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UNIVERSITY OF NORTHERN COLORADO

Greeley, Colorado

The Graduate School

A VALIDATION OF THE TACTILE EDITION OF THE BOEHM-3 PRESCHOOL

A Dissertation Submitted in Partial Fulfillment
of the Requirements for the
Degree of Philosophy

Catherine Ann Smyth

College of Education and Behavioral Sciences
School of Special Education

December, 2017

ABSTRACT

Smyth, Catherine A. *A Validation of the Tactile Edition of the Boehm-3 Preschool.* Published Doctor of Philosophy dissertation, University of Northern Colorado, 2017.

The purpose of this research was to conduct a validation study of the Boehm-3 Preschool tactile version, which was designed to allow young children with visual impairment and who use their tactile abilities as their primary modality to discover and interpret the world to demonstrate knowledge of concept understanding. It is well established that concept understanding is one of the most important skills a young child with visual impairment should master. The progression of concept development and haptic understanding of two-dimensional representation in young children with visual impairment was a focus of this research to inform parents, practitioners, and researchers.

Just as young sighted children visually (a) discriminate shape, sizes, and length for early mathematic literacy, (b) recognize salient features of letters, and (c) demonstrate knowledge of early literacy book skills and direction following, young children with visual impairment learn about their world in a tactual experiential manner though independent movement. The current lack of any formal tactual assessments that address the understanding of academic performance left a significant gap in the measurement alternatives for those wishing to conduct second-generation research to establish evidence-based practices or to determine if classroom interventions are effective.

This study was designed to build unified validity components for the Boehm-3 Preschool tactile version. Validity was established using (a) an exploratory factor analysis for unidimensionality; (b) a non-parametric Mokken analysis to provide evidence of a developmental scale; and (c) ranked Spearman correlations to show construct validity with a Smyth Developmental Rating Scale created by the investigator to assess the children's fine-motor and cognitive functional skills. One hundred and twenty scores from young children with visual impairment (ages 3 years to 5 years, 11months) across the United States were analyzed. Statistical procedures using an Item Response Theory methodology was implemented to match the unique characteristics of this low-prevalence population. Evidence was obtained to successfully build validity components for the Boehm-3 Preschool tactile version, with the result that it is the first validated tactile assessment available for young children with visual impairment.

ACKNOWLEDGEMENTS

I began this journey many years ago with the goal of adding to the research base in the field of visual impairment and early intervention. This dream has been realized with the completion of my dissertation and the support of family, friends, and my new academic family.

I am especially indebted to Dr. Kay Alicyn Ferrell, the Chair of my Dissertation Committee and Research Advisor who has been extraordinarily supportive of my career goals and has provided me with many opportunities to learn about every aspect of research. I cannot ever thank her enough for making my research dreams come true. Her professional guidance has taught me a great deal about both scientific research and life in general.

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I would like to thank the members of my Dissertation Committee for the support and opportunities they have provided for me throughout my time at the University of Northern Colorado as a graduate student. Special thanks go to Dr. Steven Pulos, who provided phenominal guidance in data analysis, and has helped me to see the world of measurement research in a way that has great meaning and value.

My journey in graduate school has been full of both surprises and satisfaction. I have learned much about myself as I struggled to find my strengths. I am grateful to all of those with whom I have had the pleasure to work during this and other related projects, both personally and professionally.

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CHAPTER I

INTRODUCTION

Measurement, or the "assigning of numbers to individuals in a systematic way as a means of representing properties of the individuals" (Bond & Fox, 2001, p. 2), is a necessary strategy to assist educators and researchers in their evaluation of eligibility for special education services and program efficacy. Additionally, measurement provides a consistent method of assessing the current skill level of individual students and a way of determining an effective program plan for learning. Measurement research in early childhood special education (ECSE) has become increasingly important as more young children are enrolled in preschools and national initiatives are supported (Division for Early Childhood [DEC] & National Association for the Education of Young Children [NAEYC], 2009; U.S. Department of Education & U.S. Department of Health and Human Services, 2015) to provide quality early learning opportunities for all children.

Current quality standards for the development and validation of measurements in ECSE have been recommended as one way to determine if a child has the necessary early literacy and early numeracy skills for learning (Bruder, 2010; Greenwood & McConnell, 2011). Leaders in the field of ECSE provide rigorous guidelines to create meaningful assessments for young children through a proposal of an intersection of the Standards for Educational and Psychological Testing produced by the American Educational Research Association (AERA), the American Psychological Association (APA), and the National

Council on Measurement in Education (NCME) (AERA, APA, & NCME, 2014); the Division of Early Childhood (DEC) Recommended Practices (DEC, 2007, 2014) and the Student Progress and Mastery Monitoring (SPMM) standards of the National Center on Response to Intervention (National Center on Response to Intervention, 2011). Although the purpose and use of assessment in ECSE may vary, the quality indicators for development and validation should be the same.

The emphasis on inclusion as a method of meaningful social interaction (Recchia & Lee, 2013) and educational practice (AERA et al., 2014; U.S. Department of Education & U.S. Department of Health and Human Services, 2015) has led to the increased use of general preschool settings as the primary site for delivering early education services to children with disabilities (DEC & NAEYC, 2009). The opportunity to participate in community-based playgroups and inclusive preschools creates a critical need for assessments that can be used to measure the knowledge and skills of all children in the classroom, not just the children on whom the measurements were normed. In order to determine the effectiveness of classroom interventions, Greenwood and McConnell (2011) emphasized that

> This reflects one of what might be the core tenets of our practice—that better understanding (as achieved through assessment) will lead to making better decisions regarding services and supports that children need, that will in turn lead to better outcomes for individuals and groups of children. (p. 173)

In order to meet the academic needs of young children who use tactual learning media, the application of universal design to schooling (Hehir, 2009; Meyer & Rose, 2005) requires that assessments be available to them in a tactual format. Researchers in the field of emergent braille literacy have found that classrooms need to make an extra effort to provide a tactual and braille-rich environment for young children who need to

transform real-world concept understanding to representational reading with their sense of touch (Durkel, 2009; Sacks, Hannan, & Erin, 2011; Wall Emerson, Holbrook, & D'Andrea, 2009). Universal design for learning (UDL) is a philosophy for creating instructional goals, methods, materials, and assessments that work for everyone, including future tactual learners. The use of universal design in adapting learning materials requires educators to be flexible and responsive to the individual learning needs of each child in the classroom. In addressing UDL in early childhood programs, valid and reliable modified tactual assessments are a necessity to collect data on acquired pre-braille skills and for program planning (Greenwood & McConnell, 2011; Mazella, Albaret, & Picard, 2014).

The need for valid and reliable assessments of all types is great in the field of visual impairment and incorporating the understanding of early literacy, numeracy, and direction following concepts is a good place to start as the foundation of all learning (Birbili, 2007; Boehm, 2001; Karoly, 2012). In preschool classrooms across the country, vision impairment professionals and general early childhood educators are using a variety of informal and ineffective measurements without rigor or consistency (Kitchener & Kitchener, 2009). Although there is significant progress regarding the research in the field of haptic understanding (Lederman & Klatsky, 2009; McLinden, 2012; Papadopoulos, Koustriava, & Kartasidou, 2012) in the last 10 years, this information has not been applied to tactual assessment (Mazella et al., 2014) or instruction for young children with visual impairment. While ongoing collaboration with educational vision professionals is critical, general education teachers in inclusive program settings should have access to assessment tools that accurately assess young children with visual

impairment to insure appropriate instructional consistency. There is a need for valid tactual assessments that are available and easy to administer in the early childhood classroom.

In this time of academic accountability and the movement to implement early learning standards (First Five Years Fund, 2015; National Governors Association Center for Best Practices, 2010), it is even more important for classroom decisions to be made using appropriate assessments. Early childhood education (ECE) quality standards are being implemented in every state, and it is essential that educational interventions address requirements in the area of concept development (Karoly, 2012). Early concept development for young sighted children includes the ability to visually: (a) discriminate shape, sizes, and length; (b) recognize salient features of letters; and (c) demonstrate knowledge of literacy and direction following (U.S. Department of Education, Office of Planning, Evaluation, and Policy Development, 2016). In a very different way, young children with visual impairment acquire conceptual understanding in a tactual, experiential manner through independent movement and routine experiences (Hatwell, 2003a; Papadopoulos et al., 2012). These early academic skills contribute to the attainment of crucial childhood outcomes and preschool standards that guide the ECE core curriculum and kindergarten academics (Bailey et al., 2006; Karoly, 2012; Scott-Little, Kagan, & Frelow, 2003).

Statement of the Problem

In order for an assessment to be a reliable and valid measure for a population in correlational research or to guide instruction, it must be carefully developed and tested with appropriate statistical procedures from measurement theory (AERA et al., 2014).

The best assessment tools are unidimensional, or they measure one identified construct at a time. Rigorous item modification as well as reliability and validity measures must be carried out over time with the specific population to establish confidence in the measure (Allen & Yen, 2002). Due to geographical distances between students and a limited presence as a low-prevalence population, children with visual impairment are rarely included in the norming samples of common early childhood assessment validations.

The search for an assessment that can accurately demonstrate or predict academic success for young children with visual impairment who require tactual modifications is a challenging one (Mazella et al., 2014). Test validation processes are complex, and they are only the first step in a process to establish causal relationships between interventions and improvements in academic progress. One way to meet the program planning and progress monitoring needs of the young tactual learner is to modify an existing reliable and valid assessment for sighted children. The Boehm-3 Preschool (Boehm, 2001) is developmentally appropriate for preschool children ages 3 to 5, has established reliability and validity on a broad sample of children with sight, and has been carefully modified into a tactual analog available to all young children with visual impairment (Ferrell, Smyth, Henderson, & Boehm, 2014).

The Boehm-3 Preschool (Boehm, 2001) was chosen by the American Printing House for the Blind (APH) to modify into a tactile edition based on the successful creation of the Tactile Test of Basic Concepts (Caton, 1983) that was modified from the original Boehm (1971). The rigorous creation of the tactile edition of the Boehm-3 Preschool (Ferrell et al., 2014) provided an opportunity to build a case for "unified validity," or evidence of content validity, criterion-related validity, and construct validity

(Allen & Yen, 2002; Clark & Watson, 1995; Messick, 1995). Collaborators of this test modification used a broad literature review of tactual development and discrimination research and pilot study data to influence careful test item creation.

Purpose of the Study

The purpose of this study was to examine the reliability and validity of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) test for young children with visual impairment. This test was designed to provide information on the concept understanding of children who use their tactile abilities as their primary modality to discover and interpret the world. This study explored the use of an item response theory (IRT) methodology (Salzburg & Sinkovics, 2006) to match the unique characteristics of this low-prevalence population and establish appropriate psychometric properties for future standardization of this test.

Research Questions

This study addressed the following research questions:

Q1 Is the tactile edition of the Boehm-3 Preschool unidimensional?

Q2 Do the Boehm-3 Preschool Tactile Edition scores fit a developmental Mokken Scale analysis?

Q3 Will the Boehm-3 Preschool Tactile Edition scores show construct validity with an investigator-created Smyth Developmental Rating Scale?

Significance of the Study

A tactual understanding of the relational concepts measured by the Boehm-3 Preschool (Boehm, 2001) is critical for early literacy and early numeracy skills and following directions at home and in the classroom (Dunst & Gorman, 2011; Koenig & Farrenkopf, 1997). The current lack of any formal tactual assessments that address

the understanding of academic performance left a significant gap in the measurement alternatives for those wishing to conduct ethical research or discover what children know in the field of visual impairment (Council for Exceptional Children [CEC], 2014; Neisworth & Bagnato, 2004; Thompson, Diamond, McWilliam, Snyder, & Snyder, 2005). Researchers are unable to establish evidence-based practices (EBP) without validated measurements to determine if interventions are effective. If the field of visual impairment is to move forward in research and practice for young children who are tactual learners, it is necessary to increase the availability of valid and reliable tactual assessments to collect data on acquired knowledge and program effectiveness and for instructional planning (Greenwood & McConnell, 2011; Mazella et al., 2014). This study sought to establish validity evidence for the recently developed Boehm-3 Preschool Tactile Edition using the item response theory of measurement. The progression of concept development and haptic understanding of two-dimensional representation in young children with visual impairment was a focus of this research to inform parents, practitioners, and researchers.

Glossary of Terms

Term	Definition
Assessment	The set of practices, procedures, or tools that are used in practice to collect information and support decision-making.
Communality	The communality of a variable is the portion of a variance of that variable that is accounted for by the common factors.
Concept Score	A combination of individual item scores measuring the same relational concept through parceling. Concept scores for the *Boehm-3 Preschool Tactile Edition* indicate the child answered both concept items correctly for a score of two, answered only one item correctly for a score of one, or neither items correctly for a score of zero.
Dichotomous Scoring	An approach in which the response to an item is always scored as either correct or incorrect, regardless of the level of difficulty, or any level of partial understanding.
Measurement	The science of determining or estimating ratios of quantities, or the ways we quantify metrics for specific constructs of interest.
Nonparametric	Statistical procedures that require fewer assumptions (e.g., they do not assume that the outcome is approximately normally distributed). These procedures are suggested when using ordinal level variables.
Parceling	A measurement practice defined as the creation of aggregate-level indicators comprised of the sum (or average) of two or more items, responses, or behaviors.
Smyth Developmental Rating Scale	The finalized title of the measurement created by the researcher to collect information from the teachers about the child's relevant cognitive and haptic developmental skills. Previously known as the *Teacher Concept Rating Scale.*
Test	A device for obtaining a sample of an individual's responses which are evaluated for their correctness or quality.
Teacher Concept Rating Scale	The original name of the measurement created by the researcher to collect information from the teachers about the child's relevant cognitive and haptic developmental skills. This is now known as the *Smyth Developmental Rating Scale.*
Universal Design for Learning	A set for principles for creating instructional goals, methods, materials, and assessments that can be customized and adjusted for an individual's needs.

CHAPTER II

LITERATURE REVIEW

Measurement in Early Childhood Special Education

The current educational atmosphere of increased accountability and the emphasis on improved child outcomes in early childhood programs (First Five Years Fund, 2015; Hirsh-Pasek, Kochanoff, Newcombe, & deVilliers, 2005; Kagan & Scott-Little, 2004) requires the means to measure not only how children are learning, but also what children know. It is necessary that assessment tools created today for young children reflect the significant changes in the anatomy and physiology taking place in their brains (Brown & Jernigan, 2012). Measurement research that accurately and appropriately reflects our understanding of the cognitive capabilities of young learners requires careful consideration of the goal of the assessment, as well as the cooperation of many adults.

The purpose of this investigation was to examine the reliability and validity of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) modified for young children with visual impairment. If the field of visual impairment is to move forward in research and practice for young children who are tactual learners, it is necessary to increase the availability of valid and reliable tactual assessments to collect data on acquired knowledge and program effectiveness and for instructional planning (Greenwood & McConnell, 201l; Mazella et al., 2014).

It is no longer enough to collect formal assessment scores to rate quality early childhood preschool classrooms to justify new levels of governmental funding and programs. In the words of the National Research Council of the National Academies (2008, p. 3), "Interpreting outcome scores collected from children in an early childhood program requires the presence of a larger system, in the context of which particular assessments are selected, implemented, and interpreted." A combination of informal observational data collection and empirically valid formal assessments (Bagnato, Goins, Pretti-Frontczak, & Neisworth, 2014; Macy, Marks, & Towle, 2014; Neisworth & Bagnato, 2004) provides educators, parents, and researchers with a more complete understanding of the processes of learning occurring in preschool settings. Therefore, the process of collecting evidence that indicates a high level of unified validity for a specific assessment must be rigorous and thoughtful. The quality of an assessment tool used with young children should reflect the ability to address the intended purpose of the assessment as well as its psychometric properties.

How We Use Measurement

Greenwood and McConnell (2011) are consistent with the recommendations of the National Research Council of the National Academies (2008) in identifying the four major areas of assessment for young children. Developmental screening, individual and societal early childhood program evaluation, test scores and observational information for instruction and progress monitoring within the classroom, and valid asessments to add to the research base are all necessary components of an educational system that truly cares about the healthy growth and development of young children.

Developmental Screening

The first critical use of assessment is to establish children's developmental status or level of functioning. This includes individual and community-based screening instruments for medical risks, diagnostic screenings to establish hearing and vision concerns, and school readiness assessments. School readiness is an area of great controversy in the early childhood field (Brassard & Boehm, 2007). "Poor performance on a readiness test may largely reflect limited prior experience, rather than an impairment that affects the child's ability to acquire knowledge" (p. 174). Young children with visual impairment are certainly at risk to have limited experiences, and the desire to improve assessment in ECSE settings has led to a greater understanding of the use of school readiness assessments (Riley-Ayers, 2014). Developmental assessment of young children with visual impairment is a complex process (Ferrell, 2011) and requires a combination of informed clinical opinion and modified observational tools.

Program Evaluation

Another use of assessment in the ECSE field is to evaluate the performance of individual classrooms or society in general (Lambert, Abbott-Shim, & Sibley, 2006). As this investigation is just beginning to work toward establishing the validity of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) program evaluation was not a part of this research. However, the Boehm-3 Preschool Tactile Edition could contribute to future educational research in the field of visual impairment (Day, McDonnell, & O'Neil, 2008; Mazella et al., 2014) through assessment of child outcomes. Paired with measures of teacher-child interactions (Hamre et al., 2012) and observational data, rigorous evaluations of preschool classrooms in specialized and inclusive settings are possible.

Guided Instruction and Progress Monitoring

Early childhood special education assessment is also used to guide instructional practices and progress monitoring. Hirsh-Pasek et al. (2005) suggested that in "providing guideposts for teachers and parents" (p. 3), well-designed assessments can determine how and what content children are learning. This is the primary purpose of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) in the early childhood classroom and was the focus of this investigation. The skills that children with visual impairment need to demonstrate an understanding of tactual concepts are developmental and measurable. Assessment is a means to measure what children know and, therefore, educates adults on how to address ongoing classroom instruction. In the beginning of the school year, instructional assessment guides what needs to be taught as the teacher discovers the "scope of each child's early academic learning and behavioral preparedness for schooling" (Brassard & Boehm, 2007, p. 172). Understanding basic relational concepts in varied contexts such as temporal, spatial, and quantitative activities leads to the ability to follow directions of increased complexity. At the end of the school year, the same assessment can provide teachers with evidence of effective teaching and formal documentation of performance levels. Best practice in ECSE assessment refers to this method of progress monitoring as a "snapshot" of discrete skills, and assessment scores should be paired with ongoing observations and portfolio examples of a child's emerging mastery of early literacy and mathematical concepts. Having a better understanding of how young children with visual impairment learn early literacy and mathematical concepts (Day et al., 2008) allows for the development of more effective teaching strategies in all preschool classrooms.

Knowledge Advancement

Finally, ECSE assessment can advance knowledge of child development in general (Ferrell, 1998; National Research Council of the National Academies, 2008). Over the course of the last 16 years, a call for second-generation research that would guide specific assessment and instructional practices for all young children with exceptionalities has resulted in few studies in the area of visual impairment (Bruder, 2010; Council for Exceptional Children's Interdivisional Research Group, 2014; Davidson & Harrison, 1997). Quality indicators around measurement in ECSE research (Bagnato et al., 2014; Greenwood & McConnell, 2011) include using multiple outcome assessments to address a variety of constructs and intervention processes, consistent test administration and scoring, and the reporting of validity and reliability. Research in the field of special education requires both formal and informal assessments (DEC, 2009; First Five Years Fund, 2015) validated on general and specific populations (Odom et al., 2005).

Research in the review of assessment in ECSE has allowed the field to move forward to develop criteria and guidelines for implementation, consistency, and development. Poor assessment practices with young children have consequences in the areas of establishing eligibility, instructional practices, and monitoring child outcomes (Macy, Bagnato, Lehman, & Salaway, 2007). These outcomes can affect the future academic and behavioral success of all children as well as the ability to determine the quality of teacher-child interactions in the classroom. It is time to make use of evidence-based criteria to create appropriate assessments for all children in the spirit of universal design to address the needs of inclusive preschool classrooms.

Evaluating Measurement

The validity of a measurement lies in a collection of evidence (Messick, 1995) that determines the ability of that instrument to provide the intended information for the intended population. This collection of evidence is composed of a series of relevant statistical procedures that best meet the needs of young children with visual impairment.

Building Validity

The recommended guidelines for quality measurement research in ECSE (Greenwood & McConnell, 2011) include clearly stating the guiding theory for statistical analysis, whether classical or contemporary. "When choosing a method of measurement modeling to build unified validity, there are many issues to consider" (p. 181). In the validation of an assessment tool to be used with young children with visual impairment, contemporary item response theory (IRT), using Mokken scale analysis (van Schuur, 2011), was more appropriate than the use of classical test theory (CTT). The Mokken scale analysis is a nonparametric, probabilistic version of the Guttman scaling procedure that allows for items to differ with regard to their distribution or difficulty (Bouwmeester & Sijtsma, 2006; Zingg & Siegrist, 2012). Although CTT (Allen & Yen, 2002) is more common in educational measurement research, there are reasons that IRT was more appropriate for the population of young children with visual impairment.

One of the most unique aspects of IRT is the ability to separate the measurement of the individual items from the measurement of each person, and then to see if the data were consistent with the model. This feature of IRT was valuable in this study as there is great diversity in the experiences of the population of young children with visual

impairment as well as in their ability levels. Individuals who did not "fit" the model were reviewed in depth to see if they have delayed fine motor or cognitive development.

Item Response Theory

Developments in the field of IRT and the unique characteristics of a tactual assessment lend themselves to validation building. Models based on CTT use statistics such as means, variances, and co-variances to assess item fit, while IRT models use observable responses in a probabilistic way (Salzburg & Sinkovics, 2006). As tactual learners in preschool classrooms proved to be a low prevalence sample of children with visual impairment, variances and co-variances would have been limited and not reflective of the true reliability of the items. In addition,

> CTT often assumes that the precision of the test, like the reliability, is uniform across all levels of the construct. This is almost certainly untrue because these tests yield much less information about individuals at either end of the distribution. (Lambert, Nelson, Brewer, & Burchinal, 2006, p. 31)

The premises of IRT did not require the data to fit a normal distribution because items and individuals were examined separately. It examined scores to predict order in understanding a construct, or in other words, the greater an individual's ability, the more difficult items the individual answered on the continuum (Bond & Fox, 2001; Curtis & Boman, 2007). For example, if there is poor ordering of test items in an age band, CTT measurement statistics will only report basic overall information that the internal consistency is poor. The benefit of using the Mokken scale was the effect of ordering on each individual, or each item was obvious and educated decisions could be made about test construction.

In collecting evidence to validate an assessment tool on such a diverse and unique population as young children with visual impairments, it was necessary to think about

reliability and validity on a variety of levels (Curtis & Boman, 2007). Not only "unbiased estimates of item properties may be obtained from nonrepresentative samples" (Embretson, 1996, p. 345), but also

> Item Response Theory methods allow for a direct assessment of whether an item or scale is biased across different populations and, therefore, are especially useful in examining the cultural sensitivity of the instrument. Bias occurs when individuals with comparable skill levels on the underlying construct receive different ability scores because the items work differently in different populations. (Lambert et al., 2006, p. 34)

Ethical Practices

Using either classical or contemporary measurement theory, choosing the appropriate tests to use for educational practice can have far-reaching consequences for children. In the use of inappropriate assessmet tools with young children, or even refusing to use assessments at all, educators are guilty of "othering" this population (Lahman, 2008) in profound ways. Messick (1995) reminded the field of education that "validity, reliability, comparability, and fairness are not just measurement principles, they are social values that have meaning and force outside of measurement whenever evaluative judgments and decisions are made" (p. 742).

Ethical codes of conduct for young children ages birth to 8 and their peers with exceptionalities are addressed by both NAEYC and DEC (part of the Council for Exceptional Children). The NAEYC Code of Ethics (2005) is divided into *Ideals*, which reflect the aspirations of practitioners, and *Principles*, which guide conduct and assist practitioners in resolving ethical dilemmas. Important *Ideals* that focus on assessment of young children include using "appropriate assessments" and the use of assessments for the purposes for which they are intended, such as eligibility or progress monitoring.

Principles focus on the requirement of using multiple sources to assess the children and never being dependent on a single assessment such as one observation or test score.

The DEC Code of Ethics (2009) covers ethical and evidence based practices (EBP) in broad terms. Included in these guidelines are the specific recommended assessment practices of including families in all levels of the process, using multiple forms of assessment, and using EBP to implement ongoing assessment. These codes of conduct provide general information for all early childhood professionals, but do not specifically address the ethical crisis that occurs for young children with visual impairment.

The ethical treatment of young children with disabilities as participants in research requires the assessment and protection of individuals who represent a vulnerable population (Liamputtong, 2007) and are at risk in the power relationships between adults and children (Lahman, 2008). Society devalues children with disabilities with deeply held developmental and biological assumptions about their competency in educational settings called “ableism” (Hehir, 2009). For children with visual impairment, ableism can be present in the classroom as a lack of braille reading choices or the use of inappropriate assessments normed on sighted students. A classroom that does not provide equal reading opportunities for children who use tactual media for learning does not acknowledge their literacy needs. Young children require a variety of books to read on their own, with adults, and with peers. If tactual books or modified assessments are not available for these literacy activities to occur, early childhood education teams are errant in providing equitable opportunities in the classroom.

Across the country, preschool educational teams are using assessments normed on sighted students with young children with visual impairment that questions ethical educational behavior (Kitchener & Kitchener, 2009). In the use of such inappropriate assessments with young children who are tactual learners, education professionals are placing them at risk with poor decision-making in the classroom. If special educators sort and label students using only theories and opinions in their specialized educational settings, these practices can affect the placement and instruction that children receive in the classroom.

The premises of universal design in early learning gives all young children opportunities to access and process information and demonstrate what they have learned (Darragh, 2007). It is a critical component of a UDL framework (Conn-Powers, Cross, Traub, & Hutter-Pishgahi, 2006) that young children who are tactual learners have access to valid modified assessments for the purposes of guiding their instruction and monitoring their progress.

Ethical codes of conduct that address assessment in ECSE require practitioners and researchers to consider single assessments as only one part of the picture in understanding how young children learn. Both observational and direct assessments are necessary to evaluate the process of learning to match updated skill acquisition by developmental theorists (Hirsh-Pasek et al., 2005). As best practices in ECSE assessment are evaluated in social validity research (Bagnato et al., 2014; Macy et al., 2014), it is critical that individual assessments meet criteria standards of utility in the learning environment, collaboration with families, and the universality of design, and that

appropriate modern measurement theories such as IRT are used to build psychometric validity.

Connections Between Cognitive and Tactual Development

In order to evaluate the success or failure of the child with visual impairment in preschool services, assessments tools with unified validity components (Messick, 1995) such as the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) are necessary to determine what modifications, adaptations, and variables affect the developing skills of the young tactual learner. However, in the field of visual impairment there is a history of teaching practices without an evidence base (Council for Exceptional Children's Interdivisional Research Group, 2014). In building a new research framework that promotes greater understanding of "what children know," there is a need for assessments with relevant population data (AERA et al., 2014; Davidson & Harrison, 1997; Mazella et al., 2014). Improved assessment and research of young children with visual impairment requires greater understanding of tactual concept learning through both haptic development research and ethical standards of practice in ECSE assessment.

Research in Tactual Development

The sense of touch is unique in that it depends on physical contact and is spread throughout the body (Hatwell, 2003a; McLinden & McCall, 2002). Touch can be receptive or "cutaneous," as when individuals feel a blanket underneath on the bed or react to the squeeze of a handshake or a hug. It can also be active and exploratory or "haptic" in nature--as when children reach to explore a texture, a toy, or manipulate an item to discover how it works. Traditionally, developmental assessments have demonstrated that a lack of vision can have a detrimental effect on haptic development

(Bak, 2000; Ochiatia & Huertes, 1993; Reynell, 1978), but more recent studies have questioned this assumption. McLinden (2012) found in a current literature review that

> While the precise role of vision in early haptic development has not yet been fully ascertained, there is evidence that its function is not as a substitute for haptic perception, but rather serves as a guide or "mediator" of haptic perceptual activities. (p. 132)

Other past research indicates that young children with visual impairment display similar characteristics in the development of tactual discrimination as infants with sight (D'Anguilli, Kennedy, & Heller, 1998; Landau, 1991; Morriengello, Humphrey, Timney, Choi, & Rocca, 1994; Schellingerhout, Smitsman, & van Galen, 1997). Vision is not critical (McCarty, Clifton, Ashmead, Lee, & Goubert, 2001) for the development of haptic skills that can lead to functional tactual discrimination and early braille literacy. Studies in tactual discrimination that used cerebral functional imagery indicate that the haptic learning system develops along similar pathways as the visual system (Gentez & Badan, 2003; Nicholas, 2010; Sera & Millett, 2011), and a recent MR-Imaging study confirms that early onset blindness leads to changes in brain functioning that supports compensatory development in tactile processing (Bauer et al., 2017).

What is Known about Haptic Development in the Young Child

The cutaneous system develops first in utero, and early in infancy the more active "haptic" skills are acquired. Using the mouth, newborns explore and can modulate pressure on objects according to their texture. Through the use of habituation research adapted for haptic procedures, studies show that very young babies can determine contour (Streri, 2003) and can discriminate texture before shape (Schellingerhout et al., 1997). This haptic exploratory mode is transitory, increasing up to seven months of age

and then decreasing at eleven months. Soon, the baby is no longer able to detect differences in shape with the hands because the mouth has taken this task on while the hands are busy transporting objects. Streri (2003) found that "infants adjust or adapt their activities to object properties in order to extract the most pertinent information" (p. 59).

