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The Role of Receptive Reasoning in the Development of Intellectual Humility

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

by

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Abstract

THE ROLE OF RECEPTIVE REASONING IN THE DEVELOPMENT OF INTELLECTUAL HUMILITY

By Cathryn E. Richmond, M.A.

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

Virginia Commonwealth University, 2020.

Major Director: Dr. Marcia Winter, Assistant Professor, Department of Psychology

Intellectual humility (IH) develops throughout childhood and adolescence and is critically important for effective learning, particularly with regard to science; however, the research examining the development of IH in children is quite limited. As such, this study utilized an exploratory, mixed methods, community-engaged research design with children ages three to 10 (n = 60; M_{age} = 5.98; 69.6% female) and their parents/guardians recruited from a public children's museum.. As the construct of IH is intended to describe adult cognition, I operationalized the set of components that may lead to the development of IH in preschool children as Receptive Reasoning (RR), including exploration, explanation, and revision of beliefs. Results indicate that the three components of RR are interrelated, particularly explanation and revision of beliefs, and these components differ by age, with exploration and explanation improving and belief revision decreasing. Further, these constructs are distinct from those of ego resiliency, approaches to learning, and emotion regulation. Findings indicate the complexity in measuring the components of RR in young children and highlight the importance of age in the development of RR.

Keywords: Intellectual humility, reasoning, early childhood, development

The Role of Receptive Reasoning in the Development of Intellectual Humility

The concept of *intellectual humility* (IH) has recently gained great interest from researchers and practitioners alike. In adults, IH involves both an accurate perception "of one's knowledge, marked by openness to new ideas; and *[sic]* regulating arrogance, marked by the ability to present one's ideas in a non-offensive manner and receive contrary ideas without taking offense, even when confronted with alternative viewpoints" (Mcelroy et al., 2014, p. 20). Accuracy regarding one's strengths and weaknesses as well as the ability to limit self-oriented emotional experiences are critical components of IH (McElroy et al., 2014).

In adults, IH is considered a component of open-mindedness (R. M. Taylor, 2016) and is associated with constructs such as religious tolerance, empathy, gratitude, and prosocial values (Hook et al., 2017; Krumrei-Mancuso, 2017). Understanding of knowledge and knowing is critical for the development of intellectual values (Kuhn, 2009), with IH in particular being viewed as a characteristic necessary for effective learning, particularly in disciplines such as science, and is associated with epistemic curiosity, openness, and need for cognition (Deffler et al., 2016).

Unsurprisingly, IH develops throughout childhood and adolescence (Danovitch et al., 2019; Hagá & Olson, 2017a; Lockhart et al., 2017). However, only one study has examined precursors to the development of IH in children (Danovitch et al., 2019). Though other scholars have explored related constructs, such as the development of scientific reasoning, to date, exploration of factors that contribute to the development of IH in childhood and adolescence is extremely limited.

Thus, less is known about how IH develops and how it's underpinnings manifest in children. The proposed study utilized an exploratory, mixed methods community-engaged

research design (Collins et al., 2018) with children ages three and older. As the construct of IH is intended to describe adult cognition and is therefore rooted in assumptions of adult cognitive and emotional capabilities, I refer to the set of components in preschool children that may lead to the subsequent development of IH as *Receptive Reasoning (RR)*, including exploration, reasoning, and revision of beliefs.

The value of this line of research lies in its potential to foster greater understanding of how children learn through their exploration and interaction with others, thereby contributing to knowledge regarding both children's scientific learning and the underpinnings of IH. As described by Lev Vygotsky's sociocultural approach (Vygotsky, 1978, 1986), development can only be truly understood by looking at the process of change (e.g., how children reason) rather than the product (e.g., the ability to repeat facts), such that learning drives development; this mechanism of development is referred to as a dialectical process, involving one idea, an opposing idea, and subsequent synthesis of the two, leading to higher-order functioning (Miller, 2011). Furthermore, this process is active rather than static (Miller, 2011; Sim & Xu, 2017); thus, cognition is viewed as "a dynamic process of trying to understand rather than a set of static stored knowledge" (Miller, 2011, p. 171), involving dynamic assessment which measures potential for learning rather than products of prior learning (Miller, 2011).

The importance of better understanding of the way in which preschool-aged children approach learning has been emphasized with increasing urgency in education and cognition research over the last decade (McDermott et al., 2011). Education often focuses on cognitive aspects of inquiry such as the scientific method while neglecting the metacognitive aspects such as the use of epistemic curiosity to formulate new ideas (Post & Walma van der Molen, 2018). As a result, children's curiosity in school often centers around other people's private lives or

lesson planning, such as being curious about the content of a secret or what they will do in class that day (Post & Walma van der Molen, 2018).

However, children express far wider experiences of curiosity outside the classroom, including cognitive and epistemological curiosity, suggesting that children do not need to be taught *how* to be curious: their environments simply need to nurture it (Post & Walma van der Molen, 2018). For example, current scholars suggest that practicing recognition and articulation of curiosity in a safe and supportive environment may be beneficial in fostering epistemic curiosity (Post & Walma van der Molen, 2018). Thus, a main inspiration underlying this study is the question of whether the ways children reason and learn influences the development of scientific curiosity and learning, and ultimately IH. Results could be used to inform early intervention for promotion of learning and curiosity that contribute to IH.

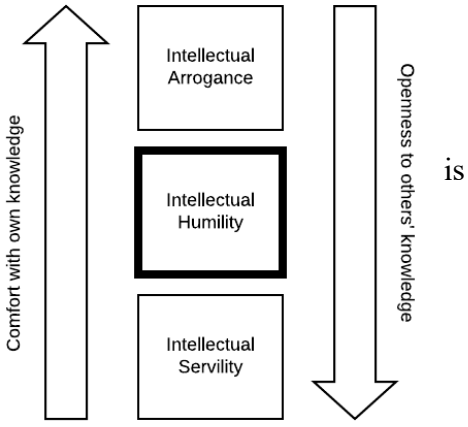
Intellectual Humility (IH)

Humility (including subtypes such as IH) is distinct from low self-esteem, modesty, or meekness (Tangney, 2002). In research focused on adults, three "higher order" components comprising IH have been identified. Specifically, accurate perceptions of one's knowledge, appreciation for the knowledge of others, and "forgetting one's self" (in other words, a limited self-focus) are all critical to IH in addition to openness (Bronk, 2008).

Intellectual arrogance (IA) is generally conceptualized as the antithesis of *intellectual servility* (IS), which represent the two extremes between which IH is conceptualized to fall (Haggard et al., 2018). Broadly, IA refers to a lack of openness to new knowledge while IS

Figure 1

Intellectual Humility (IH) Spectrum



refers to a lack of comfort with one's own knowledge. Individuals high in IA are likely to overestimate their knowledge, not question their own beliefs, be overly-skeptical of new information, and react more aggressively when their beliefs are challenged (Atir et al., 2015; Gregg et al., 2017). Conversely, individuals high in IS are likely to be overly-skeptical of their own beliefs, overly accepting of new information, and be more likely to withdraw when their beliefs are challenged (Meagher et al., 2015). IH is viewed as an appropriate balance between IA and IS (Haggard et al., 2018; see Figure 1).

While it seems logical to presume that IH would be directly associated to intelligence, this relationship is rather complex. Though greater knowledge in a given domain is associated with overestimation of one's knowledge in other domains (Fisher & Keil, 2016), it is also associated with under-, rather than over-, estimation of one's own knowledge within that domain (Plohl & Musil, 2018). Conversely, less knowledge is associated with a consistent over-estimation of one's own knowledge (Kruger & Dunning, 1999). Furthermore, these effects are moderated by education (Fisher & Keil, 2016) and confidence (Price & Stone, 2004), with both accuracy and confidence influencing judgements in adults and children alike (Tenney et al., 2011). Thus, IH appears to extend beyond simple intelligence.

Research with adults indicates that high IH is not only associated with openness during disagreements and reduced defensiveness but is also related to greater intelligence, cognitive flexibility, better performance on memory tasks, and assertiveness (Deffler et al., 2016; Meagher et al., 2015; Porter & Schumann, 2018; Van Tongeren et al., 2014; Zmigrod et al., 2019). Furthermore, IH is associated with knowledge acquisition, including reflective thinking, need for cognition, intellectual engagement, curiosity, intellectual openness, and open-minded thinking (Krumrei-Mancuso et al., 2019), and may be influenced by factors such as meaningful

relationships (Van Tongeren et al., 2014). Conversely, low IH is associated with defensiveness (which is in turn related to low cognitive control), overclaiming of knowledge, less tolerance for ambiguity, a tendency to be threatened by lack of knowledge, and motives to defend one's ego (Deffler et al., 2016; Lo et al., 2015; Plohl & Musil, 2018; Van Tongeren et al., 2014). Thus, IH has important implications in multiple domains of functioning for adults.

IH in Children

IH may also be important during childhood and adolescence, but to date research has been limited and has focused exclusively on learning and cognition with few exceptions (Danovitch et al., 2019; Hagá & Olson, 2017a; Lockhart et al., 2017). Danovitch and colleagues have examined IH from a developmental perspective and found that although confidence contributes to motivation to try new tasks, overconfidence can be an obstacle to learning new information or seeking assistance (Danovitch et al., 2019); conversely, a lack of confidence in one's competence leads to concealment rather than help-seeking throughout childhood (Marchand & Skinner, 2007). Children as young as three often overestimate their own knowledge; however, accuracy improves throughout early childhood, with individual differences emerging by age 5 (Danovitch et al., 2019; Destan & Roebers, 2015) and improvements continuing through adolescence (Lockhart et al., 2017). Furthermore, children of this age are more likely to revise their beliefs (Hagá & Olson, 2017b). By age six, children can draw accurate inferences about the knowledge of others (Danovitch et al., 2019). Moreover, IH improves with age (Danovitch et al., 2019) and is recognized and appreciated in others beginning in middle childhood (Hagá & Olson, 2017a). Thus, IH seems to develop throughout childhood and adolescence, representing a salient target for intervention in IH development.

