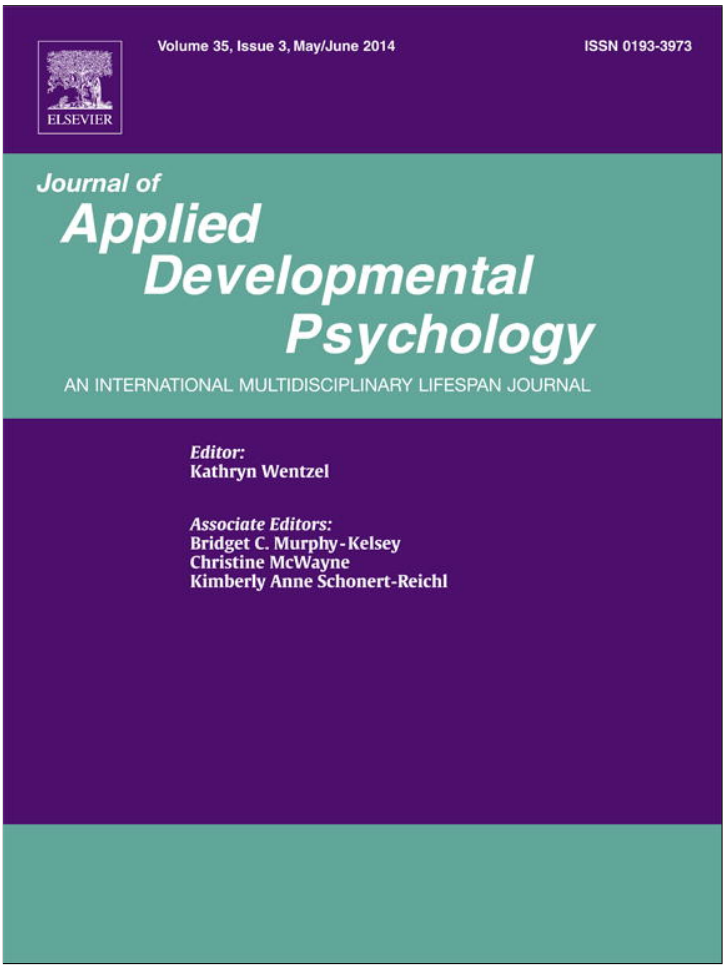

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Personalized interactive characters for toddlers' learning of seriation from a video presentation

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ABSTRACT

Children's media is rooted in relationships with onscreen characters. In this study, 18-month-old toddlers were initially exposed to one of two unfamiliar interactive media characters for 3 months. Conditions varied whether the character was personalized to them or not. At age 21 months, toddlers were tested on a seriation task that was presented onscreen by the character and compared to the performance of a 21-month-old control group who did not view a video demonstration (total $N = 48$). Toddlers learned significantly more from the personalized character, but not from the non-personalized character, when compared to the control group. Children in the personalized condition also increased in parasocial, nurturing behaviors directed at the character during play sessions, and these scores were linked to better seriation performance. The results suggest an important role for social relationships with interactive characters to teach early seriation skills.

Children's worlds are densely populated with media characters, including interactive toys that can personalize a message and respond contingently to what a child says and does. Previous video demonstrations presented by meaningful characters, such as Elmo, resulted in better toddler learning of an early mathematics concept—in this case seriation of objects—than when the same task was demonstrated by a non-meaningful character that the toddlers did not know (Lauricella, Gola, & Calvert, 2011). In the current study, we examined the role that an interactive toy character, which was programmed to be personalized or not personalized to the child, played in toddlers' subsequent learning of a seriation task that was later presented by that character onscreen. Our main hypothesis was that toddlers would learn best from the personalized character on the subsequent onscreen transfer task involving seriation skills.

Early seriation learning

U.S. children lag behind most of their international peers in learning STEM (science, technology, engineering, and mathematics) concepts, which places the U.S. at a future economic disadvantage in the world economy (U.S. Department of Education, 2011). One way to address this deficiency is to get young children involved in activities that promote the early skills required to understand more advanced mathematical concepts. Seriation is one such skill (Gola, Richards, Lauricella, & Calvert, 2013; Kirova & Bhargava, 2002; Kroesbergen & Van Luit, 2003; Piaget, 1954; Clements, Sarama & Liu, 2008).

Seriation involves an understanding that number systems have an order that reflects the relative size or amount of objects (Piaget, 1954). A typical seriation task involves the manipulation of actual objects by some dimension in which there are relative differences in attributes, such as ordering a series of sticks from the smallest to the largest (Flavell, 1963).