Research in the area of movement based haptic exploration of the young child with visual impairment is limited, but Schellingerhout, Smitsman, and Cox (2005) showed that: (a) both hands move together in synchrony; (b) the hands show a preference for textures that are increasingly dense; and (c) once a complex texture is found, movement patterns are slowed for further exploration. This study is consistent with a body of work that confirms the preference of texture over shape in the young child (Streri, 2003), but is limited by a sample of only three participants.

As infants move from using their mouths to their hands in effective exploration, the work of Lederman and Klatsky (2009) "has demonstrated a link between hand movement profiles and the perception of specific object properties, grouping these into distinctive exploratory procedures (EPs)" (McLinden, 2012, p. 130). As noted earlier, Hatwell (2003b) emphasized that the EPs cannot be "practiced simultaneously and must be performed successively because they are not compatible motorically" (p. 70). These patterns of hand movements to obtain specific information are related to the motor development and age of the child. As the exploratory needs of the infant and toddler change, EPs are rejected and accomplished (Bushnell & Boudreau, 1991). Exploratory procedure research is well established with young children with sight, but there are also multiple studies applying the use of EPs in young children with visual impairment (McLinden & McCall, 2002; McLinden, 2012; Schellingerhout et al., 1997).

Older babies prefer shape characteristics over textures because they are beginning to experiment with manual EPs. Enclosure, an EP that involves the hand closing around objects, is necessary to determine shape perception. The variability of exploratory behavior is not confined to object properties, but also applies to the opportunities presented by the environment. Research in the haptic development of shape processing has conflicting results. Rose, Feldman, Futterweit, and Janowski (1998) and Bushnell, Shaw, and Strauss (1985) indicated that very young children (infants and children under 3 years) can discriminate shapes without the benefit of vision and with greater accuracy using the left hand. A review of this research indicated "hemispheric specialization regarding the haptic processing of shape apparently sets in its adult aspect during the child's second year" (Streri, 2003, p. 56). However, the results of a four-part series of experiments using 4-year-olds (Sera & Millett, 2011) showed that "shape processing, and thus object recognition, changes significantly with development" (p. 55) and may be related to abstract concept knowledge. Sera and Millett (2011) proposed that in studies of very young children, the participants attended more closely to the stimuli, and that as they age, the children used already assimilated information to make choices and were more likely to make mistakes.

Gaps in haptic development research are most obvious in the 3- to 4-year-old age range. This is due to the fact that once they attain 3 years of age, young children no longer tolerate the screening necessary to keep participants from seeing what they are touching in habituation research (Hatwell, 2003b). As habituation is no longer successful with this age group, a valid, modified assessment that explores beginning tactual discrimination strategies and concept development could be invaluable. The following

unique characteristics of tactual measurement research guided the development of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) and was considered in this validation study.

Thinking and Haptic Discrimination Skills

Through haptic research, it is known that using mental synthesis with touch as an exploratory procedure (Lederman & Klatsky, 2009) can increase working memory load (Millar, 1994; Sebastian, Mayas, Manso, & Ballesteros, 2008). Discovering and retaining knowledge about body awareness, real objects, object relationships, and representational symbols takes significantly longer for a haptic learner (Hatwell, 2003a).

Simultaneous versus successive acquisition. One reason for this increased learning time is due to the nature of haptic learning. Pring (1994) explained that "in the encoding strategy for braille, tactual input tends to be successive while with print visual encoding may take place almost simultaneously" (p. 68). This is true for all haptic learning; acquiring information requires touching each item or letter individually, building up a successive process of understanding and memorizing new items in short-term memory, then in long-term memory (Hughes, 2011).

Recognizing salient features. Information processing theory includes the acquisition of knowledge through the learning of salient (unique) features of objects and the consistent relationships that are experienced through short-term memory. As children move information from short-term memory to more efficient working memory, they are able to "encode" experiences and additional skills. An example of using information processing theory with young children with visual impairment is demonstrated in the learning of braille symbols. Research shows that texture is salient in very young children

(Schellingerhout et al., 2005; Schellingerhout et al., 1997) and becomes more finely discriminated as they become adults. Children learn the feel of each letter representation through the salient feature (dot patterns) of the different braille cells and move additional symbols into working memory. Once the symbols are learned, combinations are "chunked" so the reading process can begin.

One meta-analysis (Dunst & Gorman, 2011) has attempted to look at "the extent to which young children with visual impairment were able to differentiate between surfaces and objects that had contrasting conditions and features" (p. 1). Criteria for the inclusion of nine studies were: (a) if the participants had visual impairment, (b) if the participants were mostly under the age of 5 years, and (c) if the study had information to be able to compare effects of contrasting surface or object conditions and features on objects or tactile exploration. The effect of the severity of the visual impairment was the only significant finding in this meta-analysis. "Children with residual vision engaged in more exploratory behavior compared to children with no residual vision" (Dunst & Gorman, 2011, p. 2). As no formal tactual assessments were attempted in any of these studies included in the meta-analysis, it is impossible to determine if tactual saliency was relevant. A listing of the variety of different textures used in the different studies were recommended for practitioners to encourage tactual exploratory skills and early literacy for braille.

Scanning skills in young children. While infants and toddlers with visual impairment engage in haptic exploratory skills to learn about their environments, play with toys, and learn to use tools, little is known about the development of the systematic scanning techniques needed for one-to-one correspondence and braille reading.

Davidson (1972) provided preliminary information regarding the haptic scanning techniques of blind and sighted adults. The results of his three experiments indicated a relationship between the scanning technique and the stimuli being scanned, differences in the gripping strategy to "triangulate" the position and shape of the stimuli and the ability of the skilled braille reader to attend to the salient characteristic of each braille symbol. Sicilian (1988), in his study of young blind children and their effective counting strategies, looked closer at the developmental scanning skills that will affect any test created for concept assessment. Children between ages 3 and 13 demonstrated significant correlations between age and accuracy in one-to-one correspondence and higher levels of scanning and organizational strategies. Efficient scanning strategies that involved learning about the characteristics of the items to be counted were more likely to result in accuracy in the number of items. Finally, Papadopoulos et al. (2012) updated the scanning literature with a multiple regression study with 30 participants that looked at the individual's ability to demonstrate spatial coding in near space. Although the participants with the most vision were able to complete the task the most effectively, those that used relational haptic strategies were more successful than those that only touched each shape. The closer an object was to the reference point, the more accurate the coding became.

The previous studies, although diverse, build a research base that the field of visual impairment can use to determine if improving haptic development skills are linked to academic and literacy skills. Improved MR-Imaging allows for studies that confirm neuroplastic changes in the brain functioning of individuals with early onset blindness that supports compensatory development in tactile processing (Bauer et al., 2017).

Cognitive information processing theory demonstrates that haptic skills develop as children learn about their world and are exposed to increasingly complex textures. Dunst and Gorman's (2011) meta-analysis encourages families and educational vision impairment professionals to give as many tactual discrimination opportunities as possible to future tactual learners. Davidson (1972) and Sicilian (1988) promoted direct teaching of haptic scanning skills to prepare young children with visual impairment for more complex tactual organizational tasks such as one-to-one correspondence and braille symbol relationships. The use of haptic relational strategies in Papadopoulos et al. (2012) may result in classroom interventions that promote independence in haptic activities. If appropriate assessment tools can identify these emerging haptic skills in young children, the field can determine which interventions are necessary to address them.

The Importance of Concept Development

For the young child who will be a braille reader, a tactual understanding of relational concepts is critical for an understanding of early academic skills, peer interactions, orientation and mobility, and the development of play (Dunst & Gorman, 2011; Koenig & Farrenkopf, 1997; Recchia, 1997). Students with visual impairment who do not have a thorough understanding of basic concepts early in life can find themselves unable to "infer, predict, comprehend and create during learning activities" (Bardin & Lewis, 2008, p. 474). In addition, measuring an understanding of basic concepts is critical to support and reinforce not only the development of literacy, but in all other areas of learning (Koenig & Farrenkopf, 1997). A significant body of research that supports the understanding of basic concepts during preschool adds to increased

vocabulary skills (Boehm, 1971, 1986; Booth & Waxman, 2002), success in the school environment (Bracken & Crawford, 2010), and the prediction of academic achievement in the early elementary years (Glutting, Kelly, Boehm, & Burnett, 1989).

Theoretical Foundations and Frameworks

Concepts are internal mental representations of the similarities of items within categories, allowing children to understand temporal and spatial relationships in their world (Birbili, 2007; Bruce & Vargas, 2012; Ferrell, 2011; Oakes & Rakison, 2003). These relationships are the foundation for understanding egocentric concepts such as body awareness as well as the more abstract allocentric concepts that are related to the use or purpose of an item (Papadopoulos et al., 2012; Plumert, Haggerty, Mickunas, Herzog, & Shadrick, 2012). As distance is a critical component of haptic learning, the instruction and assessment of concepts requires modification, adaptation, and specific educational intervention (Chen, 2014; Downing & Chen, 2003).

As the United States transforms early education with the advent of core learning standards (National Governors Association Center for Best Practices, 2010), instruction and assessment for young learners (Birbili, 2007) and the standards of performance for all teachers (Sato, 2014) are evolving at the most basic levels. It is no longer enough to guide young children through a teacher-directed process of memorization of vocabulary and directional terms. Quality teaching in the early childhood classroom now involves developing interdisciplinary learning frameworks that allow children to explore differences and similarities in the classification of concepts, recognizing patterns of relationships and making generalizations. As higher expectations for quality in ECSE programs (U.S. Department of Education & U.S. Department of Health and Human

Services, 2015) are supported through Quality Rating and Improvement Systems (Scott-Little, Bruner, Schultz, & Maxwell, 2013), the challenge is for educators and families to guide all children past the strategies of simple recitation and on to the higher-thinking processes of analyzing, synthesizing, and evaluation. Encouraging young children to experience basic relational concepts in the curriculum framework is a critical piece of early learning as Birbili (2007, p. 143) explained, "In contrast to facts, concepts change at a slower pace, cannot be forgotten, and they are both timeless and universal."

Developmental process of concept understanding. Without categorical representation, an infant would have to learn each novel item without a previous reference. This makes categorization a critical cognitive skill (Birbili, 2007; Quinn, 2003). The process of understanding concepts is often closely related to educational learning theories, and most research supports that comprehending concepts is a developmental process. Regardless of whether one is a cognitive learning theorist, a nativist, or ascribes to the theory of cognitive information processing, it is obvious that young children acquire a hierarchy of concept development from concrete to more abstract categorizations. In order for young children, especially those with visual impairment, to make sense of their individual experiences and background knowledge, they must be taught to organize facts in a conceptual framework (Birbili, 2007; Higgins, 1973; Plumert et al., 2012). As development occurs, young children acquire higher levels of concept categorization and more complex understanding is expected. For example, very young infants may only be able to explore textures with their mouths or through passive interactions with their hands. As they grow older and their motor skills improve, educators expect the child to use his or her hands in a variety of ways (holding, poking,

or squeezing) and to be able to categorize objects in new ways. Research suggests that there is a progression in how children learn to process spatial and temporal concepts (Carey, 2009; Goswami & Brown, 1990; Koerber & Sodian, 2008; Quinn, 2003), and this is valuable information for both the validation of effective assessment tools and the creation of EBP in teaching these concepts to young children with visual impairment.

Koerber and Sodian (2008) found that "the age range between 3 and 4 years appears to be the critical age range for an understanding of representation in general, as has been emphasized for mental representation, but also for non-mental representation" (p. 394). Their data analysis, using an ANOVA that looked at the main effects of sex and age, showed a significant increase in linear spatial ordering by age, no effect by sex, and the only significant finding showed that the 5-year-olds appeared to be affected by literacy introduction. In young sighted children, "findings indicate that the ability to map temporal relations onto space develops spontaneously without formal instruction and prior to the acquisition of literacy" (p. 394). There is no reason to believe that young children with visual impairment would acquire these skills differently (Davidson, 1972; Ferrell, 1998, 2011; Hall, 1983; Landau, 1991; Millar, 1994).

Theories of learning concepts. How concept development occurs is a matter of considerable debate. Historically, in the field of education for children with visual impairment, cognitive-learning theory has been accepted as the primary understanding of development (Brambring & Troester, 1994; Higgins, 1973; Warren, 1984). Cognitive-learning theory holds that development occurs through a combination of forces: biological maturation, physical experiences, and social interaction. For very young

children, Piaget (1972) believed that interactions with objects is the primary learning mode for understanding the world (Miller, 2010).

In contrast, by focusing on the belief that concept understanding is innate, some cognitive development researchers (Carey, 2009; Gibson & Walker, 1984; Streri, 2003) support the theory of evolutional acquisition, or nativism. Gibson and Walker (1984) challenged the maturational process by arguing that tactual discrimination of objects does not happen because of the environment or the individual, but occurs due to the interaction of both. Information is not out there in the environment waiting to be found. Instead, it is a learning process that emerges as a child actively engages with her surroundings. A nativist learning theory assumes that sensory and conceptual representations are present at birth and that as the child experiences mental representations though object manipulations and language exposure, they develop an understanding (Carey, 2009). Very young infants of 3 to 5 months have been shown to differentiate between textures and contours through active mouthing and limited hand explorations (Gibson & Walker, 1984; Schellingerhout et al., 2005). A tactually diverse environment for learning results in increased adaptations and interactions by the young child guided first by perceptual experiences and improving to executive exploratory procedures (Lederman & Klatsky, 2009).

In recent years, cognitive information processing theory has explored the perspective of neuroscience and how the physical development of the brain affects learning. Using advanced imaging techniques and breaking down learning into memory and processing tasks, evidence has shown that the ongoing development of the brain correlates with improvement of understanding (Gentez & Badan, 2003; Gentez &

Rossetti, 1999; Halford & Andrew, 2010). This theory includes the acquisition of knowledge through the learning of salient (unique) features of objects and the consistent relationships that are experienced through short-term memory. As children move information from short-term memory to more efficient working memory, they are able to "encode" experiences and additional skills. As the understanding of how young children learn and concept development changes over time, there are situations in which all the above-mentioned theories of cognitive learning appear to be relevant (Streri, 2003).

Assessment of Concept Development

The acquisition of concepts is measurable in numerous ways for the preschool population. Structured, validated assessments are available (Boehm, 2001a; Bracken, 2006), and several intelligence tests for young children incorporate concept development understanding (Flanagan, Alfonso, Kaminer, & Rader, 1995). However, in many ECSE settings, including specialized settings for young children with visual impairment, educators are likely to use observational developmental checklists that are normed on a sighted early childhood population and informal personal data collection (Smyth & Phangia Dewald, 2013; U.S. Department of Education, Office of Planning, Evaluation, and Policy Development, 2016). Observation is well supported as a method of assessment in ECE (DEC, 2007), and ideally, ECSE professionals work collaboratively to conduct informal observational and developmental checklists, or play-based assessments. These examples of informal assessment are relevant to daily classroom experiences and meet many of the criteria necessary to promote positive outcomes for students (DEC, 2007). Most sighted children are able to receive a combination of observations, progress monitoring and validated formative assessments in a developmentally appropriate,

authentic manner. Rarely do these required assessments have children with visual impairment included in the original validity samples and, therefore, provide no evidence base for this population.

Boehm-3 Preschool Test of Basic Concepts

The Boehm Test of Basic Concepts-3 Preschool (Boehm-3 Preschool) (Boehm, 2001a) was created as a downward extension of the Boehm Test of Basic Concepts (BTBC) (Boehm, 1986) to assess the understanding of basic relational concepts that are crucial to understanding directions and classroom routines. Basic relational concepts are also an important aspect of emergent literacy and numeracy for children ages 3 through 6. The Boehm-3 Preschool (Boehm, 2001a) is a standardized assessment that can be used by any knowledgeable professional in the early childhood classroom to determine basic concept understanding for the purpose of developing interventions, and to monitor progress over time.

Depending on the child's age range, administration begins at different starting points, but for each child there are a total of five practice items and 52 test items. The Boehm-3 Preschool (Boehm, 2001a/b) is administered individually to each child, and easier items are interspersed with challenging items to encourage children with success. The assessment includes an examiner manual with descriptive administration directions, a picture manual with the test items, a record form with a scoring key, a parent report form, a test summary, and an ongoing observation and intervention planning form (Boehm, 2001b). All of the assessment components are available in English and Spanish. The Boehm-3 Preschool Record Form is designed to provide concrete feedback to parents and teachers about the child's concept knowledge. The test summary allows

administrators or classroom professionals to create a short report to be shared with families and all educational professionals that interact with the child.

Relevant historical research. The predictive validity of concept understanding in early childhood is well established through the use of the BTBC (Boehm, 1971), the BTBC-R (Boehm, 1986), and the Boehm-3 Preschool (Boehm, 2001a/b) in measurement research. Despite the many revisions and improvements that have adapted the original assessment, concept development remains a crucial skill necessary for future academic success in early childhood settings (Karoly, 2012; Purpura, Hume, Sims, & Lonigan, 2011; Samara, Lange, Clements, & Wolfe, 2012). A brief research summary indicates the usefulness of knowing the status of young children's concept understanding to guide instruction, identify possible concerns, and predict short-term academic achievement and learning behaviors.

Several past research studies have confirmed the benefits of using multiple iterations of the BTBC to identify young children's language concepts for instructional purposes. An early factor analysis of the BTBC (Piersel & Reynolds, 1981) explained that "the results showed the BTBC to be unidimensional for measuring a general acquisition of basic language concepts" (p. 582). The relationship between language acquisition and understanding of basic relational concepts is explored in other studies (Preddy, Boehm, & Shepard, 1984; Zhou & Boehm, 2001), indicating that cross-cultural understanding of the concepts can be affected by both features of the language itself and how the concepts are presented by adults in that culture. Pictorial written languages such as Chinese often incorporate concepts into the design of the words. In addition, the experiences of children from different cultures and using different languages are likely to

affect children's understanding of basic relational concepts in their environment. This is a critical feature to consider with young children with visual impairment, as experiences through tactual development may result in different levels of understanding with their sighted peers.

Previous research has attempted to use the BTBC and the BTBC-R as an indicator of cognitive development and a predictor of school achievement. Spector (1979) urged caution when using the BTBC for future instructional planning, as poor results could indicate a variety of cognitive disabilities. Her concerns were summarized as

> Cognitive factors that appear to contribute to a lack of comprehension of basic concepts include (a) inability to focus on the key words in the directions, (b) complexity of directions, (c) deficits in spatial perception, (d) lack of knowledge of concept labels or vocabulary deficits, (e) difficult level of abstraction, (f) difficulty with negative concepts, and (g) inadequate auditory memory for sentences. (p. 567)

A child's understanding of basic concepts may be an indicator of all of these factors, and more recent recommendations include using the BTBC and the BTBC-R as well as the Boehm-3 Preschool (Boehm, 2001a), as one of many assessment tools to address assessment best practices for young children (Brassard & Boehm, 2007).

Standardization. The standardizations of both the English and Spanish version of the revised Boehm-3 Preschool (Boehm, 2001b) followed rigorous psychometric procedures over the time period of 1997 through 2001. A literature review (Boehm, 2001b) that focused on the basic concepts used in "early reading and math curricula, teacher's verbal instructions, and standardized test directions were collected" (p. 45) and incorporated into a prototype tryout edition. These test items were created by reviewing the frequencies of concepts in a variety of preschool and early school curricula. A total of 18 new items were added to the original version of the test. In the final edition,

consideration of how difficult it was to represent a concept in an illustration was part of the decision process.

User surveys were sent to practitioners who had administered an earlier edition of the assessment to determine what was needed to improve the original version. The results of these surveys included requests for more difficult test items, the need for higher quality pictures, and a Spanish version of the assessment. Most of the Boehm-3 Preschool (Boehm, 2001b) test administrators used the assessment results to determine future learning objectives.

Finally, a comprehensive bias review was completed by an expert panel in the areas of child assessment in the areas of education, speech pathology, and psychology. The findings of this panel included the need for equality in the representation of gender and increased ethnic diversity. New color drawings were created that addressed the concerns regarding gender equality and ethnic diversity. National norms were standardized for the Boehm-3 Preschool (Boehm, 2001b) on a sample of 1,600 children from all regions of the country that matched the demographics of the United States. "Norms were developed by reviewing p-values (percent of children passing), item difficulty and bias of the standardization data" (Boehm, 2001b, p. 55).

Reliability. Reliability of the Boehm-3 Preschool (Boehm, 2001a) was established through evaluating internal consistency, standard error of measurement (SEM), and test-retest reliability. Cronbach's coefficient alpha was used to examine the uniformity of test items throughout the test. The coefficient alphas were in the range of .85 to .92, indicating a high level of internal consistency. Standard error of measurement is an indicator of the amount of error associated with a given test score and balances out

the results of the Cronbach's alpha. In the Boehm-3 Preschool (Boehm, 2001b), the SEM range was from 2.08 to 2.88, showing low variability of the test scores. An individual study was conducted to establish test-retest reliability using a sample of 98 children. The test was administered once, then re-administered anywhere from 2 to 21 days later. Reliability coefficients of .90 to .94 were established using Pearson correlations. This test demonstrated overall high test-retest reliability.

Validity. The validity of the Boehm-3 Preschool (Boehm, 2001a) was built through statistical procedures that evaluated the content of test items, construct relationships to other assessments, and criterion relationships for use with older children. The relational concepts measured in the Boehm-3 Preschool (Boehm, 2001a) are found in early education curricula and standards across states and cultures (Bracken & Crawford, 2010; National Governor's Association Center for Best Practices, 2010; Zhou & Boehm, 2001). In determining content validity, relevant concepts that were reviewed through examination were found in (a) printed materials, (b) reading and mathematics curricula, and (c) teacher's verbal instructions. All but four of the Boehm-3 Preschool (Boehm, 2001b) concepts appeared in basal reading programs for grades kindergarten to grade three. A review of oral direction literature and an additional study that recorded and analyzed preschool classroom teacher's instructions showed evidence that 70% of the Boehm-3 Preschool (Boehm, 2001b) concepts are critical for success in the preschool classroom. Today, the importance of understanding relational concepts to support the development of early mathematics (Kleemans, Peeters, Segers, & Verhoeven, 2012; Samara et al., 2012) is well documented.

In looking at validity based on relationships to other variables, an additional study compared the concepts included in the revised edition of the Boehm-3 Preschool (Boehm, 2001a) to the original Boehm-3 Preschool (Boehm, 1986) using a sample of 59 children. A test-retest split-half research design resulted in a Pearson correlation coefficient of .84, establishing high concurrent validity. Another study compared the Boehm-3 Preschool (Boehm, 2001b) to the Bracken Basic Concept Scale—Revised (Bracken, 1998). A sample of 62 children participated in a test-retest split-half research design. Pearson correlation coefficients resulted in .80 for 3-year-olds and .73 for 5-year olds. It appears that all three tests measure consistent constructs, and a high level of validity among these assessments has been established.

In the criterion relationship validity study, children with a diagnosed receptive language delay were matched by age, gender, and race/ethnicity with a child that was not diagnosed with a receptive language delay in the sample. The total matched sample included 290 children. Although the results of the study showed that the children with a receptive language delay had significantly lower scores, the authors caution that the Boehm-3 Preschool should only be used as a part of a battery of tests to establish eligibility for speech/language services. This recommendation is consistent with best practice (DEC, 2007; Macy et al., 2007) that supports the assessment of young children with both observational and traditional measurement instruments over time.

Previous research in the field of early childhood and early education for young children with visual impairments has established the importance of foundational concept development. Increased educational standards, improvements to methods of teaching and learning, and a greater understanding of how young children learn have all influenced the

instruction and assessment of concept acquisition. Determining when concepts are introduced to young children, the experiential and interdisciplinary nature of instruction to support higher level thinking skills, and the predictive nature of concepts on academic success all require valid and reliable assessments normed on the population for which the assessment tool is intended.

Tactile and Cognitive Assessment

A recent review of tactual or haptic assessment (Mazella et al., 2014) indicates that previous tests were developed to either "assess non-verbal or practical intelligence, replacing vision in analogs of mainstream tests, or to assess the quality of haptic functioning in specialized tests" (p. 227). The utility of these early haptic assessments focused on a combination of the general areas of developmental skill acquisition and instructional planning.

History and Usefulness of Tactile Assessment

The majority of tactile assessments have been designed and used in research with older elementary school to adult participants, and with limited sample sizes. Accurate tactual assessment for young children with visual impairments continues to be elusive due to the unavailability of instruments and/or limited interest in this age group (Caton, 1977; Mazella et al., 2014; Simpkins, 1979)

An early tactile analog (Caton, 1977) of the Boehm Test of Basic Concepts (Boehm, 1971) for children in kindergarten through second grade was considered to assess the quality of haptic functioning as a prelude to early braille instruction. More recent cognitive research has indicated that children develop an understanding of these

basic concepts at earlier ages, most frequently during preschool (Brown & Jernigan, 2012; Koerber & Sodian, 2008; Quinn, 2003).

However, research in the field of cognitive psychology (Hatwell, 2003a) and advanced imaging techniques (Brown & Jernigan, 2012) have increased the scholarly understanding of haptic (tactual) development (Cote, 2014) in young children in recent years. Specific cognitive and haptic developmental skills are measurable and can guide the creation of an assessment with unified validity that "integrates considerations of content, criteria, and consequences for a better understanding of score meaning" (Messick, 1995, p. 741).

Just as young sighted children visually (a) discriminate shape, sizes, and length for early mathematic literacy; (b) recognize salient features of letters; and (c) demonstrate knowledge of early literacy book skills and direction following, young children with visual impairment learn about their world in a tactual experiential manner though independent movement (Hatwell, 2003a; Papadopoulos et al., 2012). These early academic skills contribute to the attainment of crucial childhood outcomes and preschool standards that guide the early childhood core curriculum (Bailey et al., 2006; Karoly, 2012; Scott-Little et al., 2003). The skills that children with visual impairment need to discriminate, recognize, and demonstrate an understanding of tactual concepts are developmental, but currently there are no appropriate assessment tools to measure them.

The need for a validated tactile measurement. Validating an assessment for young children with visual impairment in a tactual format was a challenging task. There has been significant progress regarding the research in the field of haptic understanding (Lederman & Klatsky, 2009; McLinden, 2012; Papadopoulos et al., 2012) in the last five

years, and this information was rigorously applied in the creation of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) to guide assessment and instruction for young children with visual impairment. At last there is an assessment tool that accurately measures the acquisition of concepts in a tactual form. The necessity of accomplishing a validation of a concept-based tactual measurement seemed obvious.

Home-school collaboration. Guidelines for ethical practice in assessment for young children (DEC, 2007, 2009; NAEYC, 2005) recommends that families both contribute to data collected and receive the results in a manner that supports family participation. Parent reports should encourage parents and early childhood professionals to collaborate in an understanding of which basic concepts children need to experience in everyday life. Any assessment for children in preschool should be designed to provide concrete feedback to parents and teachers about the child's concept knowledge and provide suggestions for implementing developmentally appropriate instruction, through group exploration activities or through natural routines in the home or school. Using the sense of touch to develop early academic skills is not always intuitive, and a validated tactile test of basic concepts can demonstrate gaps in learning that need to be addressed for individual children.

Measurement in research. Despite repeated calls for research that is helpful for families and educators of young children with visual impairment (Davidson, 1972; Mazella et al., 2014), there has been, until now, no valid assessment tools to guide this research and, therefore, limited quality research. Other tactual assessment tools that are available have poor or missing psychometric properties and rely on concrete three-

dimensional components which may not address the assessment of emerging cognitive abilities (Hall, 1981, 1983) in young children with visual impairment in preschool.

One of the most pressing needs for understanding the effects of haptic development on learning through guiding EBP for early literacy and braille skills. Although there is a significant literature base for the combined fields of psychology and vision impairment in research for braille reading, the samples are small and do not address the critical 3- to 5-year-old age group of preschoolers. In addition, much of this research does not meet the quality indicators for replication (Gersten et al., 2005), mostly due to poor measurement and implementation choices.

Other early literacy studies in the field of visual impairment focused on the direct teaching of braille skills and included early elementary students with visual impairment. In exploring three major literacy studies that investigated the benefits of teaching contracted or uncontracted braille, it is evident that the design of rigorous, high quality studies was affected by the lack of validated measurements.

In 2004, Hong and Erin studied eight matched student pairs as they were exposed to reading instruction using contracted and uncontracted braille. Quantitative data in the form of several reading assessment scores and qualitative data that interviewed teachers of the visually impaired and students about learning to read braille led to results that indicated virtually no difference between the two approaches. The students were followed over three years, and the limitations of the study included differences in teaching materials and no fidelity of instruction. The assessments looked at reading comprehension, reading rates, spelling, and phonemic awareness, but were not validated on a population of braille readers. No differences of any significance were noted, leading

to the conclusion that it did not matter whether contracted or uncontracted braille was used for instruction.