However, research examining the development of IH in children is extremely limited, with only three studies examining IH in childhood (Danovitch et al., 2019; Hagá & Olson, 2017a; Lockhart et al., 2017), only one of which examines the development of IH in children. Danovitch and colleagues (2019) hypothesized that developmental improvements in self-assessment of one's own knowledge may be related to self-regulation, intelligence, memory, social cognition, and executive functioning, which rapidly improve in early and middle childhood (Danovitch et al., 2019). IH was operationalized as knowledge self-assessment and willingness to defer to experts (Danovitch et al., 2019). Greater IH was associated with higher intelligence (Danovitch et al., 2019).

Other scholars have explored the contribution of other constructs to the development of IH. For example, Dr. Christine Legare discusses two competing drives: confirmation bias, which contributes to seeking out information that is consistent with one's beliefs; and discovery, meaning the tendency to seek out new information (Legare, 2017). This is particularly critical in children and contributes to both the development of IH as well as scientific learning (Legare, 2017). Together, the existing research related to IH suggests that two components are central to humility: receptiveness to new information and willingness to revise beliefs in the face of inconsistent evidence (Legare, 2017).

In order to understand how children become receptive and open to revising beliefs, it is critical to understand the ways in which children learn, including both exploration and explanation (Legare, 2014). Children's explanations guide their exploration (Legare et al., 2010; Mills et al., 2019), and exploration and explanation guide hypothesis testing (Legare, 2012). For example, learning is an active process; children acquire information through exploration and are actively interested in explaining causality, which in turn allows them to generalize to other

situations (Legare, 2017). Children who generate explanations, compared to those who simply observe and describe phenomenon, learn more effectively (Legare, 2017), and their explanations become more coherent and cohesive with age (Gelman et al., 2007). Furthermore, children are likely to engage in exploration more when encouraged by knowledgeable adults such as their parents or teachers (Marchand & Skinner, 2007; Willard et al., 2019), and by age five children are able to effectively utilize information gathered from questions asked by others (Mills et al., 2012), suggesting that outside sources are critical to children's explanations and overall learning.

However, it is less clear what motivates children to revise their explanations and beliefs. Children are more likely to trust novel information (Mills, 2013), and are motivated to explain events with the potential to teach them something new, particularly with regard to information that is inconsistent with their beliefs (Legare et al., 2010). For example, children aged five to nine are motivated to explore more information in the face of inconsistent and ambiguous evidence (Busch & Legare, 2019), and children as young as six years of age seek more information when faced with weak explanations, indicating an interest in future learning (Baum et al., 2008; Mills et al., 2017, 2019). Furthermore, children aged seven to ten are able to recognize inaccuracy in their own initial impressions following explanation (Mills & Keil, 2004), and their evaluation of the trustworthiness of other sources of information improves with age (Mills, 2013); for example, children aged 11-12 are more likely to label explanations biased by self-interest as lies, biases, or mistakes (Mills & Keil, 2005). Taken together, children's explanations are of greater quality when explaining inconsistent, ambiguous, or limited information (Legare & Lombrozo, 2014). Thus, explaining inconsistency appears to be crucial for scientific learning and openness to new ideas (Legare, 2017).

Furthermore, the sources of information matter. Beginning as early as age two, children's evaluation of information sources are influenced by characteristics such as confidence and thus competency (Birch et al., 2010), with the degree to which a source demonstrates uncertainty or inaccuracy influencing judgements in children as young as three years of age (Jaswal & Malone, 2007; Koenig et al., 2004; Sabbagh & Baldwin, 2001). Children as young as three to five years of age are able to evaluate sources of expertise (Danovitch & Noles, 2014), such as distinguishing between a knowledgeable compared to an ignorant informant (Mills et al., 2011), and utilize these third parties as a source of information (Fusaro & Harris, 2008); however, children of this age also tend to prefer information from a familiar source, regardless of evidence that the familiar source may be unreliable (Danovitch & Mills, 2014; Williams & Danovitch, 2019). By age five, children are able to not only formulate useful questions but are also able to properly distinguish between various sources of information (Mills et al., 2010), particularly when these sources are familiar (Lutz & Keil, 2002); however, these evaluations are influenced by social characteristics (Tong et al., 2020) such as niceness (Johnston et al., 2015; Landrum et al., 2013), social engagement (Rowles & Mills, 2018), stereotypes (Shenouda & Danovitch, 2013), attractiveness (Bascandziev & Harris, 2016), ability status (Jaffer & Ma, 2014), clothing (McDonald & Ma, 2015), obesity (Jaffer & Ma, 2014), and in-group membership (Elashi & Mills, 2014) above and beyond characteristics such as competence (Rowles & Mills, 2018). Taken together, this suggests that evaluation of information sources begins in early childhood but accuracy may be limited and particularly dependent on situational factors.

This accuracy improves with age. Children as young as six years of age begin to doubt self-report, particularly for self-evaluative traits such as intelligence and honesty, and this continues developing throughout middle childhood (Heyman & Legare, 2005; Spinath &

Spinath, 2005). Furthermore, children of this age are less likely to over-estimate their own knowledge and consequently are more likely to defer to experts (Aguiar et al., 2012), with their evaluation and skepticism of experts becoming more accurate with age, particularly between ages five and ten (Danovitch & Keil, 2007; Danovitch & Shenouda, 2018; Elashi & Mills, 2015; Landrum & Mills, 2015; Mills, 2013; Mills & Elashi, 2014; Mills & Keil, 2008; Mills & Landrum, 2012, 2016); however, these evaluations are often influenced by a tendency towards optimism (Grant & Mills, 2011), the cost of obtaining information (Rowles & Mills, 2019), and the type of source (Danovitch & Lane, 2020; Wang et al., 2019). Thus, accuracy improves with age, though situational context remains critical to consider.

As such, source evaluation may be particularly critical in situations involving inconsistent or ambiguous information as previously discussed. Children age seven to eight are able to recognize the degree to which ambiguous information can be interpreted differently (Carpendale & Chandler, 1996) or distorted (Mills & Elashi, 2014) and are less likely to be influenced by social characteristics such as in-group membership (Elashi & Mills, 2014) and self-interest (Mills & Keil, 2005); however, these judgements are influenced by child characteristics such as intelligence and social cognition (Mills & Elashi, 2014). Taken together, this line of research suggests that children begin evaluating various sources of information in early childhood, and accuracy of this evaluation improves with age.

To date, exploration of factors that contribute to the development of IH in childhood and adolescence is extremely limited. Although research has yet to explicate factors that may contribute to the development of IH in children, research concerned with learning and cognition sheds light on what may precede, or be reflective of what may become, IH, referred to in the current proposal as RR.

Receptive Reasoning (RR)

As previously discussed, recognition of one's own strengths and weaknesses with regard to knowledge is a critical component of IH. While being overconfident of one's strengths can increase vulnerability with regard to misinformation or manipulation, being overly skeptical regarding one's own strengths can also be problematic as it may result in missing new opportunities for learning (Heyman & Legare, 2005). For children, such missed opportunities for new/novel learning are particularly critical for education, as exploration and explanation are core to scientific learning processes (Legare, 2014). Exploration, and the types of learning it is associated with (e.g., causal learning), is an ideal milieu for generating explanations; the need to actively generate explanations is associated with greater depth of learning and further curiosity (Jirout & Klahr, 2012).

This is especially true when children are acquiring *new* knowledge. New knowledge is thought to be more effective to children's learning than confirmation of previous knowledge; children may explore when they need to figure out and explain ambiguous, unusual, or unexpected information (Legare, 2012). In addition, when children are confronted with additional evidence or contradictory/inconsistent information, the need to reconcile and explain the inconsistencies may inform the way in which new knowledge is acquired via exploration (Legare, 2012). As children age, the sophistication of their explanations is thought to increase, thereby fostering greater ability to revise beliefs. The ways that children react to new information – for example, whether they revise their beliefs – is a way that openness to new ideas manifests in children (Legare, 2012) and is therefore thought to be a key component of the development of IH in children.

Together, cognitive studies highlight three related components of (what I refer to as) RR: (1) Exploration, (2) Explanation and reasoning, and (3) Revision of beliefs. I operationalize exploration as the time spent exploring a set of new materials, such that curiosity leads to discovery (i.e., of properties of the materials). Reasoning (via explanation) is operationalized as providing greater quantity and quality of explanation for a sorting task performed as part of exploratory play. The third component – revision of beliefs – is reflected in children's willingness to revise their beliefs (i.e., change a response following introduction of new information), consistent with cognitive research.

RR has a number of potentially fruitful avenues to explore with regard to scientific learning, particularly given the strong relationships between IH and openness, authentic pride, and assertiveness supported by extant research in adolescents and adults (e.g., Haggard et al., 2018). For instance, adolescents that exemplify having a sense of purpose typically report greater degrees of humility, particularly with regard to desires for learning and growing and intellectual curiosity (Bronk, 2008). Similarly, these youth also emphasize the importance of valuing open-mindedness and embracing opposing perspectives, as well as the need to balance openness with focus (Bronk, 2008). As such, RR and ultimately IH may be important to development in moral domains in addition to cognitive and learning domains.

Furthermore, with regard to emotional domains, factors associated with resilience such as secure attachment have been demonstrated as predictive of cognitive openness (Jarvinen & Paulus, 2017), suggesting that attachment to parental figures or teachers may be a beneficial target for interventions to foster IH. Thus, further exploration of whether RR may reflect both scientific learning and IH would not only strengthen the literature as a whole and the foundation for IH-focused interventions but could also potentially provide additional directions for scholars

exploring the influences of IH in other domains, such as emotional regulation and coping with stress.

Correlates of RR in Children

Given the way in which RR has the potential to influence multiple domains of development, correlates of RR are critical to consider. In particular, factors such as ego resiliency and approaches to learning may influence the trajectory of RR and thus IH development given their potential conceptual overlap with the components of RR. In addition, developmental factors such as emotion regulation and attention develop throughout early childhood and represent a wide range of individual variability; as such, they are crucial to consider when examining the development of RR and IH in early childhood.

