CHILDREN’S MATHEMATICAL LEARNING FROM
MALE AND FEMALE INTELLIGENT CHARACTERS

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CHILDREN’S MATHEMATICAL LEARNING FROM MALE AND FEMALE INTELLIGENT CHARACTERS

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ABSTRACT

Two studies utilized data from an experiment that examined how preschool-aged children’s (N = 90; 49 girls, 41 boys; M_age = 4.42 years) parasocial interactions (e.g., talking about math) with a same-or opposite-sex unfamiliar intelligent character, and children’s gender-stereotyped toy preferences, impacted their performance on add-1 math problems. A survey of a sub-sample of these children (N = 57; 32 girls, 25 boys; M_age = 4.42) and their mothers also examined the extent to which children’s favorite characters were rated as gender-typed. Children who engaged in more math talk, particularly with an unknown same-sex intelligent character, demonstrated better performance on the math task in the virtual game and in a transfer task with physical objects. Children also reported liking unknown media characters more if the character matched their sex and chose favorite characters who were rated as gender-typed in sex, appearance, and personality traits. The results suggest that children who engage in contingent interactions about math with intelligent characters and who share a salient aspect of identity with children, in this case sex, can facilitate children’s learning of foundational math skills.
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CHAPTER I: INTRODUCTION

Children in the 21st century grow up in an ever-connected digital world. These connections provide young children opportunities to be entertained, connect with social partners, and learn. Children may wake up and video chat with a grandparent, watch a YouTube video of their favorite media character on a smartphone in the car, play an educational app in the grocery store, and ask a virtual assistant to play them a story before bedtime.

Digital media may be a venue ripe for the development of children’s educational and social skills because children under eight-years-old spend approximately two hours a day engaged with screen media (Rideout, 2017). The majority of this screen time is spent watching television programs (Rideout, 2017). However, affordances of television shows that encourage audience participation (Anderson, Bryant, Wilder, & Williams, 2000; Calvert, Strong, Jacobs, & Conger, 2007), video chatting applications (McClure, Chentsova-Dutton, Barr, Holochwost, & Parrott, 2015), and voice-activated virtual assistants allow for more interactive and contingent experiences (Rideout, 2017).

Intelligent agents, computer-generated agents that engage children in pseudo-contingent interactions, are a recent development in children’s media. Virtual assistants, like Google Home, are an example of a disembodied intelligent agent that are present in 1 out of 10 of children’s homes (Rideout, 2017). Intelligent agents may be particularly effective as 21st century peers and teachers if they are embodied as socially meaningful media characters (Brunick, Putnam, McGarry, Richards, & Calvert, 2016). For example, emerging research found that the use of an intelligent character taught foundational math skills to four-and-five-years old children (Calvert et al., 2018). Children who engaged in more parasocial interactions, conversational back-and-forth
with the intelligent character (Calvert, 2015, 2017; Liebers & Schramm, 2019), during an interactive math game demonstrated better math performance (Calvert et al., 2018).

One way an intelligent character can be socially meaningful to children is when they are embodied as characters that children have a relationship with. This one-sided emotionally tinged relationship is called a parasocial relationship (Calvert, 2015, 2017). Children’s parasocial relationships with media characters, including intelligent characters, can contribute to children’s early math learning (Calvert, 2015, 2017; Calvert et al., 2018; Calvert & Richards, 2014; Calvert, Richards, & Kent, 2014; Howard Gola, Richards, Lauricella, & Calvert, 2013; Lauricella, Gola, & Calvert, 2011). Media characters are often the focus of children’s media but move with children beyond the screen and are embedded in apps, depicted on clothing, and embodied as toys children play with (Richards & Calvert, 2017b). This transmedia presence enables characters to be not only friends to children, but teachers across multiple contexts (Calvert, 2015, 2017; Richards & Calvert, 2017b), who can improve children’s transfer of virtual learning to physical contexts (Calvert et al., 2018). Young children’s STEM skills, then, may be increased and supplemented through educational media, which is an underutilized educational tool (Calvert, 2015, 2017; Richards & Calvert, 2017b).

Increasing U.S. proficiency in STEM domains has been a long-term public policy issue (Jarrett, 2016). Building strong STEM skill sets among children in the U.S. has been recognized as a national priority and an integral part of children’s education in the United States (National Science Teachers’ Association, 2014). Engaging children in STEM domains at an early age can help them develop critical thinking and inquiry-based problem-solving skills (National Science Teachers’ Association, 2014).
Children in the U.S., however, may be at a comparative deficit in developing skills required for success in STEM domains. Negative attitudes about the appropriateness of math education for young children before they enter formal schooling may contribute to children’s greater reliance on memorization and less understanding of foundational math skills (National Research Council, 2009). Children in the U.S. fall behind international peers on indicators of science and math achievement before they reach adolescence (OECD, 2016). For example, U.S. students scored lower than average on math assessments compared to other industrialized nations (OECD, 2016). Only 6% of children scored in the top proficiency level on math assessments, which was lower than the average in other nations (OECD, 2016).

Mathematics is important for all STEM domains because early math skills are foundational for, and predictive of, children’s academic achievement (Duncan et al., 2007). Learning the add-1 rule, that adding one to a number will increase that number by exactly one unit, is an important basic addition skill that frees children’s cognitive resources and allows them to learn more advanced math skills (Baroody, 1985). Children typically learn this add-1 rule by the end of kindergarten in the U.S. (Council of Chief State School Officers, 2010). Despite a pervasive stereotype that boys are innately better at math, empirical evidence does not support a sex difference in foundational numerical competencies. Recent studies, collectively covering a large age range from 6-months-to 13-years-old, revealed that boys and girls have similar basic numerical competencies (Hutchison, Lyons, & Ansari, 2019; Kersey, Braham, Csumitta, Libertus, & Cantlon, 2018). Providing boys and girls with opportunities to practice foundational math skills at a young age, then, may be a viable pathway for engaging more children in STEM domains. In particular, opportunities and educational interventions may be most effective when children find the STEM content relevant to themselves.
A potential way to make STEM content meaningful to children is if the information is presented by a character that children perceive as similar to themselves by being part of the same gender group. Particularly if a character is unknown, that character may help children to associate the educational content to their gender identity when the content is taught by a same-sex character. Gender is a highly salient “lens” utilized in society that traditionally focused on the dichotomy of male and female in the U.S. (Bem, 1981). However, gender is currently considered a continuum and accounts for individuals that do not identify with any gender or are transgender (Blakemore, Berenbaum, & Liben, 2013). Even as culture shifts away from a strictly binary conceptualization of gender, young children are still most often categorized by themselves and others, socially and culturally, as either male or female (Blakemore et al., 2013).

Children understand that gender is part of their individual and social identity in U.S. culture and use gender schemas to organize, process, and interpret information (Martin & Halverson, 1981). Children typically identify as male or female around three-years-old and become increasingly knowledgeable and interested in gender-related information throughout the preschool years (Leaper, 2015; Trautner et al., 2005). Preschool-aged children, then, may be particularly interested in engaging with and learning from characters that are the same sex as they are (Martin & Halverson, 1981). However, media for young children depict males and females as gender-stereotyped in appearance and behaviors (Ward & Aubrey, 2017). This gender-stereotyped depiction may create expectations for children about what to expect from media characters.

Media is a context that is particularly suited to capitalize on four-year-old children’s preferences for interactions with same-sex social partners (Fabes, Martin, & Hanish, 2003; Leaper, 2015) as well as explore the implications of learning STEM skills from same-or
opposite-sex intelligent characters. Children are choosing to spend their time each day engaged with media (Rideout, 2017), leading to exposure to content that is often stereotypically directed towards boys or girls (Ward & Aubrey, 2017). Media characters are often treated as social partners by children (Richert, Robb, & Smith, 2011), and children readily engage in parasocial interactions with these friends and teachers, where the character and child interact directly with each other similar to a human-human conversation (Calvert, 2015, 2017; Horton & Wohl, 1956).

Preschoolers often encounter educational content taught by these characters. For example, foundational early math skills like counting are taught successfully in the television program *Sesame Street* that features The Sesame Street Muppets, a cast of puppet characters designed specifically for *Sesame Street* (Mares & Pan, 2013). Children may use gender schemas as cognitive shortcuts to determine whether content is “for them” and may learn STEM content better if it is related to the gender group they identify with. Boys and girls are equally likely to benefit from engagement with early math skills in media, in part because boys and girls do not demonstrate gender differences in performance on early math skills (Hutchison et al., 2019; Kersey et al., 2018). Preschool, then, may be an important period in which to explore how learning early STEM skills, parasocial interactions with media characters, and children’s interest in their gender group operate in tandem.

This first chapter of the dissertation provided an introduction to the context and topic areas that will be examined in this dissertation. The following chapters in this dissertation will examine children’s previous experience with favorite media characters and whether gender-typed preferences (i.e., for characters and toys) may influence children’s early math learning through parasocial interactions with a same-or opposite-sex intelligent character. Chapter two will review the extant literature related to contingent digital media for preschooler’s learning, gender
schemas, and children’s parasocial relationships with gender-typed media characters. Chapter three will describe and present results from an experiment with 4-year-olds that comprised two empirical studies as well as a survey of the children and their mothers. Chapter four will discuss the findings and implications of the research. Chapter five will discuss the broader contributions of this dissertation to theory and the related empirical research.
CHAPTER II: LITERATURE REVIEW

Introduction

Science, technology, engineering, and mathematics (STEM) domains drive a nation’s innovation, solve modern problems, and are central to the economic success of a developed country in the 21st century (Noonan, 2017a). Children in the 21st century need a strong skill set in these domains not only to participate in the growing STEM workforce (Noonan, 2017a), but also because STEM domains contribute to children’s understanding of the world and their ability to engage critically and creatively with it (National Science Teachers’ Association, 2014). However, children in the U.S. may be at a particular deficit in developing skills required for success in STEM domains. Prior to formal schooling, parents have negative attitudes about teaching STEM content to children (National Research Council, 2009), and both parents and early childhood educators report feeling unsure about how to support children’s STEM learning before kindergarten (Mcclure et al., 2017; National Research Council, 2009). This may result in a less developed STEM foundation for children when they enter school, and U.S. children score below comparative nations on standardized tests of STEM performance before they reach adolescence (OECD, 2016).

STEM fields also lack gender diversity in the U.S. (National Science Board, 2018; Noonan, 2017b). Boys express more interest in STEM domains and males participate more in STEM college majors and the STEM workforce, compared to girls and women (National Science Board, 2018; National Science Foundation, 2017; Noonan, 2017b). Increasing interest and skills in STEM for both boys and girls in childhood may build a competent and diverse STEM workforce in the future with children more prepared to engage in critical thinking and problem-solving as 21st century citizens (National Science Teachers’ Association, 2014).
Young children can begin to learn early STEM skills through educational digital media, such as television programs and apps, which provide informal opportunities for learning (Calvert, 2015, 2017; Richards & Calvert, 2017b). Digital media may be a particularly suitable context to engage children in STEM skill development because they are already spending approximately two hours a day using screen media (Rideout, 2017). Providing children with opportunities to mesh knowledge and practice when they use educational media may be a viable path to engaging more children in STEM domains. The Next Generation Science Standards, developed by the National Science Teachers Association and the National Research Council, has emphasized that a path to stronger STEM performance may result from encouraging children to make connections between classroom learning and applied situations (National Science Teachers’ Association, 2014). The time children are spending engaged in digital media may be able to be harnessed to provide connections between formal classroom learning and applications in an informal educational context like an educational app, interactive television program, or interactions with an intelligent agent.

Educational media and interventions may be most effective when children find the STEM content relevant to themselves, or personally meaningful. Learning may occur particularly with media that engages children contingently and provides them with feedback to facilitate learning (Kirkorian, 2018). Young children, especially during the preschool years, are increasingly interested in what it means to be male or female in their culture and are more likely to favor their own gender group (Bem, 1981; Leaper, 2015; Martin & Halverson, 1981). Gender-related information can be organized and processed using gender schemas, networks of cognitive associations between sex and the self, that guide engagement, learning, and memory (Bem, 1981; Martin & Halverson, 1981). An implication for children’s STEM learning from gender schema
theory is that since gender is such a large organizer of life, children may be more motivated to engage with and remember STEM content if it is related to the gender group they identify with (Martin & Halverson, 1981). Children may, then, process STEM content quicker and more deeply if their gender schemas are activated (Calvert & Huston, 1987).

Media characters are often a central focus in children’s media, and children engage with them similarly to other social partners in their lives (Richert et al., 2011). Media that features a same-sex intelligent character may be effective at teaching STEM skills and may encourage children to relate the STEM content to themselves, through their interest in their gender group and parasocial interactions, in which children answer a character’s conversational prompts in a pseudo-contingent conversational exchange (Calvert, 2015, 2017). Parasocial interactions can provide children with feedback on their STEM performance through scaffolds, which is when the character helps children to incrementally solve a problem (Calvert, 2015; Calvert et al., 2018; Richards & Calvert, 2017b). For example, if a child incorrectly solves the math problem 1 + 2, the intelligent character may ask the child to count individual items in order to understand how many items are on the screen (Calvert et al., 2018). Scaffolding and conversational turn-taking can approximate how children typically learn in their non-media environments (Jordan & Vaala, 2019).

Intelligent characters are designed to mimic human-human interaction through parasocial interactions during media experiences, which may make these interactions more meaningful. Examining how parasocial interactions operate when children are not familiar with a character provides information about how children may benefit from initial engagement with a game that features a novel character. However, when children encounter a new intelligent character that is linked with educational content, they are not just experiencing the interaction in the moment, but
bringing with them their previous experience with media characters, who are often gender stereotyped (Ward & Aubrey, 2017). When children do not know the character, they may rely more on the parasocial interactions per se and any salient similarities between themselves and a new character to engage with the STEM content.

**Digital Media for Learning: Contingent Social Interactions**

Young children can learn about their social world through observing and interacting with media, but they also are presented with informal opportunities for cognitive learning in digital media (Calvert, 2017). A caveat to learning from a screen is that children experience the video deficit effect, where children have more difficulty learning from a screen compared to a live interaction (Anderson & Kirkorian, 2015; Anderson & Pempek, 2005). Children also have difficulty transferring content they learn in a digital, or virtual, context to a physical context and experience a transfer deficit (Barr, 2010). Interactive media have been found to reduce barriers to learning and facilitate children’s transfer of information across contexts when children interact with other humans (Barr, 2019; Jordan & Vaala, 2019; Kirkorian, 2018; Krcmar, 2010; Myers, LeWitt, Gallo, & Maselli, 2017; Nielsen, Simcock, & Jenkins, 2008; Roseberry, Hirsh-Pasek, & Golinkoff, 2014; Troseth, Saylor, & Archer, 2006) as well as media characters (Calvert, 2015, 2017; Calvert et al., 2007; Richards & Calvert, 2017b).

Children learn about the world around them through social interactions and feedback from their environment and social partners. Touchscreen devices, video chat, and intelligent agents are newer developments in media that afford children these socially contingent opportunities in a digital context. Socially contingent interactions with people have been found to facilitate children’s educational learning from video chat interactions on screens and transfer to another context (Barr, 2019; Kirkorian, 2018; Krcmar, 2010; Myers et al., 2017; Nielsen et al.,
Social contingency means that children’s social partners engaged with children immediately, reliably, and accurately (Roseberry et al., 2014). Socially contingent screen-based interactions that yielded better learning often included references that demonstrated to the child that the interaction was relevant to themselves, like referring to the chair in children’s physical environment (Troseth et al., 2006). These interactions can be further enhanced when a socially contingent person is also socially meaningful to the child (Krcmar, 2010). Socially meaningful people facilitate children’s learning in virtual settings and facilitate transfer when a child engages with a socially meaningful person because they engage more cognitively with this person (Krcmar, 2010).

Fisch (2000, 2004) proposed that transfer of information from digital media to another context is most likely when children learn the material when it is presented initially, have a mental representation of the material, and the transfer context is similar to the initial learning context. To comprehend the content, it is important that it is developmentally appropriate for children, in terms of the educational skill and the narrative it is embedded within (Fisch, 2000; Fisch, Kirkorian, & Anderson, 2005). Children’s previous experiences will influence their comprehension and shape their mental representations of educational content they learn onscreen (Fisch, 2000; Fisch et al., 2005). For example, if a child is learning math from a television show, they may use their previous experience with math (e.g., school or other media) to understand the current lesson. In other words, children may rely on schemas, cognitive associations that organize information and serve as behavioral scripts. When children have no previous experience they can relate to the content at hand, a new representation is created. Creating a new representation may lessen children’s ability to comprehend and transfer learning because the representation may be weaker or take more time to develop (Fisch et al., 2005). Finally, children
may be most likely to transfer content from digital media when the transfer situation is similar to the situation they learned the content in (Fisch, 2000; Fisch et al., 2005).

**Digital Media for Learning: Parasocial Interaction**

In the 21st century, children are able to have more interactive experiences with media than was previously possible with observational media (Calvert, 2015, 2017; Richards & Calvert, 2017b). While devices that are touchscreen or voice-controlled are capable of interactivity, media characters themselves also appear to interact in pseudo-contingent ways with children (Brunick et al., 2016; Calvert, 2015, 2017). Children’s interactions with virtual media characters often simulate real interactions, like those with human social partners (Calvert, 2015, 2017). Parasocial interactions occur when a child replies to the character onscreen, who has engaged them in a shared interaction, rather than simply observing the media. An example of this would be if a media character “asked” a child a question during a media experience, and a child answered the character (Calvert, 2015, 2017; Richards & Calvert, 2017b). The mimicking of a conversation creates a sense of a naturalistic back and forth exchange (Brunick et al., 2016).

Parasocial interactions can occur only in media experiences between a child with a character (Liebers & Schramm, 2019) and can facilitate learning from a screen similarly to when children engage with people through screens. Four-year-old children who participated more “with” a character by answering her questions during a television episode performed better on a comprehension task when compared to children who simply observed the episode (Calvert et al., 2007). Taken together, evidence suggests that children learn best from interactive media on a variety of platforms (i.e., television, apps, intelligent characters) when media is designed to respond to children’s interactions in socially contingent ways (Calvert, 2015, 2017; Calvert et al., 2018, 2007; Kirkorian, 2018; Richert et al., 2011).
Learning the Add-1 Rule From Intelligent Agents

Intelligent agents, computer-generated characters that mimic contingent interactions, may be particularly effective as 21st century peers and teachers because they can be programmed to be socially contingent (Brunick et al., 2016). Educational media that uses intelligent agents are teachers of early math skills is one venue in which children can work repeatedly towards early STEM mastery. Intelligent agents can also be embodied as media characters, which allows for the possibility for children to engage in learning through parasocial interactions with a character they do not know - but also with a character they know well and have a one-sided emotionally tinged parasocial relationship with (Brunick et al., 2016).

Learning the add-1 rule, that adding one to a number will increase that number by exactly one unit, is a basic addition skill that frees cognitive resources and allows for children to learn more advanced math (Baroody, 1985). The add-1 rule is a foundational math skill that U.S. children are expected to master by the end of kindergarten (Council of Chief State School Officers, 2010), so preschool-aged children are working towards this mastery (Baroody, Eiland, & Thompson, 2009). Children begin to solve simple addition problems by counting, then learn to consciously reason through addition problems, and finally may solve simple addition problems fluently with nonconscious processing (National Research Council, 2009). Fluency with the add-1 rule can be measured by the appropriateness of sums generated (i.e., knowing that $1 + 2 = 3$ and $2 + 1 = 3$), efficiency (i.e., quick accuracy), and adaptiveness (i.e., transferring knowledge to new add-1 problems; Baroody, Eiland, Purpura, & Reid, 2013; Baroody, Eiland, & Thompson, 2009).

Evidence is now emerging about how parasocial relationships and parasocial interactions may influence preschool-aged children’s learning of the add-1 rule from these intelligent
characters, examining both factors independently and in combination (Calvert et al., 2018). A series of three studies revealed that attachment and friendship and parasocial interactions about math predicted children’s quicker correct answers to math problems and in transferring information about how to solve onscreen math problems to an offscreen setting (Calvert et al., 2018). Children’s latency to correctly answer add-1 math problems in a virtual math game and performance on a transfer task with physical items was examined (Calvert et al., 2018). Mastery of the add-1 rule was measured by how efficiently (i.e., quickly) children were able to answer the math problems correctly because this indicated children’s mastery of the rule in terms of automatic processing (Baroody, 1985; Baroody et al., 2013). Mastery was also measured through children’s ability to generalize the add-1 concept as a rule and transfer that from a virtual to a physical context. Latency and transfer tap into whether children understand the underlying rule (Baroody, 1985; Baroody et al., 2013). Taken together, latency and transfer provide information about how children are comprehending the add-1 content in the moment and also what their mental representations of the rule are like.

When the intelligent character was embodied as a popular character, parasocial interactions and parasocial relationships contributed to learning the add-1 rule virtually and to transferring that learning to a physical context. More parasocial interactions about math and stronger attachment and friendship predicted children’s quicker correct responses to the add-1 math problems (Calvert et al., 2018). Children who engaged in higher amounts of math talk correctly answered add-1 math problems faster when the Intelligent Character was embodied as a contingent Dora the Explorer character (Calvert et al., 2018). In addition, children with prior stronger parasocial relationships with Dora the Explorer also correctly answered math problems faster than children with weaker parasocial relationships with the character (Calvert et al., 2018).
When Dora the Explorer engaged children in contingent parasocial interactions about math, which gave children feedback on their math performance, children engaged in more math talk with the intelligent character. This math talk accounted for children’s increased transfer of the add-1 rule to a physical setting (Calvert et al., 2018). This finding suggested that an intelligent character’s parasocial interaction prompts encouraged children to engage in more parasocial interactions, which can further boost STEM learning from an intelligent character that children have a parasocial relationship with. When children are familiar with the media character embodied as an intelligent character, parasocial relationships and parasocial interactions both contributed uniquely to virtual processing of add-1 content (Calvert et al., 2018).

Parasocial interactions, with an unknown intelligent voiceover (i.e., not embodied), facilitated virtual learning of the add-1 rule; however, children were better at transferring the add-1 rule from a virtual to a physical setting with a socially meaningful intelligent character compared to a non-socially meaningful intelligent character (Calvert et al., 2018). The socially meaningful character who children had parasocial relationships with was embodied as Dora the Explorer and the non-socially meaningful character was a no-character female voiceover in the math game (Calvert et al., 2018). Children were quickest to get math problems correct when they engaged in more parasocial interactions about the math problems, regardless of whether Dora or the no-character voiceover interacted with them contingently.