The next major study was the first longitudinal study looking at braille acquisition in young children, the ABC braille study, which involved a collaboration of several researchers and included 45 subjects from 15 states and 1 province in Canada (Wall Emerson et al., 2009). Students were followed from 2002-2007 and again, although a variety of assessments were used to evaluate quantitative mean scores, no effort was made to control the teaching materials used or the fidelity of instruction. The areas of reading instruction assessed included phonology, oral reading fluency, comprehension in text, and miscues. The assessments used annually were the Texas Primary Reading Inventory (Texas Institute for Measurement, Evaluation, and Statistics, & the Center for Academic and Reading Skills, 1998), the Brigance Comprehensive Inventory of Basic Skills-Revised (Brigance, 1999), the Johns Basic Reading Inventory (Johns, 2001), and the Assessment of Braille Literacy Skills (Koenig & Farrenkopf, 1995). The criteria for choosing these assessments included familiarity in elementary classrooms and easy accessibility in braille. There was some attempt at addressing content validity as these assessment tools proposed to assess the commonly taught reading skills. However, there were no students with visual impairment in the norming samples. It is important to note in this study that as the reading instruction itself was not controlled, the ability to separate the subjects into those who were learning uncontracted braille and those learning contracted braille became impossible (Sacks et al., 2011). There was some indication that students who learned more contractions earlier were more successful in later testing. However, with the ambiguity between the two groups, even this result is questionable.

The final reading study that involved looking at the benefits of either type of braille reading instruction used an alphabetic or uncontracted braille approach (Day et al., 2008). In this study, five students and their TVIs were chosen to receive their reading instruction using a reading program that was designed for print readers, but transcribed into uncontracted braille. The rationale for this was to control for instructional fidelity by training the TVI in the use of the reading program, which was a factor that was not addressed in the other two reading studies. Another rationale for using this reading program was that it had established reliability and validity in addressing the five areas of reading instruction. This is not always the case in braille-based early reading curricula. However, because the original sample did not include braille readers, the modified curriculum did not have validity and reliability. Unified validity requires that the curriculum or assessment include the relevant characteristics of the participants that will use it in the research.

The only reading measurement was the screening tool and end-of-year progress monitoring tool that was included in the reading program and a stack of Dolch sight word reading cards, transcribed into braille. These Dolch words were presented to acquire multiple baseline data in a repeated measure single case study design model with the five participants. The resulting quantitative data very clearly indicated that the reading intervention did increase the student's abilities to read an increased number of the Dolch sight words over the year. All five participants made gains in the areas of word recognition, spelling, and reading level. This was a study with a strong scientific design and controls and had the potential to be easily replicated. The results were consistent

with earlier psychological data regarding braille and phonological awareness: that braille in its uncontracted form is more supportive of earlier reading and alphabetics.

Close examination of these three braille literacy studies indicates that the primary limitation was the lack of a validated assessment to measure the progress of these braille readers. Screening tools are not adequate to determine current skill levels and/or measure changes in learning after the implementation (Greenwood & McConnell, 2011). In order for the field of visual impairment to develop to a level where research can be replicated adequately to establish EPBs, it needs to articulate and begin to adopt standard guidelines for conducting research, including the use of assessment tools with unified validity.

Through creating and adopting rigorous standards with unified components, including the elements of content, criterion-related, and concurrent validity, measurements and research in the field of visual impairment are able to look at current practices with a more critical eye. What is the most effective method of braille instruction for young tactual readers? Will direct instruction in scanning and tactual discrimination skills benefit young children? What methods of direct tactile instruction are necessary in the inclusive preschool classroom to guide educational vision impairment professionals and early childhood educators? Establishing validity of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is only the beginning, but it is important to know that creating a valid and reliable tactual test is possible so that these questions can be answered through the rigorous use of measurement in second-generation research.

Inclusion equality. As educators and researchers responsible for the future success of young children with visual impairment, it is crucial for the field to work

toward developing and validating a variety of formal assessments that can be used in the natural context of the inclusive public preschool setting. The numbers of young children with visual impairment included in schools with their peers are increasing, and they will and should be held to the same core academic standards (National Governors Association Center for Best Practices, 2010) as all students. Towards the aim of eliminating ableism in special education (Hehir, 2009), they will be required to take the same assessments as their classmates. It is important for the field to advocate on their behalf with national test developers to include them in original samples, for educational staff to choose appropriate formal assessments and participate in available research projects in the classroom, and for university professionals to submit federal grants to request funds for measurement validations. Young children with visual impairment are entitled to the same education and adapted assessments as their peers to demonstrate their competence. As long as they cannot access assessments through tactual means or universally designed technology, they will continue to be "othered" in the educational system.

Informal assessment, with the advent of early learning standards (First Five Years Fund, 2015; National Governors Association Center for Best Practices, 2010), is no longer enough for children who will be expected to learn at the same academic level as their peers. Nor is it acceptable to only make adaptations to existing visually based measurements and assume that both tests are equivalent (Bond & Fox, 2001). Neisworth and Bagnato (2004) warned early childhood professionals that "misrepresenting children through mismeasuring them denies children their rights to beneficial expectations and opportunities" (p. 198). It is as necessary for the field of visual impairment to reflect on the instruments used to assess young children, as well as how assessment occurs.

Boehm-3 Preschool for Children with Visual Impairments

In the creation of items for a test, the developer must determine what constructs are to be measured. Individual items that contribute to the test score in a meaningful way (Allen & Yen, 2002) support the construct validity of the measure. As it was necessary that this measure include tactile and cognitive concept development constructs, it was critical that the test developers considered current research that addressed both areas. Hatwell (2003b, p. 3) urged us to understand cognitive learning factors as research has shown that "marked improvement or the evolution of haptic exploratory procedures increase with age."

The development of the Boehm-3 Preschool Tactile Edition. Requests from educators in the field of visual impairment to revise the popular Tactile Test of Basic Concepts (Caton, 1983) for children in kindergarten through second grade increased as accountability standards for young children were raised in the last few years. There are several reliable and valid assessment tools that address the overall development of young children with visual impairment (e.g., Brambring, 2006; Maxfield & Buchholz, 1958; Vervloed, Hamers, Van Mens-Weisz, & Timmer-Van de Vosse, 2000), but there has not been an assessment tool that addressed the skills needed by preschool children who use tactual media in early academic learning of literacy and math concepts. One of the primary benefits of ECSE includes the preparation of young children for academic learning (Karoly, 2012). Quality early learning environments can mitigate at-risk home environments and low socio-economic status of children that is known to affect familiarity with numbers and letters as well as social emotional skills to interact with peers and adults. Unfortunately, the focus of the assessment tools listed earlier was for

determining developmental status, not to measure knowledge of basic academic skills or guide instruction in this area.

Brambring (2006) created a scale based on differentiated acquisition of developmental milestones including sensory skills, using a very small sample, and Vervloed et al. (2000) attempted to create improved psychometric qualities for the Reynell-Zinken Developmental Scales. However, very small sample sizes and limited age ranges affect the usefulness of either of these assessment tools for progress measuring or research. Neither of these developmental assessments are used with any consistency in the United States, and they are observational checklists that do not provide objective scores as nominal level data.

The Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) was designed to be individually administered to children ages 3 years 0 months to 5 years 11 months and was adapted to tactile and large print editions in early 2011 in a collaborative effort among Dr. Ann Boehm, the American Printing House for the Blind, and the University of Northern Colorado. As the test items were chosen and modified, every effort was made to use relevant literature from both the fields of visual impairment and the most recent haptic development research and results from pilot study data (see Appendix A).

The link between cognitive understanding and tactile perceptual functioning is the most relevant in creating new test items for this age group, as this population is busy discovering the cognitive interpretation of objects and drawings through tactual discrimination, tactile-spatial perception, part-whole relationships, and an understanding of the second and third dimension. These “thinking” skills of haptic development are the closest to the “basic concept” understanding in the Boehm-3 Preschool (Boehm, 2001a).

Texture complexity. Just as preschoolers with sight are drawn to brightly colored and engaging drawings or photos in their learning environment, young children with visual impairment are more engaged in exploring increasingly complex textures (Schellingerhout et al., 2005). The implication of this information is that individual children will seek out more complex tactual test items, but as they discriminate the symbol, their attention will not be on the relationships between the items, but on each item. To avoid this distraction during the test, tactile modifications included using simple and familiar items (Decker, 2010; Spence & Gallace, 2007). In designing individual test items, a concerted effort was made to replicate everyday stimuli such as zippers, spoons, and buttons; encouraging the child to attend to the concept being measured. Concrete objects such as blocks and bowls were used in some test items due to the difficulty of representing some basic concepts with depth, but the lack of a tactile assessment using two-dimensional stimuli for this age group (Mazella et al., 2014) and the need to challenge tactual learners to move toward representational understanding (Hall, 1983) resulted in a limited test stimuli pool.

Tactile symbols and language. Throughout the visual impairment literature, the value of pairing tactile symbols with language or using verbal cuing is debated (Berlá, 1972; Millar, 1994; Pathak & Pring, 1989). Although verbal descriptions do appear to assist in the memory recall for older children of elementary school age, for the 4- to 6-year-old child with visual impairment, there is no evidence that verbal cues help in tactile discrimination. In fact, the research shows that the younger children perform better when the symbols are not named (Pathak & Pring, 1989). In the development of the administration scripting for the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014),

limited identification of the stimuli was included in the instructions. Children were encouraged to recognize the stimuli through everyday exposure and tactile discrimination. Directions were kept to the simplest form possible and monitored for age appropriate vocabulary. Test administrator feedback in the pilot study included a request for more flexibility in the test item scripting and recommendations to have a method of sharing the test item stimuli with the children before the test administration. All scripting was reviewed for simplicity, and a Getting Ready binder was created to address this feedback.

Size and spacing of tactile symbols. Studies that looked at physical size and complexity of tactual symbols with blind children indicated that presenting different sizes of stimuli affects accuracy and performance time (Berlá, 1972; Millar, 1994; Pathak & Pring, 1989). As physical size of the stimuli increases, task time increases. It appears that there is an optimal stimuli size for tactual discrimination, and that consistency across stimuli will increase accuracy. In the development of the tactile version of the Boehm-3 Preschool (Ferrell et al., 2014), it was decided to create items that varied in sizes so that preferences could be better evaluated. Feedback from the test administrators who participated in the pilot study indicated that spacing between items appeared to be more relevant than the size of the stimuli themselves. Students struggled with items that were placed close together or if there was too much on the page. Tactual page numbers on the pages were often distracting (see Appendix A). Additional observations in this validation study did not indicate differences in the size of the stimuli, but the organization of the stimuli was noted to affect some children's responses. Items that were presented in a horizontal format appeared to take less time than scanning items in a "two up, two down" format.

Differences among distractors. Another area of concern in adapting the Boehm-3 Preschool (Ferrell et al., 2014) focused on the differences between distractors. In the Tactual Picture Recognition Study (Pathak & Pring, 1989), the following results indicated that young children are more likely to mistake distractors that contain some feature of the original than items that are very different from each other. Pertinent results of this study included

> 1. Both the children who were blind and the blindfolded sighted children selected a distractor that shared some perceptual features with a target more often than a random distractor in incorrect responses.
> 2. On incorrect responses, feature distractors were only selected more frequently than random ones when the objects depicted had been previously experienced through touch. (Pathak & Pring, 1989)

In consideration of these results, test item distractors were designed to have significant feature differences to allow for less confusion while taking the assessment. Distractors that have more random differences allow for more efficient discrimination by the young tactile learner. An example would be that using a spoon and a toothbrush in an item, rather than a spoon and a fork, may support correct responses. The selection of stimuli was made with the understanding that most children of preschool age would have previous experience in their everyday lives with these items.

Uses of the Boehm-3 Preschool Tactile edition. The tactile adaptation of the Boehm-3 Preschool (Ferrell et al., 2014) by APH provided the field of visual impairment with a unique opportunity to validate a relevant assessment tool using the rigorous method of item response theory to determine its psychometric qualities. If rigorous statistical measurement research is successful, the Boehm-3 Preschool Tactile Version will be valuable for guiding instruction and progress monitoring for young children with visual impairment in the preschool learning environment. In addition, it has the potential

as a validated assessment tool to add to the second-generation research base in the field of visual impairment to drive the future understanding of early academic concept acquisition for tactual learners that affects early literacy and numeracy skills.

Summary

Tactual assessments no longer need be the purview of specialized educators who only interact with young children on a consultant basis or have limited training in early childhood teaching methods. While ongoing collaboration with educational vision professionals is critical, general education teachers in inclusive classroom settings should assess young children with visual impairments in order to insure appropriate instructional consistency. There is a need for valid tactual assessments to be available and easy to administer in the early childhood classroom. In establishing unified validity, valid tactual assessments will provide an informative tool that can determine exactly what young children with visual impairment know in the area of basic relational concepts to guide instruction and research questions. This study attempted to demonstrate that rigorous measurement validation is possible with the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014), providing an assessment tool that can assist families, instructors, and researchers in the field of visual impairment.

CHAPTER III

METHODOLOGY

The primary purpose of this study was to examine the reliability and validity of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) for young children with visual impairment. The methods by which this study examined the properties expected in genuine psychometric tests addressed the following research questions:

Q1 Is the tactile edition of the Boehm-3 Preschool unidimensional?

Q2 Do the Boehm-3 Preschool Tactile Edition scores fit a developmental Mokken Scale analysis?

Q3 Will the Boehm-3 Preschool Tactile Edition scores show construct validity with an investigator-created Smyth Developmental Rating Scale?

Three research questions were proposed to build evidence of reliability and validity in this study. Research Question 1 submitted that an exploratory factor analysis (EFA) would provide results that the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) measured a single construct and, thereby, had the desirable property of unidimensionality. Research Question 2 posed that a Mokken scale analysis of the Boehm-3 Preschool Tactile Edition would show probabilistic evidence that young children with visual impairment would be able to correctly answer more of the test items as they grow older. Exploring the sensitivity of the instrument added to its validity through the developmental structure of the test items. Research Question 3 submitted that children with age-appropriate or better haptic and concept development skills would

be able to answer test items at a similar developmental level on the Boehm-3 Preschool Tactile Edition. Construct validity would be examined with the Smyth Developmental Rating Scale and could provide guidance in the future use of the Boehm-3 Preschool Tactile Edition for instructional purposes and, thus, increase the rigor of its psychometric properties.

Research Design

A factor analysis research design was used to create a correlation matrix (R) of the sets of concept test scores collected from the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) to "identify the important variables that influence performance" (Allen & Yen, 2002, p. 113). Even with the small sample size and the presence of dichotomous scores, factor analysis would make clear the interrelationships such as correlations and factor loadings present in the collected test scores. A parallel EFA using a principle components permutation using ordinary least squares with SPSS computer software (IBM Corporation, 2013) was employed.

Validity for the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) was examined using an item response theory (IRT) method of analysis (Demars, 2010). The non-parametric Mokken Scale (van Schuur, 2011) allowed for a smaller sample size and looked at both item and person fit of dichotomous items. The probabilistic nature of the Mokken scale is more reasonable when assessing younger children whose answers may be unpredictable (Division for Early Childhood, 2007). The Mokken scale provided a method to assess sensitivity of the Boehm-3 Preschool Tactile Edition through establishing a functional hierarchy and graduated scoring of the assessment (Bagnato et al., 2014; Bouwmeester & Sijtsma, 2006). It is critical for conventional assessment tools

in early childhood education to address the recommended research standards and practice guidelines developed by the field (Barnett, Riley-Ayers, & Francis, 2015; Greenwood & McConnell, 2011; Macy et al., 2007) for future use in correlational research.

A correlational research design was employed to measure the construct convergent validity of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) with the Smyth Developmental Rating Scale, a measurement created by the researcher to collect information from the test administrators about the child's relevant cognitive and haptic developmental skills. The following study procedures that were chosen and completed during this research were designed to build validity components (see Table 1).

Internal Review Board Permission

This research study required an expedited review from the University of Northern Colorado Institutional Review Board (IRB), as data were collected on young children with visual impairment between the ages of 3-0 and 5-11 years. Permission was obtained to validate the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) through submission of the following documents to the online IRBnet system: (a) application narrative (see Appendix C), (b) consent and assent forms (see Appendix C), and (c) the project specific research tools (see Appendix B). Assent forms were necessary because the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) was administered to minor children. Consent for the testing was also requested from the children's parents or guardians. In addition, consent was sought from the recruited adult test administrators across the country. Data collection began as soon as the research project was approved. A renewal request was submitted to the online IRBnet system in September of 2016 with a change to the consent form for the adult test administrators. It was slightly amended

Table 1

Summary of Procedures

Step	Procedure
1	Submitted IRB application for approval.
2	Collected data from an expert review panel to finalize the *Smyth Developmental Rating Scale.*
3	Created online training protocol video to demonstrate best practices in administering the *Boehm-3 Preschool Tactile Edition*.
4	Entered the *Smyth Developmental Rating Scale* and the *Boehm-3 Preschool Tactile Edition* administration competency quiz into Qualtrics (2013) for data collection.
5	Contacted teachers of preschoolers with visual impairment from around the country through (a) professional relationships (b) group training sessions, and (c) online social media requests to teachers that work with children with visual impairment in preschool settings.
6	Distributed consent forms and instructions for participation to test administrators indicating an interest in the study, including access to the online training protocol video.
7	Directed consenting participants to the *Boehm-3 Preschool Tactile Edition* administration competency quiz and how to order the assessment.
8	Distributed consent forms to professionals who completed the competency quiz or arranged for a testing session for parents of children with visual impairment who were administered the *Boehm-3 Preschool Tactile Edition*.
9	The *Smyth Developmental Rating Scale* in Qualtrics (2013) generated an ID response number that was sent to the investigator through email.
10	Collected *Boehm-3 Preschool Tactile Edition* Record Form or online scores (n = 120) and Parent consents forms from participants (n = 107), and entered test scores into SPSS statistical software and R package mokken software.
11	Completed data analysis.

to address the video portion of the process as the video was never used by teacher participants. Data collection resumed as soon as the amended form was approved (see Appendix C).

Participant Selection

The nature of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) limited the number of possible participants, because it was designed for a specific population of learners. Visual impairment presents as a low prevalence exceptionality, and data are limited as to exactly how many school age children are receiving services such as braille instruction.

Numbers of young children with visual impairment in preschool are even more elusive due to poorly managed measurement, identification, and eligibility accountability standards (Macy et al., 2014). Inconsistencies among federal data systems (National Survey of Children's Health, 2012; U.S. Department of Education, 2012) in early childhood have resulted in a generalized understanding that the incidence of all exceptionalities is increasing (Boyle et al., 2011), but there was not reliable information on the specific categories of visual impairment or blindness. Due to the potential of large geographic distances between participants, funding for travel for the investigator to administer the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) was necessary. Dr. Ann Boehm, the creator of the original Boehm-3 Preschool test (Boehm, 2001a) and a collaborator on the Boehm-3 Preschool Tactile Edition, generously provided access to a fund created through donations made to Teachers College for the study of blind and visually impaired children.

Selection Criteria

The Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is an assessment tool designed to provide information about the concept understanding of children who use their tactile abilities as their primary modality to discover and interpret the world. Despite recommendations from the field (Mazella et al., 2014), a control group of sighted children was not appropriate as their previous learning experiences will have included simultaneous, visual constructs of the concepts. Vision is one of the first brain processing systems to develop (Johnson, 2010), and even preschoolers (Glass, 2002; Koerber & Sodian, 2008) have a sophisticated system of visual orientation. Therefore, the purposeful sample selected to contribute to the validation of this assessment met the following criteria:

- Children with a diagnosed visual impairment between the ages of 3-0 and 5-11 years.
- Children who primarily learned through their tactile sense and were potential braille readers.
- Children who were able to independently scan and locate tactile stimuli on a page.
- Children who had the cognitive ability to follow simple directions and answer questions with minimal adult prompting.

The child participants were identified thorough communications with individual parents, teachers, and educational organizations through national listserves and personal contacts. Child participants were invited from both inclusive community preschools and from specialized preschools for children with visual impairment. A total of 38 children were

administered the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) in inclusive community settings, and 69 children were from specialized preschool settings.

Sample size

A sample of 107 qualified participants was tested with the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014), and 46 teacher participants completed the Smyth Development Rating Scale. In order to collect sufficient data (Pearson & Mundfrom, 2010; van Schuur, 2011) across participant ages and to establish developmental scale data, the Boehm-3 Preschool Tactile Edition was administrated to 60 children in the 3 years to 3 years, 11 months age range, 30 children in the 4 years to 4 years, 11 months age range, and 30 children in the 5 years to 5 years, 11 months age range (see Table 2). The test was administered in two sections. Children ages 3 years to 3 years, 11 months began the test at the first item and finished the items through the end of the second binder. Children ages 4 years through 5 years, 11 months began the test from the beginning of the second binder and moved through the end of the third binder. This division allowed for the same amount of sample participants *(n* = 60) in each section of the test. The smaller number of participants in the 4 years to 4 years, 11 months and 5 years to 5 years, 11 months age groups had implications in the developmental scaling of the assessment and is discussed in Chapter IV.

The investigator was invited to return to administer the Boehm-3 Preschool Tactile Edition at two specialized school sites during data collection and assessed 13 children at both visits because they were then in the older age group. (See Table 3).

Table 2

Age Distribution of Participants

Age (in Months)	Number of Participants
3.0 – 3.5	26
3.6 – 3.11	34
4.0 – 4.5	15
4.6 – 4.11	15
5.0 – 5.5	19
5.6 – 5.11	11

Table 3

Ages of Children Assessed Twice (n = 13)

Age at Initial Assessment	Age at Second Assessment
3 years, 4 months	4 years
3 years, 5 months	4 years, 1 month
3 years, 6 months	4 years, 2 months
3 years, 7 months	4 years, 3 months
3 years, 7 months	4 years, 7 months
3 years, 8 months	4 years, 4 months
3 years, 9 months	4 years, 5 months
3 years, 10 months	4 years, 6 months
3 years, 10 months	4 years, 6 months
3 years, 10 months	4 years, 10 months
3 years, 11 months	4 years, 7 months
3 years, 11 months	4 years, 11 months
3 years, 11 months	4 years, 11 months

All teacher participants were contacted by email or telephone by the investigator if they demonstrated an interest in administrating the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014). In order to ensure fidelity across test administrators for this study, a training protocol video using task-analysis (Carnahan, Basham, Christman, & Hollingshed, 2012; Weng, Savage, & Bouck, 2014) was created for participants interested in submitting scores for inclusion in the validation data to access online (see Appendix B). This training protocol video was available through a private YouTube link that included a link to a brief competency quiz with a 100% pass rate requirement on test administration procedures to establish fidelity criteria. Although the training protocol video was offered to all test administrators, it was not accessed throughout the study. Instead, several test administrators asked for procedural information about the assessment over the telephone or through a through an online Skype session as the teachers preferred for the investigator to travel to administer the assessment to their students in person. Eight teachers from across the United States did inquire about administrating the assessment on their own, but as they did not show interest in the online training video, the competency quiz for reliability was not administered. The final scores that were collected by these individuals were removed from the data analysis as fidelity was considered to be compromised without competency quiz results. After this error was discovered, the competency quiz was entered into Qualtrics, and any future interested teachers were required take the quiz with a 100% pass rate. Three teachers completed and passed this competency quiz for reliability. Upon reaching competency, a teacher participation code was made available to add to the Boehm-3 Preschool Record Form.

All teachers of the child participants were asked to complete the Smyth Developmental Rating Scale and an informal survey of demographic questions to collect descriptive statistics data (see Appendix B) that included the visual diagnosis, the presence of additional disabilities, early intervention educational experiences, and current educational experiences of each participant. These data were collected through a separate online Qualtrics (Qualtrics, 2013) survey for ease of analysis. When the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) was administered by the investigator, paper copies of of the Smyth Developmental Rating Scale were given to the child's teacher to fill out onsite. No teachers were able to complete and return the paper copies. Therefore, a link to the Smyth Developmental Rating Scale was sent to every teacher participant, and reminders were sent out every two weeks if the survey was not completed. A total of 46 Smyth Developmental Rating Scale surveys were completed.

Instruments

The instruments used to build unified validity components for this study included the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) and the Smyth Developmental Rating Scale. The first was adapted into a tactile version with the application of haptic development understanding and the second is a collection of age-expected fine motor and cognitive skills acquired by young children in preschool. For young children with visual impairment, evaluating their level of competence in these areas can predict success in an academic setting as well as providing a direction for further instruction (Dunst & Gorman, 2011; Koenig & Farrenkopf, 1997).

Boehm-3 Preschool Tactile Edition

The Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014), was adapted from the Boehm-3 Preschool, a downward extension of the Boehm Test of Basic Concepts, Third Edition (Boehm, 2001a) and a test of basic concepts that requires skills in the areas of language and cognitive understanding. As the Boehm-3 Preschool Tactile Edition measures the concept relationships of the stimuli and not recognition of the stimuli itself, an introductory binder of all of the test stimuli to assure familiarity with the items was provided for use with the assessment.

The Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) consists of 82 items divided into three binders. Children ages 3-0 to 3-11 begin the test with items 1 through 24 (12 concepts) and continue till the end of Binder Two that contains items 25 through 52 (14 concepts). Children ages 4-0 to 5-11 begin the test with Binder Two (14 concepts) and continue to the end of Binder Three that contains items 53 through 82 (15 concepts). Each relational concept is tested twice for confirmation of understanding.

The development of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) began in 2011 and was a collaboration between the original author of the Boehm-3 Preschool, Dr. Ann Boehm, the University of Northern Colorado, and the American Printing House for the Blind (APH). A rigorous literature review provided guidance in choosing tactual stimuli and developmentally appropriate testing strategies. Items contained in another APH product, Tactile Treasures, were introduced to a small group of preschoolers with visual impairment to discover their preferred test stimuli for use in a tactile prototype. A limited group of functional, everyday stimuli were chosen to represent the concepts measured in the original assessment. In the pilot study, test

administrators requested the creation of a *Getting Ready* binder (see Appendix A). This addition to the Boehm-3 Preschool Tactile Edition allows early childhood teachers and vision professionals to review the stimuli present in the assessment so that participants can be focused on the conceptual relationships between the item stimuli, not the stimuli themselves. It was recommended that children should not attempt the assessment until they were able to tactually discriminate most of the stimuli in the *Getting Ready* binder.

Previous research indicated possible cognitive overload for children this age with four stimuli included in each test item, so the prototype included a random assignment of concepts with three stimuli or four stimuli. Every effort was made to match the original questions, ordering, and answer placement in the Boehm-3 Preschool (Boehm, 2001a). The initial prototype was field tested as a part of a pilot study in 2011-2012 in five different states with 13 children ages 3, 4, and 5 (see Appendix A).

Results of the pilot study demonstrated a developmental progression of correct answers, except for the 4-0 to 4-5 age group. There were no participants of this age group in the pilot study for the tactile version. Closer inspection of the data revealed a possible "fatigue factor" in the oldest group as most of the choices at the end of the assessment did not appear to be purposeful answers. Increased administration times for the tactile version supported this hypothesis. Other information that was gathered from the field test included instances of difficulty interpreting more abstract stimuli, such as arrows, or with the array of the items. Overall, horizontal presentations were preferred over vertical presentations. Braille reading instruction is modeled in a horizontal, left to right progression, and young tactile learners have few opportunities to scan vertical presentations.

Changes generated by the pilot study that were made to the initial prototype included item orientation, size, and position adjustments. Some verbal instructions were clarified to promote understanding. Stimuli were re-evaluated for consistency and clarity (the size of beads or the orientation of buttonholes), which resulted in the changing of the tactual molds created by APH. Changing the number of stimuli to three showed no evidence of significant differences in any age group, so the original number of four stimuli for each item was maintained. Some of the concepts that implied motion or 3-dimensional positioning (up, down, and front) were integrated as performance items using the child's own body or a set of manipulatives. Eighty-two test items made up the finalized assessment, divided into three three-ring binders that allowed for the test administrator to present each test item one at a time.

The Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is easily administered in the preschool classroom or natural learning environment of the child. Testing procedures for administering the Boehm-3 Preschool Tactile Edition are described in detail in Appendix B. The Record Form provided the recommended verbal instructions to allow for consistency across administrations. The informal nature of the test and ease of use means that teachers of students with visual impairment (TSVIs), early childhood special educators or early childhood educators (ECSEs/ECEs), speech/language pathologists (S/LPs), educational diagnosticians, and school psychologists were qualified to administer and interpret the assessment. Due to the unique development and learning needs of individual young children with visual impairment, it is highly recommended that the test administrator consult with a TSVI (Spungin & Ferrell, 2007) before the assessment is given. Important information to

consider and discuss before engaging in the assessment process include understanding the child's prior tactile discrimination knowledge of the item stimuli in the *Getting Ready* binder, the child's stamina for table-top tasks with high cognitive load, and the child's prior concept understanding with real life experiences. Results of the assessment should also be interpreted within a collaborative team approach to ensure that the process of tactile learning is understood and appropriate learning objectives are developed based on the information gained.

Smyth Developmental Rating Scale

The Smyth Developmental Rating Scale included in this research investigation was created to collect both demographic information on child participants and their early childhood teachers and to understand the level of relevant cognitive and haptic development skills of the participants. Demographic questions included the child participant's age, visual diagnosis, the presence of additional disabilities, and the educational setting (Table 4). The teacher participants also indicated whether the child received EI services, how old the child was when he or she started receiving those services, how long the child has been in preschool, and how long they had been the child's teacher (See Table 5). Teachers were asked their opinion if this specific administration of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) was an accurate representation of the child's current understanding of concept development. Many items in this demographic data collection were inconclusive due to the amount of missing data (see Appendix B).