Ego Resiliency

Ego resiliency is often conceptualized as similar to "perspective taking" (Gjerde et al., 1986). Ego resiliency relates to the way in which children manage behaviors and emotions when faced with stress (Z. E. Taylor, Eisenberg, Spinrad, Eggum, et al., 2013). Ego resiliency is critical in the development of empathy and prosocial behavior (Z. E. Taylor, Eisenberg, Spinrad, Eggum, et al., 2013), buffering against stressful life events and thus serving as a promotive factor contributing to resilient outcomes. Ego resiliency is thought to have both genetic and environmental bases (Z. E. Taylor, Sulik, et al., 2014), highlighting the criticality of examining its influences on childhood development. A number of researchers have supported the validity of ego resiliency across cultures, including its influences on prejudices and in-group biases, socialization, impulsivity, and internalizing problems such as depression and anxiety (Eisenberg et al., 2009; Galinsky & Ku, 2004; Galinsky & Moskowitz, 2000; Hofer et al., 2010),

emphasizing the importance of the way in which ego resiliency impacts development and educational progress (Eisenberg et al., 2003).

Approaches to Learning

Development and educational progress is further impacted by approaches to learning as they greatly influence a child's ability to benefit from a given educational experience (McDermott et al., 2011). Learning styles and behaviors impact the ways in which children approach learning, serving as "mental tools" enabling children to develop new knowledge via engagement in learning (Bustamante et al., 2018). Approaches to learning such as persistence, motivation, and flexible thinking increase a child's ability to engage effectively in learning (Bustamante et al., 2018; Danovitch et al., 2019). As such, learning behaviors, which include both behavioral and motivational mechanisms for engagement for learning, are thought to not only be predictive of academic achievement but also protective against emotion dysregulation and learning disabilities (Bustamante et al., 2018; McDermott et al., 2011). Moreover, varied approaches to learning may have differential impacts depending on the domain, such that learning behaviors may be particularly influential for learning science (Bustamante et al., 2017). Furthermore, learning behaviors have been hypothesized as relatively consistent across cultures, suggesting a potential universal factor influencing the way in which children learn (Schaefer & McDermott, 1999). In addition, approaches to learning represent a malleable target for interventions as they are readily observable and can be effectively changed through reinforcement and modeling (Schaefer & McDermott, 1999).

Emotion Regulation

Behavioral regulation related to learning behaviors is distinct from regulation of emotions, contributing to differential effects of moderating or mediating factors on behavioral

versus emotional regulation (Eisenberg et al., 1997). For example, research suggests that the relationships between regulation and social functioning may be differentially impacted depending on the type of regulation, such that emotional regulation may be strongly influenced by resiliency while behavioral regulation may be more heavily impacted by negative emotionality (Eisenberg et al., 1997). This is particularly critical to examine in children as childhood is the period during which children develop the socioemotional skills (such as ego resilience) necessary for prosocial behaviors such as empathy and IH (Z. E. Taylor, Eisenberg, et al., 2014; Z. E. Taylor, Eisenberg, Spinrad, Eggum, et al., 2013). However, research exploring the influences of factors such as emotion socialization and regulation on learning in preschool is extremely limited. For example, though anxiety disorders in preschool are disconcertingly common, there is a dearth of extant literature examining the influence of preschool anxiety symptoms on everyday life beyond the effects of the symptoms themselves (Gilbertson et al., 2017).

Attention

In addition to emotion regulation, level of attentional control is critical for both learning and social functioning, particularly for children prone to negative emotional states (Eisenberg et al., 1997). For example, attention is related to working memory which is in turn associated with school readiness outcomes such as following instructions (Capodieci et al., 2018) and academic achievement (McGoey et al., 2007). In addition, though inattention in preschool is common and typical in early development (Mahone & Schneider, 2013), factors such as ego resiliency may influence attention regulation (Z. E. Taylor, Eisenberg, Spinrad, & Widaman, 2013) while factors such as theory of mind may be associated with hyperactivity and emotion regulation (Pecora et al., 2018). Furthermore, attention from others such as parents may influence the frequency of

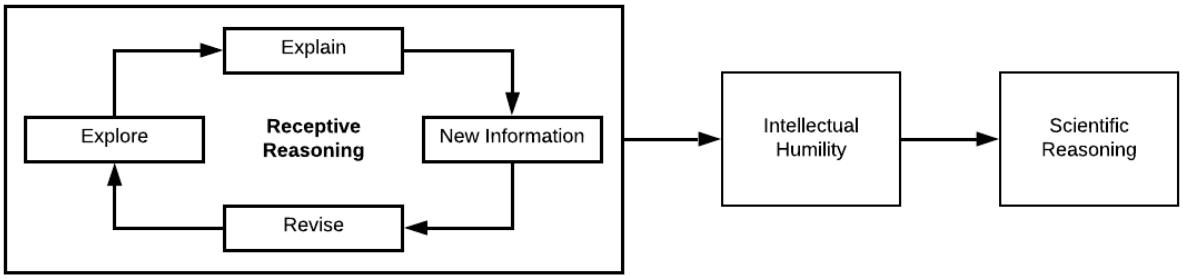
learning opportunities, particularly for preschoolers (Son & Tineo, 2016). Moreover, as novel and complex stimuli may enhance attention and curiosity in children and adults alike, particularly in museum contexts (Rönkkö et al., 2016), it is critical to consider the influences of attention in the context of scientific learning in children's science museums, the setting for the current study.

Current Study

A main inspiration for this study is the question of whether the ways children reason and learn influences the development of scientific curiosity and, ultimately, IH (see Figure 2). To begin to understand this better, I examine individual differences in the extent to which children reason in a receptive manner: If presented with new information that challenges or contradicts something a child believes, how does the child react? Are they receptive to the new information, engaging with it and evaluating whether to accept it, or do they dismiss it? How does the child evaluate the new information in light of their own expertise and the expertise of the source of the new information? How do they evaluate new information and incorporate it into their existing knowledge? What is the role of emotion in this process? The current study examines these questions within a developmentally-sensitive model that draws from research in both cognitive and emotional development.

Figure 2

Proposed Development of Intellectual Humility (IH)



As described by Lev Vygotsky's sociocultural theory, it is critical to explore questions such as these using a child-in activity-in cultural context approach, with "context" referring to both the immediate setting as well as the larger cultural context as the latter is conveyed to children through the former; as such, activity is the basic unit of analysis (Boyden & Mann, 2005; Miller, 2011). This typically occurs through examination of child participation in cultural activities such as games or classroom practices to study development (Miller, 2011), as children's learning is largely influenced by their sociocultural environment (Kurkul & Corriveau, 2018). Furthermore, as interactions between exploration and explanation are critical to the scientific process, previous scholars have emphasized the specific utility of studies conducted in children's museums (Legare, 2014; Willard et al., 2019) and the way in which such informal learning centers can support the development of scientific and mathematical reasoning skills in children (Vandermaas-Peeler et al., 2016). As such, the current study explored whether RR may reflect both scientific learning and IH in an activity within a children's play/exploration museum.

Thus, the goals of the current study are to: (1) operationalize how children react to and utilize new information, which I refer to as RR, within a newly-designed assessment paradigm, and (2) test correlations between RR and several key constructs that are likely to be associated with RR. To address these goals, the current study has three specific aims. The first aim is to explore how the components of RR are associated with one another. Significant, positive associations were hypothesized between a higher degree of curiosity and exploration (*exploration*), more reasoning and explanation (*explanation*), and greater willingness to revise beliefs (*belief revision*). The second aim is to consider the convergent validity (Barron et al., 2008) of the RR conceptualization and operationalization by testing whether the overall RR score and/or the individual component scores correlate with other conceptually similar

constructs. Hypotheses included significant, positive associations between higher RR and ego resiliency as well as between higher RR and approaches to learning. The third and final aim is to consider the concurrent validity (Barron et al., 2008) of the RR conceptualization and operationalization by testing whether the overall RR score and/or the individual component scores correlate with other key developmental constructs of early childhood, namely emotion regulation. A significant, positive association between higher RR and better emotion regulation was hypothesized. Given the developmental processes that occur throughout early childhood such as theory of mind, all analyses controlled for age and attention as warranted per preliminary analyses.

Methods

This brief pilot study was intended to inform future studies by addressing three distinct but related aims. The first study aim was to examine how the components of RR are associated with one another. Based on previous research, I hypothesized significant, positive associations among the following constructs: higher degree of curiosity and exploration, more reasoning and explanation, and greater willingness to revise beliefs. If statistically warranted, an overall composite score of RR would be constructed. The second aim of the study was to consider the validity of the RR conceptualization and operationalization by testing whether the overall RR score and/or the individual component scores correlated with other conceptually similar constructs: ego resiliency and approaches to learning. I expected that, in general, higher RR would be associated with higher ego resilience, acceptance of novelty and risk, and interpersonal responsiveness to learning. The third aim of the study was to consider the validity of the RR conceptualization and operationalization by testing whether the overall RR score and/or the individual component scores correlated with another key developmental construct of early

childhood: emotion regulation. I expected that, in general, higher RR would be associated with better emotion regulation. Aims 2 and 3 further explored whether RR was associated with child age and/or attention, and whether any significant correlations observed within the Aims 2 or 3 analyses differed by child age or attention. It was hypothesized that RR would increase with age and greater attention, with younger children being the lowest in both attention and RR.

Study Design

This study took place within Seymour's Living Laboratory as part of the existing partnership between the Children's Museum (CM) of Richmond and VCU Psychology's Child and Family Perseverance (CHAMP) Lab (https://champ.vcu.edu/research/cmor-living-lab-partnership/). Seymour's Living Laboratory (hereafter referred to as the Living Lab) is the local product that grew from the national Living Laboratory initiative, which was originally funded by the National Science Foundation (NSF) to highlight the science of child development to the public via interaction in children's museum settings.