However, a well-known embodied intelligent character facilitated transfer of add-1 rule learning better compared to a no-character intelligent voiceover. Children who played the same math game virtually with an intelligent agent Dora the Explorer solved more math problems correctly in a physical setting (i.e., successfully transferred learning) compared to children who played the game with the no-character voiceover (Calvert et al., 2018). The implication is that
parasocial interactions facilitate children’s learning STEM content from an intelligent character virtually and can learn the add-1 skill in this virtual context without a parasocial relationship. A socially meaningful intelligent character may be key to anchoring children’s learning and creating strong mental representations of the add-1 rule that can be pulled upon when children are transferring the add-1 rule to a new context.

Four-year-old children demonstrated that they had more room to learn the add-1 rule compared to five-year-old children. Five-year-old children were more likely than four-year-old children to answer all add-1 math problems correctly on the first attempt (Calvert et al., 2018). This provided evidence that four-year-old’s may have the most to gain in terms of add-1 rule mastery from intelligent characters (Calvert et al., 2018). Both boys and girls learned from the intelligent character (i.e., there were no gender differences), perhaps in part because the strength of girls’ and boys’ parasocial relationships with the female character were generally similar (Calvert et al., 2018).

**Gender Development**

While having an existing relationship with a person or character is one way that that an individual can be socially meaningful, being members of the same gender group is another way for a social partner to be meaningful. Preschool-aged children often view the world through a gendered-lens, which centers their world around the traditional male/female binary in U.S. culture (Bem, 1981; Huston, 1983; Leaper, 2015; Martin & Halverson, 1981; Ruble, Martin, & Berenbaum, 2006). Gender identity is a foundational construct of gender-typing that drives the search for gender clues in a child’s environment (Martin & Halverson, 1981). Children typically identify with a gender group by around three-years old (Leaper, 2015). Children often rigidly adhere to gender beliefs based on physical appearance (e.g., hair length) and activities during
preschool and positively evaluate their gender group during this time (Halim et al., 2014; Ruble et al., 2007). The implication for learning in digital media is that children may learn better from a new character when the character is depicted as the same sex as the child, because this may indicate that the character and its associated content is meaningful for the child engaging with them. When a child and media character share socially meaningful characteristics, like the same gender group, this may encourage children to consider the character as a friend and/or meaningful teacher.

Huston (1983) organized the body of research on gender-typing into content areas and constructs, which was later expanded upon by Ruble & Martin (1988). The six content areas are biological/categorical sex, activities and interests, personal-social attributes, social relationships, styles and symbols (Huston, 1983) and values (Ruble & Martin, 1998). These content areas reflect the ways gender-typing has been measured and documented. The four constructs (e.g., concepts or beliefs, identity or self-perception, preferences, and behavioral enactment) indicate the ways in which an individual can relate to and experience each content area (Huston, 1983). A child’s gender development, and extent to which they are gender-typed, is multidimensional and unique to each individual (Huston, 1983; Ruble et al., 2006). The process of gender-typing involves children’s understanding of how objects, activities, roles, and traits are culturally associated with one biological sex or the other (Blakemore et al., 2013). While some areas of an individual’s life may strongly align with cultural definitions of what is male and female, this is not necessarily always the case (Huston, 1983; Ruble et al., 2006).

**Gender Schema Theory**

Gender schema theory accounts for how gender-typing occurs through an active process of seeking gendered information, constructing gender schemas, and updating these schemas
when new information is experienced (Bem, 1981; Martin & Halverson, 1981). A gender schema is a network of dynamic cognitive associations about the sexes. These associations include knowledge of what it means to be male and female, including behaviors, cognitions, and emotions associated with each category as defined by an individual’s culture (Bem, 1981; Martin & Halverson, 1981). Gender schemas can differ due to individual differences (Bem, 1981) and developmental stages (Martin & Halverson, 1981). A gender schematic person would readily use gender schemas to guide behavior, emotions, and thoughts because gender-related information is relevant to them; by contrast, a gender aschematic person would be less likely to use gender categories to organize their world and consider gender-related information less relevant to themselves (Bem, 1981). Martin and Halverson’s gender schema theory focused on children’s age-related developmental changes in response to the environment (Martin & Halverson, 1981). Once children understand that they are male or female, between approximately two-and three-years-old (Leaper, 2015), they are motivated to seek out information about behaviors, thoughts, and emotions associated with their gender group (Martin & Halverson, 1981).

Children are motivated to seek out information about behaviors, thoughts, and emotions associated with their gender group in order to learn what society defines to be male and female as they define and develop their personal identity (Martin & Halverson, 1981). When gender schematic thinking is activated, children may enact “scripts” that regulate gendered behavior. New information children encounter can be organized using these gender schemas to evaluate whether the information should be placed in the “male” or “female” category and to determine how this information will be integrated, or not, into thoughts and behaviors for the self. Martin and Halverson (1981) proposed that two kinds of gender schemas, overall and own-gender, help children to evaluate gender-related information.
An overall gender schema can help children make a distinction between gender categories and determine if something is “for me” or “not for me” (Martin & Halverson, 1981). For example, if a girl turns on the television and the characters are female ballerinas, they would likely consider it “for them” based on the sex of the characters and the pink frilly tutus more so than a boy would. If information is considered “for me”, children may be more interested in that information. Once children have determined if it is for them or not, a child’s own-sex schema may serve as a script for how to engage with a given situation (Martin & Halverson, 1981). The girl watching the ballerinas may continue to watch, practice the dance moves during the show, and wear a pink dress that day whereas a boy would be more likely to turn off the program. More detailed own-gender schema, compared to opposite-gender schema, may develop because more weight and thought are given to understanding how to align themselves with their gender group.

**Gender Schematic Interests and Engagement**

Two aspects of children’s daily lives that are strongly gender-typed are their preferences for same-sex peers (Fabes et al., 2014; Leaper, 2015; Maccoby, 1998; Martin & Dinella, 2012; Martin & Fabes, 2001) and gender-typed toys (Dinella & Weisgram, 2018; Leaper, 2015). Children develop a strong preference for playing with same-gender peers as early as age two, and that preference increases throughout childhood until puberty (Fabes et al., 2014; Leaper, 2015; Maccoby, 1998; Martin & Dinella, 2012; Martin & Fabes, 2001). Play with same-sex peers provides children with opportunities to learn about toy preferences, behaviors, thoughts, and emotions associated with the gender category they identify with (Fabes et al., 2014; Leaper, 2015; Maccoby, 1998; Martin & Dinella, 2012; Martin & Fabes, 2001). Children who engage in higher amounts of same-sex play display higher amounts of gender-stereotyped behaviors (Fabes et al., 2014), gender-stereotypical thinking, and negative thoughts about the opposite gender.
(Fabes et al., 2014; Martin & Dinella, 2012; Martin & Fabes, 2001). Put another way, a social dosage effect occurs, and as children spend more time with same-sex children, they become more gender-typed over time (Martin & Fabes, 2001).

Preschool-aged children use their cognitions about gender to decide which toys they want to engage with and are more interested in toys that are labeled as “for” their gender group (Bradbard & Endsley, 1983; Bradbard, Martin, Endsley, & Halverson, 1986; Martin, Eisenbud, & Rose, 1995). When children were shown novel gender-neutral items (e.g., hole puncher) and are told by an experimenter that the item was a toy either for boys or for girls, children wanted to touch and ask questions about the item labeled for their gender group, compared to when items were labeled for the opposite gender group (Bradbard & Endsley, 1983). Even when children are offered an incentive to play with other-gender toys (Bradbard et al., 1986) or the own-gender toys are less desirable (Martin et al., 1995), they are more likely to be interested in toys that are labeled as “for” their gender group. Toys are themselves very gender-stereotyped in color and function (Sweet, 2012) and elicit gender-stereotyped patterns of social behavior (e.g., a baby doll elicits female-stereotyped behavior of nurturing; Murnen, 2018). In general, girls are more likely to focus their play around developing relationships and conversations when playing with toys like dolls; by contrast, boys are more likely to engage in play that fosters skills required for STEM domains, like spatial skills, when playing with toys like building-blocks (Fabes et al., 2014; Goble, Martin, Hanish, & Fabes, 2012; Martin & Fabes, 2001).

**Gender Schematic Processing and Memory**

Information that is consistent with children’s existing gender schemas, or considered “for me”, may be more interesting to engage with and more readily cognitively processed (Calvert & Huston, 1987). Information may more readily align with children’s gender schemas about their
gender group because these schemas are more detailed compared to their schemas about the opposite gender group (Martin & Halverson, 1981). Gender-stereotypical content may also be processed more quickly, because gender-stereotypes are a simple kind of gender schema (Calvert & Huston, 1987). Gender-stereotypes are often based in superficial qualities and reinforced across various socialization sources. Information that is inconsistent with a child’s own-sex may require slower processing as it violates expectations, which means it may be more deeply processed to join a category of exceptions to the rule (Calvert & Huston, 1987).

Children have better memory for information related to their own gender-group, compared to the opposite gender-group (Blakemore et al., 2013; Signorella, Bigler, & Liben, 1993). A meta-analysis revealed that when children are told a story orally or saw pictures of a story, boys better remembered information about a story character that was male, and girls better remembered information about a character that was a female (Signorella et al., 1993). This finding was consistent regardless of task difficulty (i.e., recall or recognition) or the amount of time between the story and the test of memory (Signorella et al., 1993). In other words, gender schemas influenced children’s memory about information related to same-sex characters because gender schemas are active constructions that support children’s memory for information that is socially meaningful.

Gender Socialization in Media

Media transmit cultural views about gender to children and socialize them about roles and expectations of males and females in society (Leaper, 2015; Ward & Aubrey, 2017). Gender socialization through media can shape children’s cognitions about themselves and others based on cultural norms. A child’s first social environment is their family, who introduces them to further socialization systems like media (Leaper, 2015). Media ubiquitously provide children
with information about gender which serves as both a window to the world as well as a mirror. Parents can act as “gatekeepers” to media by influencing the type of media and content that children are exposed to (Nikken & Schols, 2015; Pempek & Lauricella, 2017).

As opportunities for media use have become more accessible, more mobile, and more personalized, it is important to understand the developmental impact of gender socialization through media (Rideout, 2017; Ward & Aubrey, 2017). Media characters are often the main attraction and major focus of children’s media (Calvert, 2017). Children may choose to engage more with media featuring characters that align with their current gender schemas, which in turn reinforces, shapes, and strengthens those schemas (Calvert & Huston, 1987; Martin & Halverson, 1981). Children are also likely to learn about their own gender-group from same-sex characters because of their interest in their own gender group (Martin & Halverson, 1981).

Children’s media often reflects and projects gender stereotypes both in terms of representations (Coyne, Linder, Rasmussen, Nelson, & Birkbeck, 2016; Coyne, Linder, Rasmussen, Nelson, & Collier, 2014; Dohnt & Tiggemann, 2006; Elias, Sulkin, & Lemish, 2017; England, Descartes, & Collier-Meek, 2011; Smith, Pieper, Granados, & Choueiti, 2010) and gender roles (Coyne et al., 2016, 2014; Hust & Brown, 2009; Smith et al., 2010). Media is a source of information that can reinforce the gender stereotypical schemas children hold about who matters and what they can contribute to society and provide examples of how to enact that behavior in their own lives (Calvert & Huston, 1987). Male characters in media for children under six-years-old are often portrayed as physically strong and in traditionally male occupations (e.g., firefighter; England et al., 2011; Smith et al., 2010; Ward & Aubrey, 2017). Female characters appear and speak less than males in media targeted towards children, are portrayed in traditional female occupations (e.g., seamstress), and are valued for their thinness and beauty
(Dohnt & Tiggemann, 2006; Elias et al., 2017; Lemish & Russo Johnson, 2019; Ward & Aubrey, 2017). Although the reflection and perpetration of gender-stereotypes in media is common, counter-stereotyped beliefs and examples of females and male are also presented to children (Leaper, 2015). Experiences with counter-stereotyped media can alter more traditional gender-stereotyped schemas (Calvert & Huston, 1987).

Parasocial Relationships

Media characters are ubiquitously part of children’s everyday lives in the 21st century (Calvert, 2017), and children often form emotional bonds with their favorite characters (Aguiar, Richards, Bond, Brunick, & Calvert, 2019; Bond & Calvert, 2014a; Hoffner, 1996; Richards & Calvert, 2016, 2017a). These relationships are called parasocial relationships, emotionally-tinged one-sided relationships that develop between a viewer with their favorite media character or personality (Calvert, 2017; Horton & Wohl, 1956). These relationships are similar to other social relationships and exist beyond the screen children observe and interact with characters on (Calvert, 2015; Liebers & Schramm, 2019; Richards & Calvert, 2017b). That is, characters are transmedia, moving across media platforms, which can anchor children’s learning across contexts (Calvert, 2015, 2017; Richards & Calvert, 2017b).

Children’s parasocial relationships have been studied with child- and parent-report for children under 9-years-old (Aguiar, Richards, Bond, Brunick, et al., 2019; Aguiar, Richards, Bond, Putnam, & Calvert, 2019; Bond & Calvert, 2014a; Hoffner, 1996; Richards & Calvert, 2017a; Rosaen & Dibble, 2008). Parasocial relationships with favorite characters are predicted to develop through parental encouragement, repeated media experiences with the character across platforms, toy engagement, and parasocial interactions (See Figure 1; Bond & Calvert, 2014a). A child-report measure was created as a companion to the parent-report measure by Bond &
Calvert (2014a), with the three factors of social realism, humanlike needs, and attachment and friendship emerged for children ages 2-6-years old (Richards & Calvert, 2017a). Out of the three factors, only attachment and friendship reached an acceptable level of internal consistency for children who were age four and older ($\alpha = 0.70$; (Richards & Calvert, 2017a). The attachment and friendship sub-scale was based on questions about friendship, trust, safety, and cuteness of the favorite character (Richards & Calvert, 2017a).

![Path Analysis](image)

**Figure 1: Path analysis of model of parents' perceptions of young children's parasocial relationship development (Bond & Calvert, 2014a)**

Meaningful social relationships between young children and media characters can promote early STEM (i.e., seriation cup nesting) learning (Calvert, 2015, 2017). Results from a body of research on children’s socially meaningful relationships with characters for STEM learning suggests that relationships with characters who are culturally popular (e.g., Elmo; Lauricella, Gola, & Calvert, 2011) and similar to toddlers (i.e., 21 months; Calvert, Richards, & Kent, 2014) are particularly good teachers when children are familiar with the character (i.e., the character is popular, or child is purposefully familiarized). Toddlers who were familiarized with
a character that was programmed to be the same sex and have similar preferences (e.g., favorite food and color) demonstrated better learning from those characters compared to children who were familiar with a non-personalized character (Calvert et al., 2014). These findings suggested that a socially meaningful character is more effective for learning an early STEM skill, and transferring that skill to a physical context, when compared to a novel character (Calvert et al., 2014; Lauricella et al., 2011). Further, evidence suggested that these relationships can be facilitated purposefully by adults who familiarize their children with a character.

**Gender-Typed Characteristics of Parasocial Relationships**

Children’s parasocial relationships with favorite characters mirror children’s human friendship because they share similar elements (e.g., trust; (Aguiar, Richards, Bond, Brunick, et al., 2019; Bond & Calvert, 2014a; Richards & Calvert, 2016, 2017a) and because children prefer friends that are gender-typed during preschool (Fabes et al., 2014; Leaper, 2015; Maccoby, 1998; Martin & Dinella, 2012; Martin & Fabes, 2001). Liking a character, and choosing them as a favorite, is one of the major reactions a viewer can have to a media character (Cohen, 2001). Parent-reports (Aguiar, Richards, Bond, Brunick, et al., 2019; Bond & Calvert, 2014b; Richards & Calvert, 2016) and child-reports (Hoffner, 1996; Richards & Calvert, 2017a) revealed that children were most likely to have a same-sex favorite character. An implication of preferring same-sex favorite characters is that children may be exposed more often to gender-stereotypical portrayals of their gender group and learn those gendered-typed behaviors from their favorite characters (Ward & Aubrey, 2017).

A comparison of parent-and child-report for 2-6-year-old children’s favorite characters revealed that parents may be unaware of who children’s favorites are (Richards & Calvert, 2016). Despite both parents and children reporting favorite characters for children that were the
same-sex as children, only 30% of parents and their children agreed on the same favorite character (Richards & Calvert, 2016). If parents are unaware of who children consider to be their favorite character, it provides a strong rationale for using a child parasocial relationship measure. Alternatively, this finding suggests that both child and parent report about children’s favorite characters should be used in future research to further examine differences and similarities between child and parent reports of parasocial relationships.

Children’s favorite characters are not only the same-sex as children, but are rated as gender-typed in physical appearance and personality traits (Aguiar, Richards, Bond, Putnam, et al., 2019; Bond & Calvert, 2014b). An emphasis on a character’s physical cuteness is a component of parasocial relationships for children, particularly for girls who have rated their favorite characters as cuter than boys did (Richards & Calvert, 2017a). Children’s favorite media characters, as reported by parents, are also rated as more physically gender-typed as children age (Aguiar, Richards, Bond, Putnam, et al., 2019; Bond & Calvert, 2014b). More specifically, parental reports of girls’ parasocial relationships with their favorite characters reveals that as 2-9-year-old girls age, they are more likely to choose favorite characters that are rated as appearing more gender-stereotyped physically than past favorites (Aguiar, Richards, Bond, Putnam, et al., 2019; Bond & Calvert, 2014b), yet are rated as having more masculine traits compared to past favorites (Aguiar, Richards, Bond, Putnam, et al., 2019). Parent reports of 2-9-year-old boy’s parasocial relationships with favorite characters revealed that boys were more likely to select current favorite characters that were rated as more masculine in physical appearance and personality traits compared to past favorites (Bond & Calvert, 2014b).

Media characters are mainstays in children’s environments and experiences with favorite characters may prime how children respond to media content, which includes making mental
representations of characters and their associated content. Gender-stereotypical personality traits are more abstract concepts than physical appearance so children may be more likely to be influenced initially and attracted to characters that are gender-typed in appearance. Little evidence exists to support the premise that children under five-years-old are able to associate these abstract gender-typed personality traits with one sex or the other (Halim & Ruble, 2010; Huston, 1983; Leaper, 2015). However, children learn these gender-typed behaviors from characters, even if they do not consciously stereotype the behaviors, through observation and interaction with the characters (Coyne et al., 2016, 2014; Halim, Ruble, & Tamis-Lemonda, 2013; Oppliger, 2007). Learning gender-typed behaviors from characters over time can influence the cognitive and behavioral “scripts” children enact in the future when gender schemas are activated.

**The Current Studies**

The purpose of this dissertation was to examine the following empirical questions: 1) How is preschoolers’ performance on an early STEM skill in a virtual and a physical context impacted by parasocial interactions with a same-or opposite-sex intelligent character?; 2) How is preschoolers’ performance on an early STEM skill in a virtual and a physical context impacted by children’s gender-stereotyped toy preferences?; and 3) Do mothers and children report favorite characters for children that are rated similarly for gender-typed characteristics? These questions of are particular importance, given the need for more U.S. engagement in STEM domains (Noonan, 2017a), and media is an underutilized tool for increasing STEM performance. Examining how children’s gender schematic processing and interactions with intelligent characters may operate as a mechanism by which to increase STEM performance may be one pathway to increasing children’s future engagement in STEM domains.
CHAPTER III: EMPIRICAL STUDIES

Overview

This dissertation uses a sample of preschool-aged children and their mothers across three studies. Study 1a was an experiment with a 2 (child sex: boy or girl) by 2 (intelligent character: male or female character) design. Children were randomly assigned, within sex, to play the intelligent character math game with a same- or opposite-sex intelligent character. The experiment examined differences in young children’s performance on an early math skill, in a virtual and physical context, when they engaged in parasocial interactions with a same- or opposite sex intelligent character in a game. Study 1a also used maternal survey data to validate child-report of character knowledge. Study 1b explored how the same sample of children’s gender-stereotyped toy preferences were associated with their math performance. Study 1c utilized reports from pairs of mothers and children to examine the extent to which children and mothers agreed on who children’s favorite characters were. The study also examined the extent to which mothers were aware of their children’s preferences for characters that were rated as gender-typed in physical appearance and personality traits.

Study 1A

The purpose of Study 1a was to examine the impact of young children’s parasocial interactions and parasocial relationships with same-or opposite-sex intelligent characters on children’s mastery of the add-1 rule. Children’s mastery of the add-1 rule was measured by how quickly they correctly answered math problems (i.e., latency) during a virtual math game and by the number of add-1 problems children answered correctly with physical objects after game play (i.e., transfer of the add-1 rule from a virtual setting to a physical setting).
The results from Study 1a revealed that most children did not know who the characters were. The parasocial relationship measure was not internally consistent for the male intelligent character; therefore, hypotheses related to PSRs could not be examined in this study.1 Thus, the major focus of the results section in current study was focused on parasocial interactions. Mothers of these children were also surveyed about their children’s knowledge of the intelligent character children interacted with in this study, as a validity check for children’s self-reports of character knowledge.

The hypotheses were:

\[ H^1: \] Mothers and children were expected to agree about whether children knew the male and female intelligent characters, as opposed to disagree about whether children knew the male and female intelligent characters.

Parents and children were expected to report similarly about children’s knowledge of the two media characters featured in this study. Although parents and children often disagree on who children’s favorite characters are (Richards & Calvert, 2016), it was expected that parents would be aware of the characters children are exposed to and have knowledge of in this young age group.

\[ H^2: \] Children were expected to report liking a same-sex character more than an opposite-sex character, prior to game play.

Children were asked to report how much they liked the character that would be featured in the version of the game they played, as a measure of affinity for the character. Children are

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1 Parasocial relationships between children and the Intelligent Character featured in the math game children played were measured but not examined in this study. Information about the measure can be found in Appendix A.
more likely to report they have favorite characters that are their same sex, rather than the opposite sex (Bond & Calvert, 2014b; Richards & Calvert, 2016, 2017a).

$H^3$: Children that engaged in more math talk interactions with the intelligent character were expected to demonstrate reduced add-1 latency, compared to children who engaged in fewer math talk interactions with the intelligent character.

Math talk was examined as a predictor of latency because parasocial interactions about math with media characters were previously found to predict faster correct answers to add-1 math problems when preschool children played a math game with an intelligent character (Calvert et al., 2018). Parasocial interactions about math may be important to help children increase mastery of an early math skill (Calvert et al., 2018) and can also contribute to the formation and strength of a parasocial relationship with the character (Bond & Calvert, 2014a).