The Smyth Developmental Rating Scale was created by the investigator because it could be easily administered and contributed to authentic procedures as an observational

Table 4

Summary Table of Child Demographic Data collected from the Smyth Developmental Rating Scale

Characteristic	*Rating Scale Responses (n = 46)*	*M (SD)*
Visual Diagnoses		
Optic Nerve Hypoplasia	14	
Cortical Visual Impairment	7	
Albinism	5	
Retinal Disorders	5	
Anophthalmia, Microphalmia, Cryptopthalmus	4	
Aphakia, Cataracts	2	
Aniridia, Glaucoma	2	
Colobomas	2	
Nystagmus	2	
Other	2	
Preschool Attendance		
First year	19	
Second year	21	
Third year	6	
Received Early Intervention		
Yes	43	
No	3	
Time to complete *Boehm-3 Preschool* (in minutes)		22.87 (23.30)

assessment. It also provided information on the developmental concept skills of the children using the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014). An expert panel consisting of eight individuals with at least 10 years of practitioner experience were invited to review and comment on the Smyth Developmental Rating Scale, and minimal changes were made. These changes included adding clarifications to items in the form of examples describing each functional activity. The overall recommendation of the group was to provide clearer descriptions of the kinds of observations the teacher should be considering.

Table 5

Summary Table of Teacher Participant Demographic Data collected from the Smyth Developmental Rating Scale

Characteristic	*Teacher Participants (n = 19)*	*M(SD)*
Title		
TSVI	14	
Classroom Teacher	4	
COMS	1	
Years working in VI	19	8.84(8.58)
State		
Utah	6	
Colorado	4	
Missouri	4	
Texas	3	
California	2	
Program Type		
Inclusive	10	
Specialized VI	9	

Each developmental fine-motor and cognitive skill demonstrates the kind of understanding necessary for construct validity with the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014). Twenty-five items were presented in a 5-point Likert scale that consisted of levels titled *Not Yet, With Assistance or Prompt, Once, Emerging Independence,* and *Consistently*. The test administrator was asked to give the child credit at the level of observed behaviors only. Items for the Smyth Developmental Rating Scale were drawn from multiple developmental checklists for this age group (Brown, 2005; Frankenburg, Dodds, Archer, Shapiro, & Bresnick, 1992; Squires, Bricker, Twombly, & Potter, 2009). The Smyth Developmental Rating Scale does not have its own unified validity, as it was created for this investigation, but previous research in the fields of both haptic and cognitive development suggested that the functional skills it measures were

related to the success of young children with visual impairment in understanding basic relational concepts.

Data Analysis

Once all of the Smyth Developmental Rating Scale results and the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) scores were received, the investigator followed the data analysis plan. This plan is shown in Table 6.

Table 6

Boehm-3 Preschool Tactile Edition Data Analysis Plan

Research Question	Instrument	Data Analysis	Sample
Is the tactile edition of the *Boehm-3 Preschool* unidimensional?	*Boehm-3 Preschool Tactile Edition* Items 1 – 82 (41 concepts)	Kaiser-Meyer-Olkin Measure (KMO), Bartlett's Test of Sphericity Factor Analysis: Parallel Analysis Cronbach's Alpha	Concept scores of all child participants who met selection criteria: 3-year-olds (*n* = 60) 4-year-olds (*n* = 30) 5-year-olds (*n* = 30)
Will the *Boehm-3 Preschool Tactile Edition* scores show convergent construct validity with the *Smyth Developmental Rating Scale*?	*Smyth Developmental Rating Scale*	Expert Panel Review Convergent construct validity: Spearman's correlation coefficient	Team of professionals who are experts in child development for children with visual impairment (*n* = 8) Matched *Smyth Developmental Rating Scale*?results (n = 46)
Do the *Boehm-3 Preschool Tactile Edition* scores fit a developmental Mokken Scale analysis?	*Boehm-3 Preschool Tactile Edition*: Items 1-52 (26 concepts)	Mokken Scale Analysis: Monotone Homogeneity Double Monotonicity Reliability Index	Concept Scores of all Child participants who met selection criteria: 3-year-olds (*n* = 60)
	Boehm-3 Preschool Tactile Edition: Items 25-82 (29 concepts)	Mokken Scale Analysis: Monotone Homogeneity Double Monotonicity Reliability Index	Concept Scores of all Child participants who met selection criteria: 4-year-olds (*n* = 30) 5-year-olds (*n* = 30)

Exploratory Factor Analysis

Exploratory factor analysis (EFA) provided a place to begin exploring the collected data set of assessment scores. Although it is by no means error-free, or even a procedure that can establish generalizability for measurements results (Costello & Osborne, 2005), EFA is a standard beginning process in the application of rigorous measurement theory. The purpose of using factor analysis was to investigate the underlying theoretical structure present in the test. This allowed the validation process to examine each individual item to see if the item contributed to the constructs identified by the EFA. The best assessments tools are unidimensional, or they measure one identified construct at a time (Tabachnick & Fidell, 2007).

Potential factors that were considered in the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) included the "types of concepts" (Boehm, 2001b) or the original categories suggested by the author. These types include spatial, temporal, and quantity concepts. Another way to break down the factors was to look at the performance items and the tactual items separately. As a "fatigue factor" was detected in the pilot study (see Appendix A), this was another potential for factor consideration.

The initial task was to attempt to provide evidence that a correlation matrix has factors. If there are no correlations over .50, the necessity of an EFA is questionable. Both the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were relevant statistical procedures to determine EFA appropriateness (Revelle, 2017; Tabachnick & Fidell, 2007). The KMO is a ratio of the sum of squared correlations to the sum of squared correlations plus sum of squared partial correlations. If the partial correlations are small, the value will approach 1; any value above .6

indicates the possibility of an adequate EFA. Bartlett's test of sphericity is a test of the hypothesis that all diagonal values are 1, and all the non-diagonal values are 0, meaning that all the scores are not correlated. If a factor analysis is to proceed, Bartlett's Test of Sphericity must be less than 0.05. This demonstrates the validity and suitability of the responses collected for an EFA. Chapter IV includes a detailed discussion of the results of the KMO and the Bartlett's Test of Sphericity.

Characteristics of a sample can influence the necessary size of a particular sample, allowing for the use of smaller numbers (DeWinter, Dedou, & Wieringia, 2009; MacCallum, Widaman, Zhang, & Hong, 1999; Pearson & Mundfrom, 2010). For example, Reise, Comrey, and Waller (2000, p. 290) maintained that "if communalities are high (>.6) and the factors are well-defined," smaller sample sizes are adequate. Results of a previous factor analysis of the Boehm Test of Basic Concepts (Piersel & Reynolds, 1981) indicated a high coefficient of congruence (.97) and the presence of a single factor loading.

Item format can also affect factor analysis stability. "The linear factor analysis model assumes that variables are measured on continuous, interval-level scales" (Reise et al., 2000, p. 289). As the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) has dichotomously (right/wrong) scored items, this assumption could not be met. This often results in instability in the correlation matrix. However, improvements in statistical procedures and computer software analysis addressed the concerns in dichotomous item issues and did not affect the quality of this EFA (Pearson & Mundfrom, 2010).

In addition, dichotomously scored measurements are frequently more efficient, which may have been a benefit given the age range of the participants. The use of SPSS (IBM Corporation, 2013) to accomplish the EFA allowed the researcher to perform a principal component analysis (PCA) with the number of factors determined by parallel analysis (PA) in this investigation of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014).

Factor Extraction

The "best method of factor extraction" has been a controversial issue in exploratory factor analysis for many years. Determining which method was the best for this investigation was unknown until scores were collected and analyzed. However, understanding the characteristics of the data associated with this particular assessment did allow for predictions that guided the initial analysis.

This validation study analyzed the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014), which had a dichotomously scored item format with a limited sample of scores (n = 120). The typical process used to engage in factor extraction is to create a scree plot, in which the responses to all 21 or 29 concept scores (depending on the age of the participant) were compared to each individual. The linear data provided from the scree plot produced eigenvalues (a percentage of variance in a dimension) and showed an "elbow" in the data, with the higher factor loadings above the elbow (Reise et al., 2000; Tabachnick & Fidell, 2007). In using a parallel analysis, the concerns of a small sample of scores were addressed as additional random data sets were generated from the original data sets using the same number of items and participants to compare with the eigenvalues in the scree plot (Pearson & Mundform, 2010; Reise et al., 2000). Averaging

eigenvalues from multiple data matrices resulted in more robust factor estimates. The use of computer software such as SPSS (IBM Corporation, 2013) allowed for easy random data matrix construction.

Another method of factor extraction that addressed the characteristics of this study was minimal residual (minres) analysis. The minres solution is an unweighted least squares solution that adjusts the diagonal elements of the correlation matrix to minimize the squared residual when the factor model is the eigenvalue decomposition of the reduced matrix (Revelle, 2017). Off diagonal differences are considered and communalities come from the actual solution, rather than estimated as part of the solution (Tabachnick & Fidell, 2007).

Mokken Scale Analysis

Using item response theory to determine the validity of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) required the application of an ordinal model called the Mokken Scale (Smits, Timmerman, & Meijer, 2012; van Schuur, 2011). The dichotomous answers to the Boehm-3 Preschool Tactile Edition allowed for the creation of scale values, which were used as measurements to determine the relationship between participants and the concept scores. "The measurement values are ordinal, which means we know that the measurement value on the variable we measure increases from one group to the next, but we don't know how much it increases" (van Schuur, 2011, p. 8). The process of predicting scalability (or ordering by difficulty) requires an understanding of where each concept score belongs on the scale and its potential for correlation with the other scores on the scale. For example, ideally, an "easier" item would be found earlier in the scale, while a more difficult item would appear later. A perfect cumulative

deterministic scale means that all participants who answer a more difficult item on the scale were able to answer all the previous easier items on the scale. How individuals answered the questions implied that some of the questions were easier than others. Measuring abilities, such as concept knowledge, required the use of scale values on an implicational or cumulative scale.

The idea of a "perfect scale" provided a standard to identify model violations in item responses and statistical levels of error for whether items were appropriate for the scale. A perfect deterministic scale is unlikely when assessing young children, as was the case for this investigation. Factors such as fatigue, loss of interest, and limited attention spans were encountered during the test administrations (DEC, 2007; Neisworth & Bagnato, 2004).

Monotone homogeneity. In order to determine the level of error through model violations, cross tables for each concept score (scalograms) were generated to demonstrate scalability using Loevinger's (1948) coefficient of homogeneity, or H. In ordinal cumulative scale analysis, it is more appropriate to establish homogeneity than reliability. Homogeneity, or maximum internal consistency, indicates that different items measure the same latent trait. In contrast, reliability addresses the idea that when the same question is asked again, the researcher will receive the same response. In the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014), no question is repeated, although items focusing on the same relational concepts are present. Homogeneity creates the best possible scale as a result of comparing the number of errors observed with the number of errors expected under statistical independence (van Schuur, 2011, p. 21). H = 1 would be considered a perfect model because a cumulative scale is the result

of homogeneity testing. It is suggested that concept scores with a lower boundary of H = .30 are not sufficiently homogeneous to include in a cumulative scale. Scores of insufficient homogeneity are potentially unrelated to the scale. In these situations, the researcher should consider the possibility of removing these particular scores in order to improve the scale.

Double monotonicity. As mentioned earlier, a perfect scale that meets all the assumptions of a deterministic scale is unlikely when assessing young children of preschool age. Responses that do not meet the criteria of a perfect model mean that the probabilities are not just 0 or 1, but anything in between. A more probabilistic model, or the double monotonicity (DM) model, would suggest that regardless of the ability of the participant, the difficulty order of the concept scores would be the same. Double monotonicity for the entire scale looked at whether the concept scores were in the correct order for measuring the latent trait. Switching from a deterministic model to a probabilistic model requires a change in thinking and adjustments to assumptions. According to van Schuur (2011), the assumptions of the probabilistic model are:

1. The presence of a latent trait (such as relational concept knowledge) as a single trait that can be represented as a unidimensional continuum.

2. The probability of giving the positive response to each item does not decrease for participants with increasing values on the latent trait.

3. The probability of giving a positive respons to each item depends only on the scale value of the participant on the latent trait, and it is not due to any other influence. (p. 48)

In looking at the possible positive responses, if a concept score had a higher probability of a positive response for one person, then it should have the same possibility for all people, regardless of their ability. Concept scores that passed the test of the DM

model should never cross each other on the latent continuum. There are five tests of double monotonicity, and all were conducted on the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) concept scores.

A summary of fit indices with criterion for these analyses (Van der Ark, 2012) is available in Appendix B. According to Green and Frantom (2002), "a statistic known as 'fit' provides an internal mechanism for identifying inappropriate responses to the items, allowing exclusion or re-assessment of persons whose responses make no sense, i.e., do not fit, according to our understanding of the construct" (p. 5).

Examining Reliability

Best practice in measurement research for young children requires rigorous separate reporting in the areas of reliability evidence and standard errors of measurement by age level. Fidelity across test administrators was addressed through the requirement of completing the competency quiz with a 100% pass rate.

Subgroups were broken into three age bands for the two different groups, 3 years to 3 years, 11 months, and 4 years, to 5 years, 11 months, which allowed for enough concept scores in each group. Standards 2.11 and 2.12 (AERA et al., 2014) address the generally held principle that the consistency of children's responses to test stimuli and, therefore, the reliability tends to increase with age and across diverse groups. Reliability estimates based on scores from combined age groups or developmental levels are likely to be spuriously high. Measures that are intended for younger children require more narrow age ranges of the subgroups to estimate reliability (Lambert et al., 2006).

The Mokken scale analysis has a unique, but approved method of establishing reliability. This is referred to as the reliability index (Sijtsma & Molenaar, 1987, 2002),

and it is accomplished through a series of tests in the statistical package of Mokken in R (Van der Ark, 2017). A reliability index required analyzing concept score difficulties and concept score discrimination characteristics, in particular the correlations between the scores and the sum of the scores of the entire test.

One way of looking closely at the tests for the DM model was the use of the ability-based restscore groups, and another concept score analysis, such as Cronbach's alpha (Tavakol & Dennick, 2011), was a procedure used to confirm reliability. Reliability index values should increase as the number of (homogeneous) items increased. Reliabilities over 0.60 are recommended for an assessment such as Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014). These non-parametric item analysis tests (Sijtsma & Molenaar, 1987; Smits et al., 2012) have an empirical history of resulting in less bias of reliability than classical test methods.

Examining Validity

It is important for educators to use assessments that accurately measure the claims made about what the test can do. For example, if teachers are claiming to measure the understanding of relational concepts by a 3- to 5-year-old child, it is important to determine what concepts to include and in what developmental order those concepts are acquired. Once these initial decisions have been made, it is necessary to build evidence of content validity and construct validity (Allen & Yen, 2002; Clark & Watson, 1995; Messick, 1995).

Content validity involves having a thorough knowledge of the measure's subject matter through literature searches and experience in the subject area. The Boehm-3 Preschool (Boehm, 2001b) has well-established content validity, and all of the original

items were maintained throughout the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014). Some test items were modified into performance or demonstration items due to the inability to represent them in a two-dimensional format. Some test items were added from the Boehm Test of Basic Concepts (Boehm, 2001a) in an attempt to address specific skills a future braille reader might encounter. It was important to evaluate the MH model (coefficient of H) of any test items that were modified to determine if they contributed to the content validity of the assessment. Coefficients of homogeneity (H), tests of double monotonicity, and test score reliabilities were calculated on the Boehm-3 Preschool Tactile Edition concept scores using the R package Mokken (Van der Ark, 2017).

Convergent construct validity was determined by the following methods: (a) rigorous test development and administration consistency, (b) Boehm-3 Preschool Tactile Edition item analysis, and (c) an examination of Spearman correlations between the Boehm-3 Preschool Tactile Edition and the Smyth Developmental Rating Scale.

Limitations of the Study

This study was designed to examine reliability and validity of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) for children of preschool age who were tactual learners. Instrument development is a complex process and requires rigorous and thoughtful analysis. Every effort was made throughout the creation of the Boehm-3 Preschool Tactile Edition to use recommended measurement guidelines (AERA et al., 2014) and best practices in early childhood assessment (DEC, 2007; Greenwood & McConnell, 2011). Despite these efforts, there were several limitations to this investigation.

The most significant limitations focused on the nature of the sample and sample size. The Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is a test that was developed for a specific population. Therefore, only those children who meet the criteria of being a tactual learner who is within the age-related boundaries were administered the test. Within this sample population there was great diversity affected by visual diagnosis, previous educational experiences, and the presence of additional disabilities (see Appendix B).

Sample size of test scores did not prove to be a limitation during this study. While most psychometric studies of assessments require a significant sample to address the effects of missing data, guessing, and significance level, careful preventative choices of statistical method addressed these concerns. Missing data were not a significant issue as this assessment was administered by an adult to the child, and the possibility of guessing was limited by maintaining four stimuli per item (Boehm, 2001b). The use of appropriate exploratory factor analysis tests that have been shown to be effective with samples under 200 (Pearson & Mundfrom, 2010), and a nonparametric Mokken scale analysis model addressed issues with smaller sample sizes. Nonetheless, additional examination of the data was conducted throughout the study for possible sample bias effects on the scores.

An additional limitation to this study was the investigator's creation of the Smyth Developmental Rating Scale to be used as a convergent construct validity measure with the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014). This measure did not have any validity at this time, as it had never been used. Caution was used in the interpretation

of the matched score results of this measure, especially when reporting convergent validity correlations though additional analysis to address possible test administrator bias.

Summary

A convenience sample of 120 test scores from young children with visual impairment ages 3 years to 5 years, 11 months was assessed with the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) to obtain raw scores for validity and reliability analysis. In addition, convergent construct validity was assessed with the Smyth Developmetal Rating Scale to determine a connection to haptic understanding of concept development. The participants were assigned to age-based groups for Boehm-3 Preschool Tactile Edition scale ordering and developmental differences.

All Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) concept score data were analyzed using descriptive statistics, principal component and minimum residual exploratory factor analysis, and Mokken scale analysis tests of monotonicity, double monotonicity, and reliability indices using the statistical software R package for Mokken (Van der Ark, 2017). The descriptive statistics gave a broad overview of item score data. The exploratory factor analyses examined the underlying constructs in looking for unidimensionality. The Mokken scale analyses tests evaluated item homogeneity, scale responses for error, and reliability concerns to address scale creation. Item intercorrelations and Spearman correlation coefficients were calculated to establish potential construct validity between the Boehm-3 Preschool Tactile Edition and the Smyth Developmental Rating Scale.

CHAPTER IV

RESULTS

This study examined the reliability and validity of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) for young children with visual impairment. Using statistical procedures such as exploratory factor analyses (EFA), Mokken scale analysis, and Spearman rank correlations, this study attempted to demonstrate a case for a measurement with unified validity components (Messick, 1995). The results of this study are reported in relation to the three research questions:

Q1 Is the tactile edition of the Boehm-3 Preschool unidimensional?

Q2 Do the Boehm-3 Preschool Tactile Edition scores fit a developmental Mokken Scale analysis?

Q3 Will the Boehm-3 Preschool Tactile Edition scores show construct validity with an investigator-created Smyth Developemental Rating Scale?

Item Analyses of the Boehm-3 Preschool Tactile Edition

As part of the study, a total of 26 items were analyzed in the 3-year-old age group and 28 items for the 4- and 5-year-old age group for 120 Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) administrations as concept scores by using data screening and preliminary descriptive statistics. Descriptive statistics help to organize quantitative information in a manageable form. There were no items in either age group that were passed or failed by all participants, so it was unnecessary to remove any before the

scaling analyses. A summary of the distributions of the concept scores for the 3-year-old age group (see Table 7) through an investigation of the means and standard deviations indicated that the test items were not too easy or too difficult for this particular group of participants.

Table 7

Three-year-old Concept Score Descriptive Data

Concept Score	Mean	Standard Deviation
C_top	.83	.94
CP_down	.93	.82
C_empty	1.05	.93
C_under	.73	.78
C_highest	.73	.84
C_missing	.88	.94
C_next	.80	.92
C_another	1.00	.92
CP_up	.95	.87
C_full	.85	.88
C_outside	.82	.91
C_all	.85	.90
C_nearest	.80	.94
C_finished	.68	.89
C_smallest	.78	.92
C_across	.50	.73
C_different	.70	.85
C_longest	.68	.89
CP-in front of	.52	.77
C_both	.63	.86
C_around	.73	.90
C_tallest	.73	.90
C_many	.62	.87
C_same	.72	.89
C_most	.67	.90
C-largest	.55	.83

Finally, skewness (or the symmetry of score distribution) allowed the investigator to determine that the scores did not show a normal distribution for the age group data for this particular group of participants (see Figure 1). The absence of a normal score distribution is important in deciding whether to use a nonparametric statistical procedure and IRT with a given set of measurement scores.

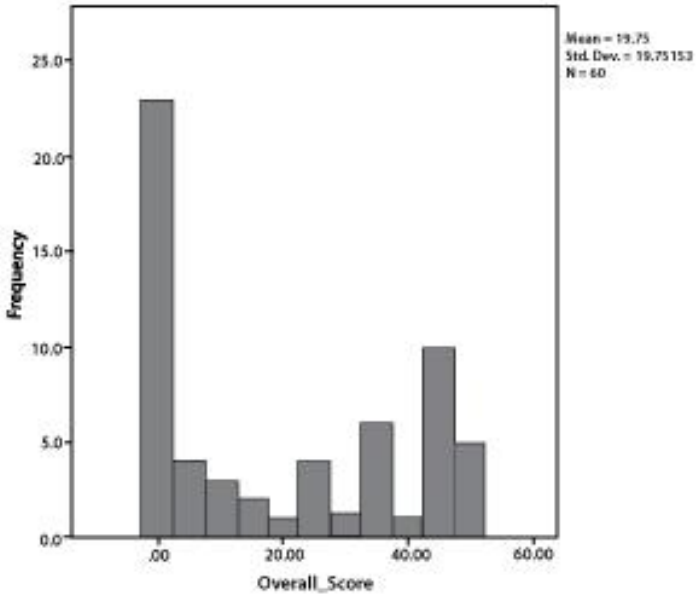

Figure 1. Concept score distribution for 3-year-old group data.

Again, a graph that demonstrates symmetry of score distribution for the age group data for the 4- and 5-year-olds allowed the investigator to determine that these scores also did not show a normal distribution. Figure 2 illustrates this distribution.

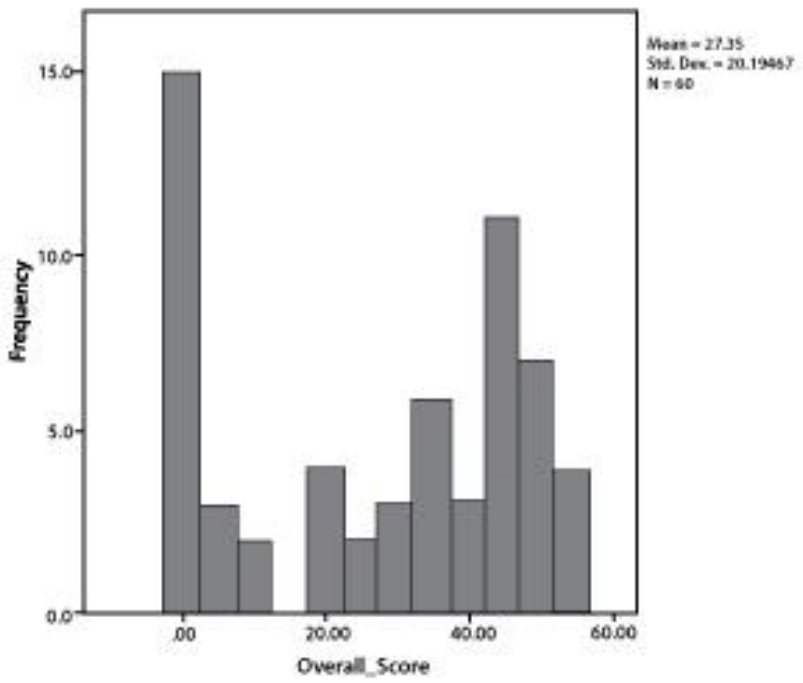

Figure 2. Concept score distribution for 4- and 5-year-old group data.

Similarly, the means and standard deviations of the concept scores for the age group data for the 4- and 5-year-olds (see Table 8) indicated that these items were also not too easy or too difficult. The descriptive statistics gave a broad overview of item score data that demonstrated evidence of a developmental scale with increased means for the age group data for the 4- and 5-year olds, and non-symmetrical score distributions.

Table 8

Four- and 5-year-old Concept Score Descriptive Data

Concept Score	Mean	Standard Deviation
C_nearest	1.15	.88
C_finished	1.28	.89
C_smallest	1.32	.87
C_across	.80	.90
C_different	1.20	.82
C_longest	1.23	.91
CP_in front	1.10	.95
C_around	1.15	.92
C_tallest	1.13	.89
C_many	1.17	.94
C_same	1.25	.91
C_most	1.20	,94
C_largest	1.15	.94
C_before	.87	.87
C_farthest	.98	.93
C_lowest	.92	.91
C_shortest	.98	.93
C_last	.97	.92
C_bottom	1.00	.92
C_together	.93	.86
C_some, bnm	.68	.79
C_middle	.83	.92
C_first	.78	.90
C_between	.67	.86
C_least	.62	.86
C_right	.75	.93
C_corner	.57	.79
C_left	.67	.86

Exploratory Factor Analysis of the Boehm-3 Preschool Tactile Edition

Establishing the unidimensionality of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) and answering the first research question required conducting an exploratory factor analysis (EFA). The initial EFA with the raw item scores was unsuccessful. The correlation matrix using 52 items for the data for the 3-year-old group and 58 items for the data of the 4-and 5-year-old group for 60 test administrations in each group had a result of "not positive definite." As noted earlier, a small sample size, a small ratio of items to people, as well as dichotomous answers, can adversely affect statistical results of an EFA (Anderson & Gerbing, 1984). Indeed, that was the situation in the current study where the communality was less than 0, and the extraction could not be performed. In this case, sampling fluctuation and limited measurement error required combining the item raw scores into "concept scores" to adjust the proportion of participants to scores. This procedure is termed parceling (Little, Cunningham, Shahar, and Widaman, 2002) and is commonly used in this type of situation. The Boehm-3 Preschool Tactile Edition supports the use of concept scores on the official record form as it is a practical way of organizing the results of the assessment. As each concept is presented twice, test administrators can indicate if children have correctly answered both instances of the concept, one of the two, or neither instance. Sixty item scores were transformed into 26 concept scores for the data for the 3-year-olds and 29 concept scores for the data for the 4- and 5-year-old participants by the investigator. If participants correctly identified both concepts, their concept score was a *2*, if they correctly identified one of the two concepts they received a score of *1*, and if they did not identify either concept correctly, they received a score of *0*. Exploratory factor analysis using the concept scores was successful for both data sets using principal component analysis

(PCA) with the number of factors determined by parallel analysis (PA). Parallel analysis (O'Connor, 2000) has been shown to be the most accurate method for determining the number of factors present in the data. The SPSS computer software (IBM Corporation, 2013) was used to complete all components of the EFA.

Evidence that data for both age groups could be successfully factored as concept scores was provided through the Kaiser-Meyer-Olkin Measure (KMO) and the Bartlett's Test of Sphericity results (see Tables 9 and 10). The KMO statistical procedure is a measure of the proportion of variance among variables that might be common variance. The lower the proportion, the more suited the data are for EFA. It is generally accepted that KMO values between .800 and 1.000 indicates the sampling is adequate **(**Cerny & Kaiser, 1977). A KMO measure of sampling adequacy was performed on 3-year-olds' scores with a result of .858, and with a result of .848 for the 4- and 5-year-old's concept scores. Kaiser (1974) labels values of 0.800 through 0.890 as "meritorious," so the KMO results for both age ranges of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) indicate that an EFA is appropriate.

Table 9

Kaiser-Meyer-Olkin Measure (KMO) and Bartlett's Test Results for 3-year-olds

Statistical Procedure	Results	
KMO Measure of Sampling Adequacy	.858	
Bartlett's Test for Sphericity	Approx. Chi Square	2581.417
	df	325
	Sig.	.000

Table 10

Kaiser-Meyer-Olkin Measure (KMO) and Bartlett's Test Results for 4 and 5-year-olds

Statistical Procedure	Results	
KMO Measure of Sampling Adequacy:	.848	
Bartlett's Test for Sphericity:	Approx. Chi Square	2182.964
	df	406
	Sig.	.000

Bartlett's Test for Sphericity (Tabachnick & Fidell, 2007) hypothesizes that the correlations in a correlation matrix are 0, or there is a redundancy between variables that can be summarized with some factors. If a factor analysis is to proceed, Bartlett's Test of Sphericity must be less than 0.05. Results from both the 3-year-olds' and the 4- and 5-year-olds' concept scores indicated a significance of 0.00.

Parallel analysis (O'Connor, 2000) determines the number of components by creating a set of random data with the same numbers of observations, variables, and distributions as the original data. A principal component analysis is conducted on the random data. When the eigenvalues from the random data are larger than from the original data set, then the components are mostly noise. This means that the number of components or factors to retain are those with eigenvalues greater than the random data.

For the concept score data of the group of 3-year-olds, the eigenvalue rule and component matrix all indicated a strong single factor with eigenvalues of 19.733 (76% of the variance), while the random data only had an eigenvalue of 2.700. In contrast, for the second and all subsequent components the eigenvalues for the random data was greater than for the original data. Thus, there was only one factor present in the data (see Table

11). Each concept score should have a factor loading of at least $|0.4|$, meaning ≥ +.4 or ≤ -.4 in order to be considered important. All factor loadings met the reasonable criteria, with the lowest at .521 (see Table 12).