As is common protocol for the Living Lab, the research team (consisting of at least two researchers) arrived at the CM with all session equipment, except for a table, desk/small table, and two small chairs that were provided by the CM. The research team members signed in so that museum personnel knew they had arrived and wore badges and/or Seymour's Living Lab shirts to identify themselves per the museum's safety protocol. Researchers set up the Living Lab research area in a visible, but relatively quiet and out-of-the-way, space on the museum floor. The area consisted of a rectangular table/cart that the researchers stood behind so that they were facing out into the museum; the small child's table and chairs were placed adjacent to the table. The study was identified by Living Lab signage. Researchers walked around the museum to inform adult visitors (caregivers) about the research occurring. Handout flyers were given to

patrons, either directly from research personnel or from front-desk staff at check-in. No contact information was requested; visitors were simply informed there is research in the Living Lab and instructed to come over to the research area if/when they would like to learn more about it.

This research is tailored specifically to the CM and Living Lab educational objectives and environment. As such, the research design of this study is specific to guidelines for effective research within that setting (e.g., engaging for children, limited to approximately 10 minutes per family, and containing an explicit educational component for participants). In addition to receiving approval from the VCU institutional review board, all research conducted in CM is vetted through the CM Education department and approved by their Board of Directors prior to study commencement.

Participants

After accounting for missing data, siblings, and intellectual disabilities, the analysis sample consisted of 60 dyads. Child age ranged from 3-10 years (*M*=5.419, *SD*=1.952), approximately two-thirds of whom were female (68.6%) and nearly half of whom identified as white (45.3%). Nearly all children attended childcare or school (90.0%), with the majority attending full-time (83.0%). The majority of caregivers were primary caregivers (96.5%; 67.4% mothers, 20.9% fathers, 8.1% unspecified parents) and three (3.5%) were not the child's primary caregiver but rather a legally authorized representative. Caregiver education ranged from 12 to 21 years (*M*=15.790, *SD*=2.350). Household take-home income ranged from $7,800 to $270,000 annually (*M*=$89,545, *SD*=$52,955). All children except one lived with two or more adults, with the majority living with two (86.1%). The number of children living with the child that participated in the study varied, with 22.2% residing with no other children, 43.1% with one other child, 29.2% with two other children, and 5.6% with three other children.

Procedures

Children and caregivers who indicated interest in participating were given more information about what participation entailed. The informed consent process and signing of the consent agreement was conducted according to VCU guidelines. Given the age of the children, assent was conducted verbally. Parents/Legally Authorized Representatives (hereafter referred to as caregivers) who consented for their own and their child's participation were asked to complete questionnaires. Children whose caregivers gave permission for them to participate were given information verbally that would typically be on a consent form, including assurance that they did not have to take part in the study, they may stop at any time, and they would not be judged nor penalized if they chose not to participate or to stop early; they were then asked if they would like to participate.

After consent was complete and the child verbally agreed to participate, the research assistant proceeded to complete two tasks with the child while the caregiver completed a short questionnaire packet (see Table 1). Specifically, the caregiver completed questionnaires assessing the child's approaches to learning, ego resiliency, emotion regulation, and attention; the child was asked to partake in an interactive activity with a researcher referred to as the "Sort Report," a novel sorting task assessment of RR. Child responses were audio recorded and all responses were recorded in writing by the research assistant on the data collection form. All study visits were conducted according to the procedures described in the research task protocol. Any deviations from the study protocol were described in a signed and dated study session note. Following the completion of all activities, the family was provided with an informational brochure, a rock informational sheet, and a Seymour's Living Lab sticker and a rock selected by the child. The entire process, including consent, took 10-15 minutes.

Table 1

Measures

Construct	Measure	Content/Description
Receptive Reasoning	"Sort Report" activity (designed for the current study)	Child activity to assess how children explore, reason and explain, and revise beliefs during a new experience (i.e., sorting rocks)
Ego Resiliency	Children's Ego Resiliency Scale (Eisenberg et al., 2003)	Caregiver report: 11-item (full scale) assessing the extent to which the child tends to be able to adapt to change
Approaches to Learning	Learning-to-Learn Scale (McDermott et al., 2009)	Caregiver report: 19 items measuring the behavioral and motivational mechanisms influencing the child's engagement: 5-item Acceptance of Novelty and Risk subscale; 9-item Interpersonal Responsiveness in Learning subscale; 5 related items that may load on one or more factor
Emotion Regulation	Emotionality, Activity, and Sociability (EAS) questionnaire (Buss & Plomin, 1984; K. L. Walker et al., 2017)	Caregiver report: 5-item Emotionality subscale measuring the degree to which the child is able to regulate his/her emotions
Attention	Strengths and Difficulties Questionnaire (*SD*Q; Goodman, 1997)	Caregiver report: 5-item Inattention/Hyperactivity subscale examining the typical attentional behavior of the child
Child & Family Descriptors	Demographic Questionnaire	Caregiver report: 12 items assessing child descriptors and family socio-demographic factors

Receptive Reasoning (Sort Report)

The "Sort Report," was designed for the current study to assess RR (see Appendix A). Children were provided a set of natural materials including rocks, minerals, and fossils and asked to sort them. Children were then showed the way in which an "expert" (i.e., a geologist) sorted these same objects and then the children were given the opportunity to modify their sort based on this new information. Throughout the activity, children were asked to report how they felt. Given the young age of the children, emotions were assessed via the five core emotions of happy, sad, mad, scared, and surprised.

This activity was informed by Lev Vygotsky's sociocultural theory (Vygotsky, 1978, 1986), particularly the way in which learning occurs through the use of tools, both technical (such as physical materials) and psychological (such as openness to revising beliefs); the latter are internally-oriented and influence ways of thinking (Legare, 2019; Miller, 2011). For example, one of the most powerful psychological tools posited by Vygotsky relates to scientific concepts, contrasted with spontaneous concepts; the former refers to concepts that are more logical and abstract, while the latter relates to those that are more intuitive and concrete (Miller, 2011). Thus, the Sort Report incorporates both technical and psychological tools to examine the ways in which children engage with scientific concepts.

Table 2

Operationalization of RR Components

Component of RR	Operational Definition	Example
Exploration	Time spend exploring a set of new materials, such that curiosity leads to discovery (i.e., of properties of the materials)	Child discovers hematite and tiger's eye are magnetic; turns over geode to discover it is a geode
Explanation & Reasoning	Quantity and quality of explanation for a sorting task performed as part of exploratory play	Child attributions for sort are more external (e.g., "Because they look similar") than individual preference (e.g., "because I like it")
Belief Revision	Willingness to revise beliefs (i.e., change a response) following introduction of new information	Child indicates willingness by choosing to re-sort rocks after viewing the geologist sort

As previously discussed, RR is conceptualized as inclusive of three interrelated but distinct processes: (1) Exploration, (2) Explanation, and (3) Revision of beliefs. Table 2 outlines how each process was operationalized. Exploration was operationalized via a sum score of three items that indicate the extent of exploration (whether the child discovered specific properties of

the items): Did the child discover the magnetic properties of the hematite; did the child discover the magnetic properties of the tiger's eye; and did the child discover the crystals inside of the geode. Higher scores indicate greater exploration.

Explanation was operationalized via the open-ended responses to an item asking, "Why did you sort [the items] the way you did?" Two separate coders performed a qualitative analysis on the data to determine a coding scheme. Three themes emerged, similar to prior research exploring reasoning with young children: external material properties, individual preference, and non-explanatory responses including "I don't know" (Legare et al., 2016; C. M. Walker et al., 2014). External properties included references to physicality (color/tone, luster, texture, size/shape, weight, type of rock, efforts to match or create patterns). Internal preference included trait (e.g., "I am smart"), preference (e.g., "My favorite"), and possessive (e.g., "These are mine") statements. Non-explanatory responses included statements such as "I don't know," "no reason," "just because," or "I just did." After determination of these themes, a separate team of three coders coded each child as primarily internal, external, or non-explanatory. Inter-rater agreement based on 95 triple-coded responses was high (kappa=.944). The few explanations on which coders' ratings disagreed were discussed until consensus was reached. Children included in this analysis were those whose explanations were rated as internal (scored as a one) or external (scored as a two), with higher scores indicating better quality explanation.

Revision of beliefs was operationalized via the child's response to the opportunity to re-sort one's materials with a stated willingness to re-sort. Children were assigned a score of one if they changed their sort and a zero if they did not, with higher scores indicating greater willingness to revise beliefs.

Based on the results of the qualitative coding, the standardized components of RR would have been combined to create a composite with higher scores indicating greater RR if it had been statistically warranted.

Caregiver Measures (see Appendix B)

Demographics. Caregivers completed a short questionnaire that included child age and child learning and behavioral issues.

Ego Resiliency. Child ego resiliency was assessed via the Children's Ego Resiliency Scale (Eisenberg et al., 2003). The full 11-item scale was used to assess the extent to which the child tends to be able to adapt to change. Responses range from 1 (not at all descriptive of resiliency) to 9 (most descriptive of resiliency). Example items include "is curious and exploring; he/she likes to learn and experience new things" and "is creative in the way he/she looks at things; the way he/she thinks, works or plays is very creative." Items are reverse-scored as appropriate and summed to create a total score, with higher scores indicating greater resiliency. Previous research has supported the reliability of this scale, with alphas ranging from .76 to .81 (Eisenberg et al., 2003). This scale has been used for a variety of ages, including children as young as 18 months through age 13 (Eisenberg et al., 2003; Z. E. Taylor, Eisenberg, Spinrad, Eggum, et al., 2013). Reliability in the current sample was sufficient (Cronbach's α=.72, n=11).

