. The executive functions are higher-cognitive processes that are involved in maintaining information on-line when attempting goal-directed tasks, such as planning, cognitive flexibility, response inhibition and working memory” (Alderson-Day, 2011, p. 401). These tasks are directly tied to the brain’s executive function, and the brain’s executive functions are typically impaired when developmental disorders occur in a child (Hill, 2014). These issues lead to difficulties in
language and problem solving, as it is “…an accepted component of executive functioning that is necessary when routine or automatic behaviors are inadequate for attaining a desired goal. Problem solving consists of several skill sets such as identifying problems, goal setting, planning, strategic thinking, and generating alternative solutions” (Marshall, 2008, p. 377). Problem solving and autism are not arbitrarily linked. Research and the educated opinions of professionals have yielded many theories about the connection that exists between problem solving difficulties and autism.

A widely-discussed and widely-accepted theory surrounding the connection between problem solving difficulties and autism is the theory of executive dysfunction. To explain the theory of executive dysfunction, Hill (2004) writes, [It] makes an explicit link to frontal lobe failure in analogy with neuropsychological patients who have suffered damage in the frontal lobes and have impaired executive functions. Executive dysfunction can be seen to underlie many of the key characteristics of autism, both in the social and non-social domains. The behavior problems addressed by this theory are rigidity and perseveration, being explained by a poverty in the initiation of new non-routine actions and the tendency to be stuck in a given task set (p. 3).

Another executive function that is deficient is children with autism is mental flexibility, or cognitive flexibility. This means that these children cannot easily switch from one task to another, and oftentimes show “perseverative, stereotyped behavior” (Hill, 2014, p. 6). A specific aspect of language that is difficult for children with autism is verbal problem solving. This occurs because they “have difficulty with spontaneously generating plans and strategies to solve new problems [and]…struggle with more ‘open-
ended’ cognitive tasks where a range of strategies could be deployed to achieve a particular goal” (Alderson-Day, 2014, p. 720). Language skills that are deficient in children with autism can be compared to children who are deaf, and these are usually evident in problems with self-regulation and impulsivity (Alderson-Day, 2014). In addition, children with autism tend to focus attention on narrow realms of information, rather than grasping concepts as a whole (Alderson-Day, 2011).

Problem solving difficulties are not exclusive to children with autism. Some children without autism struggle with problem solving, yet, few assessments geared specifically towards these populations are available. There are numerous methods and assessments available to measure and determine the degree of difficulty and inhibition that take place. These assessments attempt to pinpoint what aspect of problem solving causes the struggle. One idea is a struggle with specific concept formation, which is “a difficulty in organizing a set of items into a new grouping heuristic when [it] needs to be done spontaneously” (Alderson-Day, 2014, p. 720). The idea of concept formation plays into studies that have been conducted concerning adults with brain injuries, who possess very similar mental and executive functioning characteristics to children with autism. Both of these groups experience difficulties; the brain’s ability to use executive functioning properly is similarly impeded in both adults with traumatic brain injuries and children with autism. The overarching challenges by both populations can be explained by tracing back to the executive dysfunction theory and the challenges faced when language is required to solve problems.

*The Rapid Assessment of Problem Solving*
Clinical assessments are available to assess problem solving in adults with brain injuries who possess mental similarities to children with autism in terms of the efficacy of their brains’ executive function. However, most of these clinical assessments have only tested problem solving in adults with brain injuries. The “…assessment of the problem-solving abilities of brain-injured individuals in clinical settings is easier said than done [because] standardized measures. . . may be too complex or threatening for some brain-injured persons, particularly for those who are susceptible to fatigue or easily agitated” (Marshall, 2003, p. 333-334). These previous assessments are also difficult because the clients being evaluated have low motivation to perform well since they do not regard it as being relevant to their daily lives (Marshall, 2003). However, an assessment has been developed recently and is successful in evaluating problem solving skills. The Rapid Assessment of Problem Solving Test (RAPS) is a modification of the 20 questions test, “…developed to provide clinicians with a rapid, objective means of assessing problem solving of clients with brain injuries in settings where conventional testing may be impractical” (Marshall, 2008, p. 377). The RAPS has been used specifically for testing problem solving in adults with brain injuries, but could perhaps be used in children with and without autism as well. Unlike most other problem solving assessments, it is presented as a game and results are minimally affected by age, gender, and amount of education. This, in addition to its high test-retest reliability, deems the RAPS a valid assessment of executive function. It is “sensitive to brain damage in general” and serves as a simple and easily administrable executive function assessment (Smith, 2015).