Table 11

Parallel Analysis for Concept Scores of the 3-year-old Group

Root	Raw Data	Means	Percentile
1.000	19.773	2.474	2.679
2.000	1.390	2.227	2.445
3.000	.832	2.026	2.175
4.000	.619	1.860	1.985
5.000	.519	1.709	1.847
6.000	.425	1.581	1.684
7.000	.339	1.462	1.563
8.000	.335	1.358	1.451
9.000	.279	1.243	1.314
10.000	.260	1.159	1.247
11.000	.219	1.065	1.143
12.000	.209	.991	1.059
13.000	.161	.905	.990
14.000	.127	.822	.891
15.000	.103	.752	.832
16.000	.091	.684	.739
17.000	.069	.620	.672
18.000	.059	.555	.623
19.000	.048	.489	.545
20.000	.039	.439	.489
21.000	.034	.385	.477
22.000	.027	.331	.378
23.000	.017	.289	.343
24.000	.013	.243	.300
25.000	.056	.191	.233
26.000	.004	.141	.178

Table 12

Factor Loadings for the 3-year-old Group

Concept	Extraction
C_Top	.567
CP_Down	.651
C_ Empty	.832
C_Under	.521
C_Highest	.629
C_Missing	.760
C_ Next	.753
C_ Another	.786
CP_Up	.774
C_Full	.775
C_Outside	.686
C_All	.826
C_Nearest	.888
C_Finished	.748
C_Smallest	.889
C_Across	.631
C_Different	.828
C_Longest	.830
C_In Front of	.675
C_Both	.769
C_Around	.879
C_Tallest	.858
C_Many	.804
C_Same	.859
C_Most	.734
C_Largest	.630

Note: Extraction Method: Principal Component Analysis.

The component matrix loadings for all 26 items ranged from .72 to .95 on one factor of understanding relational concepts (see Table 13). Acceptable criteria for variables in a component matrix is generally 0.4 and above, and the results indicated that all variables contribute significantly to the assessment. These high unidimensional factor loadings also indicated that there is no need to proceed with factor rotations. The

presence of a single factor clearly established unidimensionality as a validity component and satisfied Research Question 1.

Table 13

Component Matrix for the 3-year-old Group

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	19.773	76.050	76.050	19.733	76.050	76.050
2	1.391	5.350	81.400			
3	.832	3.201	84.601			
4	.619	2.382	86.983			
5	.519	1.996	88.978			
6	.425	1.634	90.612			
7	.339	1.304	91.916			
8	.335	1.289	93.205			
9	.279	1.072	94.276			
10	.260	1.002	95.278			
11	.220	.845	96.123			
12	.209	.804	96.927			
13	.161	.620	97.548			
14	.127	.488	98.036			
15	.103	.396	98.432			
16	.091	.352	98.784			
17	.069	.267	99.051			
18	.059	.225	99.276			
19	.048	.185	99.460			
20	.040	.153	99.614			
21	.034	.132	99.746			
22	.027	.103	99.848			
23	.017	.065	99.913			
24	.013	.050	99.963			
25	.006	.023	99.986			
26	.004	.016	100.000			

Note: Extraction Method: Principal Component Analysis.

The 4- and -5-year-old data demonstrated similar results. Again, a strong single factor is suggested with an eigenvalue of 19.122 (66% of the variance) for the first factor, while the first factor for the random data had an eigenvalue of only 2.84. In contrast, for the second and all subsequent components, the eigenvalues for the random data were greater than for the original data. Thus, there was only one factor present in the data (see Table 14). Again, the presence of this single factor clearly established unidimensionality as a validity component and satisfied research question one. This data indicated that although the added variables, right, left, and corner are on the lower end of the criteria, they also met the cut-off, with the lowest at .445 (see Table 15).

Table 14

Parallel Analysis for Concept Scores of the 4- and 5-year-old Group

Root	Raw Data	Means	Percentile
1.000	19.122	2.612	2.844
2.000	1.911	2.318	2. 531
3.000	1.171	2.129	2.269
4.000	.923	1.951	2.085
5.000	.734	1.813	1.932
6.000	.656	1.684	1.808
7.000	.611	1.568	1.654
8.000	.495	1.457	1.539
9.000	.451	1.364	1.444
10.000	.379	1.261	1.362
11.000	.331	1.166	1.243
12.000	.295	1.075	1.159
13.000	.270	.998	1.083
14.000	.232	.919	.991
15.000	.194	.844	.905
16.000	.182	.775	.835
17.000	.174	.714	.777
18.000	.157	.649	.705
19.000	.148	.584	.647
20.000	.115	.527	.583
21.000	.104	.476	.526
22.000	.075	.413	.486
23.000	.066	.370	.416
24.000	.057	.324	.374
25.000	.050	.279	.324
26.000	.039	.241	.279
27.000	.028	.201	.239
28.000	.021	.159	.190
29.000	.008	.118	.156

Table 15

Factor Loadings for the 4- and 5-year-old Group

Concept	Extraction
C_Nearest	.685
C_Finished	.738
C_ Smallest	.717
C_Across	.520
C_Different	.605
C_Longest	.790
CP_ In Front of	.699
C_ Both	.776
C_Around	.661
C_Tallest	.701
C_Many	.656
C_Same	.827
C_Most	.625
C_Largest	.688
C_Before	.699
C_Farthest	.816
C_Lowest	.684
C_Shortest	.697
C_Last	.747
C_Bottom	.733
C_Together	.715
C_Some/NM	.566
C_Middle	.747
C_First	.606
C_Between	.547
C_Least	479
C_Right	.445
C_Corner	.479
C_Left	.476

Note: Extraction Method: Principal Component Analysis.

Component matrix factor loadings are high, ranging from .66 to .90, meeting all acceptable criteria, and, again, not requiring additional factor rotations (see Table 16). It should be noted that the three concepts that were added to the original Boehm-3

Preschool Tactile Edition (Ferrell et al., 2014) to measure understanding of specific pre-braille concepts (corner, left, and right) demonstrated the lowest factor loadings of .692, .690, and .667, respectively. These test items are originally presented in the Boehm Test of Basic Concepts (Boehm, 2001a) for children in grades kindergarten through second grade, which may explain their low factor loadings. However, they still met acceptable factor loading criteria and contributed to the variance of the concept scores, indicating they should be retained in the adapted tactile assessment (Reise et al., 2000).

Table 16

Component Matrix for the 4- and 5-year-old Group

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	19.122	65.939	65.939	19.122	65.939	65.939
2	1.911	6.591	72.530			
3	1.171	4.036	76.567			
4	.923	3.182	79.749			
5	.734	2.532	82.280			
6	.656	6.262	84.543			
7	.611	2.107	86.650			
8	.495	1.706	88.356			
9	.451	1.555	89.911			
10	.379	1.305	91.216			
11	.331	1.140	92.356			
12	.295	1.018	93.375			
13	.270	.931	94.306			
14	.232	.798	95.104			
15	.194	.670	95.774			
16	.189	.629	96.403			
17	.174	.599	97.002			
18	.157	.540	97.543			
19	.148	.512	98.054			
20	.115	.396	98.451			
21	.104	.360	98.811			
22	.075	.260	99.071			
23	.066	.226	99.297			
24	.057	.198	99.494			
25	.050	.173	99.667			
26	.039	.134	99.801			
27	.028	.097	99.898			
28	.021	.073	99.971			
29	.008	.029	100.000			

Note: Extraction method: Principal Component Analysis.

Reliability of the Boehm-3 Preschool Tactile Edition

The internal consistency (Cronbach's α) for both age group data sets of concept scores of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is exceptionally strong. In the data for the 3-year-old group, α was .987 with a 95% Confidence interval of between .981 and .991, and in the data for the 4- and 5-year-olds, α was .981 with a 95% confidence interval between .974 and .988. Having already established unidimensionality for both age ranges through exploratory factor analysis, the investigator is confident in the acceptability of this excellent Cronbach's alpha.

Therefore, sources of evidence collected through exploratory factor analysis to answer the first research question are conclusive. Both age ranges of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) are unidimensional, meaning that all items evaluate the same ability and the participants can be ordered reliably by ability using the total score.

Mokken Scale Analysis of the Boehm-3 Preschool Tactile Edition

Research Question 2 asks for the evaluation of a developmental scale, where it is important to look at three criteria in relation to the entire scale and between each item. One way to build validation for an individual assessment such as the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is to use appropriate fit indices for a nonparametric Mokken scale (Smits et al., 2012; Van der Ark, 2012; van Schuur, 2011) using concept scores on the individual items to see if they form a cumulative scale. There are two Mokken scale models, the monotone homogeneity (MH model) and the model of double monotonicity (DM model). The MH model is included in the DM model, which has the requirements of the MH model with the additional assumption of invariant item ordering.

When the MH model is satisfied, it means that the test orders individuals in their ability on the underlying latent trait. Consequently, the order should be robust across most applications of the scale. When only the MH model fits the data, it means that some individuals order items in a different manner, for example, as children differ among themselves on which items they find as more or less difficult than other items. Given differences in education and experience, this is not surprising. All statistical procedures were conducted using Mokken scale in R (Van der Ark, 2017), and the output will first be presented for the MH model.

The first two criteria necessary for using a Mokken scale analysis include the overall coefficient of homogeneity and critical values for individual concept scores. The MH model should be established for the total scale by looking at the coefficient of homogeneity, or Lovinger's H (van Schuur, 2011, p. 24). The coefficient of H allows a researcher to establish how well the entire scale fits the model of cumulative acquisition. The closer the coefficient of H is to 1.00, the better the scale fits the model. Although values larger then .50 are desirable, anything over .30 is acceptable and can be considered adequate. This is due to the fact that data with coefficients below .30 are not homogeneous enough to form a cumulative scale (van Schuur, 2011, p. 25). Analysis of the concept score data for the 3-year-olds demonstrated a coefficient of H of 0.817, indicating that this first analysis of model fit indicates a strong scale (Van der Ark, 2012). Analysis of the concept score data for the 4- and 5-year-olds were similar, showing a coefficient of H of 0.748. This also indicated a strong scale of monotonicity and fits the MH model with confidence.

The second criteria of a Mokken cumulative scale looks at the individual concept score items for minimum coefficient of H values and monotonicity critical values (See Tables 17 and 18). The critical value is a summary statistic of how well items fit a model. Adequate scale measures require that the highest critical value in a table not exceed 80, as this would indicate some reason for concern with the item, and if the critical value exceeded 40, there would be some doubt about the model assumption. A strong scale is present if all monotonicity critical values are 0 as is indicated in the data for the 3-year-olds (see Table 17). Critical values for the data for the 4- and 5-year-olds (see Table 18) indicated that two of the items may present a less than ideal pattern, but the critical values are not high enough to reject, as they represent an adequate scale, not exceeding the upper boundary of 80.

The Double Monotonicity Model

The double monotonicity model (DM model) for the entire scale looks at whether the items are in the correct order for measuring the latent trait. This is referred to as invariant item ordering (IIO) and implies that the same order of item difficulty should exist at all levels of ability and for most people. In order to evaluate invariant item ordering with existing procedures, it is necessary to assign individuals to subgroups based upon "ability" with at least four groups (Sijtsma, Meijer, & Van der Ark, 2011). These subgroups are known as "restscore groups," and the monotonicity of each item *i* is assessed by replacing the value of the latent trait with a restscore, which indicates the sum score of all the items except for item *i*. Unfortunately, the recommendation is that when the sample size is less than 250 participants, each restscore group must have a

Table 17

Coefficient of *H and Monotonicity Critical Values for Concept Scores of the 3-year-old Group (Total Score H = 0.817*)

Item	Coefficient of H	Standard Error	Crit Score
C_Top	0.696	(0.074)	0
CP_Down	0.789	(0.044)	0
C_ Empty	0.909	(0.037)	0
C_Under	0.707	(0.081)	0
C_Highest	0.739	(0.060)	0
C_Missing	0.818	(0.059)	0
C_Next	0.797	(0.052)	0
C_Another	0.872	(0.038)	0
CP_Up	0.844	(0.036)	0
C_Full	0.822	(0.051)	0
C_Outside	0.762	(0.064)	0
C_All	0.843	(0.034)	0
C-Nearest	0.868	(0.029)	0
C_Finished	0.800	(0.049)	0
C_Smallest	0.866	(0.029)	0
C_Across	0.784	(0.047)	0
C_Different	0.843	(0.031)	0
C_Longest	0.845	(0.035)	0
CP_In Front of	0.811	(0.037)	0
C_Both	0.822	(0.034)	0
C_Around	0.861	(0.027)	0
C_Tallest	0.851	(0.033)	0
C_Many	0.849	(0.028)	0
C_Same	0.852	(0.028)	0
C_Most	0.796	(0.043)	0
C_Largest	0.775	(0.046)	0

Note. Molenaar Sijtsma statistic (rho) = 0.990; Cronbach's alpha = 0.986.

Table 18

Coefficient of *H and Monotonicity Critical Values for Concept Scores of the 4- and 5-year-old Group (Total Score H = 0.748)*

Item	Coefficient of *H*	Standard Error	Crit Score
C_Nearest	0.744	(0.067)	0
C_Finished	0.816	(0.061)	0
C_ Smallest	0.823	(0.057)	0
C_Across	0.659	(0.060)	37
C_Different	0.716	(0.074)	0
C_Longest	0.828	(0.052)	0
CP_In Front of	0.748	(0.059)	0
C_Both	0.822	(0.056)	0
C_Around	0.730	(0.067)	0
C_Tallest	0.748	(0.054)	0
C_Many	0.739	(0.069)	0
C_Same	0.857	(0.040)	0
C_Most	0.727	(0.083)	62
C_Largest	0.752	(0.071)	0
C_Before	0.748	(0.045)	0
C_Farthest	0.795	(0.039)	0
C_Lowest	0.733	(0.050)	0
C_Shortest	0.732	(0.054)	0
C_Last	0.763	(0.041)	0
C_Bottom	0.753	(0.044)	0
C_Together	0.755	(0.047)	0
C_Some	0.715	(0.050)	0
C_Middle	0.792	(0.036)	0
C_First	0.722	(0.046)	0
C_Between	0.724	(0.047)	0
C_Least	0.698	(0.052)	0
C_Right	0.639	(0.064)	0
C_Corner	0.718	(0.051)	0
C_Left	0.678	(0.058)	0

Note. Molenaar Sijtsma statistic (rho) = 0.984; Cronbach's alpha = 0.981.

minimum of 50 participants, which precludes its use in the current study. This appears to be due to the fact that there are relatively few children at some levels of ability so it is hard to determine if they have the same order for all children.

Therefore, in order to apply the IIO and restscore analysis in Mokken R (Van der Ark, 2017), in this study it was appropriate to ignore the sample size requirements and simply divide each age sample into three groups. This was accomplished though random selection in SPSS (IBM Corporation, 2013). If a set of items fits the MH model, often it is appropriate to visually analyze the P(+, +) and P(-, -) matrices to determine the proportions of individuals giving positive and negative answers to each pair of items (van Schuur, 2011). The limited number of responses in this analysis indicated that it was not necessary to make groups for the visual P (++, --) matrix analysis for the purposes of this study. The small sample size for this study of 120 test scores means that these results are only tentative, and it is possibly the basis for the equivocal results across analysis.

Analysis of the 3-year-old age group data indicated a DM model in the "adequate" range with an H_T of .353. Restscore data of all 0s supports model fit, but the Pmatrix analysis suggests that several items are of concern (43, 48), and one is poor (110). Items with Pmatrix critical values above 40 fell within the adequate scale range, and the single item with a critical value above 80 indicates the scale is at risk, but does not require removal of the item. These results support the nonintersection of item response functions, indicating adequate invariant ordering of the tasks (see Table 19).

Table 19

Invariant Item Order for Concept Scores of the 3-year-old Group (Total Score H_T = 0.353)

Item	Restscore	IIO	Pmatrix
C_Top	0	0	**110**
CP_Down	0	0	0
C_ Empty	0	0	-28
C_Under	0	0	-6
C_Highest	0	0	18
C_Missing	0	0	0
C_Next	0	0	32
C_Another	0	0	0
CP_Up	0	0	-26
C_Full	0	0	-1
C_Outside	0	0	17
C_All	0	0	-10
C-Nearest	0	0	**43**
C_Finished	0	0	-5
C_Smallest	0	0	**48**
C_Across	0	0	-5
C_Different	0	0	**43**
C_Longest	0	0	-5
CP_In Front of	0	0	-15
C_Both	0	0	-7
C_Around	0	0	31
C_Tallest	0	0	32
C_Many	0	0	-12
C_Same	0	0	37
C_Most	0	0	-12
C_Largest	0	0	-16

Note. Bolded items indicate items of concern as they are above critical values of 40 or 80.

In the data for 4- and 5-year-old age group, more indeterminate results are evident with an H_T of .294 that is just below the criteria of an adequate DM model fit (see Table 20). As the restscores and the Pmatrix critical values are equivocal for a practically useful scale, the determination is that this data set presents results of an indeterminate nature for the DM model in this study. This simply means that the children in this age group differed more extensively among themselves than the 3-year-olds. This could be due to any number of reasons, such as the fact that there may be more developmental diversity among 4- and 5-year-olds than 3-year-olds or that there was a smaller number of participants in the age groupings (see Table 2).

Table 20

Invariant Item Order for Concept Scores of the 4- and 5-year-old Group (Total Score H_T = 0.294)

Item	Restscore	IIO	Pmatrix
C_Nearest	20	52	56
C_Finished	10	11	26
C_ Smallest	02	0	27
C_Across	55	52	**85**
C_Different	46	**115**	66
C_Longest	19	25	50
CP_In Front of	12	40	39
C_Both	12	56	30
C_Around	27	19	72
C_Tallest	16	18	**90**
C_Many	10	22	65
C_Same	09	25	21
C_Most	59	**110**	**89**
C_Largest	-07	2	55
C_Before	18	0	33
C_Farthest	44	48	56
C_Lowest	17	0	59
C_Shortest	36	45	80
C_Last	29	35	71
C_Bottom	-02	-01	56
C_Together	07	-01	43
C_Some	04	15	31
C_Middle	**101**	**142**	**94**
C_First	20	28	37
C_Between	03	12	70
C_Least	22	0	51
C_Right	**83**	**81**	**102**
C_Corner	-03	0	46
C_Left	03	2	88

Note: Bolded items indicate items of concern as they are above critical values of 40 or 80.

Pilot study data confirmed that test items in the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) were presented in developmental, age-related clusters.

Mokken scale tests of homogeneity were used to determine error violations between items and persons. The Boehm-3 Preschool Tactile Edition suggested a logical progression of item difficulty, and Mokken scale analysis confirmed that supposition. It is well known that young children have a limited attention span for testing (AERA et al., 2014; NAEYC, 2007) and that tactual adaptation results in longer assessment times (Hughes, 2011). This study demonstrates that it was unnecessary to remove or re-order items in the assessment.

Monotonicity was established for both age groups of the test and tests of double monotonicity such as restscore criterion values, and invarient item ordering (IIO) criterion value were completed using the statistical software R package for Mokken (Van der Ark, 2017). In tests of double monotonicity, the investigator analyzed the difficulty order of every pair of probable positive responses for participants with increasing scale scores based on the other (*n* - 2) items, and it was unnecessary to explore "person-fit" statistics in the final analysis.

As the concept score data for both age groups met all the criteria for the MH model of a Mokken scale evaluation, the analysis was clear that the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) answers the second research question positively. Concept score data do fit a developmental Mokken scale analysis and provide additional evidence for a unified validity component.

Evidence of Construct Validity with the Smyth Developmental Rating Scale

The final research question addressed construct validity and whether the child participant's performance on the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) was in any way related to expected developmental skills in the areas of fine motor and cognitive understanding. Previous research on concept and tactual development

indicated that for young children with visual impairment, the ability to interpret information tactually may be related to relational concept understanding. It was important, therefore, to determine if children who were successful on the Boehm-3 Preschool Tactile Edition also demonstrated age-appropriate skills on relevant cognitive and fine motor skills through teacher observation. To determine construct validity, the researcher developed the Smyth Developmental Rating Scale, which included 20 questions about the child's developmental fine motor and cognitive abilities as observed by their early childhood primary teacher. After the child was administered the Boehm-3 Preschool Tactile Edition, the teachers received an email invitation to complete the Smyth Developmental Rating Scale though Qualtrics (Qualtrics, 2017) on that individual child. Completing the Smyth Developmental Rating Scale was voluntary, and if it was not completed, reminders were sent out every two weeks for a period of two months. The response rate was 12%, with 46 responses out of a possible 120 requests. A composite total for each response was created by changing the response options of the rating scale to numerical indicators 1 through 5 and added together.

Nevertheless, Spearman correlation coefficients were calculated using SPSS software (IBM Corporation, 2013) to establish potential convergent construct validity between the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) and the Smyth Developmental Rating Scale. Spearman's rank order correlation was chosen for analysis as it is a non-parametric statistic, can be used with ordinal data, and determines the strength and direction of a monotonic relationship between the two variables. A monotonic relationship can indicate that as either the value of one of the variables increases, so does the value of the other variable, or as the value of one variable decreases, so does the value of the other variable. The importance of the monotonic

relationship is that it is “less restrictive” in that it does not have to be completely linear. Spearman correlation coefficients can have values from 1.00 to -1.00, with a perfect association being indicated by 1.00 and no association indicated by 0. The Smyth Developmental Rating Scale composite total score was matched to the total Boehm-3 Preschool concept score for the 46 responses available, and SPSS (IBM Corporation, 2013) was used to obtain the results. It should be noted that it is true that most measurements are composed of multiple items, as the understanding of a construct can rarely be represented by a single question. This justifies the use of composite scores of both measurements to create the Spearman correlation matrix.

Total concept scores for the 3-year-olds (n = 25) from the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) and the Smyth Developmental Rating Scale composite total scores produced a Spearman correlation of .663, $p < .01$, indicating a strong positive relationship. Total concept scores for the 4- and 5-year-olds (n = 21) from the Boehm-3 Preschool Tactile Edition and the Smyth Developmental Rating Scale composite total scores produced a Spearman correlation of .773, $p < .01$, also indicating a strong positive relationship.

In this particular data set, some teachers rated multiple children, and some rated only one. To prevent the considerable risk of contamination through teacher bias, for example, some teachers rating the children’s skills more critically and some rating skills more leniently, the data were analyzed again to investigate any bias effect. When scores existed for multiple children at the same age level for a teacher, only one child was randomly selected using SPSS (IBM Corporation, 2013) for analysis. The Spearman correlations for this adjusted data set demonstrated that any bias effect was minimal, with the 3-year-old’s (n = 13) data between the Boehm-3 Preschool Tactile Edition (Ferrell et

al., 2014) total concept score and the Smyth Developmental Rating Scale total score produced a Spearman correlation of .646, $p < .05$. Adjusted data for the 4- and 5-year-olds ($n = 15$) between the Boehm-3 Preschool Tactile Edition total concept score and the Smyth Developmental Rating Scale total score produced a Spearman correlation of .667, $p < .05$, indicating that there was virtually no teacher bias effect present for this age group.

Thus, the Spearman correlation results for all data sets supported strong positive relationships between the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) and the Smyth Developmental Rating Scale. They also indicated further evidence for construct validity to build a case for the validity of the Boehm-3 Preschool Tactile Edition in this study.

Summary

In terms of reliability, Cronbach's α was computed on the concept scores of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) for both the data set of the 3-year-olds and the data set of the 4- and 5-year-olds. This study found high internal consistency of .987 for the 3-year-olds and .981 for the 4- and 5-year-olds.

Validity components were established on the 120 collected Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) concept scores using the following statistical procedures: (a) exploratory factor analysis (EFA), (b) Mokken scale analyses of both the entire scale and individual items, and (c) an examination of convergent construct validity using Spearman rank correlations. Each research question had a positive outcome, and this study successfully demonstrated a case for a measure with unified validity components (Messick, 1995).

As part of the study, a total of 82 items were analyzed in 120 Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) administrations as concept scores. The component matrix loadings for all 26 concept scores of the data sets for the 3-year-olds ranged from .72 to .95 on one factor of understanding relational concepts. When analyzing the concept scores for the 4- and 5-year-olds, again, a strong single factor was suggested through component matrix loadings for all 29 concept scores between .66 to .90. Exploratory factor analysis using the concept scores was successful for both 3-year-olds and 4- and 5-year-olds using principal component analysis (PCA) with the number of factors determined by parallel analysis (PA).

Mokken scale analyses in R (Van der Ark, 2017) that included both the monotone homogeneity (MH model) and the model of double monotonicity (DM model) were applied to the concept scores for both data sets for the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014). Analysis of the concept scores for the 3-year-olds demonstrated a coefficient of H of 0.817, indicating that this MH procedure of model fit supported a strong scale (Van der Ark, 2012). Analysis of the concept scores for the 4- and 5-year-olds were similar, showing a coefficient of H of 0.748. This also indicated a strong scale of monotonicity and demonstrated fit with the MH model with confidence. The second analysis of a Mokken cumulative scale looked at the individual concept score items for minimum coefficient of H values and monotonicity critical values. Critical values for the age group data of the 3-year-olds fit this second analysis of the MH model perfectly as all values were 0. Critical values for the age group data of the 4- and 5-year-olds indicated that two of the items may present a less than ideal pattern, but the critical values were not high enough to reject, as they represented an adequate scale, not exceeding the upper

boundary of 80. These first two analyses of the MH model of the Mokken scale indicated a strong model fit of a developmental scale. When the DM model of the Mokken scale was applied to the two data sets of concept scores, the data results for the 3-year-olds supported the presence of an adequate scale, while the data results for the 4- and 5-year-olds were indeterminate for the DM model. Nevertheless, due to the clear results for both components of the MH model, concept score data did fit a developmental Mokken Scale analysis.

The final analysis in this study was to establish convergent construct validity of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) with the Smyth Developmental Rating Scale created by the investigator to assess the fine motor and cognitive skills of the children through teacher observation. Although the response rate (12%) was low, both non-parametric Spearman correlations indicate strong positive relationships, .663, $p < .01$ for the 3-year-olds and .773, $p < .01$ for the 4- and 5-year-olds. The 46 total scores of the Smyth Developmental Rating Scale supported convergent construct validity with the matched concept scores of the Boehm-3 Preschool Tactile Edition.

With the positive results for all three research questions in this analysis, validity components have been established for the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014). This is the first validation of a tactile measure designed to assess academic skill acquisition in young children with visual impairment and can be used with confidence for program planning, progress monitoring, and in appropriate replication and second-generation research.

CHAPTER V

DISCUSSION

The purpose of this study was to establish unified validity components (Messick, 1995) for the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014), which was adapted from the Boehm-3 Preschool Test of Basic Concepts (Boehm, 2001) by Dr. Ann Boehm, the American Printing House for the Blind, and the University of Northern Colorado, in a collaborative effort. It has been established (Greenwood & McConnell, 2011) that an important purpose of measurement research is that it provides a consistent method of assessing the current skill level of individual students and a way of determining an effective program plan for learning. A significant need exists in the field of visual impairment for a tactile assessment with rigorous psychometrics (Mazella et al., 2014) to support guided instruction and progress monitoring in the preschool classroom. The results of this research met this need by establishing validity components for a tactile assessment to guide instruction for the first time. This validation of the Boehm-3 Preschool Tactile Edition provides all early childhood (EC) professionals with young children with visual impairment in their classrooms an opportunity to assess their understanding of basic relational concepts, develop instructional plans to support the children for future learning, and monitor their progress.

In this study, Research Questions 1, 2, and 3 were developed to identify components of unified validity using the item response theory (IRT) method of analysis

(Demars, 2010). It was determined that IRT using a nonparametric Mokken Scale analysis was more appropriate for the intended population of young children with visual impairment than classical test theory (CTT) because models based on CTT use statistics such as means, variances, and co-variances to assess item fit, while IRT models use observable responses in a probabilistic way (Salzburg & Sinkovics, 2006). In order to apply appropriate distribution free measurement to this study of ordinal data, the following statistical procedures were used: (a) the Kaiser-Meiser-Olkin Measure and Bartlett's Test of Sphericity (Tabachinck & Fidell, 2007), which demonstrated evidence for the successful use of an exploratory factor analysis (EFA); (b) the EFA of concept scores for both groups, which supported the assessment's unidimensionality; (c) the ordinal Mokken scale analysis model that demonstrated item fit for both scales; and (d) Spearman ranked correlation coefficients (Glass & Hopkins, 2008) calculated between the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) and matched participants who were assessed with the Smyth Developmental Rating Scale, demonstrated convergent construct validity.

Implications of this Study

The implications of the results are discussed in relation to the purpose of this study as they pertain to the following issues: (a) the need for a valid and reliable tactual assessment to measure current skill levels to determine an effective program plan for learning for young children with visual impairment; (b) the choice to use nonparametric statistical procedures within the IRT framework for this study; and (c) the potential connection between tactile and cognitive development and the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014).

Developing a Valid and Reliable Tactual Assessment for Program Planning

Concept understanding is one of the most important skills a young child with visual impairment should master (Bardin & Lewis, 2008; Koenig & Farrenkopf, 1997). For tactile learners, it is critical that all EC professionals have a way to accurately assess the current understanding of their preschool students so that they can determine how to introduce what concepts they do not know. As most EC assessments rely on visual skills and behaviors to measure cognition, it is inappropriate to engage in program planning and progress monitoring using assessments that have not been rigorously validated with this population (Mazella et al., 2014). As mentioned earlier, young children who use their haptic sense to acquire new skills need to experience their learning through tactual input which is successive, rather than simultaneous, as the visual encoding of print demonstrates (Hughes, 2011; Pring, 1994). The ongoing discovery and retaining of new knowledge requires an increased working memory load (Millar, 1994; Sebastian, Mayas, Manso, & Ballesteros, 2008) and significantly more time for a haptic learner (Hatwell, 2003a). When administered to children who have little or no visual experience to draw upon, an assessment designed for a general EC population not only loses its meaning, but the child who requires tactual information loses a chance to benefit from his or her educational experience because the assessment revolves around the lack of vision instead of improved performance (National Association of Early Childhood Specialists in State Departments of Education (NAECS/SDE), 2003a; NAECS/SDE, 2003b).