Approaches to Learning. Child approaches to learning were assessed via a subset of items from the Learning-to-Learn Scale (McDermott et al., 2009). A total of 19 items were used to measure the behavioral and motivational mechanisms influencing the child's engagement: the 5-item Acceptance of Novelty and Risk subscale; the 9-item Interpersonal Responsiveness in Learning subscale; and 5 additional related items that may load on one or more factors based on the original factor analysis conducted by McDermott et al. (2009). As the full scale was unable

to be used due to time constraints, the Acceptance of Novelty and Risk and Interpersonal Responsiveness to Learning subscales were selected due to their hypothesized associations with constructs such as creativity (McDermott et al., 2011) while the additional items were included due to potentially differing factors resulting from samples in older children (Restko, 2016). Response choices range from 1 (does not apply) to 3 (consistently applies). Items were summed to create total subscale scores, with higher scores indicating greater endorsement of that approaches to learning. The validity of the LTLS subscales has been supported by both exploratory and confirmatory factor analyses and well as content validity analyses (Charles, 2018; McDermott et al., 2011). This scale has been used for samples of children in early childhood, particularly preschool age (McDermott et al., 2011). The full scale used in the current study had sufficient reliability to proceed with analyses (Cronbach's α=.87, n=19)

Emotion Regulation. Child emotion regulation was assessed via the 5-item Emotionality subscale from the Emotionality, Activity, and Sociability (EAS) questionnaire (Buss & Plomin, 1984; K. L. Walker et al., 2017). This subscale measures the degree that the child is able to regulate his/her emotions. Example items includes "tends to be somewhat emotional" and "reacts intensely when upset." Responses range from 1 (behavior is never like this) to 5 (behavior is always like this). Items are reverse scored and summed to create a total score, with higher scores indicating better emotion regulation. The validity of the subscale is supported by factor analysis and has been used in children in early childhood including children aged 3-6 (Bould et al., 2013). The reliability for this scale is the current sample was sufficient to proceed (Cronbach's α=.87, n=5).

Attention. Child attention was assessed using the 5-item Inattention/Hyperactivity subscale of the Strengths and Difficulties Questionnaire (*SD*Q; Goodman, 1997) to examine the

typical attentional behavior of the child. Example items include “restless, overactive, cannot stay still for long” and “good attention span, sees work through to the end.” Responses range from 1 (not true) to 3 (certainly true). Items were reverse-scored as appropriate and summed to create a total score, with higher scores indicating better attention. The reliability and validity of this subscale has been supported by multiple analyses and has been used in children in both early and middle childhood ranging from 3-16 years of age (Goodman, 1997; Muris et al., 2003; Sveen et al., 2013; Veselka et al., 2018). Examination of correlations and reliability statistics indicated that the alpha for the current scale is .75; however, additional analyses indicated that removal of the item “Can stop and think things out before acting” increased the alpha to .82, resulting in a four-item scale (Cronbach’s α=.82, n=4).

Data Analysis

The data was cleaned and checked for outliers, skewness, and kurtosis prior to analysis. Any children with caregiver-reported learning or behavioral issues per the demographics questionnaire were excluded, as were siblings, to reduce confounding error. Prior to main analyses, relationships between RR and potential covariates (age and attention) guided the selection of included control variables. Given the ways in which age and attention are highly related in early childhood, multiple regression analyses were conducted with both age and attention as predictors and each of the RR components as the outcome. Any variables that were significantly related to at least one RR component via multiple regression were included as covariates in remaining analyses. In order to achieve 95% power to detect large effects (0.5) using an alpha of .05, all analyses included at least 42 individuals (Erdfelder et al., 2009; Faul et al., 2007).

As previously discussed, the current study had three aims. The first aim involved examination of the ways in which the components of RR are associated with one another. Per the advice of a consultation from VCU Statistical Sciences & Operations Research department, chi-squares among the three components were calculated to examine these relationships. Given the lack of pattern of relationships among them, the components of exploration, explanation, and belief revision were not standardized and combined to create a total composite score reflective of RR.

Given the wide age range of the sample, per recommendations from the consultation with VCU Statistical Sciences and Operations Research, t-tests were conducted to determine the effect of age with children split into three age groups: 3-4, 5-7, and 8-10. Children aged 3-4 are likely still developing the theory of mind necessary for higher-order cognitive processing including receptive reasoning. Furthermore, children 5-7 are experiencing developmental changes related to early childhood, while children 8-10 are experiencing qualitatively different developmental changes related to middle childhood. As such, analyses separately analyzed group differences between children aged 3-4 compared to children aged 5-7 and 8-10.

For the second aim, partial correlation analyses explored the degree to which ego resiliency and approaches to learning are uniquely associated with the variables of interest after controlling for age. Due to the hypothesized conceptual overlap between RR, ego resiliency, and approaches to learning, it was predicted that RR would be statistically significantly associated with greater ego resiliency, more acceptance of novelty and risk, and greater interpersonal responsiveness to learning.

For the third aim, partial correlation analyses explored the degree to which emotion regulation is uniquely associated with the variables of interest after controlling for age. It was

predicted that higher RR would be statistically significantly associated with better emotion regulation.

Results

Attention scores ranged from 0 to 8, with a mean of 5.351 (*SD*=2.125). Multiple regression results with potential covariates (child age, attention, and each RR component) are displayed in Tables 3-5. Age was significantly, uniquely associated with both explanation ($p < .001$) and belief revision ($p<.001$); however, attention was not significantly associated with any RR component beyond the effects of age. As such, only age was included as a covariate in remaining analyses.

Table 3

Regression Results for Exploration with Age and Attention

	B	*SE*	*Beta*	*t*	*Sig.*
(Constant)	1.281	0.382	-	3.352	0.001**
Age	0.081	0.055	0.175	1.474	0.145
Att_Total	-0.020	0.048	-0.050	-0.424	0.673

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

Table 4

Regression Results for Explanation with Age and Attention

	B	*SE*	*Beta*	*t*	*Sig.*
(Constant)	0.424	0.282	-	1.503	0.137
Age	0.176	0.039	0.473	4.509	0.000***
Att_Total	0.023	0.035	0.070	0.663	0.509

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

Table 5

Regression Results for Belief Revision with Age and Attention

	B	*SE*	*Beta*	*t*	*Sig.*
(Constant)	1.174	0.187	-	6.295	0.000***
Age	-0.122	0.027	-0.483	-4.553	0.000***
Att_Total	-0.015	0.023	-0.071	-0.665	0.508

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

With regard to associations among the components of RR (hypothesis 1), exploration ranged from 0 (no properties identified) to 3 (all three properties identified) with a mean of 1.755 (*SD*=0.830). Explanation ranged from 1 (internal) to 2 (external) with a mean of 1.674 (*SD*=0.658). Belief revision ranged from 0 (no revision) to 1 (revision) with a mean of 0.286 (*SD*=0.456). The association between exploration and explanation was not statistically significant (χ^2=3.065, *p*=.382); the association between exploration and belief revision was nearly significant (χ^2=7.538, *p*=.057); and the association between explanation and belief revision was significant (χ^2=7.582, *p*=.006). These results as displayed in Table 6.

Table 6

RR Component Chi-Square Analyses

	n	χ^2	*df*	*Sig.*
Exploration and Explanation	59	3.065	3	0.382
Exploration and Belief Revision	66	7.538	3	0.057
Explanation and Belief Revision	57	7.582	1	0.006**

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

With regard to the effect of age, there were statistically significant differences in explanation and belief revision for children ages 3-4 compared to 5-7 (*t*=-3.431, *p*=.002; *t*=2.480, *p*=.016, respectively), as well as children 3-4 compared to 8-10 (*t*=-4.610, *p*<.001; *t*=3.349, *p*=.002, respectively). There were no statistically significant differences between children ages 5-

7 and 8-10, nor were there any statistically significant differences in exploration between age groups. These results are displayed in Tables 7-9 and Figures 3-5.

Table 7

T-Test Results for RR Components by Age Group: 3-4 and 5-7

	t	*df*	*Sig.*
Exploration	-0.546	58	0.587
Explanation	-3.431	24	0.002**
Belief Revision	2.480	54	0.016*

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

Table 8

T-Test Results for RR Components by Age Group: 5-7 and 8-10

	t	*df*	*Sig.*
Exploration	-1.082	42	0.285
Explanation	-1.795	29	0.083
Belief Revision	1.255	24	0.221

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

Table 9

T-Test Results for RR Components by Age Group: 3-4 and 8-10

	t	*df*	*Sig.*
Exploration	-1.389	38	0.173
Explanation	-4.610	17	0.000***
Belief Revision	3.349	27	0.002**