$H^4$: Children that engaged in more math talk interactions with a same-sex intelligent character were expected to demonstrate reduced add-1 latency compared to children that engaged in more math talk with an opposite-sex intelligent character.

Using gender schema theory (Bem, 1981; Martin & Halverson, 1981), children were predicted to demonstrate increased mastery of the add-1 rule when they engaged in math talk with a same-sex intelligent character, compared to when they engaged in math talk with an opposite-sex intelligent character because engaging with a same-sex intelligent character would yield quicker processing of the game content. A same-sex intelligent character that engaged children in math talk was expected to help children view the game content as socially meaningful, through their gendered “lens”.
**H5**: Children that engaged in more math talk interactions with the intelligent character during the virtual game were expected to correctly answer more add-1 transfer task problems with physical objects, compared to children who engaged in fewer math talk interactions with the intelligent character.

Math talk was examined as a predictor of the number of transfer task problems answered correctly because math talk parasocial interactions with an intelligent character were previously found to explain performance on an add-1 transfer task with physical objects after virtual game play (Calvert et al., 2018).

**H6**: Children that engaged in more math talk interactions with a same-sex intelligent character in the virtual math game were expected to correctly answer more transfer task problems with physical objects, compared to children that engaged with opposite-sex intelligent character.

Using gender schema theory (Bem, 1981; Martin & Halverson, 1981), it was expected that children who engaged in more math talk with a same-sex intelligent character would be better able to transfer content associated with a same-sex intelligent character from a virtual context to a physical context.

**Methods**

**Participants**

One-hundred and twenty-five children (age range 3.89 – 5.33 years; see Table 1) participated in a space separate from their regular classroom at their preschools or child care centers. Preschools and child care centers were recruited in the Washington D.C. metropolitan area with emails and phone calls from the Children’s Digital Media Center database. Parents provided written consent for children’s participation. Parents completed demographic
questionnaire and provided their email address, along with the paper consent form, prior to their child participating.

Children provided verbal assent at the beginning of experimental sessions and received a small toy for their participation at the end of the session. Twelve children assented to play and subsequently quit the game (8 girls, 4 boys). This yielded a sample of one-hundred and thirteen children who completed the game (age range 3.89 – 5.33 years; see Table 1). However, twenty-three of these children demonstrated ceiling level mastery of the add-1 rule by answering all 12 add-1 problems correctly on their first try (13 in the female character condition; 10 in the male character condition). Therefore, for the purpose of the current study, the children who demonstrated ceiling level mastery were excluded from analyses.

The sample of children that was analyzed in the current study were the 90 children (age range 3.89 – 5.17 years; see Table 1) who finished the game and did not demonstrate ceiling level mastery of the add-1 rule. In other words, they played the game in its entirety and answered at least one math problem incorrectly during the intelligent character math game.

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2 2 boys and 4 girls quit the female Intelligent Character game, 2 boys and 4 girls quit the male Intelligent Character game. The children who quit did not differ significantly in age from the children who completed the game (\(M_{\text{CompletedGame}} = 4.44\) years, \(SD = .35\); \(M_{\text{QuitGame}} = 4.39\) years, \(SD = .23\)).

3 7 boys, 6 girls

4 5 boys, 5 girls
Table 1: Participant demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Children</th>
<th>All Children Who Finished Game</th>
<th>Final Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female Character Condition (n = 61)</td>
<td>Male Character Condition (n = 64)</td>
<td>p</td>
</tr>
<tr>
<td>Child Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girl/Boy, ( % Female)</td>
<td>33/28 (54.10%)</td>
<td>35/29 (54.69%)</td>
<td>.95</td>
</tr>
<tr>
<td>Age in Years M (SD)</td>
<td>4.42 (.32)</td>
<td>4.46 (.35)</td>
<td>.50</td>
</tr>
<tr>
<td>Race White/Non-White, (% White)</td>
<td>47/15 (75.81%)</td>
<td>45/19 (70.31%)</td>
<td>.49</td>
</tr>
<tr>
<td>Parental Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 4-year degree/ &lt; 4-year degree, (% 4-year degree)</td>
<td>60/2 (96.77%)</td>
<td>60/4 (93.75%)</td>
<td>.43</td>
</tr>
</tbody>
</table>

Notes: Parents reported demographic information when they consented for their children to participate in Study 1. Age was calculated from parent report of month and year their child was born. The middle of the month was used as the estimated birth date. Chi-square tests were conducted to test differences between the male and female character conditions for: child sex, race, and parental education. A t-test was conducted to test the differences between male and female character conditions for age.
The sample for the current study also included fifty-one mothers of children who played the math game. All parents were re-contacted by email to answer survey questions about their child’s knowledge of the male and female intelligent characters featured in the current study’s intelligent character math game. Fifty-one mothers and nine fathers participated in this online survey; however, fathers were dropped from the sample due to low participation.

**Materials**

**Intelligent character math game.** All children played an Intelligent Character math game featuring either Dora or Diego. The Dora game featured the female media character Dora from the television program *Dora the Explorer* (See Figure 2). The Diego game featured Dora’s cousin, a male media character Diego from the television program *Go, Diego, Go!* (See Figure 2). These television programs originally aired on Nick Jr. between 2000-2014 (*Dora the Explorer*) and 2005-2011 (*Go, Diego, Go!*). The shows have been available as re-runs on the Nick Jr. channel and on streaming platforms Amazon Prime and Noggin since production of new episodes ended.

The characters were presented on a digital screen-based interface that simulated social interaction with children through the intelligent characters’ contingent verbal interactions. The games were identical except that the characters’ roles of preparing for a birthday party for the other character were reversed. The game premise was introduced to children by the main intelligent character when the game began. The character explained that they were shopping for supplies for the other character’s birthday party with their sidekick Boots the Monkey in a grocery store. The character and Boots stood at a register and asked the child to help them count items as they moved down a conveyor belt and fell into a grocery bag. Swiper the Fox, a sneaky trickster in the *Dora the Explorer* series, was present in the background and stole (i.e., swiped)
the items if children did not answer the math problems correctly. The first round of the game presented items in sequential order (i.e., $1 + 1, 2 + 1, 3 + 1,$ and $4 + 1$). Items moved down the conveyor belt faster, and in sequential order, in the second round. In the third round, the order of problems was randomized and moved at the same speed as items in round two. At the end of the game, children watched an animated scene about the birthday party they had been gathering supplies for and were asked to sing happy birthday with the intelligent character.

Both versions of the game provided children with prompt, timely, and personalized feedback from the intelligent character, who was controlled behind a room divider screen by an experimenter (i.e., the wizard) using a menu of preset response options (i.e., Wizard of Oz style). Children sat in front of a video screen to view the game and played by responding, verbally or with gestures, to the screen. The wizard viewed a live feed of the child playing the game and the data collection sessions were videotaped. The wizard was also able to hear the children’s verbal replies while they participated.

The game engaged children in math parasocial interactions (PSIs). Math PSI will be referred to as “math talk”. Math talk was accomplished through the intelligent character’s prompts to solve 12 problems with 3 sets of birthday items (balloons, party hats, and goodie bags). For each set of items, a group of one, two, three, or four items came down the conveyor belt, and the character named the number of items present. After these items fell into the grocery bag, another single item appeared. The intelligent character then asked the child to solve an addition problem based on the number of items that had come down the conveyor belt (e.g., “Here come 2 balloons [balloons moved down the conveyor belt]. Oh! Here comes 1 more balloon. What does 2 and 1 make?”).
The game provided scaffolds for children who did not answer math problems correctly (e.g., answered incorrectly, or did not answer). In the first scaffold level, the items moved down the conveyor belt slower while flashing. This scaffold increased the visual salience of the items and allowed children extra time to cognitively process the items. If children answered math problem incorrectly after the first scaffold, a second scaffold level was introduced. The intelligent character asked children to count along with them as the items appeared one-by-one on the conveyor belt. If children did not correctly solve the add-1 problem after counting with the character, a third level scaffold was introduced in which Boots provided children with the answer to the add-1 problem. Children repeated the answer to move forward to the next add-1 problem.

<table>
<thead>
<tr>
<th>Dora Game</th>
<th>Diego Game</th>
</tr>
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</table>

Figure 2: Screenshots of intelligent character math games

Measures

**Pre-game character knowledge child survey.** The pre-game character knowledge child survey was three questions and assessed the extent to which children were familiar with the
character who would be featured as an intelligent character in the version of the math game they were going to play (Appendix A). Each child was shown a photo of the featured character they were going to play the intelligent character math game with (i.e., Dora or Diego). The child was asked if they knew who the character was, as a “yes/no” measure of recognition. Children who responded “yes” were asked to say the character’s name out-loud as a measure of recall. Responses from the questions were coded into a 3-point scale as: (0) didn’t know character, (1) recognized the character, and (2) knew the character’s name.

Children were also asked how much they liked the targeted character as a measure of affinity for the character. Children responded to questions using a 5-point Likert-type smiley face scale. This kind of method has been used successfully in studies measuring children’s parasocial relationships with a favorite media character (Richards & Calvert, 2017a).

**Add-1 math problem transfer task with physical objects.** The add-1 rule transfer task was adapted from Calvert et al. (2018). Children were asked to answer add-1 math problems by the experimenter using physical silver star stickers. The task was conducted to test children’s ability to transfer the add-1 skill they had practiced virtually to a physical context, as well as their ability to generalize the add-1 rule they had practiced virtually to harder add-1 problems.

In the task, children were asked to solve ten add-1 rule math problems, ranging from 1+1 to 10 + 1 in sequential order, using star stickers held up by the experimenter. The number of transfer task problems children answered correctly was summed to create a transfer task score for each child with physical objects (range 0 – 10).

**Gender-typed toy preference task.** This task was analyzed in Study 1b and is a measure of the extent to which children are interested in gender-stereotype toys. This measure of gender-stereotyped interest in toys was previously used as part of a larger index of children’s gender-
stereotyped behaviors (Coyne et al., 2016). Children’s gender-stereotyped toy preferences were assessed by asking children to demonstrate how much they would like to play with toys (Coyne et al., 2016). Four feminine gender-stereotyped toys (e.g., doll, tea set, fairy wings, pony), four masculine gender-stereotyped toys (e.g., dress-up pirate costume, tool set, truck, action figure) and four gender-neutral toys (e.g., puzzle, letter-writing toy, slinky, and paint set) were presented to each child one at a time. The measure used in Coyne et al. (2016) had “excellent” internal consistency for female toys ($\alpha = 0.91$) and “acceptable” internal consistency for male toys ($\alpha = 0.79$). The internal consistency for neutral toys was not provided.

In the current study the toys were presented to children in a single randomized order. The experimenter asked the child to sort each toy into one of three buckets to indicate which toys they like to play with “a lot,” “a little,” or “not at all”. The buckets were labeled with a large smiley face, medium smiley face, and small smiley face, respectively. Children received a score of 2, 1, or 0 points depending on how much they would like to play with the toy. In this study, the internal consistency for the items was “good” for female toy preferences ($\alpha = 0.84$), “acceptable” for male toys ($\alpha = 0.76$), and “unacceptable” for neutral toys ($\alpha = .49$).

Next, a composite variable measuring the strength of children’s gender-stereotyped toy preferences was created from the toy preference scores. The aim of this variable was to capture the extent to which children were interested in playing with only toys that were stereotyped as for their gender (e.g., dolls for girls and action figures for boys). This was accomplished in several steps. First, a masculine toy preference score and feminine toy preference score were computed for each child by averaging the preference scores for the female toys and male toys. These scores were categorized into bins of 0 [0.0 – 0.99], 1 [1.0 – 1.99] and 2 [2.0]. Gender-neutral toy scores were not used in the analyses. Second, children’s preference for non-
traditional toys for their gender was calculated. Average masculine toy preference scores for girls and average feminine toy preference scores for boys were reverse coded. For example, if a girl indicated no average preference for masculine toys (i.e., score of 0) this was reverse coded as a 2. A girl who indicated a little preference for masculine toys (i.e., score of 1) would remain coded as 1. A girl who indicated a strong preference for masculine toys (i.e., score of 2) would receive a reserve coded score of 0. The same process was completed for a boy’s interest in feminine toys. Third, a child’s traditional toy score and non-traditional toy score were added to create the final gender-typed toy preference score for each child. For example, a girl’s feminine toy preference score (0 – 2) was added to her non-traditional masculine toy preference score that had been reverse coded (0-2). The summed variable ranged from 0 – 4 where a 0 indicated no preference for gender-typed toys and a 4 indicated a strong interest in gender-typed toys.

The gender-typed toy preference variable had a single outlier because one child scored a 0. This 0 was recoded to be a 1, and the 1 category indicated a low preference for gender-stereotyped toys. The final variable that indicated children’s gender-typed toy preferences ranged from 1- 4, low to high.

**Maternal report of character knowledge online survey.** Mothers completed an online survey to report on whether their child knew Dora and Diego. Response options were binary: (1) yes and (0) no.

**Design**

The study employed a 2 (child sex: boy or girl) by 2 (intelligent character: male or female character) design. Children were randomly assigned, within sex, to play the Dora or Diego intelligent character math game. In other words, children played the intelligent character math game with a same- or opposite-sex intelligent character.
Procedure

Children provided verbal assent to participate at the start of the experimental session. The experimenter first showed children a picture of the character featured in the game version they were randomly assigned to play. Children completed the pre-game character knowledge survey and attachment and friendship subscale questions, for that character, with the experimenter. Next, children played the intelligent character math game with the experimenter sitting beside them to assist if needed. A second experimenter was the game Wizard, who operated the intelligent character math game from a hidden location behind a room divider screen.

When the game was finished, children completed the add-1 transfer task with physical star stickers. The experimenter showed children an initial number of stickers and said, “I have [number, e.g., 3] stickers”, and placed the group of stickers into a small bag. The experimenter then showed children an additional sticker and said “Oh! I have one more sticker. How many stickers do I have?”, while holding the single sticker over the top of the bag until children provided an answer. Children responded verbally or with gestures (e.g., holding up fingers to represent a number) to the transfer task problems.

After the transfer task with physical objects, the experimenter set up three buckets with smiley faces on the front and covered the top of the buckets with a black cloth, so children were not able to see inside the buckets during the task. They told the child, “Now I am going to show you some toys. When you see each toy, you can decide how much you would like to play with the toy. If you want to play with the toy a lot you can put it in this bucket [pointed to bucket with largest smiley face]. If you want to play with the toy a little you can put it in this bucket [pointed to bucket with medium smiley face]. If you don’t want to play with the toy at all you can put it in this bucket [pointed to bucket with smallest smiley face with straight-lined mouth].” When each
toy was presented to the child the experimenter asked, “Do you want to play with this toy a lot [pointed to bucket with largest smiley face], a little [pointed to bucket with medium smiley face], or not at all [pointed to bucket with smallest smiley face with straight-lined mouth].” The child indicated the bucket they wanted to select verbally or by pointing. The experimenter placed the toy in the selected bucket and repeated the same process for the rest of the toys. When children finished the toy preference task they returned to their classrooms.

Parents were initially contacted through their child’s preschool when their children were recruited to participate in Study 1. Parents were re-contacted through e-mail once children’s consent forms for Study 1 were received by experimenters, with an invitation to participate in an online survey. The email invitation provided a link to the online questionnaire, which was administered using Qualtrics survey software. The online survey began with an informed consent page, which parents signed electronically to participate. Parents completed questions about their children’s knowledge of both Dora and Diego. Participants were entered into a drawing to win a $50 Amazon gift card as compensation for participation. Gift cards were awarded to ten randomly selected participants.

**Experimental Session Coding**

Parasocial interactions. *Math talk* parasocial interactions were coded by research assistants and entered into all analyses as a continuous variable. Math talk scores were calculated by summing the number of math talk prompts a child responded to on-task and dividing that sum by the number of math talk opportunities that were presented within the game. In other words, math talk was calculated as the amount of math talk children engaged in with the intelligent character relative to the amount of math talk prompts the intelligent character asked the child.
Math talk scores were a measure of how much children were on-task and engaging with an intelligent character about the math problems.

The number of math talk opportunities children were presented with (i.e., the number of times the character asked the child to solve a math problem) varied based on how children performed in the game (ranged 12 – 78). If the child required more scaffolds to complete a math problem correctly, then they would have more opportunities for math talk because the scaffolds repeated the math prompts until children answered correctly. The number of math talk prompts a child responded to was determined by awarding children a point for each on-task math reply. For example, when Diego asked, “What does 2 and 1 make?”, children would receive a point for responding verbally or by holding up their fingers to indicate a numerical response. If children did not reply or responded with an off-topic reply (e.g., “blue”), they would receive 0 points for that response. Math talk scores were multiplied by 100 to be used as a percentage score in analyses. Reliability, computed on 20% of the sample by two research assistants, yielded an “excellent” outcome at Cronbach’s $\alpha = 1.00$.

**Latency.** Latency to correctly answer add-1 math problems was a measure of reaction time, which may also indicate the amount of time it took children to process the math problem and provide a correct answer. This was a measure of mastery, in the moment, with the virtual math task. Average latency scores were calculated from the experimental session videos using Noldus the Observer XT version 14. Latency was operationalized as the number of seconds

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5 This range does not include math talk prompts that are provided by Boots, the main character’s sidekick. If children reached the Boots’ scaffold he would provide children with the answer (e.g., “Say 2”). The number of times children received this scaffold was determined by whether they repeated the answer Boots provided. Children that required the Boots’ scaffold required him to say the answer to the math problem 1 – 4 times before they repeated the answer.
between when the intelligent character finished the *initial* math question (e.g., “What does 2 and 1 make?”) and when the child responded correctly to the math problem (“3”). In this instance, if a child answered the initial math prompt incorrectly (e.g., “5”) and required scaffolds from the intelligent character to answer the problem correctly, then that time was included in the latency score. The average latency across the twelve add-1 problems was calculated and entered into all analyses as a continuous variable. Reliability, computed on 20% of the sample by two research assistants, yielded an “excellent” outcome at Cronbach’s $\alpha = .96$.

**Presage of Results**

To presage the results, this section discusses the implications of the unacceptable internal consistency of the attachment and friendship subscale of the Children’s Parasocial relationship Survey. When children answered questions about Diego in this study, the internal consistency of the measure was particularly low. The overall measure yielded low internal consistency as well. This methodological issue compromised the use of the attachment and friendship subscale as a predictor of add-1 math performance. Results from previous research with intelligent agents teaching the add-1 rule to preschoolers revealed that attachment and friendship was a significant predictor of latency to correctly answer add-1 math problems (Calvert et al., 2018). The measure was internally consistent at conventional levels in these studies (Calvert et al., 2018).

Children’s report of their *knowledge of the character*, a measure of familiarity with the media character, provided some more information about why the attachment and friendship subscale of the Children’s Parasocial Relationship Measure did not yield acceptable levels of internal consistency. Approximately half of the children in this study did not know the character featured in their version of the math game prior to game play in the Pre-Game Character

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6 See Appendix A for more information.
Knowledge Survey. More children were unfamiliar with Diego compared to Dora, which may explain why the internal consistency on the measure was particularly low for Diego. Data about children’s knowledge of the characters is detailed in the Results section. Character knowledge was not significantly correlated with attachment and friendship with Dora ($r = .06$), Diego ($r = -.21$) or overall attachment and friendship when the two conditions were collapsed ($r = .08$; all p’s $>.05$). Not surprisingly, then, data from this study suggested that to measure a parasocial relationship between a child and character, children must be familiar with the character.

The following results section will therefore focus on children’s parasocial interactions sans a parasocial relationship with the targeted intelligent character.

**Results**

**Knowledge of the Character**

Children reported on their familiarity with only the character they would see featured as an intelligent character in the math game version they played, and mothers reported on their children’s familiarity with both Dora and Diego. Children’s self-report of character knowledge was found to be a valid measure of children’s knowledge of the character because mothers and children had high agreement on whether the child was familiar with the characters.

**Child report.** Approximately one-third (34%) of the children were able to recall the character’s name, 18% reported that they recognized the character, and 48% reported that they did not know the character. A chi-square test was conducted to examine if there was an association between children’s level of knowledge of the character and child sex. There was a significant association. More children knew Dora’s name and fewer children had knowledge of Diego, $X^2 (2) = 25.91, p < .001$ (See Figure 3). Because children in the study had varying levels of knowledge about the character, character knowledge will be included as a continuous control
variable in the following analyses predicting add-1 rule performance in the virtual game and in the transfer task with physical objects after game play. Further, because so few children were familiar with the characters featured in this experiment and for ease of interpretation, the intelligent characters will be referred to as “unknown”, “novel”, or “unfamiliar” in the discussion chapter. Although some children did know the character and character knowledge was controlled for in the analyses, Dora and Diego were mostly unknown and evidence from this experiment suggests that they are far from popular characters or favorite characters for the children in this sample. These labels are important in order to make a distinction between the characters used in the current experiment and characters used in previous intelligent character research (Calvert et al., 2018).

![Figure 3: Child-reported character knowledge by condition](image_url)

**Maternal report.** Mothers reported on their children’s knowledge of Dora and Diego to validate children’s self-reports. The results revealed that moms reported that more than half of
their children had knowledge of Dora (66.67%) and 43.14% of children had knowledge of Diego (See Figure 4).

![Figure 4: Maternal report of character knowledge by character](image)

**Comparing child and parent report of character knowledge**

*H1*: Mothers and children were expected to agree about whether children knew the male and female intelligent characters, as opposed to disagree about whether children knew the male and female intelligent characters.

Fifty-one mother-child pairs both provided responses to the questions about whether children had knowledge of the characters. The hypothesis was supported: the majority of mothers and children agreed on whether or not children knew the characters (76.47%), while less than a quarter of mother-child pairs disagreed about whether the child knew the characters (23.53%; See Figure 5).
Liking the Character

$H^2$: Children were expected to report liking a same-sex character more than an opposite-sex character, prior to game play.