The Ravens Progressive Matrices
The Ravens Progressive Matrices (RPM), created by John Carlyle Raven in 1938, is an assessment designed to assess nonverbal abilities. As a trusted cognitive ability test, it targets aspects of nonverbal problem solving such as advanced observation and thinking skills and abstract reasoning (Talent). The test consists of 30 black and white puzzle-like pictures, and the child was asked to choose which picture fits the pattern for each picture. It was paired with the RAPS during this study because it is professionally viewed as a fair measure of ability without requiring verbal language, and it serves as an interesting comparison to an assessment requiring verbal language to solve problems.

As stated before, brain injuries, especially to the frontal lobe, can cause difficulty in an individual’s executive function. These difficulties are similar to symptoms of children with autism, as stated in several theories surrounding executive dysfunction in autism (Alderson-Day, 2011). In order to better understand how language affects problem solving in children with and without autism, researchers should generalize the data collected in studies for adults with brain injuries and apply the knowledge to children with autism. Doing so could help pinpoint what causes a child to struggle. When specific difficulties with problem solving are identified, clinicians better know how to work with children to maximize the potential of their language use to solve problems they encounter in their daily lives. In addition, using such assessments enable researchers to better understand how children without autism solve problems, and by comparing the results, more information is revealed regarding the effects autism can have when problems are encountered during day-to-day life.
CHAPTER 3

Methods

Two undergraduate students, who completed CITI training, were trained by the primary investigators to administer and collect data for the Rapid Assessment of Problems Solving test (RAPS) and the Raven’s Progressive Matrices (RPM). Twenty-seven children (12 with autism spectrum disorder and 15 neurotypical) between the ages of 10 years and 17 years 11 months were recruited for participation in this study through the Kelly Autism Program, flyer promotion, and word of mouth. Inclusion criteria for children with autism were as follows: 1) between the ages of 10 years and 17 years 11 months; 2) a reported diagnosis of autism spectrum disorder; 3) demonstrated ability to formulate and ask yes/no questions; and 4) demonstrate 80% recognition and naming of RAPS pictures. Inclusion criteria for typically developing children were as follows: 1) between the ages of 10 years and 17 years 11 months; 2) report of no known cognitive or learning disability; 3) demonstrated ability to formulate and ask yes/no questions; and 4) demonstrate 80% recognition and naming of RAPS pictures. Signatures were obtained from parents who consented for their child to participate and to allow researchers to use a paper interview for the student workers/teachers of each child with autism. Children signed an assent form as well. Paper interviews were utilized to obtain background information including child intelligence quotient, official diagnosis of autism, and socioeconomic status. A complete assessment lasted usually around one hour.

Prior to inclusion in the study, each child participated in a short screening procedure, lasting no more than ten minutes, that consisted of a question formulation task and a recognition and naming task. Thirty-two picture cards were displayed, and the
child had to correctly identify 80% of the photos in order to proceed with the screening. The child then viewed a sample board and had to formulate a yes/no question relating to a picture on the board. If a child was not able to identify 80% of the photos and/or formulate a yes/no question, the study was discontinued. This situation was not encountered during this study, as all twenty-seven children passed the screening stage.

Once the participant demonstrated competency through the screening procedure, the actual testing began. The RAPS is administered two times, with each administration equaling three boards. To begin, the examiner places the board with an array of 32 pictures in front of the child and reads aloud the following instructions:

We are going to play a question asking game. I am thinking of one of these pictures (examiner gestures to the pictures) and your job is to figure out which one it is. The way to do this is to ask me questions that I can answer “yes” or “no”. You can ask me any question you want so long as I can answer it “yes” or “no. Try to ask as few (examiner stresses word) questions as possible. When you are ready, go ahead and ask your first question (Smith, 2015, p. 5).