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

Figure 3

Exploration within Age Groups

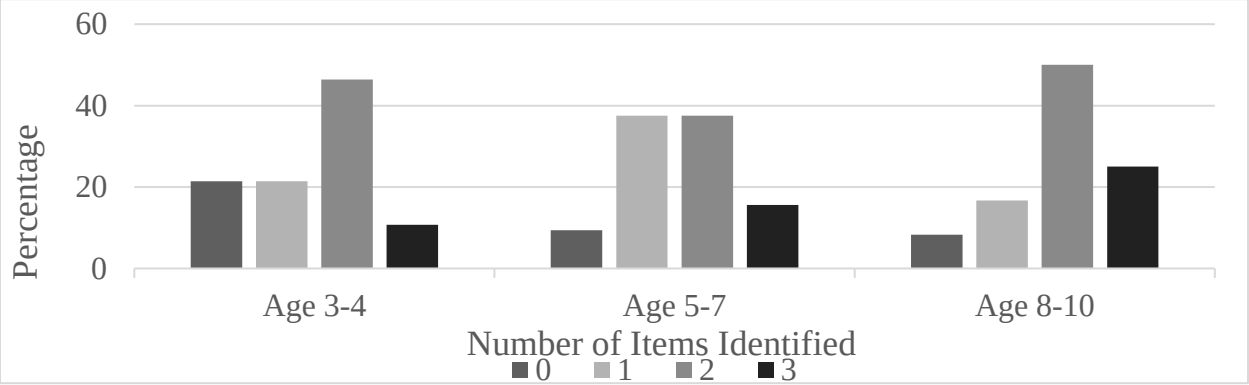


Figure 4

Explanation within Age Groups

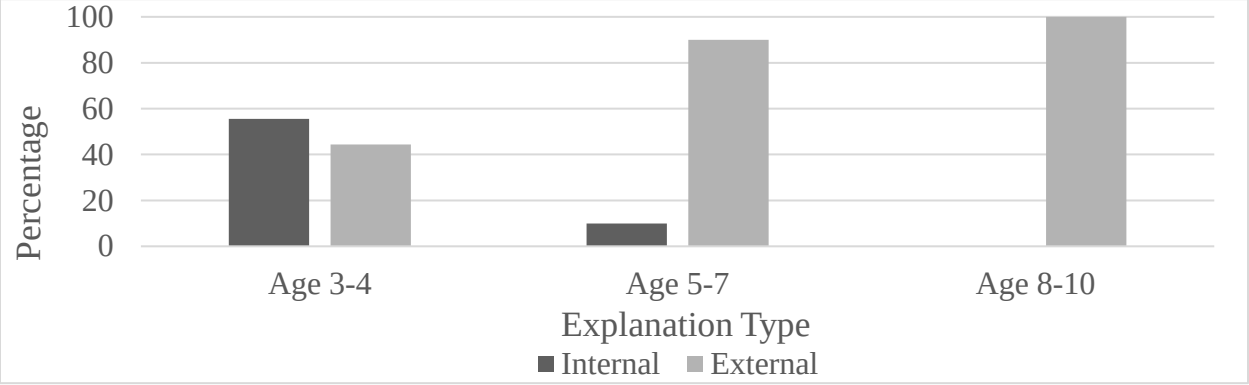
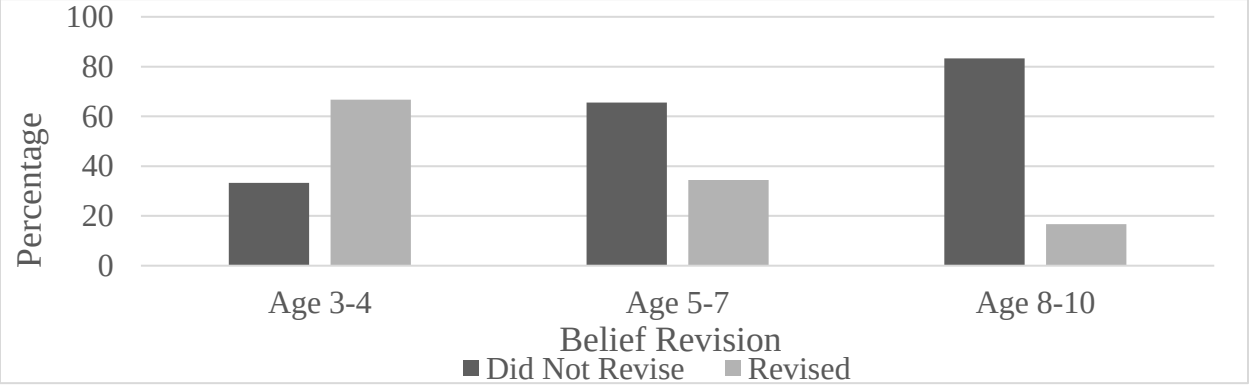


Figure 5

Belief Revision within Age Groups



As shown in Table 10, hypotheses 2a, 2b, and 3 (associations between RR and ego resiliency, approaches to learning, and emotion regulation) were not statistically significant, with none of the constructs being significantly correlated with any RR component beyond the effects of age. With regard to associations with ego resiliency (hypothesis 2a), the ego resiliency scores ranged from 35 to 73, with a mean of 60.274 (*SD*=7.964). Children aged 3-4 had a mean of 59.786 (*SD*=8.646); children aged 5-7 had a mean of 60.606 (*SD*=7.382); and children aged 8-10 had a mean of 60.500 (*SD*=8.491). With regard to associations with approaches to learning (hypothesis 2b), the LTLS novelty and risk subscale ranged from 4 to 10 with a mean of 7.859 (*SD*=1.659), while the LTLS interpersonal responsiveness to learning subscale ranged from 7 to 18 with a mean of 13.056 (*SD*=2.932). For the former, children aged 3-4 had a mean of 7.552 (*SD*=1.682); children aged 5-7 had a mean of 8.161 (*SD*=1.573); and children aged 8-10 had a mean of 7.818 (*SD*=1.834). For the latter, children aged 3-4 had a mean of 12.690 (*SD*=2.156); children aged 5-7 had a mean of 13.161 (*SD*=3.569); and children aged 8-10 had a mean of 13.727 (*SD*=2.831). With regard to associations with emotion regulation (hypothesis 3), the emotion regulation scores ranged from 6 to 25, with a mean of 17.192 (*SD*=4.780). Children aged 3-4 had a mean of 17.000 (*SD*=4.698); children aged 5-7 had a mean of 17.576 (*SD*=5.154); and children aged 8-10 had a mean of 16.583 (*SD*=4.144).

Table 10

Correlates of RR while Controlling for Age

	Pearson Correlation (Significance)		
	Exploration	Explanation	Belief Revision
Ego Resiliency	-.112 (.431)	-.147 (.298)	.020 (.890)
LTLS Novelty and Risk	-.145 (.307)	.106 (.453)	-.040 (.781)
LTLS IP Responsiveness to Learning	-.239 (.088)	.227 (.106)	-.054 (.704)
Emotion Regulation	-.248 (.077)	.060 (.675)	-.153 (.279)

Note. LTLS=Learning-to-Learn Scale. IP=Interpersonal. *N*=50.

Discussion

The results of the current study suggest that RR development in young children is rather complex. Analyses indicate that the three components of RR are generally related, most strongly explanation and belief revision. Further, results indicate that the RR components differ by age, particularly explanation and belief revision. However, the three components of RR are not statistically significantly related to ego resiliency, approaches to learning, or emotion regulation above and beyond the effects of age.

First and foremost, age is a strong predictive factor across analyses. In particular, future scholars may benefit from further exploring this phenomenon in children across ages, as those aged 3-4 appear to be statistically and practically distinct in their explanations and belief revision compared to older children. Younger children may be generally more likely to revise their beliefs regardless of context or content, with this willingness decreasing as children approach middle childhood.

For example, after children initially sorted, they were asked, (1) how sure they were that their way (or their favorite way) was the best way, and (2) which way they felt was right or correct. After they declared whether or not they wanted to revise their sort, they were asked why or why not. Anecdotally, these open-ended responses shed some light on the processes and reasoning underlying the current results. More specifically, when children who chose to re-sort their items after seeing the geologist's sort – who were mostly younger children – were asked why they revised, they tended to provide explanations grounded in their perception of the comparative *quality* of the sort (e.g., "little bit better than first time," or "because it looks better than it used to be") or authority/expertise (e.g., "because I don't know about collecting the rocks" or "because we are not experienced with them"). Conversely, when children who chose not to

re-sort their items – mostly older children - were asked why they did not revise, their explanations seemed more grounded in the *logic* of their original sort (e.g., "My way is better because it made more sense" or "because they are all put into bowls according to size"). As such, the children's willingness to revise appeared to decrease as their confidence/investment in their original sort increased. Future research would benefit from further exploring the role of confidence in the development of RR. For instance, when asked which way of sorting they thought was the best way (their own or the geologists), many children across ages provided explanations that allowed room for error (e.g., not sure their way is best because "grown up scientist is different and they learn more about rocks" or "because some stuff might be wrong"). Many children across ages also provided explanations related to the logic of their original sort (e.g., very sure theirs is best "because I think I did a good job," or "each one has something that is the same: gray + brown, shiny rocks, and black and white rocks"). Thus, confidence appears to play a role in the development of RR and may be important to factor in to future studies.

In addition, the presence of (or children's perception of) a "right" and "wrong" answer may have influenced willingness to resort. The Sort Report was worded such that there was no indication of right and wrong response, but the sort they compared their sort to was from an expert/geologist. When asked an additional follow-up question regarding which way they felt was the right or correct way to sort, many younger children referenced the geologist while many older children referenced their own method. When asked why they felt their favorite way was the best way to sort, younger children were more likely to reference authority (e.g., "I feel like the grown up way is correct so my way wouldn't be correct" or "[the geologist is] smarter than me, studied rocks"), while older children were more likely to reference the nuances of there being no right or wrong answer (e.g., "everyone has different opinions" or "there are many

possible ways to sort things"). Thus, the way in which children perceive the absoluteness of authority and the negotiability of right and wrong answers may shed light on what contributed to re-sorting and be important for future researchers exploring the development of RR to consider.

Age appears to be particularly salient in the case of explanation and belief revision. Specifically, younger children were less likely to discover all three properties of the materials via exploration; were more likely to provide explanations related to internal properties (e.g., "because I like to sort it that way" or "being creative"); and were more likely to revise their original sort after viewing the geologist sort. Alternatively, older children were more likely to discover all three properties; were more likely to provide explanations related to external properties (e.g., "rough, very rough, smooth," or "big to small" or "some were rocks, some were special, some were nature"); and were less likely to revise their sort.

The results of the first set of quantitative analyses, examining intercorrelation among RR components, suggest that there may be a qualitative difference in exploration compared to explanation and belief revision. Perhaps RR is more heavily influenced by these two latter components compared to exploration. Future research would benefit from further examination of what role, if any, exploration plays in RR.

Furthermore, and contrary to predictions, results supported an inverse relationship between explanation and belief revision. It was hypothesized that the three components would relate in ways that reflect patterns of RR such that the three components would be significantly, positively correlated with one-another. Instead, as explanations became more coherent and grounded in external properties of the materials themselves rather than internal preference, children were *less* likely to revise their sort after viewing the sort of the geologist. This may

suggest that rather than RR being something children develop with age, perhaps RR is something children instead *grow out of* as their explanations become more coherent.

The second set of analyses, designed to show links between RR components and other potentially-related concepts, suggest that these are distinct, though potentially related, constructs. In other words, there appears to be a qualitative difference between RR as measured in the current study and both ego resiliency and approaches to learning. Further, RR appears not to be associated with emotion regulation at a statistically significant level. However, future research would benefit from examination of RR from a parent perspective, as well as examination of other predictors from a child's perspective to expand our understanding of these findings.