An OLS regression was conducted to explore whether children reported liking a same-sex character more than an opposite-sex character prior to game play. *Child-character sex match* was indicated as 0 for girls who played the Diego intelligent character game and boys that played the Dora intelligent character game. Child-character sex match was indicated as 1 for girls who played the Dora intelligent character game and boys that played the Diego intelligent character game. Child-reported character knowledge and child age in days were entered as continuous control variables in the regression. The following equation was estimated:

$$Like\text{Character} = \beta_0 + \beta_1\text{Child-CharacterSexMatch} + \beta_2\text{CharacterKnowledge} + \beta_3\text{ChildAge} + \mu$$

The hypothesis was supported. Children reported liking a same-sex character significantly more than an opposite-sex character before playing the math game ($M_{\text{SameSex}} = 3.85$, $M_{\text{Opposite}} = 2.00$).
Children who were the same-sex as the character said they liked that character .71 points higher, on a 1-5-point scale, compared to children who were the opposite-sex as the character they were surveyed about ($p = .034$; See Table 2).

### Table 2: OLS regression predicting how much children reported liking character

| Model 1 |  
|------------------|------------------|
| B (SE)            |                  |
| Child-Character Sex Match | .71* (.34) |
| Character Knowledge | .32 (.19) |
| Age               | -.0004 (.001) |
| Constant          | 3.52 (2.36) |
| $R^2$             | .10             |
| Adjusted $R^2$    | .07             |
| $F$               | 4.05**          |
| $Df$              | 3, 84           |
| $N$               | 88              |

* $p \leq 0.05$; ** $p \leq 0.01$; Robust Standard Errors

Notes: Sample excludes 22 children who got all 12 math problems correct on the first try, 1 child who did not answer the survey question about how much they liked the character, and 1 child who did not answer character knowledge questions.

Child-Character Sex Match: 1 = child and character are the same-sex, 0 = child and character are the opposite-sex

Controls: Character Knowledge (0 = no knowledge, 1 = recognize character, 2 = know character’s name); Age (days)

### Game Play

The average duration of game play was 12.43 minutes ($SD = 4.41$ min, range 6.07 – 25.93) and did not differ significantly by whether the child played the game with a same- or with an opposite-sex intelligent character (i.e., condition), $t$ (88) = -.78, $p = ns$; $M_{SexMatch} = 12.79, SD = 4.70$; $M_{OppositeSex} = 12.06, SD = 4.10$). Children correctly answered an average of 8.19 add-1 math problems in the math game on their first try ($SD = 2.81$). This also did not differ significantly by
whether the child played the game with a same- or with an opposite-sex intelligent character, \( t(88) = .65, p = \text{ns}; M_{\text{SexMatch}} = 8.00, SD = 2.90; M_{\text{OppositeSex}} = 8.39, SD = 2.74 \).

**Average latency in the intelligent character math game.** Children’s average latency to correctly answer the twelve add-1 math problems in the game was 24.84 seconds \((SD = 21.59)\), and average latency did not differ significantly by whether children played the game with a same- or opposite-sex intelligent character, \( t(88) = -.48, p = \text{ns}; M_{\text{SexMatch}} = 25.91, SD = 22.88; M_{\text{OppositeSex}} = 23.73, SD = 20.37 \).7

**Math talk.** Children interacted with the intelligent character 85.55\% \((SD = 18.19\%, \text{range} = 21.62 - 100)\) of the time they were prompted by the intelligent character with a math talk question, on average. A t-test was conducted to examine if children engaged in more math talk when they played the math game with a same- or opposite-sex intelligent character. Results revealed that children engaged in similar amounts of math talk with sex-matched and opposite-sex intelligent characters, \( t(88) = .16, p = \text{ns}; M_{\text{SexMatch}} = 85.25, SD = 17.86; M_{\text{OppositeSex}} = 85.86, SD = 18.73 \).

\( H3 \): Children that engaged in more math talk interactions with the intelligent character were expected to demonstrate reduced add-1 latency, compared to children who engaged in fewer math talk interactions with the intelligent character.

An OLS regression was conducted predicting average latency by math talk, controlling for child-character sex match, child-reported character knowledge, and child age in days, to test hypothesis 3 (see model 1, Table 3). The following equation was estimated:

\[
\text{Mean Latency for Girls in Dora Condition} = 30.61 \text{ seconds, } SD = 27.28; \text{ Mean Latency for Boys in Dora Condition} = 23.20 \text{ seconds, } SD = 20.41; \text{ Mean Latency for Girls in Diego Condition} = 24.21 \text{ seconds, } SD = 20.34; \text{ Mean Latency for Boys in Diego Condition} = 20.98 \text{ seconds, } SD = 17.08.
\]
Latency = \( \beta_0 + \beta_1 \text{MathTalk} + \beta_2 \text{Child-CharacterSexMatch} + \beta_3 \text{CharacterKnowledge} + \beta_4 \text{ChildAge} + \mu \)

The hypothesis that children who engaged in more math talk were expected to demonstrate reduced add-1 latency was supported. Results revealed a significant main effect of math talk in model 1 of Table 3. Children who engaged in more math talk were significantly faster at answering add-1 math problems. For every percentage point higher children scored on math talk, they were .81 seconds faster at correctly answering add-1 math problems (\( p < .001 \)).

Math talk and child-character sex match. \( H^4 \): Children that engaged in more math talk interactions with a same-sex intelligent character were expected to demonstrate reduced add-1 latency compared to children that engaged in more math talk with an opposite-sex intelligent character.

An OLS regression was conducted predicting average latency by math talk and the interaction of math talk and child-character sex match. The regression model also included controls for child-reported character knowledge and child age in days to test hypothesis 4 (see model 2, Table 3). The following equation was estimated:

\[
\text{Latency} = \beta_0 + \beta_1 \text{MathTalk} + \beta_2 \text{MathTalk*Child-CharacterSexMatch} + \beta_3 \text{Child-CharacterSexMatch} + \beta_4 \text{CharacterKnowledge} + \beta_5 \text{ChildAge} + \mu
\]

The hypothesis that children would answer add-1 problems faster when they engaged in higher amounts of math talk with a same-sex intelligent character, compared to an opposite-sex intelligent character, was supported in model 2 of Table 3. While engaging in more math talk with either intelligent character resulted in quicker correct answers to add-1 math problems, the
significant and negative interaction term indicated that the effect of math talk was greater for children interacting with a same-sex intelligent character \((p = .006)\). Figure 6 displays the interaction of child-character sex match and math talk with raw math talk values, as opposed to the mean-centered math talk variable presented in Table 3. The figure overlays the slopes of math talk by child-character sex match on top of a histogram displaying the distribution of math talk.

The significant and negative math talk coefficient in model 2 can be interpreted as follows: the more math talk children engaged in with an opposite-sex character, the quicker they correctly answered the math problems \((p < .001)\).
Table 3: OLS regression predicting average response latency in seconds for add-one problems

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B (SE)</td>
<td>B (SE)</td>
</tr>
<tr>
<td>Math Talk</td>
<td>-.81** (.11)</td>
<td>-.57** (.14)</td>
</tr>
<tr>
<td>Child-Character Sex Match</td>
<td>---</td>
<td>-.51** (.18)</td>
</tr>
<tr>
<td>(0 = Opposite Sex, 1 = Same-Sex)</td>
<td>2.13 (3.51)</td>
<td>2.06 (3.40)</td>
</tr>
<tr>
<td>Character Knowledge</td>
<td>-1.18 (1.79)</td>
<td>-1.27 (1.72)</td>
</tr>
<tr>
<td>Age</td>
<td>.003 (.01)</td>
<td>.01 (.01)</td>
</tr>
<tr>
<td>Constant</td>
<td>20.24 (24.44)</td>
<td>14.02 (24.07)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>.45</td>
<td>.49</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>.42</td>
<td>.46</td>
</tr>
<tr>
<td>$F$</td>
<td>14.01**</td>
<td>19.89**</td>
</tr>
<tr>
<td>$Df$</td>
<td>4, 84</td>
<td>5, 83</td>
</tr>
<tr>
<td>$N$</td>
<td>89</td>
<td>89</td>
</tr>
</tbody>
</table>

*p ≤ 0.05; ** p ≤ 0.01; Robust Standard Errors

Notes: Sample excludes 22 children who got all 12 math problems correct on the first try and 1 child who did not answer character knowledge questions.
Math Talk: Calculated by dividing the number of math talk prompts a child replied to by the number of math talk prompts that were available to a child. That proportion had the possibility to range from 0 – 1 and was then multiplied by 100. This variable is mean centered at 85.55.
Controls: Child-Character Sex Match: 1 = child and character are the same-sex, 0 = child and character are the opposite-sex; Character Knowledge (0 = no knowledge, 1 = recognize character, 2 = know character’s name); Age (days)
Figure 6: Latency by math talk * child-character sex match overlaid on histogram of the math talk distribution

Notes: Math talk is presented in raw percentage values. The histogram represents the frequency of children who engaged in particular amounts of math talk, indicated on the x-axis. The mean of math talk is 85.55% (range 21.62% - 100%)

Add-1 Rule Transfer Task with Physical Objects: Star Stickers

The average number of correctly answered add-1 transfer task problems with physical objects was 3.78 (SD = 3.27, range 0 – 10). A t-test was conducted to examine whether children answered similar amounts of transfer task problems after playing the math game with same-sex and opposite-sex intelligent characters; results revealed no significant differences, t (87) = -1.57, p = ns; M_{SexMatch} = 4.31, SD = 3.47; M_{OppositeSex} = 3.23, SD = 3.00). Poisson regressions were used to

---

8 Mean Number Transfer Problems Correct for Girls in Dora Condition = 4.09, SD = 3.20; Mean Number Transfer Problems Correct for Boys in Dora Condition = 4.21, SD = 3.29; Mean Number Transfer Problems Correct for Girls in Diego Condition = 2.42, SD = 2.55 Mean Number Transfer Problems Correct for Boys in Diego Condition = 4.71, SD = 3.80.
predict the number of correctly answered transfer task problems with physical items because this dependent variable is a count. Incidence rate ratios (IRRs) are presented in the tables below.

Math talk. \(H^5\): Children that engaged in more math talk interactions with the intelligent character during the virtual game were expected to correctly answer more add-1 transfer task problems with physical objects, compared to children who engaged in fewer math talk interactions with the intelligent character.

A Poisson regression was conducted predicting the number of correctly answered transfer task problems, controlling for child-character sex match, child-reported character knowledge, and child age in days, to test hypothesis 5 (see model 1, Table 4). The following equation was estimated:

\[
\text{Number of Transfer Task Problems Answered Correctly} = \beta_0 + \beta_1 \text{MathTalk} + \beta_2 \text{Child-CharacterSexMatch} + \beta_3 \text{CharacterKnowledge} + \beta_4 \text{ChildAge} + \mu
\]

The hypothesis was not supported (See model 1 of Table 4). Math talk did not predict children’s performance in the transfer task with physical objects.

Math talk and child-character sex match. \(H^6\): Children that engaged in more math talk interactions with a same-sex intelligent character in the virtual math game were expected to correctly answer more transfer task problems with physical objects, compared to children that engaged with opposite-sex intelligent character.

A Poisson regression was conducted predicting the number of correct transfer task problems from math talk, the interaction of math talk and child-character sex match, and
controlling for child-reported character knowledge, and child age in days, to test hypothesis 6 (see model 2, Table 4). The following equation was estimated:

\[
\text{Number of Transfer Task Problems Answered Correctly} = \beta_0 + \beta_1 \text{MathTalk} + \beta_2 \text{MathTalk} \times \text{Child-CharacterSexMatch} + \beta_3 \text{Child-CharacterSexMatch} + \beta_4 \text{CharacterKnowledge} + \beta_5 \text{ChildAge} + \mu
\]

The hypothesis that children were expected to correctly answer more transfer task problems after engaging in math talk with a same-sex intelligent character, compared to an opposite-sex intelligent character, was supported in model 2 of Table 4. Children that engaged in more math talk with a same-sex intelligent character, compared to an opposite-sex intelligent character, during the virtual game correctly answered more transfer task problems with physical objects after game play. The significant interaction of math talk and child-character sex match indicated that for each additional point higher children scored on math talk in the math game, the incidence rate ratio of correctly answering more transfer task problems was significant at 1.02 times higher for children engaging with a same-sex intelligent character compared to children who engaged with an opposite-sex intelligent character \((p = .01; \text{ See Figure 7})\).
Table 4: Poisson regression predicting the number of add-1 transfer task problems answered correctly

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRR (SE)</td>
<td>IRR (SE)</td>
<td></td>
</tr>
<tr>
<td>Math Talk</td>
<td>1.00 (.01)</td>
<td>.99 (.01)</td>
</tr>
<tr>
<td>Child-Character Sex Match * Math Talk</td>
<td>---</td>
<td>1.02** (.01)</td>
</tr>
<tr>
<td>Child-Character Sex Match (0 = Opposite Sex, 1 = Same-Sex)</td>
<td>1.35 (.25)</td>
<td>1.32 (.24)</td>
</tr>
<tr>
<td>Character Knowledge</td>
<td>.97 (.11)</td>
<td>.97 (.10)</td>
</tr>
<tr>
<td>Age</td>
<td>1.00 (.001)</td>
<td>1.00 (.001)</td>
</tr>
<tr>
<td>Constant</td>
<td>.90 (1.05)</td>
<td>1.16 (1.28)</td>
</tr>
<tr>
<td>Pseudo $R^2$</td>
<td>.03</td>
<td>.05</td>
</tr>
<tr>
<td>Wald $X^2$</td>
<td>5.46</td>
<td>10.34</td>
</tr>
<tr>
<td>$Df$</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>$N$</td>
<td>88</td>
<td>88</td>
</tr>
</tbody>
</table>

*p ≤ 0.05; ** p ≤ 0.01; Robust Standard Errors

Notes: Sample excludes 22 children who got all 12 math problems correct on the first try, 1 child who did not answer character knowledge questions, and 1 child who refused to complete the transfer task. Math Talk: Calculated by dividing the number of math talk prompts a child replied to by the number of math talk prompts that were available to a child. That proportion had the possibility to range from 0 – 1 and was then multiplied by 100. This variable is mean centered at 85.55. Controls: Child-Character Sex Match: 1 = child and character are the same-sex, 0 = child and character are the opposite-sex; Character Knowledge (0 = no knowledge, 1 = recognize character, 2 = know character’s name); Age (days)
Figure 7: Incidence rate ratio (IRR) of the number of transfer task problems answered correctly by math talk * child-character sex match

*Note: Math talk is presented in raw percentage values (range 21.62% - 100%).

Results Summary

Approximately half of the children in the study reported that they didn’t know the character they played the intelligent character math game with and only an additional 18% were able to recognize the character. More children were unfamiliar with Diego, compared to Dora. Similarly, mothers reported that approximately two-thirds of their children knew Dora but that less than half of their children knew Diego. Children and their mothers had high agreement on whether or not the children knew the characters. Children reported liking a same-sex character
significantly more than an opposite-sex character, before playing the math game with that intelligent character.

Children who engaged in more math talk with either intelligent character demonstrated quicker reaction times to correctly answer add-1 math problems in the game; however, children who engaged in more math talk with a same-sex intelligent character were particularly fast. The relationship between latency and math talk is moderated by children’s sex-match to the character.

Children who engaged in more math talk with a same-sex intelligent character during the virtual math game were more successful at correctly answering add-1 transfer task problems with physical objects, compared to children who engaged in math talk with an opposite-sex intelligent character. In other words, math talk alone was not predicting better transfer task performance. It was only in the context of the child and intelligent character being the same sex that transfer was facilitated.
Study 1b
The purpose of Study 1b was to explore the impact of young children’s gender-stereotyped toy preferences on add-1 problem performance when they played the math game with a same-sex intelligent character or an opposite-sex intelligent character. In Study 1b, outcomes of interest were the same latency and transfer task outcome data from the intelligent character game in Study 1a. The current study also explored whether the effects of math talk and child-character sex match, found in Study 1a, were impacted by children’s preference for gender-typed toys. See Study 1a for methods, materials, measures, study design, procedure, and experimental session coding.

Results

Gender-Typed Toy Preference Task

Two chi-square analyses were conducted to test whether there was an association between child sex and preferences for feminine-typed and masculine-typed toys, respectively. These analyses served as both a validity and reliability check (Coyne et al., 2016) for the measure. Girls were more likely to report a preference for feminine toys compared to boys, $X^2 (2) = 28.03, p < .001$; See Figure 8. Boys were more likely to report a preference for masculine toys compared to girls, $X^2 (2) = 13.78, p = .001$; See Figure 8.
Figure 8: Frequency of children's preferences for feminine-typed and masculine-typed toys

Note: Feminine toys: doll, pony, tea set, fairy wings; Masculine toys: action figure, monster truck, pirate costume, tool set

The average overall gender-stereotype toy preference score was 2.73 (SD = .90), and a t-test revealed that boys and girls were similarly gender-stereotyped in their toy preferences, $t(88) = -1.93, p = ns$; $M_{Boys} = 2.54, SD = .92; M_{Girls} = 2.90, SD = .85)$. This variable measured the gender-stereotyped toy preferences of both boys and girls in one variable.

**Gender-Stereotyped Toy Preferences, Child-Character Sex Match, and Add-1 Math Performance**

Children with stronger gender-stereotyped toy preferences were expected to demonstrate increased math performance, in a virtual and physical context, when playing with a same-sex intelligent character compared to an opposite-sex intelligent character. These hypotheses were not supported. Neither children’s latency to correctly answer add-1 math problems in a virtual context nor the number of correctly answered transfer task add-1 problems with physical objects
were impacted by the interaction of gender-typed toy preferences and child-character sex match to the intelligent character.⁹

Math Talk, Gender-Stereotyped Toy Preferences, and Child-Character Sex Match

*RQ*: How are math talk, gender-stereotyped toy preferences, and their interactions with child-character sex match related to virtual and physical add-1 math performance outcomes?

**Average latency in the intelligent character math game.** A series of OLS regressions were conducted to determine if the effects of math talk and child-character sex match varied according to children’s gender-typed toy preferences when predicting add-1 latency scores (Table 5). Model 1 estimated the equation below, and models 2 – 5 included interactions of math talk, gender-typed toy preferences, and child-character sex match as well as controlling for character knowledge and child age (See Table 5, models 2 – 5).

\[
\text{Latency} = \beta_0 + \beta_1 \text{MathTalk} + \beta_2 \text{GenderStereotypedToyPreference} + \beta_3 \text{Child-CharacterSexMatch} \\
+ \beta_4 \text{CharacterKnowledge} + \beta_5 \text{ChildAge} + \mu
\]

Results from model 1 revealed that math talk had a significant impact on how quickly children correctly answered add-1 math problems when holding gender-typed toy preferences, constant. Children who do more math talk answered math problems correctly faster \((p < .001)\). Model 2 revealed a significant interaction of math talk and children’s gender-typed toy preferences. Math talk was more effective at decreasing children’s latency to correctly answer add-1 math problems for children who are more gender-typed \((p = .03)\). Model 3 revealed that math talk generally yielded quicker correct responses by children on the add-1 math problems \(p \)

---

⁹ Hypotheses, statistical tests, and non-significant results can be found in Appendix B.
and that effect was greater for children interacting with a same-sex intelligent character, controlling for gender-typed toy preferences ($p < .001$). Model 4 again revealed a significant effect of math talk on children’s latency to correctly answer add-1 math problems ($p < .001$). Model 5 revealed that there is no indication that the effects of math talk and child-character sex match differ by children’s gender-typed toy preferences.
### Table 5: OLS regression predicting average response latency in seconds for add-one problems

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B (SE)</td>
<td>B (SE)</td>
<td>B (SE)</td>
<td>B (SE)</td>
<td>B (SE)</td>
</tr>
<tr>
<td>Math Talk</td>
<td>-0.81** (.11)</td>
<td>-0.13 (.32)</td>
<td>-0.56** (.14)</td>
<td>-0.81** (.11)</td>
<td>-0.11 (.41)</td>
</tr>
<tr>
<td>Gender Stereotyped Toy Preference</td>
<td>-0.01 (1.98)</td>
<td>-0.07 (1.93)</td>
<td>-0.52 (1.90)</td>
<td>-2.96 (3.07)</td>
<td>-3.98 (2.88)</td>
</tr>
<tr>
<td>Math Talk * Gender Stereotyped Toy Preference</td>
<td>---</td>
<td>-0.29* (.13)</td>
<td>---</td>
<td>---</td>
<td>-0.20 (.17)</td>
</tr>
<tr>
<td>Math Talk * Child-Character Sex Match</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>-0.48 (.50)</td>
</tr>
<tr>
<td>Gender Stereotyped Toy Preference * Child-Character Sex Match</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>6.42 (4.19)</td>
<td>7.54 (4.11)</td>
</tr>
<tr>
<td>Math Talk * Gender Stereotyped Toy Preference * Child-Character Sex Match</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Child-Character Sex Match (0 = Opposite Sex, 1 = Same-Sex)</td>
<td>2.14 (3.41)</td>
<td>1.11 (3.39)</td>
<td>2.17 (3.33)</td>
<td>-15.18 (12.06)</td>
<td>18.88 (11.28)</td>
</tr>
<tr>
<td>Character Knowledge</td>
<td>-1.18 (1.85)</td>
<td>-0.47 (1.96)</td>
<td>-1.20 (1.78)</td>
<td>-1.76 (1.89)</td>
<td>-1.41 (1.99)</td>
</tr>
<tr>
<td>Age</td>
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<td>.01 (.01)</td>
<td>.01 (.01)</td>
<td>.002 (.01)</td>
<td>.01 (.01)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>.41</td>
<td>.48</td>
<td>.49</td>
<td>.46</td>
<td>.53</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>.45</td>
<td>.45</td>
<td>.45</td>
<td>.42</td>
<td>.48</td>
</tr>
<tr>
<td>$F$</td>
<td>11.08**</td>
<td>15.22**</td>
<td>6.82</td>
<td>8.59**</td>
<td>22.75**</td>
</tr>
<tr>
<td>$Df$</td>
<td>5, 83</td>
<td>6, 82</td>
<td>6, 82</td>
<td>6, 82</td>
<td>9, 79</td>
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<tr>
<td>$N$</td>
<td>89</td>
<td>89</td>
<td>89</td>
<td>89</td>
<td>89</td>
</tr>
</tbody>
</table>