With the validation of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014), it is relevant to mention that attempts to identify validity components of tactual tests have been limited to developmental assessments in the past (Brambring, 2006; Maxfield & Buchholz, 1958; Vervloed et al., 2000). Developmental assessments are

important to establish eligibility for special education services, but not usually specific enough to assist in lesson planning that can support early literacy and early numeracy development. The Boehm-3 Preschool Tactile Edition is now a valid assessment that for the first time provides EC professionals with formative results to guide their instruction of the young tactile learner. In a policy brief that addresses measuring child outcomes in the early years, Barnett et al. (2015) defined formative assessment as "the use of assessment to inform teaching, with some definitions going so far as to equate formative assessments with scaffolding. It looks forward in a process that is responsive to the needs of the learner" (p. 1). As EC programs decide how they will use various assessments, the guidelines provided through the Center on Enhancing Early Learning Outcomes (CEELO) (discussed below) provide a framework to determine if the Boehm-3 Preschool Tactile Edition will be beneficial for children and EC professionals.

Effectively Measuring Child Outcomes

Using a national framework for measuring child outcomes (Barnett et al., 2015) allows the results of this study to be compared to quality recommendations for preschool programs. This framework includes the following criteria: (a) measuring what matters, (b) measuring well, and (c) measuring feasibility and cost. There are multiple reasons to require preschool assessments, some of which are to make high stakes decisions about children (e.g., kindergarten entry) or teacher performance (e.g., program evaluation or teacher evaluation). The use of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014), to provide formative assessment information about early academic preparedness can demonstrate early childhood responsiveness to state and federal legislation

requirements (Brassard & Boehm, 2007; National Response to Intervention, 2011; Scott-Little, Bruner, Schultz, & Maxwell, 2013). Assessment processes for all young children required by the *Every Student Succeeds Act* (Five First Years Fund, 2015) and kindergarten entry assessments (U.S. Department of Education, 2016) should include the benefit of program planning and progress monitoring that the Boehm-3 Preschool Tactile Edition provides. Although The American Educational Research Association (AERA), the American Psychological Association (APA), and the National Council on Measurement in Education disclaim any liability in the development or validation of a particular test, they do have a history of being recognized by regulatory agencies and lgal authorities for "setting the professional standards that developers and users of tests follow" (AERA, APA, & NCME, 2014, p. 2). The Boehm-3 Preschool Tactile Edition was carefully developed to meet the sandards and address best practices in EC assessment. A combination of informal observational data collection and empirically valid formal assessments (Bagnato et al., 2014; Macy et al., 2014; Neisworth & Bagnato, 2004) provide educators, parents, and researchers with a more complete understanding of the processes of learning occurring in preschool settings. The quality of a measurement used with young children should reflect the ability to address the intended purpose of the assessment, as well as its psychometric properties.

The use of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is not recommended to support high-stakes policies as it provides only a "snapshot" in time of a child's abilities, but it does meet the criterion for one of the most common practices, tracking child and program outcomes over time.

Measuring what matters: Basic relational concepts. Assessment of all young children requires a broad view of desirable skills and behaviors of the whole child in multiple settings. It is critical that no one assessment be used to determine a child's abilities or potential as research has shown that a variety of experiences at home, EC settings, and personal traits affect each individual child's success in education (Bagnato et al., 2014; Bailey et al., 2006). Comprehensive as well as relevant assessment tools should be carefully chosen to meet the needs of the educational setting and participants.

Research in the field of visual impairment has indicated that the understanding of relational concepts by young children is critical to support and reinforce not only early literacy and numeracy skills, but all other areas of learning (Koenig & Farrenkopf, 1997). This study proposed that not only is it necessary to address the needs of young children with visual impairment to understand body awareness and categorization of objects in their environment, but these young children with visual impairment should have the opportunity to demonstrate an understanding of basic relational concepts in varied contexts such as temporal, spatial, and quantitative activities that lead to the ability to follow directions of increased complexity.

All young children are represented through a significant body of research that supports the understanding of basic concepts during preschool that adds to increased vocabulary skills (Boehm, 1971, 1986; Booth & Waxman, 2002), success in the school environment (Bracken & Crawford, 2010), and the prediction of academic achievement in the early elementary years (Glutting et al., 1989). Therefore, the evidence of having a well-crafted assessment that measures these important relational concept skills for young children with visual impairment meets the recommended criteria of "measuring what matters" with the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) through instructional guideposts. EC professionals and families will be able to have a greater

understanding of what relational concepts children have mastered and create learning plans to address the more challenging concepts. Clear instructional goals can be developed, such as identifying objects that are "longest" or "in the middle," and can be addressed in a variety of tasks in the preschool classroom or at home with everyday objects. Interactions with families during this study indicated there was excitement when observations of their child's understanding of concepts at home and the results of the Boehm-3 Preschool Tactile Edition were consistent. Knowing that the child excelled at spatial items or needed to work on quantitative items was helpful in educational planning with the EC professionals.

During this study, some of the child participants were unable to complete the assessment due to their inability to answer the questions asked by the test administrators. Although these children met the selection criteria for the study, when the investigator presented them with the practice items before beginning the test, they were unsure how to engage with the materials and or answer the directions regardless of being given extended time or an alternative presentation. These child participants received a *0* for a total concept score, and their teachers were given instruction on how to use the *Getting Ready* binder and ideas to incorporate concept understanding into their everyday routines. Understanding directions and demonstrating knowledge is a critical skill for preschoolers, whether accomplished through gestures or language (Plumert et al., 2012; Rimm-Kaufman, Pianta, & Cox, 2000). This finding is consistent with a landmark study, the National Center for Early Development and Learning's *Transitions Practices Study* (Rous, Hallan, McCormick, & Cox, 2010), which examined kindergarten teacher's perceptions of children's difficulties upon entry to school. Results from the Transitions Practices Study indicated that 46% of kindergarten teachers (N = 3595) surveyed felt that

over half of their class or more had difficulties following directions. The Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is one way to provide an opportunity to practice making choices and answering questions in a developmentally appropriate manner, while measuring knowledge expected of this age group.

Measuring well: Desirable features of assessments. Barnett et al. (2015) maintained that in order for assessments to be useful, they must be valid and reliable. This has been a concern in the field of visual impairment, as there have not been assessments for over 50 years to use for instructional guidance or progress monitoring with validity and reliability (Mazella et al., 2014). The lack of any formal assessments that are validated for understanding the academic performance of tactual learners is a significant gap in the measurement needs for those wishing to understand the abilities of young children with visual impairment or conducting second generation research to create evidence-based practices in the field. The purpose of this research using the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) was to establish evidence of its unified validity components. The results of all three research questions support validity and reliability through: (a) unidimensionality, (b) supporting acceptable fit levels with a Mokken scale analysis, and (c) demonstrating convergent construct validity with the Smyth Developmental Rating Scale.

In conducting an exploratory factor analysis (EFA) of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014), unidimensionality was confirmed by the presence of a single factor loading for both age groups. All concept scores were supported by a factor loading over of at least $|0.4|$, meaning $\geq +.4$ or $\leq -.4$ in order to be considered important. Validity should include items that demonstrate complete representation of the

construct throughout the assessment tool and should not include irrelevant items (Barnett et al., 2015). Confirmed unidimensionality is the initial building block necessary for establishing components for a valid assessment tool (Messick, 1995).

It was critical to establish that the structure of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) demonstrated acceptable fit levels to indicate a developmental scale. This means that as the young children with visual impairment take the Boehm-3 Preschool Tactile Edition at one age, their ability to answer the questions in six months or one year from the initial administration should increase. The researcher observed this improvement multiple times, especially when she was able to test the same child participant as a 3-year-old, and then as a 4-year-old (*n = 13)*. It was exciting for the researcher and the child's primary teacher to see a child who could not even begin to take the assessment at age three complete the full assessment with confidence at age four. These demonstrations of improved knowledge were powerful, but anecdotal experiences are not enough to contribute to unified validity components. However, the application of a nonparametric Mokken scale analysis (Smits et al.,2012; Van der Ark, 2012; van Schuur, 2011) for both age group data indicated successful fit indices for the monotone homogeneity (MH model), and the 3-year-old group scores meet adequate scale fit indices for the double monotonicity model (DM model). The data for the 4- and 5-year-old group scores was inteterminate for the DM model, but this does not mean that the Mokken scale analysis is not valid for this group. There can be multiple reasons that a strong scale was not attained by this statistical procedure, including the fact that there may have been additional diversity from a greater age span among the 4- and 5-year-olds, items with great similarity can cause the order to slip easily, or the individual's concept

score can be affected by his or her situation, rather than by his or her development. In addition, if there would have been scores from 60 4-year-olds and 60 5-year-olds, the results may have been more conclusive. It is sufficient for both age groups to meet strong scale criteria through the MH model of Mokken scale analysis, and another component of unified validity was accomplished.

Ideally, convergent construct validity should be correlated with a valid assessment that measures a similar construct (Barnett et al., 2015). In the case of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014), this was not possible because there were not any valid assessments that measure a similar construct. The Smyth Developmental Rating Scale was created by the investigator to determine if the literature review-based skills of age-expected fine motor and cognitive domains were necessary for success with the Boehm-3 Preschool Tactile Edition. Spearman ranked correlations (Glass & Hopkins, 2008) for both age groups were used to prove a high degree of evidence of validity between total scores of the Smyth Developmental Rating Scale and the concept scores of the Boehm-3 Preschool Tactile Edition, despite a limited response rate. The EC professionals that did complete the Smyth Developmental Rating Scale did indicate that it appeared to be a promising assessment that addressed the combined early fine motor, cognitive, and direction following skills needed to complete the Boehm-3 Preschool Tactile Edition. The Smyth Developemental Rating Scale demonstrated an adequate level of sensitivity though the use of its clearly different scale choices. The component of construct validity was achieved for both age group data and meets the criteria expected by CEELO to measure child outcomes well.

Barnett et al. (2015) mentioned two additional criteria in the area of "measuring well," and although they are not specifically addressed through the research questions for this study, both criteria of design and reliability can be addressed. The authors of the CEELO document note that "assuring validity for many assessments is not simply a matter of design, but also of assuring procedures for individual children" (Barnett et al., 2015, p. 6). They specifically call out measures for children with vision and hearing impairments and the need for appropriate accommodations. Researchers in the field of emergent braille literacy have found that preschool classrooms need to make an extra effort to provide a tactual and braille-rich environment for young children who need to transform real world concept understanding to representational reading with their sense of touch (Durkel, 2009; Sacks, Hannan, & Erin, 2011; Wall Emerson et al., 2009). The existence of this study is an attempt to meet this request from both the CEELO report and these previous early braille literacy researchers, as it is critical to validate this tactual assessment on the population that will be using it. The need for an assessment tool that addresses universal design components (Conn-Powers et al., 2006; Darraugh, 2007; Meyer & Rose, 2005) for tactual preschool learners is great, and significant care has been taken in the creation of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014), both in the instrument design and the procedures to administer the assessment.

Reliability can be increased in multiple ways in the use of an assessment tool. Beyond the strong internal consistency results for both age group data, "minimizing the influence of incidental factors in the environment or assessment circumstances and subjective interpretation also increase reliability as does guidance and training for the assessors" (Barnett et al., 2015, p. 6). Clear guidelines on test administration in this study

that included a developmentally appropriate script for each item, objective interpretation of dichotomous responses, and well-defined scoring procedures all contribute to the high reliability of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014).

Feasibility and cost. Barnett et al. (2015) asserted that if an assessment tool is not reasonable to administer and affordable, then no one will use it. One of the significant benefits of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is that it is available on federal quota funds from the American Printing House for the Blind (APH) for children that meet the following criteria: (a) meet the definition of blindness or function at the definition of blindness; (b) are enrolled in an instructional program for at least 20 hours per week; and (c) were registered for at least three months of instruction during the preceding calendar year. Federal quota funds are "a per capita amount of money designated for the purchase of educational materials produced by APH (APH, 2017, para 1). Therefore, the majority of tactual learners with visual impairment are, by definition, eligible for access to the Boehm-3 Preschool Tactile Edition at no cost. Training will soon be available through the video this researcher has created as a training module on the APH website.

Feasibility will be more challenging for some individual EC primary providers. The CEELO report identifies the concern that if the time it takes for training or administering the measure is significantly more than the benefit the teacher will receive in the formative results, teachers are unlikely to administer the assessment tool. During this study, many teachers seemed reluctant to invest the time to learn about the test and preferred to have the investigator administer the assessment tool. However, more than once after observing the assessment being administered, the teachers became excited

about the performance of their students and indicated they would like to try administering the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) on their own. As this is a formative assessment that can assist in guiding direct instruction and progress monitoring, it appears to benefit both the test administrator and the child if the assessment can be given over time to reduce fatigue and optimal item presentation. The researcher was limited in how long she could spend with each child, and some children showed visible signs of fatigue. As the Boehm-3 Preschool Tactile Edition was designed to address the additional time and heavy working memory load young children with visual impairment may require, the test can be administered over several sessions. One can assume that the child who has the opportunity to complee the assessment over several sessions will score higher on the latter portion of the test. In the CEELO report (2015), it was noted that the time to assess every child in the early childhood classroom may detract from child interaction time, but it is unlikely that there would be many children in one class who could be administered the Boehm-3 Preschool Tactile Edition. In the cases where there are multiple children in one class who would benefit from the Boehm-3 Preschool Tactile Edition, the time spent with each individual child would be valuable as it is likely the only assessment that is appropriate for them to demonstrate what they know about tactile representation. Tests such as the Boehm-3 Preschool Tactile Edition also increase the reliability, validity, and fairness of assessments by reducing assessor bias.

Item Response Theory and Successful Results

The low-prevelance population of this research study necessitated thoughtful consideration of whether to use classical test theory (CTT) or item response theory (IRT)

for statistical procedures. The American Educational Research Association (AERA), the American Psychological Association (APA), and the National Council on Measurement in Education (NCME) (AERA, et al., 2014) support both as acceptable methods of determining statistical precision and errors of measurement. While both models are used to score tests or surveys and both define item difficulty as the likelihood of correct response (DeMars, 2010), nonparametric IRT statistical procedures such as the Mokken Scale analysis is not dependent on a normal distribution of scores because items and individuals were examined separately. It is well known that diversity in the experiences of the population of young children with visual impairment, as well as their ability levels, is a challenge in the validation of assessments (Brambring, 2006; Hannan, 2007; Mazella et al., 2014; Vervloed et al., 2000). One of the most unique aspects of IRT nonparametric models is the ability to separate the measurement of the individual items from the scores of each person, and then to see if the data are consistent with the model. The Smyth Developmental Rating Scale allowed the researcher to explore the possibility that individuals who did not "fit" the model had possible delayed fine motor or cognitive development. Strong ranked Spearman coefficients confirmed this premise, adding another level of unified validity (Messick, 1995).

Descriptive statistics for this analysis (see Tables 7 and 8) demonstrated the need to apply nonparametric IRT statistical procedures with a population of young children with visual impairment. As most models based on CTT use statistics such as means, variances, and co-variances to assess item fit, this statistical method would have resulted in poor validity components for this unique population (Salzburg & Sinkovics, 2006). The variances and co-variances are limited and not reflective of the true reliability of the

items. The histograms for both age groupings (see Figures 1 and 2) clearly indicate that a normal distribution is not present in this analysis. This research has shown that the Mokken Scale nonparametic analysis (van Schuur, 2011) is an effective statistical method choice when attempting to validate an existing assessment in a tactile form for young children with visual impairment.

Cognitive and Fine Motor Skills Are Important

The Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is a tactual adaptation of the Boehm-3 Preschool Test of Basic Concepts (Boehm, 2001a), which measures the understanding of basic relational concepts for the 3 years to 5 years, 11 months age range. Research in the early childhood education field (Gibson & Walker, 1984; Goswami & Brown, 1990; Halford & Andrew, 2010; Johnson, 2010; Koerber & Sodian, 2008; Oakes & Rakison, 2003; Purpura et al., 2011; Sera & Millet, 2011) as well as the fields of visual impairment (Berlá, 1972; Bruce & Vargas, 2012; D'Anguilli et al., 1998; Dunst & Gorman, 2011; Ferrell, 1998, 2011; Hall, 1981, 1983; Hughes, 2011; Landau, 1991; Millar, 1994, Morriengello et al.,1994; Nicholas, 2010; Ochiatia & Huertes, 1993; Papadopoulos et al., 2012; Sicilian, 1988; Simpkins, 1979) and tactual development (Bushnell & Boudreau,1991; Cote, 2014; Davidson, 1972; Decker, 2010; Gentez & Badan, 2003; Hatwell, 2003a, 2003b; Lederman & Klatsky, 2009; McLinden, 2012; Schellingerhout et al., 2005; Sebastian et al., 2008; Streri, 2003) has hinted at connections between cognitive and fine-motor development. In the successful use of the Smyth Developmental Rating Scale as a measure to determine construct validity with the Boehm-3 Preschool Tactile Edition, this study provided evidence to support the need for teaching specific fine-motor and cognitive skills in the early literacy and numeracy

process. Learners who prefer tactual presentations need to have strong, or at least age-expected, fine motor skills to master determination of tactual concept representations. Dunst and Gorman's (2011) recommendations for young children with visual impairment to have varied tactual experiences are an important first step, but a more systematic understanding of the connection between fine motor development and tactual development is required. There are many steps between discriminating real objects, representational tactual items, and reading braille.

As previously mentioned, the skills that children with visual impairment need to discriminate, recognize, and demonstrate an understanding of tactual concepts are developmental and measurable, and now there is an appropriate assessment tool to use for program planning and progress monitoring. Having a better understanding of how young children with visual impairment learn early literacy and mathematical concepts (Day et al., 2008) as a tactual process will allow for the research-based development of more effective teaching strategies for this population in the early childhood setting.

Limitations

It was noted earlier in this study that measurement development is a complex and exacting process, and the many tasks to accomplish the creation of a valid and reliable instrument require rigorous and thoughtful analysis. This study was no exception, and every effort was made throughout the creation of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) to use recommended measurement guidelines (AERA et al., 2014) and best practices in early childhood assessment (Barnett et al., 2015; Greenwood & McConnell, 2011). Despite these efforts, there were several limitations to this investigation.

The most significant limitation focused on acquiring enough child participants to meet the necessary sample size requirements to run the needed statistical procedures. The Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is a test that has been developed for a specific population. Therefore, only those children who met the selection criteria of being both a tactual learner and within the age-related boundaries were administered the test. Young children with visual impairment are part of a low-prevalence population which affected the completion of this study. This limitation was addressed through the use of nonparametric statistical procedures such as the Mokken Scale analysis and Spearman correlation coefficients.

Although specific strategies for this study were designed to overcome the geographical distances between participants, such as video training and online score entry, the reluctance of the children's EC teachers and vision professionals to administer the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) on their own was somewhat surprising. Very few teachers of individual children were willing to participate in the study from a distance, and even specialized school programs with significant numbers of children who met the criteria for the study preferred to have the researcher come and administer the Boehm-3 Preschool Tactile Edition to the children enrolled in their programs. The reasons for this reluctance seemed varied and unclear. Some teachers indicated that they felt unqualified to administer the assessment, while others were uncertain if the children would be successful. Other potential test administrators shared that they were against "testing in general," as it was not beneficial for the students, or that they did not have time to learn how to give the assessment tool. These reactions are consistent with a survey of teachers of students with visual impairment (TSVIs) that explored their opinions about the use of various assessment tools in specialized schools

(Hannan, 2007). Many of the participants in Hannan's survey believed the assessments were not valid, or even useful, when administered to students with visual impairment, or that they did not measure the true skills of the students. Even when the researcher in this study offered to review the testing materials in depth on the telephone or through video tele-intervention with potential teacher participants, they continued to express reluctance. This behavior proved to be a significant limitation to data collection, causing the time to extend to almost two years and to result in very few test administrations by other individuals.

An additional limitation to this study was the investigator's creation of the Smyth Developmental Rating Scale to be used as a convergent construct validity measure with the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014). This measure did not have any established validity for this study, as it had never been used. To address this limitation, caution was used in the interpretation of the matched score results of this measure, especially when reporting convergent validity correlations though additional analysis to address possible test administrator bias.

Future Research

The process of establishing validity components for the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) is only the beginning of discovering how it can be used to meet other educational and research-based questions in the field of visual impairment. The potential to apply a valid tactual assessment to intervention-based or program evaluation second generation research is significant.

The researcher would like to further investigate the limitations that were discovered in the process of conducting this study. The Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) provides a unique opportunity for EC professionals to

determine clear program instruction for their preschool students with visual impairment. The reluctance of these professionals to administer the assessment is something that requires additional investigation. In order to support EC professionals in the use of the Boehm-3 Preschool Tactile Edition, it is critical to understand what is at the root of the reluctance. Is it a distrust of testing for this population in general? Are they concerned that the results will reflect on their teaching abilities? Are they unsure of their students' skills in this area? The answers are unclear, and a future qualitative, semi-structured interview process applied to the EC professionals who observed their students participate in this study and those who have not had any exposure to the Boehm-3 Preschool Tactile Edition may shed some light on this question. It was this investigator's experience that many of the EC professionals who observed the test being administered acquired more confidence in their potential to administer the Boehm-3 Preschool Tactile Edition as a portion of the assessment process in their classroom. It is possible that an introduction to the test in a preservice assessment course may alleviate new teacher's anxiety.

Another surprise was the positive feedback that the investigator-created Smyth Developmental Rating Scale received from the EC professionals who reviewed and completed it. Although the scale is not valid at this time, it would be helpful to pursue its further use with the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014). There are, of course, multiple developmental assessments available that address some of these age-expected fine motor and cognitive skills within the traditional domain-based format (Brown, 2005; Squires et al., 2009). It should be noted, however, that the Smyth Developmental Rating Scale is written in a more functionally-based activity format and allows the EC professional to indicate different levels of skill acquisition. Additional

construct validity assurance of the Smyth Developmental Rating Scale could potentially support supplementary program planning materials when using the Boehm-3 Preschool Tactile Edition.

Further research could also address the criteria for using the Boehm-3 Preschool tactile edition (Ferrell et al., 2014). One of the original criteria for participating in this study included "Children who primarily learn through their tactile sense and are potential braille readers." Initially, it seemed fairly clear that this statement would help to identify the appropriate participants to validate the tactile assessment. Instead, there were more inquiries about this statement than any other. It appears there are many TSVIs that have not yet considered if preschoolers have a learning preference for using their tactile sense. Many TSVIs were concerned that a child on their caseloads had "too much vision" to participate in this study, or that using a tactile assessment would limit them in some way. These conversations have caused the researcher to think deeply about how the field of visual impairment makes decisions about learning media and how it bases many educational recommendations on the level of visual functioning a child demonstrates. Is it appropriate to designate a child a "visual learner" if they have a certain level of visual functioning? What if they fatigue quickly, or are more accurate when using their tactile sense?

The field of visual impairment professes to promote "sensory efficiency" for children (Anthony, 2017) to assure that children are using the optimal sensory channel for learning in the classroom. Little is understood about how individual children acquire visual and tactile preferences (Johnson, 2010; McLinden, 2012). APH has adapted the Boehm-3 Preschool Test of Basic Concepts (Boehm, 2001) into both the tactile edition

and the big picture edition, and additional research could be conducted to look at whether levels of visual functioning are truly related to the child's learning abilities.

Finally, the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) could allow for additional research into the potential effects of visual impairment on learning to follow directions. Tasks such as following directions and understanding relational concept language are necessary for the transition of moving from discriminating real objects to representational tactual items. Previous research (Plumert et al., 2012) indicated that children ages 2 years, 5 months to 3 years, 5 months with sight were more successful in following directions describing a location that was related to a person, rather than an object. Is this true for children with visual impairment as well? Is the typical developmental acquisition of direction following the reason that many participants in the 3-year-old age group could not complete the assessment? Do we, as TSVIs of young children with visual impairment, need to provide more opportunities to follow directions in the everyday routines of home and the preschool classroom? There is much work to do here, and now that the field of visual impairment has an assessment with strong validity components, this research can be attempted.

Conclusions

The Boehm-3 Preschool Test of Basic Concepts (Boehm, 2001) has an established history of validity and reliability as an assessment for children ages 3- through 6-years-old with age-expected skills and behaviors. The current study examined the validity of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) for use with young children who are tactile learners with visual impairment. This study: (a) used an EFA (O'Connor, 2000) to establish unidimensionality, (b) used a nonparametric Mokken Scale model (van

Schuur, 2011) to determine item analysis fit, and (c) applied Spearman ranked correlation coefficients (Glass & Hopkins, 2008) to determine construct validity (AERA et al., 2014) using an investigater created Smyth Developmental Rating Scale. The design of this study was focused on three research questions.

Research Question 1 (*Is the tactile edition of the Boehm-3 Preschool unidimensional?*) showed evidence of positive results. The EFA used a parallel analysis of concept scores for both 3-year-olds and 4- and 5-year-olds with a principal component rotation to indicate the presence of a single factor. In addition, the internal consistency (Cronbach's α) of both age groups demonstrated high reliability.

Research Question 2 (*Do the Boehm-3 Preschool Tactile Edition scores fit a developmental Mokken Scale analysis?*) showed evidence of a developmental scale for concept scores in both age groups based on the application of a monotone homogeneity (MH model), and the 3-year-old group also met the criteria for the double monotonicity (DM model). Although the DM model showed indeterminate fit with the 4- and 5-year-olds' concept scores, the results did not indicate poor item development. Demonstration of an adequate scale using the MH model and low participant numbers in some age ranges of the sample support the fit of a Mokken scale, which should lead to the future use of this statistical procedure in the field of visual impairment. The Mokken scale reliability index was also high for both groups, confirming the previous internal consistency results and establishing strong reliability.

Research Question 3 (*Will the Boehm-3 Preschool Tactile Edition scores show construct validity with an investigator created Smyth Developmental Rating Scale?*) demonstrated a positive outcome for both 3-year-olds and 4-and 5-year-old age groups

using nonparametric Spearman ranked correlation coefficients. The Smyth Developmental Rating Scale was created specifically for this study, and although the response rate was low at 12%, strong positive relationships were demonstrated with the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) for both age groups.

In conclusion, the psychometric properties of the Boehm-3 Preschool Tactile Edition (Ferrell et al., 2014) supported unified validity components (Messick, 1995) for young children who are tactile learners with visual impairment. The Boehm-3 Preschool Tactile Edition appears to be a stable instrument and can be reliably used in the preschool classroom for the purposes of instructional planning and progress monitoring.

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APPENDIX A

AMERICAN PRINTING HOUSE FOR THE BLIND FIELD TEST RESULTS (EXCERPTS FROM INTERNAL REPORT RELATED TO FIELD-TEST RESULTS)

Review Panel Rating Sheet FY2015
[excerpts]

Name of Product: Boehm-3 Preschool (Tactile and Big Print Editions)

The *Boehm-3 Preschool* is a tactile and large print adaptation of the *Boehm Test of Basic Concepts (3rd edition)—Preschool* (Boehm, 2001). APH successfully adapted the original *Boehm* and sold it as the *Tactile Test of Basic Concepts* (Caton, 1983) for many years. This tactile version is no longer available. No other test has emerged that provides the same quality of information about young children's knowledge of basic concepts for school readiness.

For children with visual impairment, development of these concepts is particularly important, as it leads not only to school-age competency in academics (Ferrell, 1998, 2011), but to a foundation for orientation and mobility within the environment (Skellenger & Hill, 1997). Simeonnsson and Rosenthal (2001) suggest that the value of the *Boehm*-3 is twofold:

1. As a measure of a child's cognitive and language abilities; and
2. As "the basis of determining the appropriateness of administering other measures with known requirements of knowledge of basic concepts" (p. 57).

Simeonnsson and Rosenthal also point out that the availability of the tactile version of the *Test of Basic Concepts* (1983) made the test a particularly valuable assessment for children with disabilities.