Because Piagetian seriation tasks are "generative of future learning" of mathematics concepts, the Early Math Assessment Measure includes these tasks as a targeted skill for mastery by preschool-aged children (Clements et al., 2008). Programs such as *Big Math for Little Kids*, which is designed to teach 4- to 5-year-old children deep mathematical concepts, incorporates seriation skills into lesson plans, allowing children to exercise coordination of relative dimensions by one or more attributes (Greenes, Ginsburg, & Balfanz, 2004). Meta-analyses demonstrate that children, such as special needs elementary-aged students, benefit from learning seriation skills as a precursor for more advanced mathematical concept mastery (Kroesbergen & Van Luit, 2003).

As early as age 21 months, some toddlers can seriate simple tasks, such as nesting cups by size, when exposed to a live adult who demonstrates the task (Fragaszy, Galloway, Johnson-Pynn, & Brakke, 2002; Greenfield, Nelson, & Saltzman, 1972). Based on the extant research, seriation skills were targeted as an early mathematics skill for our study, in this instance having toddlers nest cups by size as the transfer task to be taught by onscreen characters.

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Learning from socially relevant video characters

Favorite teachers have always been a source of inspiration to their students, motivating them to perform their very best. The social and emotional relationships that children form with adults, such as their teachers, can influence learning, as can the social relationships that children have formed with onscreen media characters (Richert, Robb, & Smith, 2011). Indeed, children learn best from media that is *socially relevant* to them (Troseth, Saylor, & Archer, 2006). In recent years, the concept of social relevancy has been broken into two distinct theoretical parts (Krcmar, 2010): 1) social meaningfulness and 2) social contingency. Social meaningfulness was subsequently linked to emotional, *parasocial relationships*, whereas the perception of social contingency was linked to *parasocial interactions* (see Bond & Calvert, 2014; Calvert & Richards, 2014).

Parasocial relationships

Meaningful social relationships with onscreen personalities are defined as parasocial relationships (Calvert & Richards, 2014). More specifically, parasocial relationships involve a one-sided, emotionally tinged relationship with a media character or onscreen person that lasts over time (Hoffner, 2008).[1] In other words, parasocial relationships are ongoing affective bonds with media characters (Bond & Calvert, 2014).

Toddlers who have meaningful relationships with characters learn well when those characters present content onscreen. For example, 21-month-olds performed better on a seriation task demonstrated by the popular Elmo character than when children viewed a Taiwanese character named DoDo, who is unknown to U.S. children, demonstrate the exact same task with the same Elmo-like voice. Furthermore, only children who viewed the Elmo demonstration performed significantly better on the seriation task when compared to another group of children who saw no video demonstration at all (Lauricella et al., 2011).

In a follow-up study, one group of toddlers was familiarized with the DoDo character through play sessions with a puppet version of him and exposure to videos of him doing everyday activities, like eating breakfast. This familiarized condition also learned the seriation task better from his video demonstration than a control group who had no prior exposure to the character before viewing the video demonstration. By contrast, toddlers who only viewed DoDo perform the seriation task onscreen with no other exposure to the character performed no better than the control group on the seriation task. Within the familiarized condition, those who nurtured the puppet character during play sessions by feeding him and putting him to bed—a behavioral indicator of a parasocial relationship—performed better on the seriation task than those who did not nurture the character during play sessions (Gola et al., 2013).

Parasocial interactions

In children's media, parasocial interactions involve a production practice that simulates the perception of social contingency (Calvert & Richards, 2014). This perception is created by having a media character such as Dora the Explorer speak to the audience, pause for a reply during which the child ostensibly says or does something requested by the character, and then act as if the child actually did respond (Lauricella et al., 2011). These kinds of pseudo-interactions can get children actively involved with the program content, with children often responding to and interacting with the characters (Anderson et al., 2000), and can lead to better comprehension of plot-relevant content when these interactive prompts are included versus excluded (Calvert, Strong, Jacobs, & Conger, 2007). The production practice of creating the illusion of a social interaction is now very common in children's television programming (Calvert & Wartella, 2014). Nevertheless, characters who speak to children and wait for a reply to create the illusion of an interaction do not necessarily facilitate improved learning (Lauricella et al., 2011).

Children can have a parasocial relationship with a character without these kinds of pseudo-interaction programming practices taking place. That is, children can observe and learn from onscreen characters whose experiences only involve other characters, with the characters saying nothing to the audience (O'Doherty et al., 2011). In these situations, children can become emotionally invested in the characters and create parasocial relationships through observational learning, i.e., social cognitive theory (Bandura, 1986).