A RAPS board with an array of 32 pictures is presented to the subject as a “game”. After each question is asked, the examiner covers the eliminated pictures and records the asked question before the next turn begins. The process continues until the problem is solved, which is when two or fewer pictures remain. “Administrative guidelines govern the examiner’s actions if the examinee only guesses, fails to ask yes/no questions, or if the examiner is not sure which pictures are affected by a question” (Smith, 2015, p. 5). One round of RAPS consists of solving three boards, and an entire session would consist of two rounds of RAPS and an RPM assessment on an iPad, or an
RPM assessment on an iPad followed by two rounds of boards. Each administration order was employed for approximately fifty percent of participants to attempt to prevent skewing of data based on a potential learning effect; however, such results were not preliminarily obtained. Upon session completion, the subjects are given a small compensatory prize as an appreciation for the time they devoted to the study. Brain breaks were provided in between each round of the RAPS and between the RAPS and Ravens administrations, and these breaks were in the form of five minutes of an iPad game of choice: Fruit Ninja, Candy Crush, or Temple Run. The brain breaks were included to prevent mental fatigue and maintain motivation to complete the full assessment to the participants’ full potentials.

Scoring for the RAPS was documented and considered in the following areas: question asking efficiency, integration planning score, and strategy. Question asking efficiency (QAE) was determined by the number of questions eliminated divided by the number of questions targeted with a particular question. For example, if there are 12 pictures remaining with 8 pictures pertaining to sports, a question of “does it have to do with sports” would yield a high QAE, since half of the remaining pictures were targeted. The integration planning score was a numerical score of 1-6, based on the number of pictures targeted with the first question: one picture = 1, two or three pictures = 2, four or five pictures = 3, six or seven pictures = 4, eight pictures = 5, and nine or more pictures = 6. Lastly, a score was assigned according to the strategy most widely used when determining what questions to ask.

All questions were categorized as novel, category-limited, narrowing, inefficient constraint questions, or frank guesses. Novel questions are “questions that target 9 or
more pictures and/or have efficiency scores above 50%” (Smith, 2015, appendix B).

Category-limited questions “target all pictures in one category” (Smith, 2015, appendix B). Narrowing questions are “questions asked after the target picture’s category is known; narrowing questions further reduce the pictures in a known category” (Smith, 2015, appendix B). Inefficient constraint questions are “questions with efficiency scores at or less than 50% that are not category-limited, narrowing, or novel questions” (Smith, 2015, appendix B). Frank guesses are “questions that target one picture in the array, solve the problem if answered ‘yes’ and eliminate one picture if answered ‘no’” (Smith, 2015, appendix B).

The RPM assessments were automatically scored, as the test was electronically administered and completed on an iPad. The scores yielded a raw score of each assessment, obtained by dividing the number of correct questions by 28, the total number of questions. To directly compare scores of the RAPS to the RPM, the RAPS QAE average score, in decimal form, is compared to the RPM’s raw score in decimal form.
CHAPTER 4

Results

This study sought to determine whether typically developing children perform differently on two problem solving measures in comparison to children with a diagnosis of autism spectrum disorder. The results of this study were accepted as preliminary due to their small sample size basis, and they are subject to change if this study were repeated with a larger pool or participants. After analyzing and comparing the scores of the Rapid Assessment of Problem Solving (RAPS) and Raven’s Progressive Matrices (RPM) of all test subjects, it was determined that, as a whole, typically developing children scored higher on both the RAPS and RPM than their age matched counterparts with an ASD diagnosis. To obtain comparative data for the RAPS, the question asking efficiency (QAE) scores of the first and second set were averaged. The comparative data from the RPM was obtained by converting the raw score (number correct out of 28) into percent form. The results, in percent form, are illustrated in figures 1-3 below. The two data points on each X value represents two children—one neurotypical and one with autism—whose data were directly compared since they are age-matched.