Statement	Comments
There is evidence that APH made the decision to produce this product based on a standardized process of product selection.	Ann Boehm, an Emerita Professor of School Psychology at Teachers College, Columbia University, has a strong interest in young blind children and sought out a previous member of this panel (Jane Farber, at the time a teacher at the Maryland School for the Blind), who submitted the idea to APH . . . in January, 2009. Shortly thereafter, Farber shared the idea with Kay Ferrell (also a member of this panel), who became interested in the adaptation because of her work in early childhood special education, her admiration for the original *Tactile Test of Basic Concepts* (which she had used often during her years of practice), and her relationship with Dr. Boehm when she was a member of the Teachers College faculty. The product idea was evaluated both by Farber and by Barbara Henderson . . . , then APH's

Statement	Comments
	Project Leader in Tests and Measurements. Henderson recommended obtaining permission from the test publisher, Pearson, first, which occurred in 2010. The product was approved by PARC on August 11, 2010 . . . . Kay Ferrell, serving as an Executive-in-Residence for APH, remained committed to this project and eventually became Project Leader after the retirement of Henderson. After development of prototypes, subsequent field-testing, and revisions based on the field testing, the product was approved for quota on October 13, 2013 . . . .
There is evidence that APH sought opinions of knowledgeable individuals to determine the need for this product.	The idea for this product was brought forth by a teacher of students with visual impairments. The original product idea form indicated that she had consulted with Kay Ferrell and Cay Holbrook. Ferrell recruited one of her doctoral students, Catherine Smyth, to work on the project (coincidentally, her dissertation focuses on validating the tactile edition of the test). Kat Boisvert, Ed.D., Northeast Regional Center for Vision Education, University of Massachusetts at Boston, was also consulted prior to test development, because she had developed an earlier prototype for her dissertation. The following teachers of preschool children participated in the field test: Patricia J. Beecher, Coordinator, Early Childhood Program, New Mexico School for the Blind and Visually Impaired, Albuquerque, NM Sue Chisolm, New Mexico School for the Blind and Visually Impaired, Early Childhood Programs, Albuquerque, NM Kara Conroy, Principal, The Ethel and Samuel J. LeFrak School, Lighthouse International Child Development Center, New York, NY Joanne Devine, Pittsburgh Public Schools, PA Coleen Donaldson, Carroll County Public Schools, Westminster, MD

Statement	Comments
	Jane E. Farber, Prince Georges County Public Schools, MD Joanne Garrety, Philadelphia, PA Karen Karnes, Harford County Public Schools, Bel Air, MD Traci Moretto, Lighthouse International Child Development Center, New York, NY Kim Perlongo, Lavelle School for the Blind Preschool Program, Bronx, NY Dawn Regan, Lavelle School for the Blind Preschool Program, Bronx, NY Regina Rizzo, Lighthouse International Child Development Center, New York, NY Catherine A. Smyth, Anchor Center for Blind Children, Denver, CO The Team from Visually Impaired Preschool Services, Louisville, KY Dena Zorbach, Harford County Public Schools, Bel Air, MD Unfortunately, some of the field test materials were lost in shipping and never made it back to APH from New York. Consequently, data were lost for both individual children and for teachers' review of the materials. A summary of the teachers' review is included in [pages 166-171], for the six reviewer forms that were received.
Statement	Comments
Data were gathered using an appropriate method.	A field test was conducted with 12 children between the ages of 3-0 and 5-9 using the Tactile Edition and 23 children of the same ages using the Big Picture edition. The field test procedures were reviewed by the Institutional Review Board at the University of Northern Colorado. Consent was obtained from parents, and the children were asked for assent (although this was somewhat questionable with the youngest children). Additional children were tested in New York, but those forms were lost in the mail.
There is evidence that research data are considered as part of decision-making in product completion	The *Boehm-3 Preschool* Tactile and Big Print Editions went through an iterative development process among APH staff, consultants, and Dr. Boehm. APH incorporated findings from the haptic and cognitive research (Lederman &

Statement	Comments
	Klatsky, 2009; Withagen, Vervloed, Janssen, Knoors, & Verhoeven, 2010) into the design of the Tactile Edition. Research in the area of haptic exploration of the young child with visual impairment shows that (a) both hands move together in synchrony, (b) the hands show a preference for textures that are increasingly dense, and (c) once a complex texture is found, movement patterns are slowed for further exploration (Schellingerhout, Smitsman, & Cox, 2005). The implication of this information is that individual children will seek out more complex tactual test items, but as they discriminate the symbol, their attention will not be on the relationships between the items, but on each item. To avoid this distraction during the test, tactile adaptations were kept simple and familiar (Decker, 2010; Spence & Gallace, 2007). In designing individual test items for the Tactile Analog, APH made a concentrated effort to replicate everyday stimuli (such as zippers, spoons, buttons, etc.), encouraging the child to attend to the concept being measured. Administration scripting for the *Boehm-3:Preschool* Tactile Edition included limiting the instructions to the simplest form possible and monitoring for age appropriate vocabulary. Data from the field \test [pages 173-180] and comments from teachers [pages 167-172] were used to revise the Big Print graphics and the Tactile Edition stimuli. Each item was discussed by Ferrell, Henderson, Smyth, and Boehm, in consultation with APH model makers and APH graphic artists. Initially there was concern that the original Boehm's use of four graphic choices per page would, when turned into a tactile representation, result in too much information to process for a young blind child. Since each concept is tested twice, Dr. Boehm gave her permission to alter one item for each concept by reducing it to three-stimuli. The order of presentation of three-stimuli items was randomly assigned, although for various reasons only 32 pairs (three vs. four) of

Statement	Comments
	concepts were available for analysis. Field test results indicated that more children responded correctly to the three-stimuli concept items, the difference was not significant ((*t* = 1.600, *df* = 31, *p* = .120). We thus decided to maintain the integrity of the original *Boehm-3 Preschool* and developed all tactile concept items with four-stimuli (*see* Table [22]).
The research method used collected sufficient information.	[Pages166-171] contains the reviewers' comments (n = 6) and [Tables 21- 26] contain the data for each concept tested.
Data were gathered from a geographically diverse U.S. population.	The field test occurred in Colorado, Kentucky, Maryland, New Mexico, New York, and Pennsylvania. The field test could have been more diverse, but losing test materials in the mail prohibited further distribution.
Data were gathered from appropriately qualified individuals.	Teachers of students with visual impairments administered the tests in the above states.
Data were gathered from an adequate number of sources.	Ten prototype sets were created for the field test, but some never made it back for re-distribution. The 35 children and 15 teachers who participated in the field test were adequate and provided sufficient information to revise and publish the product.
Data were gathered on student/consumer outcomes	Student performance data are found in [Tables 21-26]**.**

…

Field Reviewer Questionnaire
Large Print and Tactile Prototypes

Boehm-3 Preschool

Field Test Evaluation Questionnaire

Part I: General Evaluation **of test administrator and examinee materials (to be completed by all field reviewers)**

Please answer the following questions about general aspects of the Boehm-3 Preschool materials after you have administered the test(s).

1. Is the design of the stimulus books appropriate for use with children aged 3-0 to 5-11?

   ___ yes = **6** ___ no = **0**

If no, please explain:

2. The stimuli are appropriate for use with students who have the following: (check all that apply)

   ___ multiple disabilities = **2**
   ___ low vision = **5**
   ___ blindness = **6**
   ___ learning disabilities = **1**
   ___ deafblindness
   ___ other_____

3. Did your students make any notable comments about the test stimuli?

   ___ yes = **3** ___ no = **3**

Please list student comments here:
They made comments about the bright colors; the cute animals-they loved the animals
Student was interested in the graphics and enjoyed the activity
Students seemed to enjoy the beads and cookie. Vertically presented stimuli were confusing. Tactile numbers were distracting.

4. Was the tactile analog easy to use?

   ___ yes = **3** ___ no = **2**

Explain:
Yes--rings on binder need to be larger due to pages falling out; tough for solo admin and slows down the process
No--It was for the most part. But we were confused by the items that required student to stand up and comment on the position, i.e. first or last
Yes--Student was able to manipulate the pages and images. The 3rd book was very thick and bulky. I had to remove the pages to allow the student to use the pages one at a time and have them lying flat on his desk.
No. The binders were too small. Suggest changing size to fit standard binders.
Yes--I like the size of the pages and that they were separate.

5. Was the large print analog easy to use?

___ yes = **5** ___ no = **0**

Explain:
Yes--It was very direct. But for some children that have color blindness there should be black/white or other 3-D pictures
Yes--the directions were very clear and direct. All tools were provided for the evaluator
Yes--love the format

6. Were the instructions for administration of the Boehm-3 Preschool prototypes clear and understandable?

___ yes = **6** ___ no = **0**

If no, please explain or make suggestions:
Some--there needs to be more flexibility with questions
Yes--the instructions were clear and understandable but there could have been a little more flexibility with the wording of the questions.

Part II: Evaluation of Tactile Prototype Features

Please answer the following questions about the tactile prototype:

1. Is the white plastic used for the tactile stimuli appropriate for children ages 3-0 to 5-11?

___ yes = **5** ___ no = **0**

If no, please explain:

2. Are the stimulus shapes engaging for the students?

___ yes = **5** ___ no = **0**

If no, please explain:
Kids particularly liked the beads and cookie

3. Is the raised print numbering/lettering on the sheets helpful to the test administrator?

___ yes = **5** ___ no = **0**

If no, please explain:
Yes—but one student confused the page number as a possible answer.
Yes—but distracting to some children.

4. Which shape(s) did your students like *best*?

___	circle = **1**	___	box
___	button = **1**	___	gingerbread cookie = **5**
___	zipper = **3**	___	bead = **1**
___	star = **4**	___	toothbrush
___	spoon = **4**	___	arrow

Comments:
Circle, button, star, spoon, g.b. cookie, bead – all were easily recognized.

5. What shape(s) did your students like the *least*?

___	circle	___	box = **2**
___	button = **2**	___	gingerbread cookie
___	zipper =**1**	___	bead = **2**
___	star	___	toothbrush
___	spoon	___	arrow = **3**

Comments:
Box, arrow—the student had some diff distinguishing the edges of the boxes and was unfamiliar with the arrow
Button, bead. One child thought the arrow was a house.

6. Are there any added features or modifications to the tactile stimuli or administrator's materials that you would recommend?

___ yes = **2** ___ no = **2**

If yes, please describe and explain:
Yes—I suggest adding " _____ out of 26 test items" at end of each subsection.
Yes—The size of the buttons and stars inside the boxes was close to the edges and caused some confusion.

7. Are three or four stimuli per page more appropriate for young children?

___ three = **2** ___ four = **3**

Please explain your thinking:
Three children with MD may perform better with less clutter and fewer choices.
Four—3-year-olds did better with 3; 4 & 5 year olds did well with both 3 & 4 stimuli.
Three—older children seemed to do fine with four. I would change the "middle" concept pages to three items rather than five.

8. Did the children like the manipulatives set?

___ yes = **4** ___ no

Explain and recommend changes:
Yes—they loved the chair.
Yes—I think they enjoy the break from tactile stimuli. Can use to check if they have concepts with objects, for any item.

Part III: Evaluation of Large Print Stimuli (enlarged picture manual)

Please answer the following questions about the large print (enlarged) materials:

1. Is the weight/thickness of the paper acceptable for its intended use?

___ yes = **4** ___ no = **1**

If no, please explain:
No—a little thicker paper is needed.

2. Is the color of the paper right for this product?

___ yes = 4 ___ no

If no, please explain:
Yes/no--some pictures could be more colorful with contrast

3. Were the visual stimuli large enough for your students to see clearly?

___ yes = **5** ___ no

If no, please explain:
Yes—some pictures were clear with good contrast. Some pictures could be more 3-dimensional.

4. Did your students seem to be engaged by the visual stimuli?

___ yes = **5** ___ no

Please explain:
Yes—they took time to look at details in the pictures.
Yes—the children were very interested in seeing the pictures. The pictures and questions keep the children's attention.

5. Are the colors in the picture stimuli bright enough for your students?

___ yes = **4** ___ no

If no, please explain:
Yes—for the most part; 3 students had trouble with the contrast in the food bowls and cats.
Yes/no—some black and white colors should be incorporated.
Yes—a few could have had more contrast.

6. Are there any changes you would suggest for the picture stimuli?

___ yes = **4** ___ no = **1**

Explain and add any other comments you wish to make (use other side if necessary):
Yes—laminate pages with non-reflective material. Children liked touching pages and turning them so lamination would protect pages from small hands.
Yes—Most of the pictures and colors were appropriate. Some of theunder/next to concepts were a bit confusing because the 3-dimensionals weren't clear.
Yes—I found most of the pictures, sizes, and colors to be appropriate.
Yes—laminated paper for durability. May need two folders for this.

Please return your review, picture manual, and comments to:

Barbara Henderson, Test & Assessment Project Leader
American Printing House for the Blind
1839 Frankfort Avenue
P.O. Box 6085
Louisville, KY 40206

Child Field Test Outcomes

Table 21

Correct Responses and Mean Test Duration for Children Administered the Boehm-3 Preschool Tactile Edition

Age	N	Proportion of Correct Responses	Mean Test Duration (Minutes: Seconds)
3-0 to 3-11 years	4	68.3%	24:02
4-0 to 4-11 years	3	72.3%	25:00
5-0 to 5-11 years	5	80.8%	37:20
Total	12	74.5%	29:52

Note. A 13th child (age 3-0 years) was not able to progress past the sample items, and the test was terminated. A 14th child (age 6-7 years) was tested, but the results are not included here because the child was outside the designated age for test administration.

Table 22

Proportion Passing 3- vs. 4-stimuli Items, Tactile Edition of the Boehm-3 Preschool

Item #	Concept	Number of Stimuli (First/Second)	Proportion Passing 3-Stimuli (Mean = **0.829%)**	Proportion Passing 4-Stimuli Mean = **0.748%)**
1/13	Top	4/3	0.667%	0.250%
2/14	Down	¾	0.750%	0.250%
3/15	Empty	¾	0.750%	1.000%
4/16	Under	-/3	1.000%	
5/17	Highest	4/3	1.000%	1.000%
6/18	Missing	4/3	1.000%	1.000%
7/19	Next	4/3	1.000%	1.000%
8/20	Another	4/3	1.000%	1.000%
9/21	Up	4/3	0.667%	0.333%
10/22	Full	¾	1.000%	0.667%
11/23	Outside	¾	0.667%	1.000%
12/24	All	-/-		
25/39	Nearest	4/3	0.909%	0.727%
26/40	Finished	4/4		0.750%
27/41	Smallest	4/3	0.800%	0.909%
28/42	Across	4/4		0.571%
29/43	Different	4/3	0.857%	
30/44	Longest	¾	0.800%	0.909%
31/45	In front	-/-	Perf.	Perf.
32/46	Both	-/3		
33/47	Around	4/3	1.000%	0.500%
34/48	Tallest	4/3	0.857%	
35/49	Many	4/3	0.636%	0.900%
36/50	Same	4/3	0.857%	
37/51	Most	4/3	1.000%	0.727%
38/52	Largest	¾	0.818%	0.800%
53/65	Before	¾	1.000%	1.000%
54/66	Farthest	-/-	1.000%	1.000%
55/67	Lowest	4/3	0.800%	0.800%
56/68	Shortest	4/4	1.000%	0.600%
57/69	Last	4/3	1.000%	
58/70	Bottom	4/4	0.800%	1.000%
59/71	Together	3/3	0.800%	1.000%
60/72	Some, but not many	4/3	0.800%	0.600%
61/73	Middle	-/-	0.800%	
62/74	First	-/-	0.900%	
63/75	Between	¾	0.400%	0.600%
64/76	Least	3/3	1.000%	0.600%
77/83	Right	¾	0.800%	1.000%
78/84	Left	3/3	0.800%	1.000%
79/85	Corner	4/3	0.800%	0.400%
80/86	Slanted	¾	0.600%	0.600%
81/87	Thickest	¾	0.600%	0.600%
82/88	Thinnest	4/3	0.600%	0.200%

Note. - indicates item not passed; Perf = Performance item; 32 pairs analyzed (t = 1.600, df = 31, p = .120).

Table 23

Correct Responses and Mean Test Duration for Children Using the Boehm-3 Preschool Big Print Edition

Age	N	Proportion of Correct Responses	Mean Test Duration (Minutes: Seconds)
3-0 to 3-11 years	5	63.5%	13:31
4-0 to 4-11 years	14	72.3%	22:12
5-0 to 5-11 years	4	92.9%	37:20
Total	23	74.0%	19:32

Table 24

Proportion of 3-0 to 5-11 Year Olds Passing Concept at Least Once, Big Print Edition

Item #	Concept	Proportion of 3-Year-Olds Passing (once)	Proportion of 4-&-5-Year Olds Passing (once)
1/13	Top	1.000%	
2/14	Down	1.000%	
3/15	Empty	0.800%	
4/16	Under	0.800%	
5/17	Highest	0.800%	
6/18	Missing	0.800%	
7/19	Next	0.800%	
8/20	Another	0.800%	
9/21	Up	0.500%	
10/22	Full	1.000%	
11/23	Outside	1.000%	
12/24	All	1.000%	
25/39	Nearest	0.750%	1.000%
26/40	Finished	0.750%	0.941%
27/41	Smallest	1.000%	1.000%
28/42	Across	0.750%	0.941%
29/43	Different	0.750%	0.882%
30/44	Longest	0.750%	0.824%
31/45	In front	0.750%	1.000%
32/46	Both	0.250%	0.941%
33/47	Around	0.500%	0.882%
34/48	Tallest	1.000%	0.941%
35/49	Many	0.500%	0.882%
36/50	Same	0.500%	0.882%
37/51	Most	0.667%	0.941%
38/52	Largest	1.000%	0.882%
53/65	Before		0.867%
54/66	Farthest		0.733%
55/67	Lowest		0.867%
56/68	Shortest		0.733%
57/69	Last		0.600%
58/70	Bottom		0.867%
59/71	Together		0.667%
60/72	Some, but not many		0.867%

Table 24 (continued)

Item #	Concept	Proportion of 3-Year-Olds Passing (once)	Proportion of 4-&-5-Year Olds Passing (once)
61/73	Middle		0.733%
62/74	First		0.600%
63/75	Between		0.800%
64/76	Least		0.400%

Note: Children between the ages of 3-0 and 3-11 complete items 1 – 52. Children between the ages of 4-0 and 5-11 complete items 25 – 76.

Table 25

Greater Than 70% Passing on Tactile and Big Print Editions, by Age Group

		> .70 of 3-year-olds Passed Once		> .70 of 4-&-5-Year-Olds Passed Once	
Item #	Concept	Tactile (n = 4)	Big Print (n = 5)	Tactile (n = 8)	Big Print (n = 18)
1/13	Top		X		
2/14	Down	X	X		
3/15	Empty	X	X		
4/16	Under	X	X		
5/17	Highest	X	X		
6/18	Missing	X	X		
7/19	Next	X	X		
8/20	Another	X	X		
9/21	Up				
10/22	Full	X	X		
11/23	Outside	X	X		
12/24	All	X	X		
25/39	Nearest	X	X	X	X
26/40	Finished		X	X	X
27/41	Smallest	X	X	X	X
28/42	Across		X	X	X
29/43	Different	X	X	X	X
30/44	Longest		X	X	X
31/45	In front	X	X	X	X
32/46	Both	X		X	X
33/47	Around	X		X	X
34/48	Tallest	X	X	X	X
35/49	Many	X		X	X
36/50	Same	X		X	X
37/51	Most			X	X
38/52	Largest		X	X	X
53/65	Before			X	X
54/66	Farthest			X	X
55/67	Lowest			X	X
56/68	Shortest			X	X
57/69	Last			X	
58/70	Bottom			X	X

Table 25 (continued)

Item #	Concept	> .70 of 3-year-olds Passed Once		> .70 of 4-&-5-Year-Olds Passed Once	
		Tactile (n = 4)	Big Print (n = 5)	Tactile (n = 8)	Big Print (n = 18)
59/71	Together				
60/72	Some, but not many			X	X
61/73	Middle			X	X
62/74	First			X	
63/75	Between				X
64/76	Least			X	
77/83	Right			X	
78/84	Left			X	
79/85	Corner			X	
80/86	Slanted			X	
81/87	Thickest			X	
82/88	Thinnest			X	

Note: Children between the ages of 3-0 and 3-11 completed items 1–52; children between the ages of 4-0 and 5-11 completed items 25–76; items 77–88 were added to the tactile prototype *only* at the suggestion of APH staff and were intended for ages 4-0 to 5-11.

Table 26

Percent Correct for Large Print and Tactile Prototypes of the Boehm-3 Preschool, Both Editions

Version	Age at Time of Administration (in Years-Months)					
	3-0 to 3-5	3-6 to 3-11	4-0 to 4-5	4-6 to 4-11	5-0 to 5-5	5-6 to 5-11
Big print	67.2% (n = 2)	71.2% (n = 3)	64.7% (n = 8)	80.4% (n = 6)	93.4% (n = 4)	np
Tactile	np	77.7% (n = 4)	np	76.9% (n = 3)	81.7% (n = 3)	93.3% (n = 2)

Note: While there appears to be a progression in the number of correct responses by age group, the numbers are too small in each group to be definitive. Age 4-0 to 4-5 seems somewhat of an anomaly and requires further exploration; np = no participant in this age group

APPENDIX B

RESEARCH TOOLS

Smyth Developmental Rating Scale

1. What is your title?

2. How long have you worked with young children with visual impairment?

3. How long have you been this child's teacher?

4. How did you prepare to administer the *Boehm-3 tactile version*?

Administrators manual Online Video Both Neither

5. Did this child receive Early Intervention (EI) Vision Services?

Yes No Unknown

6. If yes, what age did EI Vision services begin?

7. How long has the child been in Preschool? 1st year 2nd year 3rd year

8. Do you believe this administration of the *Boehm-3 tactile version* is an accurate reflection of this child's understanding of basic concepts?

Why or Why Not?

_____

_____

_____

_____

_____

_____

_____

_____

_____

The next few questions will ask you about the child's cognitive and tactile exploration skills. These skills are included in multiple developmental checklists for this age group such as the *Ages and Stages Questionnaire,* the *Denver II Developmental Screening,* the *Oregon Preschool Project, etc.* Please answer the questions to the best of your ability. Think of when you have **observed** the child accomplish the task and whether he or she is able to complete these skills on a regular basis.

Rate child for each skill on the following five level rating scale. The child should only receive credit for the skill if you have **observed** him or her perform the item

Understands basic relational concepts **on** their body. (Knows front, back, side, under, etc.).

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Place Blocks or small items in a cup (Releases one item into a container)

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Shows interest in texture differences (quiets, rubs, verbalizes, etc.)

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Uses one hand to scan for dropped object with open hand next to body

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Child can follow simple directions. (Give me your hand, sit down, let go)

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Orients toys to body (For example: Can you put the toy on your head? Can you sit next to the ball?)

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Turns pages of books

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Uses fingers for counting or “fingerplays”

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Can fasten clothing (zippers, buttons)

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Maintains search for dropped object in familiar environment

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Answers simple questions accurately (Yes, No, name, place: *This does NOT have to be with speech, can include gestures*)

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Rolls, pats, pounds, or pinches clay ball

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Matches textures

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Sorts objects by size

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Sorts objects by shape

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Inserts pegs in a pegboard

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Tactually locates requested objects on page

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Traces around the outside of a shape

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Places small items in a slot (pennies in a bank)

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Imitates a horizontal line with a crayon or drawing instrument

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Builds with interlocking toys

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Pour liquid from one container to another

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Identifies three dimensional shapes with fingers

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Labels or identifies textures

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Identifies the stimuli in the *Getting Ready* binder.

Not Yet	Only with Assistance or prompt	Once	Emerging Independence	Consistently

Table 27

Child Demographics Collected from the Smyth Developmental Rating Scale

Visual Diagnosis	Years in Preschool	Additional Medical Diagnosis?	Received Early Intervention	Age Started EI?	Time to Complete Boehm-3 (min.)
Cryptophthalmus	1	No	Yes	6 wks.	0.00
LCA	1	No	Yes	Birth	0.00
Cryptophthalmus	2	No	Yes	6 wks.	60.00
Optic nerve hypoplasia	2	No	Yes		30.00
Colobomas	1	No	Yes		22.00
Albinism	1	-	Yes		25.00
Optic nerve hypoplasia	1	-	Yes		0.00
Microphthalmia	1	-	Yes		25.00
Optic nerve hypoplasia	1	-	No		30.00
Cortical visual impairment	1	Hemisphectomy	Yes		60.00
Bullseye maculopathy	1	Cohen Syndrome	Yes		30.00
LCA	1	No	Yes	18 mos.	60.00
Bardet-Bidell	2	No	Yes	1 yr.	60.00
Optic nerve hypoplasia	2	-	Yes		30.00
Optic nerve hypoplasia	1	-	Yes	6 mos.	30.00
Hemianopsia, myopia	3	Hemiplegia	Yes		90.00
Cortical visual impairment	2	Hearing Impaired	Yes		45.00

Table 27 (continued)

Visual Diagnosis	Years in Preschool	Additional Medical Diagnosis?	Received Early Intervention	Age Started EI?	Time to complete Boehm-3(min)
LCA	1	-	Yes	10 mos.	0.00
Albinism	1	-	Yes		20.00
Cataracts	1	-	Yes		30.00
Albinism	2	-	Yes		30.00
Cortical visual impairment	2	Heart defect, Seizures	Yes		30.00
Optic nerve hypoplasia	2	Down's Syndrome	Yes		0.00
Albinism	1	-	Yes		45.00
Colobomas	2	-	Yes		45.00
Optic nerve hypoplasia	2	-	Yes		0.00
Optic nerve hypoplasia	3	-	Yes		0.00
Microphthalmia	3	-	Yes		0.00
Anopthalmia	2	No	Yes		30.00
Optic nerve hypoplasia	1	-	Yes		0.00
Optic nerve hypoplasia	2	-	Yes		30.00
Cortical visual impairment	2	Autism	No		0.00
Glaucoma	2	Hypotonia	Yes	2 yrs.	15.00
Cortical visual impairment, optic nerve atrophy	3	-	Yes		0.00
Cortical visual impairment, optic nerve atrophy	2	-	Yes		60.00

Table 27 (continued)

Visual Diagnosis	Years in Preschool	Additional Medical Diagnosis?	Received Early Intervention	Age Started EI?	Time to Complete Boehm-3 (min.)
Cortical visual impairment	2	-	Yes		0.00
Nystagmus, high myopia	2	-	Yes		0.00
Albinism	3	-	Yes		15.00
Optic nerve hypoplasia	2	-	Yes		30.00
Aphakia	3	-	Yes	1 yr.	0.00
Nystagmus	2	-	Yes		0.00
Glaucoma, aniridia	1	-	No		0.00
Optic nerve hypoplasia	1	-	Yes		0.00
Optic nerve hypoplasia	1	-	Yes	6 mos.	0.00
PVHV	2	No	Yes	5 mos.	60.00
Optic nerve hypoplasia	2	-	Yes		15.00

Table 28

Teacher Demographics collected from Smyth Developmental Rating Scale

Teacher Participant Title	How Long Working with Children with VI?	How Long Working with This Child?	Program Type
TSVI	19 yrs.	3 mos.	Inclusive
TSVI	32 yrs.	1 yr.	Inclusive
TSVI	20 yrs.	1 yr.	Inclusive
TSVI	27 yrs.	1 yr.	Inclusive
TSVI	2 yrs.	5 mos.	Specialized VI
TSVI	4 yrs.	5 mos.	Specialized VI
TSVI	4 yrs.	5 mos.	Specialized VI
TSVI	4 yrs.	5 mos.	Specialized VI
TSVI	4 yrs.	1 yr.	Specialized VI
TSVI	4 yrs.	1 yr.	Specialized VI
TSVI	4 yrs.	1 yr.	Specialized VI
COMS	6 mos.	6 mos.	Inclusive
TSVI	7 yrs.	2.5 yrs.	Inclusive
TSVI	15 yrs.	1.5 yrs.	Inclusive
TSVI	15 yrs.	6 mos.	Inclusive
TSVI	9 mos.	2 mos.	Inclusive
TSVI	2 yrs.	6 mos.	Inclusive
TSVI	2 yrs.	6 mos.	Inclusive
TSVI	15 yrs.	1 yr.	Inclusive
TSVI	15 yrs.	1 yr.	Inclusive
TSVI	8 yrs.	6 mos.	Specialized VI
TSVI	8 yrs.	6 mos.	Specialized VI
TSVI	5 yrs.	2 yrs.	Specialized VI
TSVI	5 yrs.	2 yrs.	Specialized VI
TSVI	5 yrs.	8 mos.	Specialized VI
TSVI	5 yrs.	2 yrs.	Specialized VI
TSVI	1.5 yrs.	8 mos.	Specialized VI
Classroom Teacher	4 yrs.	1 yr.	Specialized VI
Classroom Teacher	3 yrs.	2 yrs.	Specialized VI
TSVI	1.5 yrs.	5 mos.	Specialized VI
Classroom Teacher	3 yrs.	1 yr.	Specialized VI
Classroom Teacher	3 yrs.	1 yr.	Specialized VI
TSVI	5 yrs.	6 mos.	Specialized VI
TSVI	5 yrs.	6 mos.	Specialized VI
TSVI	8 yrs.	1 yr.	Specialized VI
TSVI	8 yrs.	1 yr.	Specialized VI
TSVI	8 yrs.	1 yr.	Specialized VI
Classroom Teacher	6 yrs.	8 mos.	Specialized VI
Classroom Teacher	6 yrs.	8 mos.	Specialized VI
Classroom Teacher	6 yrs.	8 mos.	Specialized VI
TSVI	5 yrs.	1 mos.	Inclusive
TSVI	2 yrs.	2 mos.	Inclusive
TSVI	2 yrs.	3 mos.	Inclusive
TSVI	2 yrs.	6 mos.	Inclusive
TSVI	10 yrs.	1.5 yrs.	Inclusive
TSVI	10 yrs.	1.5 yrs.	Inclusive

Test Administrator Competency Quiz
(administered in Qualtrics)

The purpose of this survey is to maintain test administration reliability across all administrators of the Boehm-3 Preschool Tactile Edition. Accurate test administration is critical for fidelity.

1. It is important that the child recognizes all of the stimuli in the Boehm-3 Preschool Tactile Edition before they attempt to take the test. True **False**

2. Which of the following answers is NOT TRUE when you are computing the child's chronological age?

a. When you need to borrow days, always borrow 30, regardless of the month
b. Round the ages up or down.
c. If the test was given in two sessions, use the date of the final testing.
d. The child's chronological age is important so that you know where to start

3. When indicating the child's answer on the Test Record Form, only + and – are allowed.
True **False**

4. Which of the following answers is TRUE when presenting the Practice items?

a. Include the answers to all of the Practice items in the raw score total.
b. If the child cannot complete the Practice items or does not understand, discontinue testing.
c. You may only present the directions for the Practice items once.
d. The Practice items are a waste of time for most children.