Parasocial interactions, then, can occur without a character being meaningful to a child, but sometimes those characters are meaningful to them. Similarly, a child can develop a parasocial relationship with a media character, regardless of whether or not production practices are used that can create the illusion of a two-way interaction. In other words, children can have both parasocial relationships and parasocial interactions with a media character, or only one of these kinds of parasocial experiences.

Implications for learning

We believe parasocial relationships are at the heart of children's learning from media characters, as it indicates an emotional investment in a character, which should increase engagement and potentially learning. For instance, parasocial interaction production practices were used in the DoDo seriation video, but only those who had been familiarized with DoDo performed better than the control group; by contrast, those who had no prior relationship with DoDo did not perform any better than the control group (Gola et al., 2013). Therefore, even after holding levels of parasocial interaction production practices in the DVD constant, parasocial relationships still emerged as a significant influence in children's learning from onscreen presentations.

Taken together, these findings suggest that very young children act as if their favorite media characters are alive, forming parasocial relationships with them and treating them as humans. Indeed, Piaget (1954) and Piaget, Tomilson, and Tomilson (2007) long held that children in the preoperational stage of development believed in animism, giving human attributes to non-human objects. For example, young children sometimes believe that their stuffed toys and dolls are alive, talk to them, and treat them as friends. In a similar way, children may 'breathe life' into their favorite characters with whom they have formed parasocial relationships. Although these relationships with onscreen characters are unidirectional, from the child to a character, the fact that media characters walk, talk, have friends, and look like other people may overpower the fact that the character is not actually real (Calvert & Richards, 2014).

Learning from interactive characters

Interactive characters can personalize their responses to young children, perhaps further blurring the line between what is real and what is pretense. The largest difference between programmable, interactive characters and those that are observed in television or film presentations may be that interactive characters can be more responsive than television characters can be. When programmed, interactive characters can say a child's name, share their favorite activities, engage the child in a socially contingent conversation, and create the illusion that the character is child-like. These properties parallel the ways that children develop preferences for peers (Bond & Calvert, 2014).

Although children do not typically define their own gender prior to age 2 (Kohlberg, 1966), toddlers prefer toys that are the same gender as they are as early as age 18 months (Serbin, Poulin-Dubois, Colburne, Sen, & Eichstedt, 2001). Moreover, children prefer to play with a puppet that has the same physical appearance and favorite food as they do (Fawcett & Markson, 2010). This personal resemblance, in turn, influences learning. That is, children learn more from characters that closely

[1] Note that the terms parasocial relationship and parasocial interaction were originally used interchangeably (Horton & Wohl, 1956). The terms have now been separated conceptually (Schramm & Hartmann, 2008) and will be discussed as distinct concepts in this article.

resemble them, even when the characters are not truly interactive (Fisch, 2004).

Some early interactive characters included interfaces in which animated plush dolls that resembled familiar media characters, like Barney, DW, and Arthur, were designed to create social and emotional bonds between children and characters (Strommen, 1998). Early research demonstrated that children treated these intelligent interfaces as they would a friend (Strommen & Alexander, 1999), just as they would a character with whom they have developed a parasocial relationship. Positive attributes of interactive characters, such as warmth, personalities that are familiar and authentic, humor, and spontaneity, were used to develop these interfaces that built on the concept of reciprocal social responses (Strommen & Alexander, 1999).

Recent research further documents the link between emotion and how people treat an artificial agent as a person. In particular, young adults were often emotionally distressed after viewing a dinosaur robot being tortured (Rosenthal-von der Pütten, Krämer, Hoffmann, Sobieraj, & Eimler, 2013). Although less pronounced for the robot, the same neural circuitry in the limbic system was activated when viewing the dinosaur robot being tortured as when viewing a human ostensibly being tortured (Rosenthal-von der Pütten et al., 2013). These findings suggest that parasocial relationships involve empathic responding in which children and adults come to treat characters as if they have emotions, just as humans do.

Parent roles in children's learning from media

Parents are key to their young children's learning from media content. Based in Vygotsky's theory, parents can provide scaffolds for their children that provide a bridge between what the child knows and what the onscreen presentation is trying to teach (Barr & Wyss, 2008; Richert et al., 2011).