*p ≤ 0.05; **p ≤ 0.01; Robust Standard Errors

**Notes:** Sample excludes 22 children who got all 12 math problems correct on the first try and 1 child who did not answer character knowledge questions; Math Talk: Calculated by dividing the number of math talk prompts a child replied to by the number of math talk prompts that were available to a child. That proportion had the possibility to range from 0 – 1 and was then multiplied by 100. This variable is mean centered at 85.55.; Gender Stereotyped Toy Preference: Range of 1 (weak gender-stereotyped toy preference)– 4 (strong gender-stereotyped toy preference); Controls: Child-Character Sex Match: 1 = child and intelligent character are the same-sex, 0 = child and intelligent character are the opposite-sex; Character Knowledge (0 = no knowledge, 1 = recognize character, 2 = know character’s name); Age (days)
**Add-1 rule transfer task with physical objects: star stickers.** A series of Poisson regressions, displayed with incidence rate ratios (IRRs), were conducted to determine if the effects of math talk and child-character sex match varied according to children’s gender-typed toy preferences when predicting the number of transfer task problems with physical stickers children answered correctly (Table 6). Model 1 estimated the equation below and models 2 – 5 included interactions of math talk, gender-typed toy preferences, and child-character sex match as well as controlling for character knowledge and child age (See Table 6, models 2 – 5).

\[
\text{Number of Transfer Task Problems Correct} = \beta_0 + \beta_1\text{MathTalk} + \\
\beta_2\text{GenderStereotypedToyPreference} + \beta_3\text{Child-CharacterSexMatch} + \beta_4\text{CharacterKnowledge} + \\
\beta_5\text{ChildAge} + \mu
\]

Model 1 supported findings in Study 1a and Study 1b that there were no main effects of math talk or gender-typed toy preferences on the number of correct transfer task problems with physical objects. Model 2 revealed an interaction between math talk and gender-typed toy preferences. Math talk was more effective at increasing the number of transfer task problems answered correctly for children who were more gender-typed \((p = .04)\). Model 3 revealed that the interaction of math talk and child-character sex match predicting the number of transfer task problems correct reported in Study 1a remained when holding gender-typed toy preferences constant \((p = .01)\). Model 4 revealed no evidence of gender-typed toy preferences varying by whether the child was matched in sex to the intelligent character or not. Model 5 revealed no evidence that the effects of math talk and child-character sex match differ by children’s gender-
typed toy preferences when predicting the number of transfer task problems answered correctly with physical objects.
Table 6: Poisson regression predicting the number of add-1 transfer task problems answered correctly

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>(IRR (SE))</td>
<td>(IRR (SE))</td>
<td>(IRR (SE))</td>
<td>(IRR (SE))</td>
<td>(IRR (SE))</td>
<td>(IRR (SE))</td>
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<tr>
<td>Math Talk</td>
<td>1.00 (.01)</td>
<td>.98 (.01)</td>
<td>.99 (.01)</td>
<td>1.00 (.005)</td>
<td>.98 (.01)</td>
</tr>
<tr>
<td>Gender Stereotyped Toy Preference</td>
<td>.98 (.11)</td>
<td>.98 (.11)</td>
<td>1.01 (.12)</td>
<td>.79 (.13)</td>
<td>.83 (.15)</td>
</tr>
<tr>
<td>Math Talk * Gender Stereotyped Toy Preference</td>
<td>---</td>
<td>1.01* (.01)</td>
<td>---</td>
<td>---</td>
<td>1.01 (.01)</td>
</tr>
<tr>
<td>Math Talk * Child-Character Sex Match</td>
<td>---</td>
<td>---</td>
<td>1.02** (.01)</td>
<td>---</td>
<td>1.01 (.03)</td>
</tr>
<tr>
<td>Gender Stereotyped Toy Preference * Child-Character Sex Match</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>1.50 (.32)</td>
<td>1.40 (.31)</td>
</tr>
<tr>
<td>Math Talk * Gender Stereotyped Toy Preference * Child-Character Sex Match</td>
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<td>---</td>
<td>---</td>
<td>---</td>
<td>1.00 (.01)</td>
</tr>
<tr>
<td>Child-Character Sex Match</td>
<td>1.35 (.25)</td>
<td>1.41 (.27)</td>
<td>1.31 (.24)</td>
<td>.46 (.29)</td>
<td>.54 (.36)</td>
</tr>
<tr>
<td>(0 = Opposite Sex, 1 = Same-Sex)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Character Knowledge</td>
<td>.98 (.11)</td>
<td>.95 (.11)</td>
<td>.97 (.11)</td>
<td>.94 (.09)</td>
<td>.92 (.10)</td>
</tr>
<tr>
<td>Age</td>
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<td>1.00 (.001)</td>
<td>1.00 (.001)</td>
<td>1.00 (.001)</td>
<td>1.00 (.001)</td>
</tr>
<tr>
<td>Constant</td>
<td>.90 (1.05)</td>
<td>1.12 (1.27)</td>
<td>1.16 (1.28)</td>
<td>1.69 (2.05)</td>
<td>2.11 (2.48)</td>
</tr>
<tr>
<td>Pseudo $R^2$</td>
<td>.03</td>
<td>.04</td>
<td>.05</td>
<td>.05</td>
<td>.07</td>
</tr>
<tr>
<td>Wald $X^2$</td>
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<td>10.56</td>
<td>10.66</td>
<td>12.86</td>
<td>24.32</td>
</tr>
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<td>6</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>$N$</td>
<td>88</td>
<td>88</td>
<td>88</td>
<td>88</td>
<td>88</td>
</tr>
</tbody>
</table>

*p ≤ 0.05; **p ≤ 0.01; Robust Standard Errors; IRR: Incidence Rate Ratios

Notes: Sample excludes 22 children who got all 12 math problems correct on the first try, 1 child who did not answer character knowledge questions, and 1 child who refused to complete the transfer task; Math Talk: Calculated by dividing the number of math talk prompts a child replied to by the number of math talk prompts that were available to a child. That proportion had the possibility to range from 0 – 1 and was then multiplied by 100. This variable is mean centered at 85.55; Gender Stereotyped Toy Preference: Range of 1 (weak gender-stereotyped toy preference) – 4 (strong gender-stereotyped toy preference); Controls: Child-Character Sex Match: 1 = child and character are the same-sex, 0 = child and character are the opposite-sex; Character Knowledge (0 = no knowledge, 1 = recognize character, 2 = know character’s name); Age (days)
Results Summary

Results from the gender-typed toy preference task aligned with the literature on children’s toy preferences, finding that boys and girls indicated a preference for playing with gender-stereotyped toys (Dinella & Weisgram, 2018; Leaper, 2015). However, no evidence for the impact of children’s gender-stereotyped toy preferences by child-character sex match on add-1 math performance was found. This suggested that although children are gender-stereotyped in their toy preferences, these gender-typed preferences do not play a role in add-1 performance in the virtual task or in the transfer task with physical objects. There was no evidence that the effects of math talk and child-character sex match on add-1 math problem performance (see Study 1a), in a virtual or physical context, were impacted by the extent to which children preferred gender-typed toys.

10 See Appendix B for details.
Study 1c

The purpose of Study 1c was to examine who children’s favorite characters were and the ratings by adult coders of the gender-typed characteristics of those characters. Understanding the gender-typed characteristics of favorite media characters (e.g., sex, physical appearance, personality traits) provided information about the experiences and expectations children may have for experiences with new media characters. This was particularly of interest because evidence from Study 1a demonstrated that the effect of math talk was greater when children interacted with same-sex characters as opposed to opposite-sex characters. In addition to understanding these expectations children may have for experiences with media characters, another purpose of the current survey was to examine whether parents are aware of children’s gendered-typed preferences in order to provide them with opportunities that may yield enhanced educational outcomes.

The hypotheses were:

\( H^0: \) Parents and children were expected to report that girls were more likely to have current favorite media characters that were female and that boys were more likely to have current favorite media characters that were male.

This is expected because previous research on children’s favorite media characters, with whom children have parasocial relationships with, consistently has found that parents reported their children’s favorite characters were the same sex as their child (Aguiar, Richards, Bond, Brunick, et al., 2019; Bond & Calvert, 2014b; Richards & Calvert, 2016) Similarly, children also reported they have favorite characters that are the same sex as they are (Hoffner, 1996; Richards & Calvert, 2017a).
The favorite characters reported by boys and mothers of boys were expected to be rated by coders as more masculine in physical appearance compared to the favorite characters reported by girls and mothers of girls, who will be rated by coders as more feminine.

A difference in the ratings of characters’ gender-typed physical appearance was expected because media characters often are portrayed as physically gender-stereotyped (e.g., princesses with long hair, superhero males with large muscles; Ward & Aubrey, 2017). Female characters are often valued in media representations for their physical appearance and male characters often are presented as physically strong and muscular, which can negatively impact children’s ideas about what males and females look like (Ward & Aubrey, 2017).

The favorite characters reported by girls and mothers of girls were expected to be rated by coders as having more feminine personality traits compared to the ratings of favorite characters reported by boys and mothers of boys.

Feminine personality traits were assessed separately from male personality traits (examined in hypothesis 9 below) because masculine and feminine personality traits are separate dimensions (Bem, 1981). Female characters, most often the favorite characters of girls, are often depicted in gender-stereotyped roles and ways (e.g., damsel in distress, physically present but not speaking), which has been associated with children’s cognitions about gender and gender-typed behaviors (Ward & Aubrey, 2017).

The favorite characters reported by boys and mothers of boys were expected to be rated by coders as having more masculine personality traits compared to the ratings of favorite characters reported by girls and mothers of girls.

Similarly to female characters, male characters, most often the favorite characters of boys, are often depicted in gender-stereotyped roles and ways (e.g., assertive and aggressive
hero’s). This is associated with children’s strict and limited ideas of what it means to be a man (Ward & Aubrey, 2017).

A research question was as follows:

*RQ*²: Are children’s gender-typed toy preferences associated with gendered-typed physical appearance and gendered typed-personality traits ratings for favorite characters reported by children and their mothers?

**Methods**

**Participants**

One hundred and twenty-five parents living in the Washington D.C. metropolitan area, who consented for their children to participate in Study 1a, were surveyed online about their children’s favorite character. Sixty-nine mothers and twelve fathers reported on who they believed their child’s current favorite character was (63.20% retention rate from Study 1a). Fathers were dropped from the sample due to low response rate about their children’s favorite characters. Seventy-one children who participated in Study 1a reported on who their favorite characters were. Among the sixty-nine mothers and seventy-one children that provided information about children’s favorite characters, there were fifty-seven mother-child pairs that answered the survey question.

Only the fifty-seven mother-child pairs were retained in the current study’s final sample. The sample consisted of mothers of 32 girls and 25 boys (*M*age = 4.42, *SD* = .31, age range 3.92 – 5.10). The sample was 74.07% Caucasian, and 96.30% of mothers had a college degree or more.¹¹

¹¹ Three mothers did not report on parental education or child race.
Measures

**Parent report of children’s favorite character.** Parents were asked to report the name of their child’s favorite character in an online survey.

**Child report of children’s favorite character.** Children were asked to report the name of their favorite character to an experimenter.

**Toy preference task.** See Study 1a.

**Character sex, gender-typed traits, and physical appearance.** A database of children’s favorite characters was coded for their sex, gender-typed physical appearance, and gender-typed personality traits (Aguiar, Richards, Bond, Putnam, et al., 2019). Characters were coded using still images of each character obtained from a Google Image search. The coding method used is described below. In the current study, if a favorite character was not in the database from the parent reports about their children’s parasocial breakups (Aguiar, Richards, Bond, Putnam, et al., 2019), the primary coder for the database added the new character to the database and coded their sex, physical appearance, and personality traits.

**Character sex.** Character sex was coded as (0) male or (1) female. Internal consistency in the database was perfect ($\alpha = 1.0$; Aguiar, Richards, Bond, Putnam, et al., 2019).

**Physical appearance.** Coders rated the gender-typed physical appearance of each media character using a continuous -2 to +2 semantic differential scale (See Appendix C; Aguiar, Richards, Bond, Putnam, et al., 2019). Scores at the negative end of the distribution indicated a hyper masculine appearance (e.g., The Hulk) and scores at the positive end of the distribution indicated a hyper feminine appearance (e.g., Ariel), while scores near zero indicated a gender-neutral appearance (e.g., Slinky Dog from Toy Story). Internal consistency in the database on
physical appearance scores was “almost perfect” (α = .98; Aguiar, Richards, Bond, Putnam, et al., 2019).

**Gender-typed personality traits.** The self-report from the Bem Sex-Role Inventory Short Form (1981) was adapted for use in previous parent report surveys of children’s parasocial breakups (Aguiar, Richards, Bond, Putnam, et al., 2019; Bond & Calvert, 2014b); See Appendix C). Masculinity and femininity are separate dimensions (Bem, 1981) and were coded separately. Characters were coded on 10 traditionally masculine traits (e.g., assertive, dominant, independent) and 10 traditionally feminine traits (e.g., gentle, understanding, warm). Coders rated the characters on 4-point Likert scales, where “0” indicated “not at all” and “3” indicated “very”. Raw scores from two coders were averaged to create composite scores for traditionally masculine traits (α = .81) and traditionally feminine traits (α = .85), indicating “good” internal consistency for the ratings in the database (Aguiar, Richards, Bond, Putnam, et al., 2019).

**Procedure**

Parents were initially contacted through their child’s preschool when their children were recruited to participate in Study 1a. Parents were re-contacted with an e-mail once children’s consent forms for Study 1 were received by experimenters, with an invitation to participate in an online survey. The email invitation provided a link to the online questionnaire, which was administered using Qualtrics survey software. The online survey began with an informed consent form, which parents signed electronically to participate. All parents were asked to first report who they thought their child’s favorite character to be. Parents responded to this question prior to answering the survey questions about their children’s character knowledge in Study 1a.
Children were asked by an experimenter who their favorite character was before children began participating in Study 1a. Children also completed the gender-typed toy preference task as part of Study 1a.

**Results**

**Media Platforms for Favorite Characters**

While most favorite characters reported by mothers and children were originally created for more traditional digital media formats like television program stations and movies\(^\text{12}\) (e.g., Disney movies, PBS, Nick Jr.), children also have access to approximately half of these characters on streaming platforms. Sixty-three percent of children reported favorite characters who appeared on at least one streaming platform (e.g., Netflix, Amazon Prime, Hulu) in 2018-2019. Seventy-nine percent of parents reported favorite characters were available on at least one streaming platform in 2018-2019.

It is also important to note that children were likely to have viewed these characters on YouTube. In a recent survey by Pew Research Center, 81% of U.S. parents reported that their children had watched YouTube videos. Out of those parents with children who have watched YouTube, 34% reported their children were regular viewers (Pew Research Center, 2018).

**Mother-Child Agreement About Children’s Favorite Media Characters**

Mothers and children often did *not* agree on who a child’s favorite character was. Only 15.79% \((n = 9)\) of mother-child pairs agreed on the child’s current favorite character. Table 7 details a full list of mother-child pairs and agreements are highlighted in bold text. Almost all

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\(^{12}\) 2 children reported Barbie, traditionally a toy, as their favorite media character. Barbie is featured on a children’s program on Barbie.com.
disagreements were the result of a parent naming specific characters and children naming a different specific character. However, one child reported that they did not have a favorite character and their parents reported a specific character (e.g., The Little Mermaid). Also, five parents reported their children did not have a favorite character, and their children reported specific characters.
Table 7: Mother-child reported favorite characters

<table>
<thead>
<tr>
<th>Maternal-Reported Favorite Character</th>
<th>Child-Reported Favorite Character</th>
<th>$n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elsa</td>
<td>Elsa</td>
<td>2</td>
</tr>
<tr>
<td>Elsa</td>
<td>Elsa and Anna</td>
<td>2</td>
</tr>
<tr>
<td>All Dinosaur Characters</td>
<td>Moana</td>
<td>1</td>
</tr>
<tr>
<td><strong>Any Disney Princess</strong></td>
<td><strong>Cinderella</strong></td>
<td>1</td>
</tr>
<tr>
<td>Anyone from The Magic School Bus</td>
<td>Luke Skywalker</td>
<td>1</td>
</tr>
<tr>
<td>Batman</td>
<td>Ninjas</td>
<td>1</td>
</tr>
<tr>
<td>Ben Ten</td>
<td>Ninja Turtles, He-Man, Elsa</td>
<td>1</td>
</tr>
<tr>
<td>Chase from Paw Patrol</td>
<td>Captain America</td>
<td>1</td>
</tr>
<tr>
<td>Chase from Paw Patrol</td>
<td>Slinky Dog</td>
<td>1</td>
</tr>
<tr>
<td>Chibi USA from Sailor Moon</td>
<td>Turby</td>
<td>1</td>
</tr>
<tr>
<td>Dan from Dino Dan</td>
<td>Chase and Marshall from Paw Patrol</td>
<td>1</td>
</tr>
<tr>
<td>Daniel Tiger</td>
<td>Elsa and Anna, Descendants</td>
<td>1</td>
</tr>
<tr>
<td>Daniel Tiger</td>
<td>Pinkalicious</td>
<td>1</td>
</tr>
<tr>
<td>Dinosaur</td>
<td>Mufasa</td>
<td>1</td>
</tr>
<tr>
<td>Dora</td>
<td>Barbie</td>
<td>1</td>
</tr>
<tr>
<td>Dora</td>
<td>Chewbacca</td>
<td>1</td>
</tr>
<tr>
<td>Dora</td>
<td>Elsa</td>
<td>1</td>
</tr>
<tr>
<td>Dora</td>
<td>Michael Jackson</td>
<td>1</td>
</tr>
<tr>
<td>Dora</td>
<td>Peter Rabbit</td>
<td>1</td>
</tr>
<tr>
<td>Dora</td>
<td>Skipper</td>
<td>1</td>
</tr>
<tr>
<td>Elena from Elena of Avalor</td>
<td>Mickey Mouse</td>
<td>1</td>
</tr>
<tr>
<td>Elsa</td>
<td>Ariel</td>
<td>1</td>
</tr>
<tr>
<td>Elsa</td>
<td>Dizzy and Jet from Super Wings</td>
<td>1</td>
</tr>
<tr>
<td>Fancy Nancy</td>
<td>Wonder Woman</td>
<td>1</td>
</tr>
<tr>
<td>Gecko Boy from PJ Masks</td>
<td>Elsa</td>
<td>1</td>
</tr>
<tr>
<td>Heatwave from Rescue Bots</td>
<td>Batman</td>
<td>1</td>
</tr>
<tr>
<td>LOL Dolls</td>
<td>The Grinch</td>
<td>1</td>
</tr>
<tr>
<td>Lucky from Spirit</td>
<td>Superman</td>
<td>1</td>
</tr>
<tr>
<td>Masha and Bear</td>
<td>Barbie</td>
<td>1</td>
</tr>
<tr>
<td><strong>Moana</strong></td>
<td><strong>Moana</strong></td>
<td>1</td>
</tr>
<tr>
<td>Nella</td>
<td>Beyoncé</td>
<td>1</td>
</tr>
<tr>
<td><strong>Ninjago</strong></td>
<td><strong>Lord Gobodon</strong></td>
<td>1</td>
</tr>
<tr>
<td>No Favorite</td>
<td>Daniel Tiger</td>
<td>1</td>
</tr>
<tr>
<td>No Favorite</td>
<td>Elmo</td>
<td>1</td>
</tr>
<tr>
<td>No Favorite</td>
<td>Johnny from Sing</td>
<td>1</td>
</tr>
<tr>
<td>No Favorite</td>
<td>Moana</td>
<td>1</td>
</tr>
<tr>
<td>No Favorite</td>
<td>The Grinch and Max</td>
<td>1</td>
</tr>
<tr>
<td><strong>Owlette from PJ Masks</strong></td>
<td><strong>PJ Masks</strong></td>
<td>1</td>
</tr>
<tr>
<td>Paw Patrol</td>
<td>Blaze from Blaze and the Monster Machines</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 7 (cont.)

| Paw Patrol | Mario | 1 |
| Paw Patrol and Characters from Cat Boy | Princess With Powerful Necklace Kind of Mean | 1 |
| Pikachu | Optimus Prime | 1 |
| Poppy from Trolls | Elsa | 1 |
| Rainbow Dash from My Little Pony | Doggie from Barbie | 1 |
| Rapunzel | Moana | 1 |
| Rescue Bots | Barry from the Bee Movie | 1 |
| Rubble from Paw Patrol | Iron Man | 1 |
| Skye from Paw Patrol and Rainbow Dash from My Little Pony | Twilight Sparkle | 1 |
| The Little Mermaid | No Favorite | 1 |
| **Thomas the Tank Engine** | **Thomas the Tank Engine** | **1** |
| Vampirina | Cinderella | 1 |
| Vampirina | Cinderella and Tianna | 1 |
| Wild Krats | Ash from Sing | 1 |
| Wild Krats | Spiderman | 1 |
| Wonder Woman | Owlette from PJ Masks | 1 |

*Note: All mother-child pairs that were considered as a match are indicated in bold text.*

\(H^0\): Parents and children were expected to report that girls were more likely to have current favorite media characters that were female and that boys were more likely to have current favorite media characters that were male.

The hypothesis that girls would have favorite female characters and boys would have favorite male characters was supported both when children self-reported on their favorite characters and when mothers reported on their perception of who their child’s favorite character was.

**Child report.** A chi-square test was conducted to determine if there was an association between a child’s sex and the sex of the character *children* reported as their favorite. Character sex was indicated with a (0) for male, (1) for female, and (2) for a mixed-sex group (i.e., Paw...
Patrol). Boys were more likely to report male favorite characters and girls were more likely to report female favorite characters, $X^2 (2) = 20.63, p < .000$; Table 8.

<table>
<thead>
<tr>
<th>Character Sex</th>
<th>Child Sex</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boy</td>
<td>Girl</td>
</tr>
<tr>
<td>Male Character</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>Female Character</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>Mixed - Sex Group</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>31</td>
</tr>
</tbody>
</table>

Notes: 3 children reported a character whose sex could not be determined (e.g., Ninjas) and 1 child reported they did not have a favorite character. These children were not included in this analysis. Mixed sex group: children report a group of characters as their favorite (i.e., Owlette, Gecko Boy, and Cat Boy).

Maternal report. A chi-square test was conducted to determine if there was an association between a child’s sex and the sex of the character mothers reported as their children’s favorite (See Table 9). Moms of girls were more likely to report that daughters had a favorite character that was a female, compared to sons. Mothers of boys were more likely to report that sons had a favorite character that was male, $X^2 (2) = 16.84, p < .001$. The mixed-sex favorites reported as boys’ favorite characters were mostly explained by parents reporting “Paw Patrol” ($n = 3$) as at least one of the favorite groups of characters. Although the cast of characters in Paw Patrol includes a female character, the majority of the cast is male.
Table 9: Maternal report of sex of child’s favorite character

<table>
<thead>
<tr>
<th></th>
<th>Child Sex</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boy</td>
<td>Girl</td>
</tr>
<tr>
<td>Male Character</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Female Character</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>Mixed-Sex Group</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>29</td>
</tr>
</tbody>
</table>

Notes: 2 parents reported their children’s favorite character whose sex could not be determined (e.g., Dinosaur), 5 parents reported their child did not have a favorite character, and 1 parent reported a character that was not a media character, but a toy (e.g., LOL Dolls), and were not included in this analysis.