5. When preparing for testing, which activities are necessary?

a. Gather materials, compute child's chronological age, only give the test in one sitting.
b. Expose the child to the *Getting Ready* binder, make the child sit in a chair, start everyone with Binder 1.
c. Develop a rapport with the child, have the child look at test items in the full binder, give additional hints for every test item when needed.
d. Expose the child to the *Getting Ready* binder, gather all materials, make sure the child is comfortable, compute the child's chronological age.

6. What information on the *Parent Report Form* is important to share?

a. The basic relational concepts demonstrated by their child at this time.
b. Typical relational concepts that preschoolers should know.
c. A general performance range for their child.
d. All of the above.

Boehm-3 Preschool Tactile Edition Training Protocol

The instructional video demonstrates the same testing procedures indicated in the Administration Manual:

1. Overview of the APH administration guidelines for the Boehm-3 Preschool tactile edition.
2. The purpose and use of the "Getting Ready" Binder
2. How to compute the child's exact chronological age for beginning testing and fill out the child demographics on the provided Record form.
3. An overview of the assessment materials and how to set up the testing environment. These items should include
    a. The Boehm-3 Preschool Tactile Edition record form;
    b. Binders One, Two, and Three, depending on the age of the child; and
    c. The APH manipulatives necessary for the performance items.
4. How to remove the testing pages from the appropriate binders, depending on the child's age. Using a non-slip surface is recommended.
5. How to present the practice items to the child:
    a. Read the directions for each page exactly as written;
    b. Do not read the practice item letters;
    c. Emphasize the concept words in italics;
    d. Repeat the directions if necessary and encourage the child to guess;
    e. If the child does not understand the practice items, discontinue testing and re-introduce the Getting Ready Binder items through classroom activities.
6. How to administer the test items:
    a. Make sure the child is attentive before reading test items. Prompting with words such as "Ready?" is encouraged.
    b. Read the directions for each page exactly as written.
    c. Do not read the test item numbers.
    d. Emphasize the concept words in italics.
    e. Encourage the child after each answer, but do not indicate that the child's answers are right or wrong.
    f. If the child changes his/her answer, indicate this on the record form.
        i. Do NOT reword directions for test items.
        ii. Do NOT cue the child, or give hints, such as telling the meaning of words.
    g. Do NOT answer questions that children ask about the content of the test items, such as "Is this the Top?" Redirect the child to choose the answer she /he thinks is best.
7. How to score and record the results:
    a. Passing or failing the practice items on the second page of the record form should be indicated, but not included in the child's raw score.
    b. Next to the picture icon of each test item is a "Score" box. All items should be scored with a "1' for a correct response, a "NR" for no response,

an “A” for antonym or the opposite response, or an “E” if they pointed to every response and did not give a clear answer.

c. At the end of the testing session, total the scores in the “raw score” box of the Test Results page. This is the child’s “total raw score.” To determine the “percent correct,” divide the child’s raw score by the number of items (52 for the 3-year-olds, and 58 for the 4- and 5-year-olds).

d. Determine the child’s “concept score” by indicating on the Test Performance Summary Pages how many times the child mastered an item (each concept is tested twice). To determine the “percent correct” of the Concept score, total the number of times the child mastered both concepts correctly, then divide by the number of concepts.

8. Sharing results with others:

a. Suggestions for using the Test Summary of the Boehm-3 Preschool Tactile Edition results with professionals/families in the child’s early childhood setting to determine learning objectives in the Individualized Educational Program (IEP).

b. Complete the Parent Letter for sharing Boehm-3 Preschool Tactile Edition results with families through in-person meetings or phone calls.

Summary of Fit Indices for Mokken Scale Using R Mokken

Fit Indices	R Mokken functions[1]	Adequate Scale	Good Scale	Strong Scale
TOTAL SCALE				
Monotonicity				
H	Coefficient of H	.3 ‴ Ht < .4	.4 ‴ Ht < .5	.5 ‴ Ht
Double Monotonicity				
HT (H^T, HTrans)	summary (check.iio (X))	.3 ‴ Ht < .4	.4 ‴ Ht < .5	.5 ‴ Ht
INDIVIDUAL ITEMS[2]				
Monotonicity				
Minimum H_i values	Coefficient of H	None below .3	None below .4	None below.5
Monotonicity Crit. Value	Summary (check. monotonicity (X))	All below 80	All below 40	All zero
Double Monotonicity				
Restscore Crit. Value	summary (check.restscore(X))	All below 80	All below 40	All zero
Pmatrix Crit. Value	summary (check.pmatrix(X))	All below 80	All below 40	All zero
IIO Crit. Value	summary (check.iio(X))	All below 80	All below 40	All zero

[1]For details see van, Ark (2012). Package‘mokken’ version 2.7, http://spitswww.uvt.nl/~avdrark/

APPENDIX C

IRB REVIEW FORMS

Form A: Application for IRB Review

A. Purpose

1. Purpose of the Study

The purpose of this study is to examine the reliability and validity of the *Boehm-3 Preschool Tactile Edition* (Ferrell, Smyth, Henderson, & Boehm, 2014) for young children with visual impairments. Valid and reliable assessments in the field of visual impairment are extremely limited due to small sample sizes and outdated publication data. Not one of these assessments addresses early childhood standards for measurement development, nor do they lend themselves for use in instructional planning or progress monitoring (Mazella, Albaret, & Picard, 2014). For young children who will be tactual learners, incorporating the understanding of pre-literacy and direction following concepts is a good place to start, as the foundation of all learning (Birbili, 2007; Boehm, 2001; Karoly, 2012). The skills that children with visual impairment need to demonstrate an understanding of tactual concepts are developmental and measurable, but currently there are no appropriate measurements to assess them.

In preschool classrooms across the United States, vision impairment professionals and general early childhood educators are using a variety of informal and inappropriate measurements without rigor or consistency. Although there has been significant progress regarding the research in the field of haptic understanding (Lederman & Klatsky, 2009; McLinden, 2012; Papadopoulos, Koustriavia, & Kartasidou, 2012) in the last five years, this information has not been applied to tactual assessment or instruction for young children with visual impairment. This study will investigate connections between concept development and success in using the *Boehm-3 Preschool Tactile Edition* through the administration of the investigator created *Teacher Concept Rating Scale*. There is a need for valid tactual assessments to be available and easy to administer in the early childhood classroom.

The *Boehm-3 Preschool Tactile Edition* was designed to be individually administered to children ages 3 years 0 months to 5 years 11 months and was adapted to a tactile analog in early 2011 in a collaborative effort between Dr. Ann Boehm, the University of Northern Colorado, and the American Printing House for the Blind (Ferrell et al., 2014). As the test items were adapted, every effort was made to use relevant literature from both the fields of visual impairment and more recent haptic development research.

The questions that will be addressed in this test validation study include the following:

1. Is the tactile edition of the *Boehm-3 Preschool* unidimensional?

2. Do the *Boehm-3 Preschool Tactile Edition* scores fit a developmental Mokken Scale analysis?
3. Will the *Boehm-3 Preschool Tactile Edition* scores show construct validity with *Teacher Concept Rating Scale?*

2. Type of Review

This study requires an expedited review because the participants are young children. Online data security is a feature of Qualtrics (Qualtrics, 2013) survey software through password protection. Because of the parental and participant permissions that will be sought and are necessary to obtain, accidental disclosure will not place the participants at risk. Every effort will be made to increase anonymity through the use of numerical identifiers in data analysis and written materials. The data sensitivity will be low, and the researcher will provide Level 1 security for the data that is collected in a locked cabinet.

B. Methods

1. Participants

A purposeful sample of young children with visual impairment will be recruited through professional contacts with early childhood professionals, vision professionals, or educational diagnosticians who are the primary teacher for identified child participants. These potential test administrators will identify and recruit child participation through contacting their qualifying student's parents and using the Parent Recruitment Script. This can be used as a script for a conversation with a parent, or sent home as a letter. The potential test administrator will request parent consent for the child to participate in the study and return the signed parent consent form to the lead researcher. They will also copy the letter for the parent and save the original consent form.

Child participants for the *Boehm Test of Basic Concepts-Preschool* tactile edition validation study may receive educational services in any educational setting (inclusive preschool classrooms, specialized preschool settings, child care or home settings) but they must meet the following criteria:

1. Children with a diagnosed visual impairment between the ages of 3-0 and 5-11.

2. Children who primarily learn through their tactile sense and are potential braille readers.

3 Children who are able to independently scan and locate tactile stimuli on a page.

4. Children who have the cognitive ability to follow simple directions and answer questions with minimal adult prompting.

Criteria for the educational test administrators who will participate in this study will include:

1. Participating educational test administrators for the *Boehm-3 Preschool Tactile Edition* must be early childhood professionals, vision professionals, or educational diagnosticians who are the primary teacher for identified child participants.
2. Participating educational test administrators for the *Boehm-3 Preschool Tactile Edition* must review the *Boehm-3 Preschool Tactile Edition* Administrator Manual or watch a brief instructional video on administrating the *Boehm-3 Preschool* tactile version, and pass a short quiz at 100% to demonstrate understanding.
3. Participating educational test administrators must be willing to collect and return parental permission forms for each child participant, personal permission forms for themselves, and enter *Teacher Concept Rating Scale* survey answers and *Boehm-3 Preschool Tactile Edition* test scores online or in sealed envelopes. Because the educational test administrators will be collecting the consent forms, they will have the opportunity to have their questions answered directly by the investigator and her Research Advisor if they wish.

Through the *Teacher Concept Rating Scale,* informal demographic and developmental data will be completed by each participant's primary teacher to collect information that includes the visual diagnosis, the presence of additional disabilities, early intervention educational experiences, current educational experiences, and developmental skills of each participant. This survey data will be collected through an online Qualtrics survey. This sample of participants will be identified thorough communications with individual parents, teachers, and educational organizations through national listservs and personal contacts. It is anticipated that a sample of 120 qualified participants will be tested with the *Boehm-3 Preschool Tactile Edition* and the *Teacher Concept Rating Scale.* Although this group of participants represents a vulnerable population, the *Boehm-3 Preschool Tactile Edition* is developmentally appropriate and the results will not penalize the children in any way. In addition, data collection and analysis methods will minimize the risk of identifying information in future journal articles and presentations.

The nature of educational services for young children with visual impairments is often provided through itinerant and consultative services. It is likely that educational test

administrators may only have one or two students in a large geographic area that would meet the participant criteria. In addition, as the *Boehm-3 Preschool Tactile Edition* is already available to the public, test administrators may currently be including the test as a part of the student's assessment protocol to determine instructional goals or monitor progress. For these reasons, it does not appear acquiring school district permission for so few participants is practical or necessary. If a test administrator does have a large number of children who qualify and the employer requires that we officially apply for permission (e.g. for a specialized school for children with visual impairments), the lead investigator will certainly comply. This test is not administered as part of group or class assessment, and should have no effect on the child's participation in their preschool classroom. The difficulty in locating qualified participants for such research may actually be compromised by seeking school district permission that may only apply to one child.

2. Data Collection Procedures

The *Boehm-3 Preschool Tactile Edition* is easily administered in the preschool classroom or natural learning environment of the child. The informal nature of the test means that a variety of educational professionals familiar with young children with visual impairments will be able to administer the test in addition to the lead investigator. This test administration should follow the child's IEP assessment guidelines for preparation, timing and settings. If the child receives educational services at home or in another setting, participation should not be affected. If the lead investigator will be administering the test, the parent may request that the test administration take place in the home. In an attempt to increase the sample size for this assessment validation, scores will be accepted from test administrators across the United States who have watched an instructional video created or read the Administration Manual to address critical components of the *Boehm-3 Preschool Tactile Edition* and passed an online competency evaluation using Qualtrics. The following is a list of data collection procedures to demonstrate the activities that will occur during the study:

a. Secure consent from educational test administrators to administer the *Boehm-3 Preschool Tactile Edition* to students who meet the identified criteria. Participants will have the opportunity to read the consent form, ask questions prior to signing it, and retain a copy for their future reference.

b. Educational test administrators distribute and collect parental consent forms and student assent forms for each student who takes the *Boehm-3 Preschool Tactile Edition*.

c. Educational test administrators who wish to participate online for inclusion in the contribution of validation data from a distance will watch a training protocol video and pass an online competency evaluation at 100%. If they do not pass, they will be prompted to watch the video again.

d. The lead investigator or the educational test administrators will fill out a *Teacher Concept Rating Scale* in Qualtrics for each child participant.

e. The lead investigator or the educational test administrators will administer the *Boehm-3 Preschool Tactile Edition* to the child, following instructions.

f. The lead investigator or the educational test administrators will record responses and time required for each item during the test administration.

g. The lead investigator or the educational test administrators will conclude the test, and say goodbye to child.

h. The lead investigator or the educational test administrators will use labels to mark permission documents and test score answer sheets with matching numeric identifiers, and mail the results to the lead investigator.

Data that will be collected for each **educational test administrator**: Title; years of experience teaching young children with visual impairments; time spent with specific child; type of educational setting; previous early intervention educational experiences; preschool specific information about the child, and the developmental skills survey. Educational test administrators who watch the training protocol online will also indicate:
Title identifies the role of the educational test administrator.
Years of experience will indicate how long the participant has worked with young children with visual impairment.
Time spent with specific participant indicates time the test administrator is with the child in an educational setting.
Type of educational setting indicates whether the child is an inclusive or specialized setting.
Watched the online training protocol or read the Administration Manual addresses reliability training for test administrators.
Previous early intervention educational experiences allows for potential differences among child participants due to participation in Early Intervention services.
How long has the child been in Preschool?
Does the test administrator feel the *Boehm-3 Preschool Tactile Edition* is an accurate reflection of the child's abilities?
Teacher Concept Rating Scale developmental items.

Data that will be collected for each **child participant:** Birthdate; visual diagnosis; presence of additional disabilites; responses to *Boehm-3 Preschool Tactile Edition* test items; and time to complete *Boehm-3 Preschool Tactile Edition* test items.

Birthdate is required to determine chronological age, which indicates the starting point for the test.
Visual diagnosis allows for potential differences among child participants.
Presence of Additional medical Diagnosis allows for potential differences among child participants.
Responses to *Boehm-3 Preschool Tactile Edition* test items are recorded as "+" or "-". Item responses are necessary to perform item analysis for validation.
Time to complete *Boehm-3 Preschool Tactile Edition* test items will provide additional information on item difficulty.

9. Data Analysis Procedures

All *Boehm-3 Preschool Tactile Edition* raw score data will be collected and analyzed using descriptive statistics; parallel, minimum residual, and regularized exploratory factor analysis using FACTOR 9.3 software, and Mokken Scale analysis tests of monotonicity, double monotonicity, and reliability indices using the statistical software *R* package for **mokken.** The descriptive statistics will give a broad overview of item score data of organization and inform item analysis. The exploratory factor analyses will examine the underlying constructs of the *Boehm-3 Preschool Tactile Edition* looking for unidimensionality. The Mokken scale analyses tests will evaluate item homogeneity, and scale responses for error, and reliability concerns to address scale creation. If Mokken scale analyses are unsuccessful, certain items will be considered for removal to create a more reliable and valid instrument. Validity correlation coefficients will be calculated between the *Boehm-3 Preschool Tactile Edition* and the Teacher Concept Rating Scale to determine construct validity between tactual development and concept understanding.

4. Data Handling Procedures

All paperwork will be kept in a locked file cabinet in the School of Special Education office (McKee 29) at the University of Northern Colorado. Only the lead investigator and her Research Advisor will have access to the collected data. Consent forms, assent forms, and record forms will be kept in separate folders.

Each student participant will be assigned a numerical indicator that will match descriptive survey data, *Boehm-3 Preschool Tactile Edition* test scores (record forms), and *Teacher Concept Rating Scale* scores. Numerical identifiers will be geographically

organized so that the researchers can identify the results by educational settings, but not by individuals. Survey data and *Teacher Concept Rating Scale* scores will only be accessible through online password protection. All data collected will be kept for at least three years and will be available for future research. Identifiable records, such as the consent forms, will be destroyed after three years.

While confidentiality cannot be guaranteed, every attempt will be made to maximize confidentiality and protect the anonymity of the source of the data. Participants will be recruited from a wide variety of educational settings in geographic areas so individuals are not recognizable.

C. Risks, Discomforts and Benefits

This research appears to pose minimal risk to the children who match participant criteria for this research. For some young children, this may be their first experience with this type of "sit-down" testing, so administrators will be instructed to test the child at his or her level of comfort (including sitting on the floor). Otherwise, the risks associated with this validation are no greater than those normally encountered in a preschool or primary classroom setting. While the most care possible will be taken in keeping participants' information confidential, we cannot guarantee absolute confidentiality, but every step of our research project will be completed in a way to lessen the risk. In the use of online demographic surveys and score collection, it is possible to address confidentiality by never connecting a child's name to assessment data. Through password protection, online data collection will remain secure.

The only direct benefits to the participants of this research will be that their parents will receive the results through the educational test administrator in the form of the parent report. The field of visual impairment will benefit substantially with the possible validation of a tactual assessment of concepts for this age group. In order to move forward in research and practice for young children who are tactual learners, it is necessary to increase the availability of valid and reliable tactual assessments to collect data on acquired knowledge, program effectiveness, and for instructional planning.

D. Costs and Compensation:

There will not be any costs involved in collecting data from the teacher test administrators who choose to participate. The *Boehm-3 Preschool Tactile Edition* is available on Federal Quota funds through state repositories for children with documented visual impairments, and the American Printing House for the Blind does provide limited access to products for research purchases. Most educational test administrators who wish to participate in this study will be able to access the *Boehm-3 Preschool Tactile Edition* at

no cost. For those that are unable to do so, the lead investigator can administer the assessment directly. Any technological equipment or software necessary is already available to the lead investigator. Parents and teachers of the study participants will be able to use the *Boehm-3 Preschool Tactile Edition* results to guide instruction as a benefit of this study. No incentives will be provided to teachers or students other than gratitude and praise for contributing to the field of visual impairment.

E. Grant Information

Challenges regarding data collection involve the geographical distances among potential participants. The nature of the *Boehm-3 Preschool Tactile Edition* itself limits the number of possible participants, because it was designed for a specific population of learners. Visual impairment presents as a low prevalence exceptionality, and data are limited as to exactly how many school age children are receiving services such as braille instruction. Numbers of young children with visual impairment in preschool are even more elusive due to poorly managed measurement, identification, and eligibility accountability standards (Macy, Marks, & Towle, 2014). Therefore, funding for travel for the investigator to administer the *Boehm-3 Preschool Tactile Edition* to some of the participants will be necessary. Dr. Ann Boehm, the creator of the original *Boehm-3 Preschool* test (Boehm, 2001) and a collaborator on the *Boehm-3 Preschool Tactile Edition*, has generously created and will administer a travel fund that can be accessed by the lead investigator and the Research Advisor through Teacher's College, Columbia University.

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Consent and Assessment Forms

UNIVERSITY OF
NORTHERN COLORADO

ASSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: A Validation Study of the *Boehm-3 Preschool* (tactile edition)
Researcher: Catherine Smyth, M.S.Ed., Doctoral Candidate
Phone: 720-205-3147 **E-mail:** catherine.smyth@unco.edu
Research Advisor: Kay Alicyn Ferrell, Ph.D. College of Education and Behavioral Sciences
Phone: 970-351-2691 **E-mail:** kay.ferrell@unco.edu

Hi!

My name is _____ and I am a teacher/ student at_____.

I am trying to find out if the game I have is interesting and helpful for children like you. I would like to see how well children understand the meaning of different words. If you want, you can be one of the children that helps me.

If you want to help me, I will show you some pictures you can feel with your hands. For each one, I will ask you to tell me the meaning of a word by finding the picture. It will take a little while to answer my questions and play the game. Would you like to play with me? *(Wait for positive response before continuing).*

Talking with me probably won't help or hurt you. Your parents have said it's okay for you to talk with me, but you do not have to. It's up to you. If you say "yes", you can always change your mind later or you can stop anytime that you want to. Do you have any questions for me about what we are going to do?

If you want to be one of the children that tells me the meanings of the words, or plays the game, please write your name here (*point to the line below and keep your finger there as a guide*), or you can tell me "yes" and I will ask (*name of adult witness)* to sign his or her name. Is it okay to play the game with you? Thanks!

Student/Witness_____Date _____

Test Administrator_____ _____ Date _____

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PARENT CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: A Validation Study of the *Boehm-3 Preschool* (tactile edition)
Researcher: Catherine Smyth, M.S.Ed., Doctoral Candidate
Phone: 720-205-3147 **E-mail:** catherine.smyth@unco.edu
Research Advisor: Kay Alicyn Ferrell, Ph.D. College of Education and Behavioral Sciences **Phone:** 970-351-2691 **E-mail:** kay.ferrell@unco.edu

As a part of my research, I am conducting a validation study of the tactile edition of the *Boehm Test of Basic Concepts-Preschool* that was recently produced by the American Printing House for the Blind. A validation study looks at whether a test actually measures what it says it will measure, and if the results are meaningful. Basic relational concepts are important because they require children to demonstrate skills in the areas of language and cognitive understanding. If you grant permission, and if your child indicates a willingness to participate, he or she will be asked to tell us the meaning of various concept words by choosing the tactile image that best describes the word. In order to determine where to begin the test, we will request the child's birthdate and write it on the record form, but we will not write your child's name on the form.

This test administration will follow the child's IEP assessment guidelines for preparation, timing and settings. Extended time should not affect the results, but we anticipate that most children's participation in this test will not take longer than 40-45 minutes. We will ask his or her teacher the best time to work with your child to avoid missing anything important in the classroom.

If your child receives educational services at home or in another setting, participation should not be affected. If the lead investigator will be administering the test, you may request that the test administration take place in the home. This study is designed not to cause any known discomfort or risk to your child. We foresee no risks to your child beyond those that are normally encountered in taking a test in a preschool classroom.

Your consent form will be maintained in alphabetical order in a locked file cabinet in a secure data room with limited access. Because the record form will only contain the geographic area and a consecutive number based on the order of testing (Denver #1, Denver #2, etc.), it is unlikely that the record form and this consent form can be matched to each other. As a part of the validation process, we will collect your child's visual diagnosis and any additional medical diagnosis, but again, this information will not be connected to the assigned number based on the testing order.

Every effort will be made to maintain confidentiality and your child's name will not appear in any professional report of this research.
Your child's teacher will be encouraged to fill out the Parent Report and share the test results with you to help guide concept instruction. The test results will not have any impact on your child's academic record. Participation in this study is not expected to have any direct benefits to your child as an individual; however, participation will contribute to the field of visual impairment.

Please feel free to contact me if you have any questions or concerns about this study, and please retain a copy of this letter for your records.

Thank you for assisting us with this research,
Sincerely,

Catherine Smyth, M.S. Ed.
Doctoral Candidate

Kay Alicyn Ferrell, Ph.D.
Research Advisor

Participation is voluntary. You may decide not to allow your child to participate in this study and if she/he begins participation you or she/he may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of services to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like your child to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact Sherry May, IRB Administrator, Office of Sponsored Programs, 25 Kepner Hall, University of Northern Colorado, Greeley, CO 80639; 970-351-1910.

Child's Full Name (please print) Child's Birth Date (month/day/year)

Parent/Guardian's Signature Date

Researcher's Signature Date

UNIVERSITY OF
NORTHERN COLORADO

TEACHER/TEST ADMINISTRATOR CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH UNIVERSITY OF NORTHERN COLORADO

Project Title: A Validation Study of the *Boehm-3 Preschool* (tactile edition)
Researcher: Catherine Smyth, M.S of Ed., Doctoral Candidate
Phone: 720-205-3147 **E-mail:** catherine.smyth@unco.edu
Research Advisor: Kay Alicyn Ferrell, Ph.D. College of Education and Behavioral Sciences
Phone: 970-351-2691 **E-mail:** kay.ferrell@unco.edu

Purpose and Description: The primary purpose of this study is to conduct a validation study of the tactile edition of the *Boehm Test of Basic Concepts-Preschool* that was recently produced by the American Printing House for the Blind (APH). A validation study looks at whether a test actually measures what it says it will measure, and if the results are meaningful. Basic relational concepts are important because they require children to demonstrate skills in the areas of language and cognitive understanding.

This study will require that you recruit and identify students with visual impairments ages 3.0 through 5.11 that are tactile learners for test administration. After collecting parent permission and student assent, you will be asked to watch a brief online training video and complete a very short competency evaluation. Next, we will ask you to complete a short *Teacher Concept Rating Scale* online for *each* child that includes demographic information about yourself and the child, and a rating scale about the child's relevant developmental skills. When the *Teacher Concept Rating Scale* is complete, you will receive a number ID that will be used for any correspondence. We will provide an envelope for you to return the completed test record form and appropriate permission forms. We anticipate that your participation in this study will not take longer than 40-45 minutes beyond the time it takes to administer the test to the child. You are encouraged to fill out the Parent Report form and share the test results with the family and use it to guide concept instruction or progress monitoring.

Your consent form will be maintained in alphabetical order in a locked file cabinet in a secure data room with limited access. Because the record form will only contain the geographic area and a consecutive number based on the order of testing (Denver #1, Denver #2, etc.), it is unlikely that the record form and this consent form can be matched to each other. We have done this deliberately to protect your privacy. All information collection will be held in strict confidence.

This study is designed such that the risk will not be beyond that encountered when administrating any test in a preschool classroom. Participation in this study is not expected to have any direct benefits to you as an individual; however, participation will contribute to the field of visual impairment. In addition, you will have collected concept development information that may help to guide the instruction of this child in school and at home. This information can be shared for relevant educational planning.

Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of services to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact Sherry May, IRB Administrator, Office of Sponsored Programs, 25 Kepner Hall, University of Northern Colorado, Greeley, CO 80639; 970-351-1910.

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Subject's Signature Date

_____

Researcher's Signature Date

Form C: Amended Consent Form

UNIVERSITY OF
NORTHERN COLORADO

TEACHER/TEST ADMINISTRATOR CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH UNIVERSITY OF NORTHERN COLORADO

Project Title: A Validation Study of the *Boehm-3 Preschool* (tactile edition)
Researcher: Catherine Smyth, M.S of Ed., Doctoral Candidate
Phone: 720-205-3147 **E-mail:** catherine.smyth@unco.edu
Research Advisor: Kay Alicyn Ferrell, Ph.D. College of Education and Behavioral Sciences
Phone: 970-351-2691 **E-mail:** kay.ferrell@unco.edu

Purpose and Description: The primary purpose of this study is to conduct a validation study of the tactile edition of the *Boehm Test of Basic Concepts-Preschool* that was recently produced by the American Printing House for the Blind (APH). A validation study looks at whether a test actually measures what it says it will measure, and if the results are meaningful. Basic relational concepts are important because they require children to demonstrate skills in the areas of language and cognitive understanding.

This study will require that you recruit and identify students with visual impairments ages 3.0 through 5.11 that are tactile learners for test administration. After collecting parent permission, we will ask you to complete a short *Teacher Concept Rating Scale* online for *each* child that includes demographic information about yourself and the child, and a rating scale about the child's relevant developmental skills. When the *Teacher Concept Rating Scale* is complete, your answers will be identified only by a number ID that will be used for any correspondence. We will collect all permission forms at the time of test administration. We anticipate that your participation in this study will not take longer than 40-45 minutes You will receive the completed Parent Report form and are encouraged share the test results with the family and use it to guide concept instruction or progress monitoring.

Your consent form will be maintained in alphabetical order in a locked file cabinet in a secure room with limited access. Because the record form will only contain the geographic area and a consecutive number based on the order of testing (Denver #1, Denver #2, etc.), it is unlikely that the record form and this consent form can be matched to each other. We have done this deliberately to protect your privacy. All information collected will be held in strict confidence.

This study is designed such that the risk will not be beyond that encountered when administrating any test in a preschool classroom. Participation in this study is not expected to have any direct benefits to you as an individual; however, participation will contribute to the field of visual impairment. In addition, you will have collected concept development information that may help to guide the instruction of this child in school and at home. This information can be shared for relevant educational planning.

Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of services to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact Sherry May, IRB Administrator, Office of Sponsored Programs, 25 Kepner Hall, University of Northern Colorado, Greeley, CO 80639; 970-351-1910.

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Subject's Signature Date

_____

Researcher's Signature Date

Form D: IRB Approval Letter

UNIVERSITY OF
NORTHERN COLORADO

Institutional Review Board

DATE:	August 24, 2016
TO:	Catherine Smyth, MSEd
FROM:	University of Northern Colorado (UNCO) IRB
PROJECT TITLE:	[801903-3] A Validation of the Tactile Edition of the Boehm-3 Preschool
SUBMISSION TYPE:	Continuing Review/Progress Report
ACTION:	APPROVED
APPROVAL DATE:	August 24, 2016
EXPIRATION DATE:	August 24, 2017
REVIEW TYPE:	Expedited Review

Thank you for your submission of Continuing Review/Progress Report materials for this project. The University of Northern Colorado (UNCO) IRB has APPROVED your submission. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on applicable federal regulations.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of August 24, 2017.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Sherry May at 970-351-1910 or Sherry.May@unco.edu. Please include your project title and reference number in all correspondence with this committee.

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