![RAPS Scores Chart]
The raw score on the RPM is most comparable to the QAE of the RAPS score and was used to connect the results of both assessments. Standardized scores particular to certain adult populations, derived from the raw scores of the RPM, are provided, but such scores are not available for a pediatric population. Thus, the QAE of the RAPS score was necessary to derive reference points and direct comparisons to the RPM scores. The scores on the graph below (figure 2) are the percent of questions answered correctly of the 28. Neurotypical children scored an average of 15 questions correct out of 28, and children with autism scored an average of 9.6 questions correct out of 28.
Additionally, this study sought to determine if typically developing children use different strategies to solve problems than children with autism. This data was gathered by categorizing each question that was asked and comparing the strategies used by each assessment group. The data is found by assigning the strategy used the most for both games, yielding a total of 15 data points for neurotypical children and 12 for children with autism. Evident in figure 4 below, neurotypical children asked category-focused, mixed, and novel questions, while children with autism did not ask a single novel question and relied heavily on guesses and mixed questions.
The object of the RAPS game is to solve the board with as few questions as possible, and category focused questions are a strategy that enables higher scores on this game. Neurotypical children obtained a higher QAE score on the assessment than children with autism, using more category-focused questions. The participants with autism performed lower comparatively on the RPM and the RAPS than the participants without autism. Participants without autism scored comparatively higher on both assessments than the participants with autism due to strategies employed during the RAPS. The participants without autism used mostly category-focused and mixed strategies and the participants with autism used a mixed approach strategy, as well as guessing. The RPM scores, however, were closer together than the RAPS scores for each age comparison, due to its nonverbal nature and not requiring spoken words to solve the problems. Thus, in a nonverbal problem solving situation, children with and without autism perform more comparatively than in a verbal problem solving situation.
CHAPTER 5

Discussion

Differences in assessment scores

As a whole, differences in scoring between neurotypical children and children with autism were present, strongly implying that children with and without autism approach problem solving methods differently. Two problem solving methods were used to analyze both verbal problem solving, the Rapid Assessment of Problem Solving (RAPS), and nonverbal problem solving, the Raven’s Progressive Matrices (RPM), in order to gain a fuller understanding and analysis of problem solving as a whole. The targeted research questions were addressed through conducting this study, and the hypotheses were supported according to the generated data. Additionally, these results show promise that, with additional widespread research, the RAPS and RPM can develop normative data for children with and without autism and accurately assess problem solving in the pediatric population.

Typically developing children performed differently on the RAPS and RPM than children with autism, and this can be attributed to children with autism having difficulty in their brains’ executive functioning. Neurotypical children scored higher on the RAPS, evident in analyzing the results and question asking efficiency score, because their brains’ executive function allowed them to realize certain categories on the picture board and ask questions that targeted a large percentage of pictures. Children with autism, paired with executive dysfunction, did not recognize categories in the pictures and guessed specific items on the board rather than eliminating multiple pictures with each
question. The ability to recognize the categories on the board explained the difference in strategies employed between the two groups tested.

Limitations

Although the data yielded results that supported the hypotheses of the study, several limitations were still in play. The sample size from which data was drawn was small compared to most large-scale studies, and the results are accepted as preliminary and subject to change if this study was to be repeated with a large sample size. Additionally, these results are from male subjects only. Efforts were made to recruit females to diversify the sample size, but the females that were recruited chose not to participate. The socioeconomic status (SES) of the participants’ families were not included as a factor in the results. Attempts were made to recruit a variety of SES categories, but all tested subjects belonged overall to a middle to high SES category. The intelligence quotient (IQ) of each client could not be considered in the results, as this information was solicited but not provided by the participants’ families. The RPM assessment, administered and scored digitally, did not offer standard scoring for the age group assessed in this study, so only raw scores were available for direct comparison to the RAPS.

Clinical Implications

By completing this project, it is anticipated that the normative data for the RAPS and RPM can be expanded to include more children with and without autism. This information, with further research in this area, has the potential to advance the development of the RAPS and fill a literature gap that exists concerning the utility of the
RAPS. With this information, the RAPS can be used more extensively and broadly in clinical settings for both children who are typically developing and children with autism. It is a problem solving assessment that differs from other assessments designed to assess this skill, and it does not require specific, limited outside contexts in order for problem solving skills to be demonstrated.

**Future Research**

Based on this research, a need exists for a RAPS protocol specifically designed to reflect the vocabulary and scope of knowledge of children. The pictures and categories were designed for an adult audience; children could benefit from more extensive and inclusive research with a child-specific protocol. This finding led the research team to create a plan to develop a RAPS for child assessment, which will pilot in fall 2018 with Western Kentucky University’s Department of Communication Sciences and Disorders.
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