Gender-Typed Physical Appearance of Favorite Characters

$H^7$: The favorite characters reported by boys and mothers of boys were expected to be rated by coders as more masculine in physical appearance compared to the favorite characters reported by girls and mothers of girls, who will be rated by coders as more feminine in physical appearance.

Favorite characters reported by children and mothers were rated on their gender-typed physical appearance using the -2 (hypermasculine) to +2 (hyperfeminine) semantic differential scale. Characters reported by boys and mothers of boys were expected to be rated closer to the negative end of the scale while characters reported by girls and mothers of girls were expected to be rated closer to the positive end of the scale. This hypothesis was supported both when children reported favorite characters and when mothers reported on their children’s favorite characters.

Child report. A t-test was conducted to test whether child-reported favorite characters were rated by coders as more feminine or masculine in appearance by child sex (i.e., boy, girl). Results revealed that girls reported favorite characters that were rated as significantly more feminine looking ($M = 1.23$, $SD = 1.14$) compared to the favorite characters reported by boys.
who were rated as more masculine ($M = -0.36, SD = 1.43$; $t (50) = -4.49, p < .0001$; See Figure 9).

**Maternal report.** A t-test was conducted to test whether characters reported by mothers were rated by coders as more feminine or masculine in appearance by child sex (i.e., boy, girl). Results revealed that mothers reported favorite characters for their daughters that were rated as significantly more feminine in appearance ($M = 1.21, SD = 1.01$) compared to the favorite characters moms reported for their sons who were rated as more masculine ($M = -0.20, SD = 1.11$; $t (47) = -4.60, p < .0001$; See Figure 9).

![Figure 9: Ratings of gender-typed appearance of child- and maternal-reported favorite characters by child sex](image)

Note: -2 (hypermasculine), +2 (hyper feminine); error bars represent a 95% confidence interval
Gender-Typed Personality Traits of Favorite Characters

$H^8$: The favorite characters reported by girls and mothers of girls were expected to be rated by coders as having more feminine personality traits compared to the personality traits ratings of favorite characters reported by boys and mothers of boys.

Characters reported by girls and their mothers as favorites on ten traditionally feminine traits were expected to be rated as more feminine by coders compared to characters reported by boys and moms. Average scores ranged from 0 (not at all traditionally feminine traits) to 3 (highly traditionally feminine). This hypothesis was supported for the ratings of characters children reported as favorites but was not supported for the ratings of characters mothers reported as their children’s favorites.

Child report. The average feminine personality traits scores rated for the favorite characters reported by children was 2.03 ($SD = 1.00$) overall. A t-test was conducted to test whether child-reported favorite characters were rated as significantly different in feminine personality traits by child sex. Girls reported favorite characters that were rated by coders as having more feminine personality traits compared to the ratings of boys’ favorite characters ($M_{Girls} = 2.39, SD = .83; M_{Boys} = 1.54, SD = 1.01; t (50) = -3.32, p = .001$; See Figure 10).

Maternal report. The average feminine personality traits score rated for the characters moms reported as their children’s favorite was 2.27 ($SD = .70$) overall. A t-test was conducted to explore whether maternal-reported favorite characters were rated as significantly different in feminine personality traits by child sex. Moms did not report favorite characters for their sons and daughters that were rated as significantly different in feminine personality traits by coders ($M_{Sons} = 2.09, SD = .82; M_{Daughters} = 2.39, SD = .58; t (45) = -1.55, p > .05$; See Figure 10.)
Figure 10: Ratings of feminine-typed personality traits of child- and maternal-reported favorite characters by child sex

Notes: 0 (not at all traditionally feminine) - 3 (very traditionally feminine); error bars represent a 95% confidence interval
$H^0$: The favorite characters reported by boys and mothers of boys were expected to be rated by coders as having more masculine personality traits compared to the personality trait ratings of favorite characters reported by girls and mothers of girls.

Characters reported by boys and their moms as favorites on ten traditionally masculine personality traits were expected to be rated as more masculine by coders compared to characters reported by girls and moms of girls. Average scores ranged from 0 (not at all traditionally masculine traits) to 3 (highly traditionally masculine traits). This hypothesis was supported for the personality trait ratings of characters children reported as favorites but was not supported for the personality trait ratings of characters mothers reported as their children’s favorites.

**Child report.** The average masculine personality traits scores rated for the favorite characters reported by children was 1.48 ($SD = .91$) overall. A t-test was conducted to test whether child-reported favorite characters were rated as significantly different in masculine personality traits by child sex. Boys reported favorite characters that were rated by coders as having more masculine personality traits compared to favorite characters reported by girls ($M_{Boys} = 1.98$, $SD = .85$; $M_{Girls} = 1.12$, $SD = .78$; $t(50) = 3.75$, $p = .001$; See Figure 11).

**Maternal report.** The average masculine personality traits score rated for the characters moms reported as their children’s favorite was 1.32 overall ($SD = .78$). A t-test was conducted to examine whether maternal-reported favorite characters were rated as significantly different in masculine personality traits by child sex. Moms reported favorite characters for their sons that were rated as having similar masculine personality traits compared to the characters they reported at their daughter’s favorites ($M_{Sons} = 1.58$, $SD = .79$; $M_{Daughters} = 1.14$, $SD = .74$; $t(47) = 1.97$, $p > .05$; See Figure 11).
Figure 11: Ratings of masculine-typed personality traits of child- and maternal-reported favorite characters by child sex

Notes: 0 (not at all traditionally masculine) - 3 (very traditionally masculine); error bars represent a 95% confidence interval

Association of Gender-Stereotyped Toy Preferences, Physical Appearance, and Personality Traits

*RQ*²: Are children’s gender-typed toy preferences associated with gendered physical appearance and gendered-trait ratings for favorite characters reported by children and their mothers?

While mothers and children disagreed on who children’s favorite characters were, the characters reported by girls and their mothers were both rated as significantly more feminine in physical appearance and the characters reported by boys and their mothers were both rated as significantly more masculine in physical appearance. However, this was not the case for ratings of gender-typed personality traits of favorite characters. Mothers reported favorite characters for both boys and girls who were *not* rated as differentially gender-typed in personality traits.
Children, on the other hand, reported favorite characters that were differentially rated as being gender-typed in their personality traits. Specifically, girls chose favorite characters that were rated as having more feminine-typed personality traits compared to the characters boys chose as their favorites. Boys chose favorite characters that were rated as having more masculine-typed personality traits compared to the characters girls chose as their favorites.

Correlations were conducted to explore whether children’s gender-typed preferences were aligned consistently across Study 1b and Study 1c. Of particular interest was whether mothers or children reported consistent patterns of gender-typed preferences for children because of the discrepancy in personality ratings of favorite characters reported by mothers and children. Children were expected to report consistent preferences for gender-typed toys and favorite characters. In other words, it was expected that physical appearance and personality trait ratings of favorite characters reported by children would be associated with children’s gender-typed toy preference scores in Study 1b.

Correlations were also conducted to explore whether the ratings of character’s physical appearance and personality traits for characters mothers reported in the current study were associated with children’s gender-typed toy preferences from Study 1b. It was expected that ratings of physical appearance, but not personality traits, for maternal reported favorite characters would be associated with children’s gender-typed toy preference scores.

**Gender-typed appearance and children’s gender-typed toy preferences.** A correlation was conducted to examine the associations between children’s gender-typed toy preferences, gender-typed physical appearance ratings of child-reported favorite characters, and gender-typed physical appearance ratings of maternal-reported favorite characters. Results revealed weak, and non-significant, correlations between children’s gender-typed toy preferences
and 1) gender-typed physical appearance ratings of child-reported favorite characters ($r = -.05, p > .05$) and 2) gender-typed physical appearance ratings of maternal-reported favorite characters ($r = .10, p > .05$).

**Ratings of children’s feminine-typed personality traits and children’s gender-typed toy preferences.** Separate correlations were conducted for boys and girls to examine the associations between children’s gender-typed toy preferences and feminine-typed personality traits ratings of child-reported favorite characters. The correlations were run separately for boys and girls because it was expected that a girl with a higher gender-typed toy preference score would have reported a favorite character rated as having higher feminine-typed personality traits compared to a boy with a higher gender-typed toy preference score. No significant correlations were found between gender-typed toy preference scores and feminine-typed personality traits character ratings for girls ($r = .03, p > .05$) or boys ($r = -.17, p > .05$).

A correlation was conducted separately for boys and girls to examine the associations between children’s gender-typed toy preferences and feminine-typed personality traits ratings of mother-reported favorite characters. No significant correlations were revealed between gender-typed toy preference scores and feminine-typed personality traits character ratings for girls ($r = .14, p > .05$) or boys ($r = .30, p > .05$).

**Ratings of children’s masculine-typed personality traits and children’s gender-typed toy preferences.** Separate correlations were conducted for boys and girls to examine the associations between children’s gender-typed toy preferences and masculine-typed personality traits ratings of child-reported favorite characters. The correlations were run separately for boys and girls because it was expected that boys with a higher gender-typed toy preference score would have reported a favorite character rated as having higher masculine-typed
personality traits compared to a girl with a higher gender-typed toy preference score. No significant correlations were revealed between gender-typed toy preference scores and masculine-typed personality traits character ratings for boys \( r = .21, p > .05 \) or girl \( r = -.16, p > .05 \).

A correlation was conducted to examine the associations between children’s gender-typed toy preferences and masculine-typed personality traits ratings of mother-reported favorite characters, separately for boys and girls. No significant correlations were revealed between gender-typed toy preference scores and masculine-typed personality traits character ratings for boys \( r = .11, p > .05 \) or girls \( r = .13, p > .05 \).

**Summary of Results**

Children viewed favorite characters in more traditional media settings like in movies or on television but also likely viewed these characters on streaming platforms like Netflix or Hulu. Parents and children rarely agreed on who a child’s favorite character was, but both mothers and children reported that girls were more likely to have favorite characters that were rated by coders as female, and boys as more likely to have favorite characters that were rated by coders as male. These favorite characters reported by both parents and children were rated as more gender-typed in physical appearance. In other words, favorite female characters were rated by coders as more feminine in physical appearance and male characters were rated by coders as more masculine in physical appearance.

Mothers did not report favorite characters for their children that were rated as significantly different in feminine or masculine personality traits. However, girls self-reported favorite characters that were rated by coders as having more feminine personality traits compared to the ratings of favorite characters boys reported for themselves. Boys also reported
favorite characters that were rated by coders as having more masculine personality traits compared to the ratings of favorite characters girls reported for themselves. No correlations were found between children’s gender-typed toy preferences and the gender-typed physical appearance and personality traits ratings of favorite characters reported by children or their mothers.

**General Summary of Results**

The findings of Study 1a provided evidence that math talk resulted in faster correct answers to virtual add-1 math problems for all children, and the effect of math talk was greater when children interacted with a same-sex intelligent character. Children also reported liking same-sex characters more than opposite-sex characters prior to game-play, indicating they had a same-sex preference for media characters before the math lesson with the intelligent character began. Most children did not know who the media characters were that were featured in their version of the intelligent character math game, which was validated by maternal reports.

Results from Study 1b revealed that while girls preferred feminine-typed toys and boys preferred masculine-typed toys, children’s gender-stereotyped toy preferences were not related to performance on add-1 tasks in a virtual or physical context. No evidence was found that suggested the effects of math talk and child-character sex match were influenced by children’s gender-typed toy preferences for the toys children were surveyed about in the study.

Study 1c results revealed that mothers rarely matched their child in their identification of their child’s favorite character, but mothers and children both reported that children have same-sex favorites. This study provided evidence that mothers perceived their boys and girls as having favorite media characters that are *not* rated as differentially gender-typed in traits but *are* differentially gender-typed in physical appearance. Boys and girls, by contrast, report favorite
characters that are rated as differentially gender-typed in both personality traits and physical appearance. Children’s gender-typed toy preferences were unrelated to ratings of maternal- and child-reported favorite characters’ gender-typed traits and physical appearance.
CHAPTER IV: DISCUSSION

Overview

The purpose of this dissertation was to examine how preschool-aged children’s gender-typing influenced children’s preferences for media characters and learning from an intelligent media character. Children who engaged in more math talk parasocial interactions with an intelligent character correctly answered add-1 math problems quicker; however, this effect was greater for children that engaged with a same-sex intelligent character compared to an opposite-sex intelligent character. Children who engaged in more parasocial interactions with a same-sex intelligent character during the virtual game, compared to an opposite sex intelligent character, also answered more transfer task problems correctly.

Several aspects of gender-typing were assessed to determine how they were related to children’s add-1 performance. Children reported on how much they liked a media character that would later be featured as the intelligent character in their version of the math game. Contrary to expectation, many of these children did not know the characters, particularly the male character. This unexpected finding may have led children to base their decisions about likeability on superficial characteristics, such as the character’s gender. Consistent with this interpretation, children who were asked about the same-sex character reported higher levels of liking compared to children who were asked about the opposite-sex character.

The results from the survey about children’s favorite characters revealed that favorite characters were the same-sex as the child, gender-typed in appearance, and gender-typed in personality traits. Previous experience with favorite gender-typed characters may have influenced children’s interest in unknown same-sex characters and subsequent add-1 performance when taught by that intelligent character.
Gender schema theory provided a theoretical framework through which to explore these different and complementary facets of gender-typing (Bem, 1981; Huston, 1983; Martin & Halverson, 1981; Ruble et al., 2006). The studies provided new evidence that interaction with a same-sex character may activate gender schemas and increase performance in early STEM skills. This experience with the character contributed to providing both boys and girls experience relevant to mastery of the add-1 rule. Children’s relationships with favorite same-sex media characters may have served as a gender schematic script for children’s engagement with unknown intelligent characters in the math game. This idea was supported by children’s preference for same-sex media characters who were often unknown to children before they played the game. Contingent interactions with an unknown same-sex intelligent character had a greater effect on children’s response time to correctly answer add-1 math problems virtually and the number of transfer task problems answered correctly with physical objects. Taken together, the three studies in this dissertation provide evidence that while some content areas and constructs of gender-typing are related to children’s performance on an early STEM skill, others-in this case gender stereotyped toys- are not.

The findings are discussed in more detail below.

**Parasocial Interactions, Same-Sex Intelligent Characters, and Math Performance**

The effect of parasocial interactions with same-sex intelligent characters on children’s performance in both a virtual intelligent character math game and in a transfer task with physical objects was examined in this experiment. Children’s performance in the math game was measured by the average amount of time children took to correctly answer the add-1 math problems in the game, or latency. Latency was a way to measure children’s mastery of the add-1 rule in the moment through their processing speed. The number of transfer task problems
children answered correctly with physical star stickers was a measure of children’s skills to demonstrate mastery of the underlying add-1 rule in a context different from the one they learned the rule in.

**The effect of math talk was greater with a same-sex intelligent character.** In the intelligent character experiment, children’s math talk parasocial interactions with a same-sex intelligent character had a stronger effect on reducing latency to correctly answer add-1 math problems, compared to children’s math talk parasocial interactions with an opposite-sex intelligent character. This finding suggested that cognitive processing speed may have increased due to activation of gender schemas, which can act as informational filters (Bem, 1981). The majority of children and their mothers reported that children were not familiar with Dora and Diego, the female and male intelligent characters featured in the math game. When children were unfamiliar with a media character but saw that the media character was male or female, this may have activated simple gender schemas, or gender-stereotypes (Calvert & Huston, 1987). Preschool-aged children more often play with same-sex peers (Fabes et al., 2014; Goble et al., 2012; Leaper, 2015; Maccoby, 1998; Martin & Dinella, 2012; Martin & Fabes, 2001), so the sex of an intelligent character may be a signal for children that the intelligent character is an appropriate social partner based on that salient characteristic.

Gender schematic processing may be particularly likely for children during the preschool years when rigid adherence to gender stereotypes is common and own-gender group interest is high (Trautner et al., 2005). These gender schemas may have been activated and guided processing and organization of information in the math game quickly for their gender-group (i.e., “I see a girl character, I am a girl, this content is for me”; Calvert & Huston, 1987). The association between a same-sex character and content that was considered “for me” may
strengthen a child’s associations between math skills and their sense of self. The results suggested that both boys and girls were likely to incorporate their experience with a same-sex intelligent character into their own-gender schemas because both sexes benefited from math talk with a same-sex intelligent character.

The same-sex intelligent characters may have activated gender schemas not only because the intelligent character looked male or female, but also because characters are typically gender-stereotyped (Baker & Raney, 2007; Ellithorpe & Bleakley, 2016; Geena Davis Institute on Gender in Media, 2016, 2017; Gerding & Signorielli, 2014; Lemish & Russo Johnson, 2019; Ward & Aubrey, 2017). In other words, the sex of the character may have evoked thoughts about gender-stereotypes in media (Calvert & Huston, 1987). Children’s media characters are commonly gender-stereotyped in appearance and roles, so seeing a media character that is gender-typed as male or female may have served as an implicit label of whether the character and associated content is “for boys” or “for girls”. When children saw an unknown intelligent character that was the same sex as they were, the sex of the character may have served as a “green light” for children to think that the add-1 content was something worthy of their engagement and that the featured character was a potential social partner (Bem, 1981; Martin & Halverson, 1981; Martin, Ruble, & Szkrybalo, 2002).

Math talk with an unknown same-sex intelligent character may have streamlined children’s cognitive processing when children’s gender schemas were activated. Streamlining children’s processing of gender-related information associated with add-1 math problem content may benefit children because they can expend more resources on mastery of the add-1 rule (Baroody et al., 2013, 2009). When children have mastered the add-1 rule, they no longer have to count on their fingers or reason through add-1 problems; rather, children have an automatic
understanding of the underlying math concept (National Research Council, 2009). Automatic processing of the add-1 rule frees children’s cognitive resources and allows for an increased ability to learn more advanced math (Baroody, 1985). The implication is that when STEM content was linked with an unknown same-sex intelligent character that engaged children in parasocial interactions, children more quickly provided correct answers because their cognitive burden was lessened.

The experiment also extended the line of research on children’s STEM learning from intelligent characters (Calvert et al., 2018) and contributed novel information about how math talk may operate differently when unknown intelligent characters match, or don’t match, children’s sex. Previous research that used a female intelligent character, Dora the Explorer, to teach children the add-1 rule revealed that parasocial relationships and parasocial interactions both contributed to quicker correct add-1 answers (Calvert et al., 2018). Dora was very popular at the time of the previous experiments (Richards & Calvert, 2016, 2017a), but likely due to the rapidly changing landscape of children’s media, she was unknown by most children in the current experiment.

The current experiment suggested that when children engaged in parasocial interactions with unknown intelligent characters (i.e., no parasocial relationship) that they may have defaulted instead to using superficial characteristics like character sex to guide their learning. Children often make gender schematic judgements in order to decide which social partners (Fabes et al., 2014; Martin & Fabes, 2001) they want to engage with, which may have explained the results from the current experiment. While relying on gender schemas did not result in a greater amount of math talk with a same-sex character, it may have enhanced the learning process. However, children didn’t engage in a greater amount of math talk with same-sex
intelligent characters compared to opposite-sex characters. This finding suggests that when children engaged in parasocial interactions with an unknown same-sex intelligent character, these interactions had a greater effect on math outcomes. When children engaged in math talk with a same-sex intelligent character the sex-matched character may have provided children a context that enhanced their encoding, or efficacy of retrieval from memory, of the add-1 math content. In other words, the math talk with a same-sex character enhanced learning compared to an opposite sex character.

**Children transferred add-1 learning better after math talk with a same-sex intelligent character.** Children who engaged in more parasocial interactions with a same-sex intelligent character also demonstrated better performance in transferring learning about the add-1 rule from a virtual to a physical context. That is, more math talk with an unknown same-sex intelligent characters, compared to an opposite-sex intelligent character, facilitated children correctly answering more add-1 transfer task problems with physical objects. The salient similarity of sex between a child and character was a factor that supported memory and transfer of previously learned math skills. These findings were consistent with gender schema theory, in that children learn information better that is related to their gender-group (Bradbard & Endsley, 1983; Bradbard et al., 1986; Leaper, 2015; Martin & Halverson, 1981; Signorella et al., 1993), which may lead to better transfer of learning.

Math talk parasocial interactions facilitated transfer only in the context of a sex-matched intelligent character. Transfer may have been facilitated when children engaged in math talk with same-sex intelligent characters because shared membership in a gender group made parasocial interactions with the character more socially meaningful for children. Parasocial interactions contribute to parasocial relationships (Bond & Calvert, 2014a), which can anchor and facilitate
children’s learning across contexts (Calvert et al., 2018). The sex-match between children and the character may make the character and its associated content more meaningful in the absence of a parasocial relationship. Although many children were not familiar with the intelligent characters in the current experiment, being the same sex as the intelligent character was sufficient to operate as an anchor for learning across contexts. Previous research supports this interpretation as children’s transfer of learning from a virtual to a physical setting has been facilitated by socially meaningful people (Krcmar, 2010; Roseberry et al., 2014; Troseth et al., 2006).

Krcmar (2010) suggested transfer across contexts was facilitated by social meaningfulness because social meaningfulness engaged children cognitively. Preschool children have more cognitive engagement with and interest in toys, people, and information related to their gender-group, which results in increased gender-typed memory (Bradbard & Endsley, 1983; Bradbard et al., 1986; Leaper, 2015; Martin & Halverson, 1981; Signorella et al., 1993). Through increased cognitive engagement with the same-sex intelligent character, children’s memory may also have increased and contributed to children’s success in the transfer task. While the transfer task included a memory component (i.e., memory for previously learned content), the major accomplishment of the transfer task was that children learned the add-1 rule in a virtual setting and were able to apply the add-1 rule flexibly when using physical objects.