Taken together, results indicate that exploration, explanation, and belief revision are interrelated yet distinct from one another. Further, these abilities change with age, with statistically significant differences between ages 3-4, 5-7, and 8-10. Additionally, though these components have conceptual overlap to some degree with ego resiliency and approaches to learning, these appear to be distinct constructs when controlling for age. Further, though emotion regulation may impact RR, there is no significant association between any RR component and emotion regulation beyond the effects of age. Limitations

The current study has a number of limitations. First and foremost, operationalization definitions were exploratory and thus, conclusions that can be drawn are rather limited. For example, exploration was operationalized as the degree to which children discovered the properties of three specific materials. Future research would benefit from additional operationalization of the time spent exploring materials and the methods of exploration (hands-on, observational, etc.). Similarly, explanation was operationalized via the response to a single question of, "Why did you sort it the way you did?" Future research would benefit from

operationalizing explanation in a more comprehensive way reflective of reasoning. Finally, belief revision was operationalized as whether or not a child was willing to change their sort after seeing the expert's sort; however, given that revising one's sort is not directly representative of openness to new ideas, future research would benefit from a more nuanced operationalization of belief revision that may be more developmentally appropriate.

An additional limitation relates to the convenience sample utilized in the current study. The analysis utilized data that was collected from the children who attended the museum during the day, which represents a very specific population. First and foremost, the caregivers for these children must be available during the day and be able to provide funds to attend the museum. Further, the majority of children in the current study attended childcare or school, and all but one came from households with at least two adults. Additionally, the small sample size greatly limited the power available for analyses.

Furthermore, the limited range and variability of the variables included in the analyses greatly restricted the findings. For example, the explanation variable was ultimately dichotomous (internal vs. external) , with external (2) operationalized as representing better quality explanation. Future research would benefit from operationalizing explanation in a more comprehensive manner. For example, one approach would be to separately code each specific reference to physicality (e.g., luster, size, shape, etc.) and sum them; this more continuous score would allow for more a nuanced examination of explanation, allowing for more sophisticated analyses. Similarly, belief revision was also binary, greatly restricting variance. Future research would benefit from operationalizing belief revision based on willingness to revise beliefs in addition to the reasoning underlying the revision, similar to explanation.

Furthermore, the museum setting has its limitations as well. For example, the setting is very busy with a number of distractions, which may have impacted engagement. Furthermore, though caregivers were asked to sit away from the child and not to assist them with the sorting task, the presence of the caregiver may have impacted the child's responses.

In addition, all of the survey measures were caregiver report. Though the young age of many of the children rendered them unlikely to be able to complete questionnaires on such complex, self-reflective topics, the sole reliance on parent report nevertheless may be biased given the ways in which parents tend to rate their children more positively compared to outside observers such as teachers.

Implications

The operationalization of RR was exploratory and findings are complex, particularly with regard to age. Therefore, many of the implications of this study are centered around implications for future research. Firstly, and as discussed above, the operationalization of exploration, explanation, and belief revision warrants scrutiny; the responses to our follow-up, open-ended questions hint at some potential directions. Secondly, research would benefit from further exploring the relationships among exploration, explanation, and belief revision. Given the statistically significant association between explanation and belief revision, future scholars may explore the degree to which these two components may be more reflective of RR beyond the effects of exploration. In addition, t-test results indicate significant differences in the components by age, suggesting that additional research would benefit from examining each component in further depth during both early and middle childhood. Thirdly, the findings regarding ego resiliency, approaches to learning, and emotion regulation suggest that though these factors may be useful to consider conceptually when examining the components of RR, their effects are

distinct when controlling for age. Additional factors, including other approaches to learning and a more comprehensive exploration of emotion-related factors such as anxiety interference, may help illuminate the ways in which other key constructs of child development influence the development of RR.

Future Directions

Despite the relative lack of statistically significant findings in the current study, there is importance to examining the development of RR in children. IH is viewed as a potential mechanism for fostering knowledge acquisition (Krumrei-Mancuso et al., 2019) beyond general humility (Porter & Schumann, 2018). This includes reflective thinking, need for cognition, intellectual engagement, curiosity, intellectual openness, open-minded thinking, openness to experience, and objectivism (Krumrei-Mancuso et al., 2019; Porter & Schumann, 2018). IH is associated with better academic learning, including better performance on both standardized and academic tests, higher course grades, and higher grade-point averages (Krumrei-Mancuso et al., 2019). Furthermore, IH is thought to be a component of wise reasoning (Porter et al., 2019) along with seeking out and integrating different perspectives as well as recognizing uncertainty and change (Santos et al., 2017). Moreover, wisdom is trait-based (rather than state-based), indicating that it is a viable target to foster throughout development (Brienza et al., 2018).

IH is one of many "intellectual virtues" along with characteristics such as curiosity and open-mindedness (Baehr, 2016). These virtues are considered characteristic of "good thinkers or learners" (Baehr, 2016, p. 117) and thus represent a logical and highly desired educational aim. Teachers already engage in efforts to enhance intellectual virtues by encouraging deep understanding of concepts and constructs beyond simple memorization and standardized test scores (Baehr, 2016). Indeed, educational goals are increasingly moving toward such aims,

emphasizing quality of skills rather than quantity of knowledge (Baehr, 2016). Such movement allows for changes in both teaching and administration with regard to what is valued and how students are taught (Baehr, 2016). This is similarly reflected in the job market as many recruiters focus more on "soft skills" such as IH, curiosity, and open-mindedness over factual knowledge gained throughout school (Baehr, 2016). Given the ways in which IH is thought to be associated with openness to learning in both school and on the job (Porter & Schumann, 2018), intellectual virtues such as IH have dramatic implications for education as well as employment.

Furthermore, politically-engaged outcomes such as civic engagement are closely tied with morality which is in turn closely tied with intellectual virtues such as IH. Given the ways in which humans act on the basis of beliefs, intellectual virtues such as IH are central to morally responsible action given the ways that IH informs development of beliefs (Baehr, 2016). Morally responsible action is inherently tied to outcomes such as civic engagement, particularly in adolescence, with stronger endorsement of morality being associated with greater civic engagement (Killen & Smetana, 2015).

Furthermore, a successful government requires a willingness for public debates in which disagreements are inherent. Thus, interpersonal characteristics such as IH that involve attitudes and acts towards others (Priest, 2017) enhance one's ability to engage in debates with others with conflicting perspectives in a more open-minded and productive manner that is central to a successful democracy. Moreover, IH is associated with less "social vigilantism," meaning the belief that others are inadequate and inferior compared to oneself (Krumrei-Mancuso et al., 2019), a critically important characteristic to consider in the context of debates and disagreements.

Given the potential utility of RR in development of IH, the findings of the current study have a number of implications for future research. The ways in which children respond to authority is central to the current findings, as their opportunity to revise their sort was based on exposure to an "expert" authoritative source (the geologist). Results may have greatly differed had the participants been presented with a peer's sort or the sort of another figure with less authority. Future research would benefit from extending the current study to incorporate the influence of peers in addition to authority figures.

Results also suggest that RR extends beyond simple intelligence. The majority of U.S. cognitive intelligence tests would focus on the number of properties identified during exploration as well as the degree to which explanations were coherent and involved external attributions; however, the results make it clear that this is not positively related to one's willingness to revise their beliefs in the face of new information. Intelligence is rather narrowly defined in the U.S., with other definitions of intelligence including components such as social responsibility (Serpell, 2011). Thus, future research would benefit from extending the current study to explore the way in which both U.S. and other definitions of intelligence relate to RR, if at all.

The findings also have important implications for informal learning environments such as museums. Results of the current study indicating the occurrence of scientific reasoning support the way in which informal learning outside of school is critical for child development (Song et al., 2017), and the ways in which guided participation in activities in informal learning settings can support the informal learning of participants (Zimmerman & McClain, 2016). Interactions with others, including in informal settings such as museums, can influence a host of types of learning including causal (Jant et al., 2014; Legare et al., 2017); discussion of children's reasoning as they complete exploratory and scientific tasks is an example of such an interaction.

Given the ways in which older children referenced there being no right or wrong answer, future researchers would benefit from exploring the ways in which informal learning environments foster non-traditional learning, meaning learning in informal settings in the presence of others, in the context of caregivers and peers.

Future educators could also benefit from exploring the benefits of learning in informal settings in a more *systematic* manner. As stated by Yoon and colleagues, "the episodic structure of activities characteristic of informal learning environments [sic] makes capturing and measuring learning gains difficult" (Yoon et al., 2012, p. 159). In the current study, operationalizations may not have directly tapped into the phenomenon intended, highlighting the ways in which measurement of such informal learning is difficult. Future educators would benefit from more systematically evaluating the ways in which children learn in informal settings, meaning evaluating learning in more experimental and quantitative ways.

Taken together, findings of the current study suggest important avenues for exploring the influence of exploration, explanation, and belief revision in the development of IH in children in early and middle childhood. The influence of age in particular is a salient factor in the development of RR. Though there are many limitations to the current study, results nevertheless suggest associations between explanation and belief revision across age that future research would benefit from further exploring.

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Appendix A: Child Measures

I'm going to put this away for a minute because I have something else to show you.
Return all items on the tray to their original placement, then put it away. Bring out crayon box.

1. What do you think is in this box? ☐Crayons ☐Other, specify: _____

Open the box and show the child the rock inside.

2. Imagine that another child your age walked over here. What would they think is in the box? ☐Crayons ☐Rock ☐Other, specify: _____

3. What would a grown-up geologist, a scientist who studies rocks, think is in the box? ☐Crayons ☐Rock ☐Other, specify: _____

"What's in the box?" notes:

_____

_____

Okay, now we're going to do something else.
Put the child tray on the table, show the child the items, and say:
Go ahead and explore and play with them a minute.
Discreetly start the stopwatch out of view of the child. Wait 1 minute, then proceed with the below.
As the child is exploring, write the date and participation ID on the pages of this form and the dry erase board.

Stopwatch start time: _____ : _____ Stopwatch end time: _____ : _____

1. How do you feel right now?
[If needed] Please point to the face that shows how you are feeling.


(happy)

(sad)

(mad)

(scared)

(surprised)
[circle one]

Push all rocks & magnets into a pile in front of the child. Now, I would like you to help me by sorting these *[point to pile]* into three bowls *[point at the bowls].* Please put the stuff on the table into these bowls however it makes the most sense to you.
*[If needed and appropriate for the child's age for any objects except the magnet – do **NOT** require the magnet to be sorted]* Oops, it looks like we're missing some. Can you please put the rest of those items into the bowl that you think they belong in?