One scaffold that adults can provide is verbal labels of content that summarize information and point out key aspects of the content for children (Friedrich & Stein, 1975). Another scaffold involves role playing, in which important character actions are demonstrated, sometimes through puppet play (Friedrich & Stein, 1975). Role playing with puppets is associated with increases in actions that are consistent with what the onscreen characters are doing, such as helping and sharing (Friedrich & Stein, 1975), and verbal labels are associated with better learning of targeted content (Barr & Wyss, 2008; Friedrich & Stein, 1975). Joint toy play provides parents with a way to improve their young children's conceptual learning, including language development and problem solving skills (Wooldridge & Shapka, 2012).

We explore the possibility here that parents who play with their child using an interactive plush toy character may help their child develop a parasocial relationship with that character. In doing so, parents may be setting the stage for their child to learn more when that character demonstrates a concept onscreen.

The present study

The purpose of the current study was to examine the qualities of interactive characters that lead to the development of a parasocial relationship and subsequent learning of a seriation task from a video presentation during the toddler years, as well as the role that parents play in this process. The strength of the parasocial relationship with an interactive character was also linked to toddlers' learning on the seriation transfer task. Our hypotheses were as follows:

1) Toddlers in a personalized interactive toy condition, in which the character was programmed to be similar to the child, would perform better on a seriation transfer task than those in a control group, but such benefits would not be found for those in a non-personalized interactive toy condition in which the character was programmed to be dissimilar to the child;
2) Toddlers in a personalized interactive character condition would be more likely than those in a non-personalized interactive character condition to develop a parasocial, nurturing relationship with the character;
3) Toddlers who were more involved with the character during play sessions, as measured by more parasocial nurturing behaviors, calling the character by name, and interacting with the character by pressing his or her paws, would perform best on the subsequent seriation task;
4) Parents who provided scaffolds between the child and the character through play were expected to increase the strength of the parasocial relationship that developed.

Method

Participants

The sample consisted of 48 toddlers, equally distributed by gender. Children were recruited from a database of more than 700 children living in the Washington, D.C. metropolitan area. Parents were initially contacted by phone or email and asked if their child had any prior experience with the characters *Scout* and *Violet* distributed by LeapFrog Enterprises. Those whose children did not know the characters were randomly assigned to one of two treatment groups: a personalized interactive character treatment group ($n = 16$; 8 males, 8 females), or a non-personalized interactive character treatment group ($n = 16$; 8 males, 8 females). Those whose children did know the characters were invited to participate in the control group ($n = 16$; 10 males, 6 females). Toddlers in the treatment conditions began the study at age 18 months and completed the study at age 21 months. The control group was examined only at age 21 months.

The ethnic background of the children was predominately Caucasian ($n = 37$), but also included children who were African American ($n = 2$), Asian American ($n = 2$), and other or mixed ethnicities ($n = 6$). One parent did not report ethnicity. Parents had between 14 and 27 years of education ($M = 18.52$, $SD = 2.66$): 63% of parents had a Master's degree or higher. There were no significant differences in parent education between the three conditions, $p > .05$.

Treatment conditions

Scout and Violet are interactive plush toy dogs. Scout is a green and white male dog, and Violet is a lavender and white female dog. These interactive plush toy characters can be programmed to say a child's name and to have personal favorites. The characters speak or play songs when the characters' paws are pushed. Scout and Violet both had the same voice, narrated by a young boy.

Prior to the home visit in which toddlers in the treatment conditions were introduced to their interactive character, parents filled out a questionnaire about their child's favorite things, such as their favorite food, color, and song. Favorites were based on a list of options that the experimenters could potentially program the characters to say. For favorite song, experimenters gave parents a CD to listen to, which cataloged all songs that Scout and Violet were capable of playing.

This information was then used to program the interactive character to be personalized or not personalized to the child. Specifically, the personalized character was pre-programmed to call each child by name, to be the same gender as the child (Violet for girls and Scout for boys), and to have interests that were similar to the child, such as saying that they liked the same favorite food and song as the child did. By contrast, the non-personalized character was pre-programmed to call the child by the generic name “Pal,” to have the opposite gender as the child, and to have randomly selected favorites.

Procedure

For children in the two treatment conditions, two experimenters visited the 18-month-old toddlers' homes and gave children one of the two interactive toy dog characters. These characters were not part of any video presentations in the *LeapFrog* product line so prior screen exposure to the characters was not possible. Additionally, parents had reported that children had no prior exposure to the toys.