The experiment also contributed novel information about factors that facilitated children’s transfer of add-1 content learned from intelligent characters. Same-sex intelligent characters may have served as contingent social anchors through which children were able to understand that the content was “for them” in the game. The same-sex intelligent characters may have been more socially meaningful than the opposite-sex intelligent characters and resulted in
better learning of the add-1 rule, which then led to a better understanding of how to apply the add-1 rule across contexts. Previous research on intelligent characters teaching the add-1 rule has found that transfer was facilitated when add-1 rule learning was driven by children’s parasocial relationships compared to no parasocial relationship, or to their contingent parasocial interactions, compared to non-contingent interactions, with a character they had a parasocial relationship with (Calvert et al., 2018). Parasocial relationships are relationships that span different settings (e.g., television, toys, apps; Calvert, 2015; Liebers & Schramm, 2019), which may be why children transfer add-1 learning better when taught by a character they have a parasocial relationship with (Calvert et al., 2018). Being part of the same social group, sex in this case, may operate similarly when other information is not known about the intelligent character.

Children’s increased performance on the transfer task after interacting with same-sex, compared to opposite-sex, intelligent characters suggested that children made a stronger mental representation of the underlying add-1 rule. This finding contributes to the emerging research on learning the add-1 rule from intelligent characters (Calvert et al., 2018) and from electronic games (Baroody et al., 2013). The creation of stronger mental representations during virtual game play were likely facilitated by gender schemas streamlining cognitive processing of the add-1 math content. Success on the transfer task included children to generalize the add-1 rule to harder math problems than previously practiced in the game (5+1 – 10 + 1), which supported this interpretation because it indicated children were able to demonstrate a deeper understanding of the add-1 rule.

Preferences for same-sex media characters, but not gender-stereotyped toys, may have contributed to math performance. Possible contributions to children’s math performance were children’s preferences for media characters and gender-stereotyped toys. Children’s
preferences for media characters could provide information about why children benefit from parasocial interactions with same-sex intelligent characters. Children’s gender-stereotyped toy interests could provide information about how strong of a gender-typed lens children are bringing into the intelligent character math game. Both possibilities are considered below.

**Children liked unknown gender-typed media characters.** Prior to playing the intelligent character math game, children reported higher liking of same-sex characters, characters who would then be embedded in their games. The majority of children also reported that they were not familiar with the character they reported liking for, indicating that the characters they then played the intelligent character math game with was novel to them. This positive attitude about novel characters, one of the major reactions a viewer can have towards a character (Cohen, 2001), is consistent with a body of research finding that children prefer same-sex playmates (Fabes et al., 2014; Goble et al., 2012; Leaper, 2015; Maccoby, 1998; Martin & Dinella, 2012; Martin & Fabes, 2001), are likely to identify with favorite or popular same-sex characters (Calvert et al., 2007; Hoffner, 1996), and prefer favorite same-sex characters (Aguiar, Richards, Bond, Putnam, et al., 2019; Bond & Calvert, 2014b; Richards & Calvert, 2017a).

Children’s more positive reactions to a same-sex character is a potential explanation for why math talk may be more meaningful to children and result in increased math performance with a same-sex intelligent character. In particular, a character’s sex may initially attract a child to a character who they may engage in parasocial interactions with via digital media (Calvert, 2015, 2017; Liebers & Schramm, 2019; Richards & Calvert, 2017b), which can then potentially develop into a parasocial relationship across a variety of settings (Calvert, 2015, 2017; Liebers & Schramm, 2019; Richards & Calvert, 2017b). Parasocial interactions, then, may provide a
pathway to deeper relationships (Bond & Calvert, 2014a), particularly when a character is unknown.

The finding that children liked unknown same-sex media characters more than opposite-sex media characters is consistent with gender schema theory in that preschool-aged children are more interested in their gender group (i.e., I like this character more because they are “like me”; Martin & Halverson, 1981; Ruble et al., 2007). Information associated with a child’s gender group is likely to be salient to children during the preschool years (Martin & Halverson, 1981) and incorporated into children’s concepts of what means to be male or female (Bem, 1981; Leaper, 2015; Martin & Halverson, 1981). The educational content associated with same-sex intelligent characters, then, may interest children more than when those things are associated with an opposite-sex intelligent character. Because of this interest to learn about things related to their own gender-group, parasocial interactions that occurred during the virtual interactions with the same-sex intelligent character (Liebers & Schramm, 2019) may have benefitted children to a greater extent.

*Children’s favorite characters were gender-typed.* Children may have benefited from parasocial interactions with a same- more than an opposite-sex intelligent character on the add-1 math tasks because of previous experience with favorite media characters that are gender-typed. In the current survey about children’s favorite characters, children and their mothers reported favorite characters that were rated by adult coders as the same-sex as children and more gender-typed in physical appearance. Children also reported favorite characters that were rated as gender-typed in personality traits (e.g., boys’ favorite characters more forceful and dominant, girls’ favorite characters more sensitive and gentler). Favorite characters are social partners and teachers for children (Calvert, 2015; Richert et al., 2011), and children develop parasocial
relationships with them through repeated exposure via media, toy play, parasocial interactions, and parental encouragement (Bond & Calvert, 2014a). It is during this engagement with favorite characters across settings that gender-typed physical appearance and personality traits of same-sex favorite characters may be integrated children’s own-gender schemas and perhaps prime how children will engage with media characters in the future (Calvert & Huston, 1987; Martin & Halverson, 1981).

Children may use their past experiences with favorite characters as a reference point for what to expect from an unknown character that is the same sex. This expectation, which is based on the character’s sex and/or activation of gender schematic scripts, may drive children’s processing and memory of information from a novel same-sex intelligent character. During the preschool years, children’s gender-typed favorite characters can teach children STEM skills (Calvert et al., 2018, 2014, 2007; Howard Gola et al., 2013; Lauricella et al., 2011), as well as how their gender group should look and behave, due to this intensified period of own-gender group interest (Bem, 1981; Calvert & Huston, 1987; Martin & Halverson, 1981).

The results of the favorite character survey are consistent with previous research on children’s preference for same-sex friendships (Fabes et al., 2003; Leaper, 2015) and same-sex parasocial relationships (Hoffner, 1996; Richards & Calvert, 2016, 2017a) with characters who are rated as gender-typed (Aguiar, Richards, Bond, Putnam, et al., 2019; Bond & Calvert, 2014b). Children become more gender-typed over time when they spend more time with same-sex friends (Martin & Fabes, 2001), which is likely to also occur through spending more time with favorite characters that are gender-typed. This is supported by evidence that found higher amounts of engagement with gender-typed children’s media genres (i.e., princess and superhero) resulted in more gender-typed behaviors (Coyne et al., 2016, 2014). The current survey
contributed further evidence that children are forming close social relationships with characters that look and behave in gender-typed ways (Coyne et al., 2016, 2014; Hust & Brown, 2009; Smith, Pieper, Granados, & Choueiti, 2010; Ward & Aubrey, 2017).

The results of the favorite character survey also indicated that children likely have experience with favorite media characters across a range of platforms. Over sixty percent of favorite characters reported by children, and almost eighty percent of favorite characters reported by mothers, were available on both traditional platforms (e.g., television) and on streaming platforms (e.g., Netflix). Streaming platforms afford opportunities for gender-typed favorite media characters to be viewed on-demand and ubiquitously travel throughout daily life with children. These gender-typed favorite characters are transmedia (Richards & Calvert, 2017b), which is one reason they are effective anchors for helping children learn and transfer STEM content across contexts (Calvert et al., 2018).

The survey about favorite characters, however, also indicated that mothers may not be aware of which character may optimize children’s STEM learning through parasocial relationships (Calvert et al., 2018, 2014, 2007; Howard Gola et al., 2013; Lauricella et al., 2011). The favorite characters reported by mothers for sons and daughters were rated similarly in personality traits for sons and daughters, although children’s reported favorite characters were rated as gender-typed in personality traits. Moms may perceive their children to be less gender-typed than children demonstrate themselves. This perception may have implications for the characters children are exposed to because parents serve as gatekeepers to media for children (Barr, 2019). Parents can encourage their children’s relationships with media characters and purchase toy versions of the characters for their children, which can foster and strengthen parasocial relationships with favorite characters (Bond & Calvert, 2014a). The data from the
survey about favorite characters indicated that while the mismatch in awareness of favorite characters may lead to missed educational opportunities that harness the educational benefits of parasocial relationships, that it is likely parents are aware that children like characters that match their sex. Mothers’ awareness of children’s interest in same-sex characters is promising, given the results of Study 1a, that children’s parasocial interactions have a greater effect in the context of a sex-match to the character.

**Gender-stereotyped toy preferences did not predict math performance.** Contrary to prediction, gender-typed toy preferences did not predict children’s add-1 performance in either virtual or physical contexts, when children engaged in parasocial interactions with either sex intelligent character in the experiment. It was notable that children expressed a stronger preference to play with gender-typed toys, consistent with research on preschool children’s toy choices (Dinella & Weisgram, 2018); however, in the current study, gender-typed toy preferences were unrelated to math performance. The sample of children that was studied in this dissertation the distribution lacked the variation (i.e., more children at the low end of the distribution) needed to identify the effect of gender-stereotyped toy preferences. To examine how toy preferences relate to children’s add-1 math performance sufficiently, the sample would have had to be much larger to detect an effect. Future research should collect a larger sample of children to further examine the full range of toy preferences possible for preschool children and how that may influence math-related outcomes.

Future research should also ask children about their preferences for toys associated with STEM domains, and how often they play with these toys, to examine whether the extent to which children prefer them may be related to children’s add-1 performance in the intelligent character game. While toys like board games, chess, and blocks have been associated with helping
children cultivate skills needed for STEM (e.g., spatial skills; Liben, Schroeder, Borriello, & Weisgram, 2018), the toys used in the current experiment (e.g., doll, monster truck) were not related to STEM skills. This difference between the toys used in the experiment and the kind of skills the toys fostered may explain why the toys did not predict math performance.

Parasocial Interactions, Opposite-Sex Intelligent Characters, and Math Performance

The effect of parasocial interactions with opposite-sex intelligent characters on children’s math performance was also examined. Parasocial interactions in the context of engagement with an opposite-sex intelligent character were predicted to yield different outcomes compared to parasocial interactions with a same-sex intelligent character. Latency and transfer task outcomes were considered below.

Virtual learning was facilitated by math talk with an opposite-sex intelligent character. Although the effect of math talk was greater for children who learned the add-1 rule when engaging with a same-sex character, children who engaged in more parasocial interactions with opposite-sex intelligent characters also produced quicker correct answers to add-1 math problems in the virtual game. This finding was consistent with previous research on the beneficial role of math talk for children’s math learning from intelligent characters (Calvert et al., 2018) and supports research that has documented the positive role of social contingency in children’s learning from educational digital media (Barr, 2019; Calvert et al., 2018, 2007; Krcmar, 2010; Lauricella, Pempek, Barr, & Calvert, 2010; Roseberry et al., 2014; Troseth et al., 2006).

Intelligent characters can facilitate children’s learning through engaging children in the conversational back-and-forth of parasocial interactions, even when the intelligent character is not socially meaningful. However, engaging in more parasocial interactions with an opposite-sex
character had a lesser effect compared to a same-sex character on children’s latency to correctly answer add-1 math problems. This finding is consistent with gender schema theory in that information that is new and not relevant to one’s gender may be processed slower, in relation to information related to the child’s gender (Bem, 1981; Calvert & Huston, 1987). The opposite-sex characters were not socially meaningful, but were socially contingent partners that responded to children immediately, reliably, and accurately (Roseberry et al., 2014) through parasocial interactions. Socially contingent conversational turn-taking (i.e., parasocial interactions) facilitated learning from a screen, consistent with previous research (Barr, 2019; Calvert et al., 2007; Krcmar, 2010; Lauricella et al., 2010; Roseberry et al., 2014; Troseth et al., 2006).

Intelligent characters are more capable, compared to traditional media characters, of engaging children in interactions more similar to human-human interaction because they mimic natural conversational turn-taking (Brunick et al., 2016). Results from the current experiment demonstrated that this social contingency can drive learning experiences for children, helping them to process onscreen content faster when they engage in a greater amount of parasocial interactions.

The results provide support for the idea that pathways to learning from intelligent characters can occur through parasocial interactions with a character in the absence of a parasocial relationship (Calvert et al., 2018). Consistent with the results from the current intelligent character experiment, children who engaged in more math talk with a no-character intelligent character female voiceover (i.e., no parasocial relationship) demonstrated reduced latency to answer add-1 math problems correctly in a previous study (see study 2 in Calvert et al., 2018). When previous research featured a popular female media character as the intelligent character teaching math, parasocial interactions and parasocial relationships each uniquely
contributed to children’s quicker correct response times (see studies 1 and 2 in Calvert et al., 2018). When children do not know, or do not share salient physical similarities with the character (e.g., sex), it may be particularly important for characters to provide ample opportunities for a conversational back-and-forth interaction about the STEM content at hand.

The intelligent character experiment also demonstrated that parasocial interactions with opposite-sex intelligent characters can engage children in social opportunities less typical for their gender group. Boys and girls readily engaged in similar amounts of math talk interactions with same-and opposite-sex intelligent characters; however, with human social partners, preschool-aged children most often engage with same-sex peers on a regular basis (Fabes et al., 2003; Leaper, 2015). In the current study, children responded to 86% of math talk parasocial interaction prompts on average from the unknown intelligent characters. This level of parasocial interaction is similar to previous research, which ranged from 92% to 94% with known intelligent characters and an unknown intelligent voiceover (Calvert et al., 2018). Future research should examine if repeated exposure to an opposite-sex intelligent character may influence children’s interest in engaging with opposite-sex human peers. If children become more comfortable and experienced interacting with an opposite-sex intelligent character, then they may apply this experience to other social relationships.

Unfamiliar opposite-sex intelligent characters did not facilitate transfer to physical objects. Contrary to prediction, more math talk in the virtual game with an opposite-sex intelligent character did not predict children’s performance in the transfer task with physical objects in the current experiment. Transferring learning from digital media to the physical world is a difficult task for children (Anderson & Kirkorian, 2015; Bonus & Mares, 2015; Fisch et al., 2005). The results of the current experiment suggested that parasocial interactions about STEM
content in a virtual game may not, on their own, facilitate add-1 rule transfer with physical objects.

Children may have experienced higher processing demands when they engaged with an opposite-sex intelligent character and/or created a weaker mental representation (Fisch, 2000) of the add-1 rule because they were not able to see the content as relevant to themselves or their gender group (Martin & Halverson, 1981). The cognitive requirements of the transfer task may have been higher for children who engaged in parasocial interactions with an opposite-sex intelligent character. Children are better at transferring content across virtual to physical domains as they get older, particularly for observational media when they are over 30-months-old (Anderson & Kirkorian, 2015; Barr, 2010; Bonus & Mares, 2015; Fisch et al., 2005; Hust & Brown, 2009). The demands of both interactive media and the math task itself may have yielded a difficult task for four-year-old children (Kirkorian, 2018), thereby creating a challenging transfer task. Interactive media that engages children, using content that is relevant to them or that is contingent, can facilitate learning (Kirkorian, 2018). In the current experiment, the character was contingent but was lacking social meaningfulness that would help them to relate the add-1 content relevant to themselves.

Children may have been too young, at four-years-old, to bridge the virtual to physical contexts without the support of contingent scaffolding from a socially relevant character to guide their learning experience across contexts in a self-relevant way. The results suggest that the add-1 rule may not have been learned well enough in the math game when taught by an opposite-sex intelligent character to transfer the add-1 rule across contexts. Children have demonstrated poorer add-1 performance with physical objects after interacting with unknown female voice-only intelligent character, compared to a socially meaningful Dora the Explorer intelligent
character that they had a parasocial relationship with (see study 2 in Calvert et al., 2018). Taken together with previous research on intelligent agents teaching the add-1 rule, the implication of the current study is that when a character is new to a child and teaching them educational content, it may be particularly important for the character to be perceived as sharing characteristics salient to a child’s identity.

Limitations and Future Directions

The attachment and friendship sub-scale of the Children’s Parasocial Relationship Survey was conducted in the intelligent character experiment but could not be used as a measure of children’s parasocial relationships with Dora or Diego. This was an unanticipated methodological issue due to the internal consistency of the attachment and friendship sub-scale of the Children’s Parasocial Relationship Survey (Richards & Calvert, 2017a) being below acceptable thresholds in the current study. This compromised its use as a predictor of children’s add-1 performance in the current experiment. Previously, the sub-scale measured children’s attachment and friendship with well-known (Calvert et al., 2018) and favorite characters (Richards & Calvert, 2017a). The series of studies by Calvert and colleagues (2018) featured Dora the Explorer after Richards & Calvert (2016, 2017) conducted a survey that revealed Dora was a very popular character among preschoolers sampled.

However, in the intelligent character experiment in the current studies, most of the children reported that they did not know the media characters- Dora or Diego- featured in the intelligent agent math game. Children’s lack of character knowledge was validated by their mothers who reported that most of their children did not know Dora or Diego. It is notable that more children knew Dora compared to Diego, but results suggest that neither character is currently a staple of children’s media exposure. Children who do not know a character cannot
have an emotionally-tinged parasocial relationship with that character. In the future, it may be more efficient for researchers examining questions related to specific media characters to ask children whether they know the character and only proceed with the Children’s Parasocial Relationship Survey if children respond affirmatively and can name or recognize the character’s name. Another approach is to familiarize children with novel characters and build parasocial relationships to assess their educational impact (Calvert et al., 2014; Howard Gola et al., 2013). Children’s unfamiliarity with characters who had recently been popular highlights a challenge in studying children’s digital media and technology, which can change more rapidly than the pace of research can account for.

A limitation of the data measuring children’s gender-stereotyped toy preferences was that it may not accurately estimate the true impact of gender-stereotyped toy preferences. The findings in the current intelligent character experiment supported a body of evidence finding that preschool-aged children have a preference for gender-stereotyped typed toys (Dinella & Weisgram, 2018; Leaper, 2015), but gender-stereotyped toy preference did not predict math performance. The gender-stereotyped toy preference variable lacked sufficient variation, likely due to the sample size of the experiment, to fully examine the main effect of gender-typed toy preferences, the interaction of these preferences with math talk, and the three-way interaction between toy preferences, child-character sex match, and math talk. The standard errors of the gender-stereotyped toy preference variable are large and yield underpowered and imprecise examinations of the main effects and interactions of the variable.13

A limitation that spans the intelligent character experiment and favorite character survey is that the sample is mostly comprised of families that hold college degrees or higher, indicating

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13 See Study 1b and Appendix B for details
they likely have high socioeconomic status. In short, the current sample lacked socioeconomic diversity. Intelligent characters may hold promise as an educational intervention for children living in poverty. Future research should explore how a more diverse sample of children may engage with, and learn from, same-and opposite-sex intelligent characters. Children living in households with limited resources may have fewer opportunities for cognitive stimulation through informal educational opportunities and less exposure to more words at home (Gilkerson et al., 2017; Hart & Risley, 2003). These children may benefit from experience with an intelligent character, who can engage with them as a social partner and be programmed to expose children to vocabulary and content they may not otherwise have exposure to. If the intelligent character math game was used at home, it may also be able to serve as a model for parents about how to engage children in add-1 rule practice outside of the school setting.

The ratings of favorite characters in the survey about favorite character may be biased, which also presented a limitation in this dataset. The limitation introduced is that characters may be rated as more gender-typed than they may objectively be in practice. Inter-rater reliability for ratings of the sex, physical appearance, and personality traits of children’s favorite characters was high between the two adult coders for our database; however, it is possible that these ratings may reflect cultural gender-stereotypes based on categorical sex. In the procedure used here, a character’s sex was coded first, physical appearance second, and personality traits third. Coders may have been primed to code character’s physical appearance and personality traits more stereotypically after applying a sex label to that character. Future research could address this limitation by using separate pairs for coding character sex, physical appearance, and personality traits to ensure these ratings are independent.
A direction of future work is that other characters can be substituted into the intelligent character math game. The intelligent character math game was designed so different characters and their voices could be swapped for the original version featuring Dora. Although these two characters were unknown to children, Dora and Diego represent only two ways to physically express being male or female (Huston, 1983). Future research should explore the impact of swapping Dora and Diego for highly gender-stereotyped (e.g., princess and superhero) novel intelligent characters on children’s performance on the add-1 rule. Utilizing intelligent characters that represent extreme gender stereotypes would help to parse whether the extent to which an intelligent character embodies gender stereotypes impacts math performance differentially.

Characters could also be substituted in the intelligent character game that match children on other major parts of their identity, such as race and ethnicity or cultural indicators like dialect. The current intelligent character experiment was not able to address the question of similarities in race and ethnicity because Dora and Diego are Hispanic and most of the child participants were Caucasian. Other research with an intelligent agent, whose gender was ambiguous, supports the idea that cultural similarity can support STEM learning (Finkelstein, 2018). For example, children learned science lessons better when an unknown intelligent agent interacted with them in both Standard English dialect and in the dialect children in the study typically use in non-formal educational settings, African-American Vernacular English (Finkelstein, 2018).

Implications for Education

The main educational implication of these studies is that even unknown intelligent characters hold promise as educators, particularly when they are the same-sex as children. A media character’s sex may operate as a strong indication to children of when media content is “for them” or “not for them” when children are first encountering the character, similar to exploring new toys
in aisles filled with pink and blue in a toy store. Although the current studies examine math performance at a single time point with unknown intelligent characters, the math game is a venue in which children can work repeatedly towards fluency with add-1 problems. This dissertation provides evidence that children are able to benefit to a greater extent, at least initially, when engaging in parasocial interactions in order to learn from a same-sex intelligent character. Repeated exposure to the intelligent character math game could be part of classroom math education rather than verbal math drills or worksheets.

Preschool-aged children rely on gender schemas to organize their worlds, as well as process and remember information. Although gender-stereotype knowledge is building in the preschool years (Leaper, 2015), boys and girls do not demonstrate differences in math skills (Hutchison et al., 2019; Kersey et al., 2018). Preschool, then, may be an important period in which to increase interest and skills in STEM for both boys and girls. Children are gravitating to favorite media characters who are the gender-typed, so utilizing this preference to build skills and create associations between children’s identity and math may be a viable pathway to more STEM engagement for children later in life.

However, using media characters that are the same sex as children does not simply mean that a female character would make the content “girl math” or that a male character would make the content “boy math”. It is vital to embed a range of representations of what it looks like, both in physical appearance and personality traits, to be male or female and engage in math. Stereotypical depictions can limit children’s concepts of how to be a male or female in their culture (Coyne et al., 2016, 2014; Leaper, 2015; Martin & Halverson, 1981; Ward & Aubrey, 2017). Exposure to stereotyped media can reinforce and shape more traditional gender schemas and is associated with engaging in gender-stereotyped behaviors (Calvert & Huston, 1987; Coyne et al.,
Providing children with a range of media character options would allow them to select a character they identify with most, perhaps on biological sex or another salient feature like race, which may drive increased performance in early STEM skills.