2. *Did the child discover the magnetic properties of the **hematite**?* ☐No ☐Yes
[Examples: separated from magnet, attached to magnet, verbalized]

3. *Did the child discover the magnetic properties of the **Tiger's eye**?* ☐No ☐Yes
[Examples: separated from magnet, attached to magnet, verbalized]

4. *Did the child discover the crystals inside of the **geode**?* ☐No ☐Yes
[Examples: turned over, verbalized]

Place the dry erase board with the date and participant ID by the child's sort and take a photograph.

Initials of RA who took the photo: _____

Using the photograph, complete the chart below. *This can occur after the visit concludes.*

1. *How did the child sort?* ***NA=item not available for sorting***

[spiral fossil]	**Ammonite**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
	Arrowhead	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
["turtle poo"]	**Coprolite**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[fossils more visible if wet]	**Petosky stone**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
	Magnet	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
	Driftwood	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
	Pottery	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[white, smooth]	**Sea glass**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[yellow]	**Amber calcite**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[purple]	**Amethyst**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
	Black lava	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
***Place face down**	**Broken geode**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[green]	**Fuchsite**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[ball]	**Gypsum rosette**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
***Attach round magnet**	**Hematite**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[red]	**Jasper**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[lightweight]	**Pumice**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[fool's gold]	**Pyrite**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[white, rough]	**Quartz**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[white, rectangle]	**Selenite**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
[blue]	**Sodalite**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA
***Place away from magnets**	**Tiger's eye**	☐ Yellow	☐ Blue	☐ Orange	☐ Not sorted	☐ NA

Initials of RA completing the checklist: _____

Initials of RA emailing the photograph: _____

1. Why did you sort them the way you did? *[enter what the child says verbatim]*
[If needed] How do the things in the yellow bowl go together? How about the blue? The orange?

_____

_____

_____

2. How sure are you that your way is the best way to sort things – not sure, kind of sure, or very sure?

☐ Not sure ☐ Kind of sure ☐ Very sure

   a. Why? _____

_____

_____

3. How you feel right now?
[If needed] Please point to the face that shows how you are feeling.


(happy) (sad) (mad) (scared) (surprised)

Remove the child's sorted bowls with all items intact.
Guess what? We asked a real-life geologist to sort this same stuff, and here is how they sorted it.
Take out the expert tray with the pre-sorted bowls and allow the child to explore them.

4. Which way to sort do you like best?

☐ Own ☐ Geologist ☐ Both ☐ Neither

☐ Other, specify: _____

5. Which way to sort do you think is <u>the right way</u> (or the correct way)?

☐ Own ☐ Geologist ☐ Both ☐ Neither

☐ Other, specify: _____

6. How sure are you that the way you like best *[remind child of response to question 9]* is the best way to sort things – not sure, kind of sure, or very sure?

☐ Not sure ☐ Kind of sure ☐ Very sure

   a. Why? _____

_____

7. How do you feel right now?
[If needed] Please point to the face that shows how you are feeling.


(happy) (sad) (mad) (scared) (surprised)

Move the geologist tray to the side (but visible to the child) and set the child's tray in front of the child.

1. Now that we know how a geologist sorted the things, do you want to change anything about your sorting? ☐No ☐Yes
   You can move things around if you want to, but you don't have to.
   [If the child is confused] Now that you've seen this way that the geologist did it *[point to geologist sort]*, is there anything you want to change about your sort?

   a. Why [did you change it/ keep it the same]? _____

   b. How sure are you that your new way is the best way to sort things – not sure, kind of sure, or very sure? ☐Not sure ☐Kind of sure ☐Very sure

      i. Why? _____

2. How do you feel right now?
   [If needed] Please point to the face that shows how you are feeling.

Sort Report notes:

_____

_____

_____

_____

You know what is neat about this? There really is no right or wrong way to sort these! So, your way is great, the geologist's way is great, and if another kid did it, their way would be great too! Thanks so much for sorting things with me today; it was fun!

Appendix B: Caregiver Measures

Please tell us a bit about this child and his/her family. If you don't know or prefer not to answer, write "Don't know" or "DK." If you know, but prefer not to answer, please draw an "X" over the question.

1. What is your relationship to this child? Mother Father Other: _____
2. Are you the child's "primary caregiver?" No Yes
3. How many years of school did the child's **primary caregiver** complete? _____ years

Approximate Examples: High school graduate or GED=12; Associate's degree or technical school graduate=14; Bachelor's degree=16; Post-Baccalaureate training/certificate=17; Master's degree=18; Doctorate degree=21

4. What is the child's sex on their birth certificate? _____
5. What is the child's date of birth? ____ / ____ / ____ *(MM / DD / YYYY)*
   --OR--
   What is the child's age? _____ years _____ months
6. Has this child been diagnosed with any learning or behavioral issues? No Yes
   a. If yes, please describe:
7. What is the child's family's approximate take-home income? $ _____ every _____ Week(s) Month(s) Year(s)

   Example: $ 820 every 2 Week(s)
8. How many people live with this child? _____ Adults _____ Children *(if only child, enter zero)*
9. What is the child's ethnicity? _____
10. What is the child's race? _____
11. What is the child's zipcode? _____ _____ _____ _____ _____
12. Does the child go to school, preschool, daycare, etc.? No Yes
    a. If yes, where is it located? County: _____
       State: Virginia Other: _____
    b. If yes, is it outside of the home? No Yes
       i. If yes, is the program full- or part-time? Full-time Part-time
       ii. If yes, institution/program name: _____
       iii. If K-12, is the school public or private? Public Private N/A *(not K-12)*

Please read the statements below to describe the child's behaviors observed across the past month.
[please check one option per question]

	Does Not Apply	Sometimes Applies	Consistently Applies
1. Acts in a receptive and confident way when asked to participate in a new task or activity	O	O	O
2. Participates in an activity or lesson introduced by an adult	O	O	O
3. Even though previous attempts at new activities were unsuccessful, still tries other new activities.	O	O	O
4. Identifies alternate uses for an object or toy (e.g., uses blocks for sorting rather than building)	O	O	O
5. Learns by accepting constructive feedback on work products	O	O	O
6. Responds to questions about own ideas or differing opinions without becoming upset	O	O	O
7. Refrains from acting out aggressively when frustrated	O	O	O
8. Shows interest in learning by maintaining a positive attitude toward new and unfamiliar activities (e.g., smiles, appears eager)	O	O	O
9. Willingly participates in unfamiliar group activities	O	O	O
10. Responds positively to assistance and suggestions from peers (e.g., smiles, says "thank you")	O	O	O
11. Shows acceptance of an adult's advice by following it	O	O	O
12. Remains attentive when spoken to directly by an adult (i.e., makes eye contact, orients body to speaker)	O	O	O
13. Shows a sense of humor about his or her own errors	O	O	O
14. Responds positively to suggestions for an alternative way to complete a task or activity (i.e., positive verbal or nonverbal response)	O	O	O
15. Shows acceptance of peer advice by following it	O	O	O
16. During group activity, listens and waits for turn to speak	O	O	O
17. Takes turns when working in a small group, without needing to be reminded	O	O	O
18. When given a choice, tries new task rather than repeating a familiar one	O	O	O
19. Remains attentive when an adult leads a group activity	O	O	O

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Please indicate the degree to which the following are true of this child over the last six months.
[please check one box per question]

	Not True	Somewhat True	Certainly True
1. Restless, overactive, cannot stay still for long			
2. Constantly fidgeting or squirming			
3. Easily distracted, concentration wanders			
4. Can stop and think things out before acting			
5. Good attention span, sees work through to the end			

Please indicate the degree to which the following behaviors are true of this child using the below scale.
[please circle one number per question]

1 2 3 4 5 6 7

Very Untrue ***Neither*** ***Very True***

1. Is resourceful in initiating activities (finds ways to make things happen and get things done).	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. Freezes up when things are stressful, or else keeps doing the same thing over and over again.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. Is curious and exploring; he/she likes to learn and experience new things.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. Can bounce back or recover after a stressful or bad experience.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. When under stress, he/she gives up and backs off.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. Shows specific mannerisms or behavioral rituals (e.g., has specific habits or patterns of behavior--taps fingers, bites fingernails, or stutters or bites lips).	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7. Tends to get sick when things go wrong or when there is a lot of stress (for example, gets headaches, stomach aches, throws up).	**1**	**2**	**3**	**4**	**5**	**6**	**7**
8. Tends to go to pieces under stress; becomes rattled and disorganized when things are tough.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
9. Can talk about unpleasant things that have happened to him/her.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
10. Is creative in the way he/she looks at things; the way he/she thinks, works or plays is very creative.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
11. Uses and responds to reason (thinks things out and you can explain things to him/her like you can an adult).	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Does being anxious or very shy upset or distress this child? *[please check one box]*	Not at all	Only a little	Sometimes	Quite a lot	A great deal
	☐	☐	☐	☐	☐

Please indicate the degree to which the following behaviors are typical or characteristic of this child.
[please check one box per question]

1 2 3 4 5

Not at All Typical ***Very Typical***

	1	**2**	**3**	**4**	**5**
1. Cries easily	☐	☐	☐	☐	☐
2. Tends to be somewhat emotional	☐	☐	☐	☐	☐
3. Often fusses and cries	☐	☐	☐	☐	☐
4. Gets upset easily	☐	☐	☐	☐	☐
5. Reacts intensely when upset	☐	☐	☐	☐	☐

Curriculum Vita

Cathryn Richmond was born on April 10, 1987 in Frederick, Maryland. She graduated from Linganore High School, Frederick, Maryland in 2005. She received an associate degree in liberal arts from Frederick Community College, Frederick, Maryland in 2008. She received a bachelor's degree in psychology from the University of Maryland, College Park, Maryland in 2010. She subsequently worked at a corporate research organization in Rockville, Maryland beginning in 2010. She received a Master of Arts degree in Psychological Sciences from James Madison University, Harrisonburg, Virginia in 2015.