Play sessions

From ages 18–21 months, toddlers in the two treatment conditions had access to and played with one of these interactive characters in their homes. Over that period, three visits to the toddler's home took place: at age 18 months when the toddler was introduced to the character and an initial play session took place, at age 19.5 months when a second play session took place, and at age 21 months when a seriation transfer task was assessed and a play session then took place. During each play session, parents and children were videotaped for approximately 5 min playing with the LeapFrog plush toy.

Measures

Parent surveys

At Visit 1, parents completed a questionnaire about whether or not their child had a favorite media character, whether or not their child's favorite toy was interactive or electronic, amount of media use (e.g., how much time their child spent watching television on a typical day), and background demographic information (e.g., years of parental education and ethnicity). Parents also filled out later surveys about children's experiences with Scout or Violet approximately one week after the first visit, at Visit 2 (toddler is 19.5 months), and at Visit 3 (toddler is 21 months). In these surveys, parents were asked how often their child was playing with the interactive toy and the extent to which the parent was co-engaged with their child in interactive toy play, which we encouraged them to do.

Parents also filled out the short form of the *MacArthur Communicative Development Inventory Checklist Level II* (CDI). In this measure, parents check off all the words that their child says as a measure of the toddler's productive language skills (Fenson et al., 2000). The number of words that parents reported their child has said is summed to create a child's total score. Children in the treatment conditions were assessed twice on the CDI, once at 18 months and again at age 21 months. Children in the control group were tested on their CDI only at 21 months.

Seriation task

During the third visit, each toddler in the treatment conditions viewed a video of their respective interactive characters performing a seriation task, which involved nesting cups by size. In the 4-minute video, the seriation task was demonstrated twice and either Scout or Violet, depending on the condition, was depicted nesting 5 plastic cups of different colors. The cups varied in size from 3.65 cm in diameter and 6.19 cm in height to 11.75 cm in diameter and 10.32 cm in height.

To create the video demonstrations, experimenters took the stuffing out of a Scout and Violet interactive doll in order to make puppets that could be manipulated to perform the seriation task by an adult puppeteer. The voice of the characters was the same as that of the interactive plush toy characters and was dubbed onto each video.

In the video, children were initially shown the goal state of how the cups would look when they were nested, which was again shown at the end of the video demonstration. The onscreen character told the child that they were going to put the cups in order from the "smallest to biggest." As the character spoke, Scout and Violet used their bodies to provide additional cues about the task to the child. For example, the characters would scrunch up their arms and legs to make their bodies very small, and then jump up in the air with arms and legs outstretched to be really big to represent the concept of putting the cups in order from the smallest to largest.

Next the character lined up all 5 cups in sequential order. Then the character put each successive group of nested cups into a larger cup, as the character labeled the actions (i.e., "First we take the teeny tiny cup and put it in this one; then we take this cup and put it in this one; then we take this cup and put it in this one; and last, we take all the cups and put them in the really big cup."). Children in the control condition did not see this video demonstration.

During the test phase, an experimenter gave each toddler a set of cups to play with that matched the ones in the seriation video. Toddlers had 2 min to nest the cups, beginning from the moment when they first touched a cup. Children in the two treatment conditions were videotaped as they watched the seriation demonstration video, and all three groups were videotaped when they played with the nesting cups. Mean age at the time of seriation testing was 654 days ($SD = 10.21$ days).

Seriation scoring

Seriation scores were computed based on a prior scoring system developed by Wright et al. (1984), which was subsequently adapted for cup nesting by Lauricella et al. (2011). The score, based on two parts, was calculated as follows: 1) the cups had to be nested or lined up in the correct sequential order, for which one point was awarded for nesting or ordering a cup that was smaller within or beside a cup that was larger; and 2) cups had to be placed in the exact sequential order (e.g., cup 2 inside or beside cup 3), for which children received one additional point. The two scores were added together for a total possible score of 14. Following procedures developed by DeLoache, Sugarman, and Brown (1985), only cups that were nested inside one another, not those that were nested upside down, received credit. The child's best set served as the child's seriation score.

Reliability, assessed for 60% of the sample, was $r = .99$, computed as an intraclass correlation coefficient. There was one disagreement between coders for cup coding, which was later analyzed by a third coder to determine a definitive answer.

Scoring visual attention to the videos

The duration of time that children were attentive to the video demonstration was also coded by research assistants. The amount of time that children spent attending to the demonstration video was divided by the total length of the video to create a proportion. Ninety percent of the sample was double-coded, yielding an intraclass correlation coefficient of $r = .99$.