**Summary**

Preschool-aged children demonstrated a greater increase in performance on an add-1 math task, both in a virtual and physical context, when they engaged in parasocial interactions with an unknown same-sex, compared to opposite-sex, intelligent character. Results from the survey about children’s favorite characters suggested performance may be explained, in part, because children have favorite characters that were the same sex as children as well as gender-typed in physical appearance and personality traits. In addition to having same-sex favorite characters, children reported that they liked an unknown same-sex character more than an opposite-sex character (i.e. Dora or Diego) before they had experience with one of those characters in the intelligent agent math game.

The results provide evidence that parasocial interactions in children’s educational media are central to children’s learning; moreover, parasocial interactions can be optimized when children learn from same-sex characters. Children readily engaged with media characters in parasocial interactions in the current study. As children are becoming more familiar with intelligent agents (Rideout, 2017), using intelligent characters as educators is a viable path to engaging children in STEM domains. The approach of teaching STEM skills through an interactive intelligent character math game was able to meet children developmentally where they were and harness their interest in their gender group, as well as their willingness to engage with media characters as social partners. Creating more opportunities for preschooler-aged
children to learn informally in ways that utilize their interests and promote parasocial interaction with the content may be a viable pathway to engaging more children in 21st century STEM domains.
CHAPTER V: CONCLUSION

Digital media and the media characters that inhabit the virtual worlds within this media are a part of daily life and regular social interaction for children in the 21st century. This dissertation provides evidence that intelligent characters, a new direction in educational media, can provide children rich learning opportunities, particularly when an unfamiliar character is the same sex as the child. Media that aim to teach children early STEM skills should not only be mindful to depict characters that children of both sexes can see as “for them” but use characters that engage children in conversational back-and-forth exchanges, i.e., parasocial interaction, to optimize learning.

Parasocial interactions, in this context interacting with a same-sex intelligent character through math talk, not only had a greater impact on decreasing latency scores during the virtual game compared to interactions with an opposite-sex intelligent character, but also extended to a physical context with actual objects. Transfer, in which children can apply knowledge from a digital to a physical setting, is a central aspect of learning and is very difficult for young children to achieve (Barr, 2010; Kirkorian, 2018; Zack, Gerhardstein, Meltzoff, & Barr, 2013). That intelligent media characters can help young children traverse digital and physical boundaries is an important contribution to theory as well as educational practice.

The current research does not suggest that screen-based intelligent characters replace the physical presence and flexible expertise of a human, but it may be a useful tool in tandem with educators and parents. These contingent social partners can be programmed to be similar to children and encourage children’s active involvement with and processing of early STEM content. Teachers may be able to better personalize support for children who are struggling as well as those who are moving rapidly in skill mastery. Supporting children’s formal classroom
learning with intelligent agents is an approach that can help children to combine classroom knowledge with practice. Schools and parents may encourage their children’s learning if they support children’s engagement in more parasocial interactions through toy play with the character, encouragement, and repeated exposure (Bond & Calvert, 2014a). Through parasocial interactions, children may form a deeper relationship with a character which may motivate them to return to the game for additional learning opportunities (Calvert, 2015).

On an applied level, the findings from this dissertation support the recommendation that developers create more female characters for children’s media, as there are far more male than female characters (Lemish & Russo Johnson, 2019). If girls benefit more through parasocial interactions (e.g., math talk) with female characters and boys benefit more through parasocial interactions with male characters, then more female characters are needed to teach young girls. Early learning with media characters may foster more engagement with STEM domains and engage children with characters that may foster feelings of gender inclusion within STEM domains.

An implication for public policy from this dissertation is that it contributes to an emerging body of research that finds intelligent character tutoring is effective at teaching foundational science and math skills (Calvert et al., 2018; Finkelstein, 2018). In addition to the promise of novel same-sex intelligent characters for educational interventions, it may be motivating for children to learn using this new technology because it gives them first-hand experience with a new technology. This experience may spur children’s interest in innovating and pursuing skills, like engineering and computer coding, required to develop technological advancements in the 21st century.
This dissertation provides a contemporary contribution to the field of media research, one that focuses on emerging interactive intelligent agents. The rapidly changing landscape of research on educational media has moved from observational media, like traditional television programs, towards observational media experiences in which parasocial interactions were used to engage children, but that lacked true contingency due to technological constraints (Anderson et al., 2000). That is, while a character could ask a question and pause for a reply, the character would move forward without being able to provide children with a personalized reply about their expertise in a topic. Computer technologies, including touchscreen devices, ushered in a new wave of technological transformation and affordances that give children opportunities to interact contingently with digital media like never before (Kirkorian, 2018). The current dissertation provides a deeper understanding of how emerging technologies and practices can best harness media characters to maximize children’s educational opportunities.

In the future, technological advancements like virtual reality and holograms will enable children to feel more physically present with embodied characters, but these characters will remain socially continent partners. The current research can be used to inform educators, parents, and media developers about how to enrich children’s current and future 21st digital learning landscapes and support children to extend virtual learning seamlessly into their everyday lives.
APPENDIX

Appendix A: Study 1A

Measure Name: Pre-game character knowledge child survey
Completed by: Child

1. Do you know who this is? (1) Yes | (0) No
   *Note: Experimenter only showed the child the photo of the character they saw featured in the Intelligent Character math game.

2. Do you know her/his name? (1) Yes | (0) No
   *If no: “Well, this is Dora/Diego from the TV show Dora the Explorer/Go Diego Go”

3. How much do you like [DORA/DIEGO]? (5) A whole lot (really big smiley face)
   (4) A lot (big smiley face)
   (3) Kind of (medium smiley face)
   (2) A little bit (small smiley face)
   (1) Not at all (very small face with straight line where smile would be)

Smiley Face Likert-Scale
Measure Name: Parasocial relationship child survey: attachment and friendship sub-scale
Completed by: Child

1. Do you believe what [DORA/DIEGO] tells you...
   (5) All of the time (really big smiley face)
   (4) A lot of the time (big smiley face)
   (3) Sometimes (medium smiley face)
   (2) A little bit of the time (small smiley face)
   (1) Not at all (very small face with straight line where smile would be)
   (. NA
2. Is [DORA/DIEGO]...
   (5) Your best friend (really big smiley face)
   (4) Your good friend (big smiley face)
   (3) Kind of a friend (medium smiley face)
   (2) A little bit of a friend (small smiley face)
   (1) Not your friend at all (very small face with straight line where smile would be)
   (. NA
3. How safe does [DORA/DIEGO] make you feel when you are scared?
   (5) Really safe (really big smiley face)
   (4) Safe (big smiley face)
   (3) Kind of safe (medium smiley face)
   (2) A little bit safe (small smiley face)
   (1) Not safe at all (very small face with straight line where smile would be)
   (. NA
4. Is [DORA/DIEGO]...
   (5) Really cute (really big smiley face)
   (4) Cute (big smiley face)
   (3) Kind of cute (medium smiley face)
   (2) A little bit cute (small smiley face)
   (1) Not cute at all (very small face with straight line where smile would be)
   (. NA
Information About the Children’s Parasocial Relationship Survey: Attachment and Friendship Sub-Scale. A reduced form of the Children’s Parasocial Relationship Survey (Richards & Calvert, 2017a) included questions about children’s attachment and friendship with the male or female character featured in their version of the Intelligent Character math game (Appendix A). The attachment and friendship items asked children how good of a friend the character was, how much they trusted the character, how cute they thought the character is, and how safe the character made them feel. Children responded to the questions using the same smiley face scale from the pre-game character knowledge child survey. The average of the Likert scale responses on these items was calculated as the child’s attachment and friendship score (range 1 – 5).

This sub-scale was found to have acceptable internal consistency for children 4-6-years old in previous research (α = 0.70), which increased for older children (4.5-6-year-olds’ α = 0.72) and decreased when including 3-year-old children (α = 0.69; Richards & Calvert, 2017a). The attachment and friendship sub-scale has also been found to predict 4-5-year-old’s performance in solving simple addition problems. Specifically, young children who reported higher attachment and friendship scores with the female character Dora were able to solve add-one math problems correctly quicker (Calvert et al., 2018).

In this study, however, the attachment and friendship sub-scale had “questionable” internal consistency (α = .61). The sub-scale reached “acceptable” levels in the Dora condition (α = .73) but was “unacceptable” in the Diego condition (α = .46). The poor internal consistency of the measure in the current sample of children presented a methodological issue and compromised its use as a predictor of latency in the Intelligent Character math game. This problem with the
measure was probably because children did not know the characters well (in some cases not at all), as described in the Results section of Study 1a.
Appendix B: Study 1b

The hypotheses in Study 1b were:

$H^{10}$: Children with stronger gender-stereotyped toy preferences were expected to demonstrate reduced latency on add-1 math problems to a greater extent when playing the math game featuring a same-sex intelligent character, compared to an opposite-sex intelligent character.

Children with stronger gender-typed toy preferences were expected to correctly answer add-1 math problems faster when playing with a same-sex intelligent character because gender schema theory would predict that these children would view a same-sex Intelligent Character and the content associated as more “for them” (Bem, 1981; Martin & Halverson, 1981). Children may view a same-sex intelligent character as relevant to themselves and as a result engage quicker with that character.

$H^{11}$: Children with stronger gender-stereotyped toy preferences were expected to answer more add-1 rule transfer task problems with physical objects correctly after playing the math game featuring a same-sex intelligent character, compared to an opposite-sex intelligent character.

Using gender schema theory (Bem, 1981; Martin & Halverson, 1981), it was predicted that children with stronger gender-stereotyped toy preferences were expected to answer more add-1 rule transfer task problems after playing a math game featuring a same-sex intelligent character, compared to an opposite-sex intelligent character. This is expected because children have better memories for content associated with their gender because they view it as “for them” and have more differentiated and detailed gender schemas of what is associated with their gender group. When a same-sex intelligent character is associated with content, this was expected to
increase the memory even more so for children who demonstrated a high interest in gender-typed toys, culturally associated with their sex.

**Results**

**Average Latency in the Intelligent Character Math Game**

**Gender-Stereotyped Toy Preferences and Child-Character Sex Match.** Stronger gender-stereotyped preferences were not hypothesized to influence add-1 latency performance on their own. A correlation was conducted that demonstrated gender-stereotyped toy preferences were not significantly associated with children’s latency to correctly answer add-1 math problems in the virtual math game ($r = -.08, p > .05$).

$H^{10}$: Children with stronger gender-stereotyped toy preferences were expected to demonstrate reduced latency on add-1 math problems to a greater extent when playing the math game featuring a same-sex intelligent character, compared to an opposite-sex intelligent character.

A series of OLS regressions were conducted predicting average latency by children’s gender-stereotyped toy preference scores, controlling for child-character sex match, child-reported character knowledge, and child age in days (see model 1, Table 10). In the second model, the hypothesized interaction of children’s gender-stereotyped toy preferences and child-character sex match was included to test hypothesis 1 (see model 2, Table 10). The following equation was estimated:

$$\text{Latency} = \beta_0 + \beta_1 \text{GenderStereotypedToyPreferences} + \beta_2 \text{GenderStereotypedToyPreferences} \times \text{Child-CharacterSexMatch} + \beta_3 \text{Child-CharacterSexMatch} + \beta_4 \text{CharacterKnowledge} + \beta_5 \text{ChildAge} + \mu$$

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The hypothesis that children with stronger gender-stereotyped toy preferences would demonstrate a greater reduction in latency to correctly answer add-1 math problems when playing the math game with a same-sex intelligent character was not supported. Results did not reveal a significant interaction in model 2 of Table 10.

**Add-1 Rule Transfer Task with Physical Objects: Star Stickers**

**Gender-Stereotyped Toy Preferences and Child-Character Sex Match.** Stronger gender-stereotyped preferences were not hypothesized to influence children’s add-1 transfer task performance with physical objects, on their own. A correlation was conducted that confirmed gender-stereotyped toy preferences were not significantly associated with the number of transfer task problems children answered correctly (r = .04, p > .05). Since the transfer task dependent variables are count variables, incidence rate ratios (IRRs) from Poisson regression results are presented for the transfer task analyses below.

*H11*: Children with stronger gender-stereotyped toy preferences were expected to answer more add-1 rule transfer task problems with physical objects correctly after playing the math game featuring a same-sex intelligent character, compared to an opposite-sex intelligent character.

A series of Poisson regressions were conducted predicting the number of transfer task problems children answered correctly by children’s gender-stereotyped toy preference scores, controlling for child-character sex match, child-reported character knowledge, and child age in days (see model 1, Table 11). In model 2, the hypothesized interaction of children’s gender-stereotyped toy preferences and child-character sex match was included to test hypothesis 12 (see model 2, Table 11). The following equation was estimated:
\[ \text{Number of Transfer Task Problems Correct} = \beta_0 + \beta_1 \text{GenderStereotypedToyPreferences} + \beta_2 \text{GenderStereotypedToyPreferences} \times \text{Child-CharacterSexMatch} + \beta_3 \text{Child-CharacterSexMatch} + \beta_4 \text{CharacterKnowledge} + \beta_5 \text{ChildAge} + \mu \]

The hypothesis that children with stronger gender-stereotyped toy preferences would answer more transfer task problems with physical objects correctly after playing the math game with a same-sex intelligent character, compared to an opposite-sex intelligent character, was not supported. Results did not reveal a significant interaction in model 2 of Table 11.
Table 10: OLS regression predicting average response latency in seconds for add-one problems

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B (SE)</td>
<td>B (SE)</td>
</tr>
<tr>
<td>Gender Stereotyped Toy Preference</td>
<td>-1.67 (2.42)</td>
<td>-4.86 (3.02)</td>
</tr>
<tr>
<td>Child-Character Sex Match * Gender Stereotyped Toy Preference</td>
<td>---</td>
<td>6.93 (5.11)</td>
</tr>
<tr>
<td>Child-Character Sex Match (0 = Opposite Sex, 1 = Same-Sex)</td>
<td>1.86 (4.40)</td>
<td>-16.84 (14.92)</td>
</tr>
<tr>
<td>Character Knowledge</td>
<td>3.03 (2.66)</td>
<td>2.38 (2.78)</td>
</tr>
<tr>
<td>Age</td>
<td>-.02 (.02)</td>
<td>-.02 (.02)</td>
</tr>
<tr>
<td>Constant</td>
<td>58.73 (28.09)</td>
<td>67.27 (28.07)</td>
</tr>
</tbody>
</table>

R²          | .04           | .06           |
Adjusted R² | -.004         | .004          |
F           | .65           | 1.29          |
df          | 4, 84         | 5, 83         |
N           | 89            | 89            |

*p ≤ 0.05; **p ≤ 0.01; Robust Standard Errors

Notes: Sample excludes 22 children who got all 12 math problems correct on the first try and 1 child who did not answer character knowledge questions.
Gender Stereotyped Toy Preference: Range of 1 (weak gender-stereotyped toy preference)– 4 (strong gender-stereotyped toy preference)
Controls: Child-Character Sex Match: 1 = child and character are the same-sex, 0 = child and character are the opposite-sex; Character Knowledge (0 = no knowledge, 1 = recognize character, 2 = know character’s name); Age (days)
### Table 11: Poisson regression predicting the number of add-1 transfer task problems answered correctly

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IRR (SE)</td>
<td>IRR (SE)</td>
</tr>
<tr>
<td>Gender-Stereotyped Toy Preference</td>
<td>.99 (.11)</td>
<td>.79 (.13)</td>
</tr>
<tr>
<td>Child-Character Sex Match * Gender-Stereotyped Toy Preference</td>
<td>---</td>
<td>1.49 (.32)</td>
</tr>
<tr>
<td>Child-Character Sex Match (0 = Opposite Sex, 1 = Same-Sex)</td>
<td>1.36 (.25)</td>
<td>.47 (.29)</td>
</tr>
<tr>
<td>Character Knowledge</td>
<td>.97 (.10)</td>
<td>.93 (.09)</td>
</tr>
<tr>
<td>Age</td>
<td>1.00 (.001)</td>
<td>1.00 (.001)</td>
</tr>
<tr>
<td>Constant</td>
<td>.82 (.91)</td>
<td>1.52 (1.74)</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>.02</td>
<td>.04</td>
</tr>
<tr>
<td>Wald X²</td>
<td>5.85</td>
<td>12.76*</td>
</tr>
<tr>
<td>df</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>N</td>
<td>88</td>
<td>88</td>
</tr>
</tbody>
</table>

*p ≤ 0.05; **p ≤ 0.01; Robust Standard Errors

**IRR: Incidence Rate Ratio**

*Notes: Sample excludes 22 children who got all 12 math problems correct on the first try, 1 child who did not answer character knowledge questions, and 1 child who refused to complete the transfer task.
Gender Stereotyped Toy Preference: Range of 1 (weak gender-stereotyped toy preference) – 4 (strong gender-stereotyped toy preference)

Controls: Child-Character Sex Match: 1 = child and character are the same-sex, 0 = child and character are the opposite-sex; Character Knowledge (0 = no knowledge, 1 = recognize character, 2 = know character’s name); Age (days)
Appendix C: Study 1c

Measure Name: Gender-Typed Physical Appearance
Completed by: Adult Coder

Masculine/feminine appearance. Does the character appear to be masculine, feminine, gender neutral?

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>very masculine</td>
</tr>
<tr>
<td>-1</td>
<td>somewhat masculine</td>
</tr>
<tr>
<td>0</td>
<td>gender neutral</td>
</tr>
<tr>
<td>1</td>
<td>somewhat feminine</td>
</tr>
<tr>
<td>2</td>
<td>very feminine</td>
</tr>
</tbody>
</table>
**Measure Name:** Character Gender-Typed Traits; Adapted from the Bem Sex-Role Inventory Short Form (1981)  
**Completed by:** Adult Coder  

**BEM sex inventory items.** All of the below items will be coded based on the scale of:  
0 = not at all; 1 = a little; 2 = somewhat; 3 = very

<table>
<thead>
<tr>
<th></th>
<th>not at all</th>
<th>a little</th>
<th>somewhat</th>
<th>very</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>assertive</td>
<td>assertive</td>
<td>assertive</td>
<td>assertive</td>
</tr>
<tr>
<td>2.</td>
<td>no</td>
<td>leadership ability</td>
<td>leadership ability</td>
<td>leadership ability</td>
</tr>
<tr>
<td>3.</td>
<td>not at all</td>
<td>a little</td>
<td>somewhat</td>
<td>very</td>
</tr>
<tr>
<td></td>
<td>dominant</td>
<td>dominant</td>
<td>dominant</td>
<td>dominant</td>
</tr>
<tr>
<td>4.</td>
<td>not at all</td>
<td>a little</td>
<td>somewhat</td>
<td>very</td>
</tr>
<tr>
<td></td>
<td>strong personality</td>
<td>strong personality</td>
<td>strong personality</td>
<td>strong personality</td>
</tr>
<tr>
<td>5.</td>
<td>not at all</td>
<td>a little</td>
<td>somewhat</td>
<td>very</td>
</tr>
<tr>
<td></td>
<td>forceful</td>
<td>forceful</td>
<td>forceful</td>
<td>forceful</td>
</tr>
<tr>
<td>6.</td>
<td>not at all</td>
<td>a little</td>
<td>somewhat</td>
<td>very</td>
</tr>
<tr>
<td></td>
<td>aggressive</td>
<td>aggressive</td>
<td>aggressive</td>
<td>aggressive</td>
</tr>
<tr>
<td>7.</td>
<td>not at all</td>
<td>a little</td>
<td>somewhat</td>
<td>very</td>
</tr>
<tr>
<td></td>
<td>willing to take a stand</td>
<td>willing to take a stand</td>
<td>willing to take a stand</td>
<td>willing to take a stand</td>
</tr>
<tr>
<td>8.</td>
<td>not at all</td>
<td>a little</td>
<td>somewhat</td>
<td>very</td>
</tr>
<tr>
<td></td>
<td>independent</td>
<td>independent</td>
<td>independent</td>
<td>independent</td>
</tr>
<tr>
<td>9.</td>
<td>never</td>
<td>sometimes</td>
<td>often</td>
<td>always</td>
</tr>
<tr>
<td></td>
<td>defends own beliefs</td>
<td>defends own beliefs</td>
<td>defends own beliefs</td>
<td>defends own beliefs</td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>not at all</td>
<td>a little</td>
<td>somewhat</td>
<td>very</td>
</tr>
<tr>
<td>---</td>
<td>------------</td>
<td>----------</td>
<td>----------</td>
<td>------</td>
</tr>
<tr>
<td>11. not at all</td>
<td>understanding</td>
<td>a little</td>
<td>somewhat</td>
<td>very understanding</td>
</tr>
<tr>
<td>12. not at all</td>
<td>sympathetic</td>
<td>a little</td>
<td>somewhat</td>
<td>very sympathetic</td>
</tr>
<tr>
<td>13. not at all</td>
<td>eager to soothe</td>
<td>a little</td>
<td>somewhat</td>
<td>very eager to soothe</td>
</tr>
<tr>
<td>14. not at all</td>
<td>sensitive to needs of others</td>
<td>a little</td>
<td>somewhat</td>
<td>very sensitive to needs of others</td>
</tr>
<tr>
<td>15. not at all</td>
<td>compassionate</td>
<td>a little</td>
<td>somewhat</td>
<td>very compassionate</td>
</tr>
<tr>
<td>16. does not love children</td>
<td>a little</td>
<td>somewhat</td>
<td>a lot loves children</td>
<td></td>
</tr>
<tr>
<td>17. not at all</td>
<td>affectionate</td>
<td>a little</td>
<td>somewhat</td>
<td>very affectionate</td>
</tr>
<tr>
<td>18. not at all</td>
<td>gentle</td>
<td>a little</td>
<td>somewhat</td>
<td>very gentle</td>
</tr>
<tr>
<td>19. not at all</td>
<td>warm</td>
<td>a little</td>
<td>somewhat</td>
<td>very warm</td>
</tr>
<tr>
<td>20. not at all</td>
<td>tender</td>
<td>a little</td>
<td>somewhat</td>
<td>very tender</td>
</tr>
</tbody>
</table>
REFERENCES


Hutchison, J. E., Lyons, I. M., & Ansari, D. (2019). More similar than different: Gender differences in children’s basic numerical skills are the exception not the rule. *Child Development, 90*(1), e66–e79.


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