Play session scoring

Research assistants later coded the toddlers' play behaviors using Noldus, the Observer XT 7.0 software. Based on prior procedures (Gola et al., 2013), research assistants coded the number of times that toddlers engaged in parasocial, emotionally-tinged behaviors directed at Scout or Violet that suggested that the character had humanlike needs (e.g., feeding the character, tucking the character in for a nap), pressed the character's paws to get the character to interact with them, said the character's name during play sessions, and the duration of time that toddlers smiled.

Thirty percent of the videos in the sample were double-coded. Reliability, computed as an intraclass correlation coefficient, was $r = .94$ for child parasocial nurturing behaviors; $r = .80$ for child pressing the character's paws; and $r = .89$ for child smiling. Due to low frequency, item reliability for the child saying the character's name was calculated as two times the number of agreements divided by the total number of scores for Observers 1 and 2 (Wright et al., 1984), yielding a reliability coefficient of .96.

Parents were also scored for encouraging their child to do each of these same behaviors during the play sessions. Specifically, parents were coded each time that they encouraged their child to: (1) engage in parasocial nurturing behaviors (e.g., "Scout is thirsty, can you give

him some milk?"), (2) press the character's paws (e.g., "Press the button on his paw!"), and (3) say the character's name (e.g., "What is her name?" or "Can you say his name?"). Parents were also coded for the proportion of time that they were smiling out of the total amount of time their face was visible onscreen. One quarter of the sample was double-coded for reliability. Intraclass correlation coefficients for these items were $r = .82$ for encouraging parasocial nurturing, behaviors, $r = .93$ for encouraging their child to press the character's paws, $r = .79$ for encouraging their child to say the character's name, and $r = .83$ for the duration of parent smiling.

In addition to each individual play session score, composite scores were created for each child and parent, respectively, by summing the number of times each of these target behaviors occurred over the course of the three visits. Because each play session was a slightly different length, the composite summed behavior score was divided by the amount of time parents and children were recorded on video playing with each other over the course of the entire study.

Results

Descriptive statistics

Table 1 presents the means and standard deviations for children's seriation scores, CDI scores, prior cup-nesting experience, and attention to the cup-nesting video demonstration. A 2 (condition) × 2 (gender) ANOVA with visual attention to the video demonstration as the dependent variable revealed that there were no significant differences in attention between conditions, p's > .05. Children in the no-exposure control group did have significantly higher CDI scores than those in the personalized character condition, $F(2, 45) = 3.37$, $p = .04$. However, CDI scores were not correlated with seriation scores for any condition. Based on these analyses, neither visual attention nor CDI scores were incorporated in other analyses.

Based on data from the first survey when the child was 18 months old, only 4.2% of parents reported that their toddler's favorite stuffed animal was interactive or electronic. Parents also reported that approximately 48% of their toddlers had a favorite media character. Chi-square tests revealed that there was a significant difference between conditions in the number of children who had a favorite media character, $\chi^2(2, N = 48) = 20.70$, $p < .001$. Follow-up tests revealed that children in the personalized character condition, $\chi^2(1, N = 32) = 18.29$, $p < .001$, as well as the non-personalized character condition, $\chi^2(1, N = 32) = 13.33$, $p < .001$, were less likely to have a favorite media character than children in the no-exposure control group. Because children in the control group did not view a video with a character, favorite characters were not included in subsequent analyses.

Throughout the study, children remained fairly engaged with their LeapFrog characters. At the first periodic survey a week after getting introduced to the character, 62.5% of parents (in each condition, respectively) reported that their child played with his or her LeapFrog Doll "Sometimes" or "Usually." By 19.5 months of age, even more children played with their doll if it was personalized for them (68.8% personalized vs. 43.8% non-personalized). However, at 21 months, parental report of how often their child played with his or her toy was roughly similar across conditions (56.3% personalized and 62.5% non-personalized).

Parent–child play with the LeapFrog interactive toy characters declined over time. During the 18 month survey, 62.5% of parents in the personalized condition and 68.8% in the non-personalized condition said that they played together with the LeapFrog character "Somewhat," "A Whole Lot" or "Always." When toddlers were 19.5 months, parent interest dropped off, particularly in the non-personalized condition (62.5% personalized vs. 37.5% non-personalized). Parent interest in interactive toy play with their children and the characters continued to decrease in the survey when their children were age 21 months (56.3% personalized vs. 31.3% non-personalized).

Seriation performance

A 3 (condition) × 2 (gender) ANOVA computed on the number of cups correctly nested yielded a main effect of condition, $F(2, 42) = 3.45$, $p = .04$, $\eta_p^2 = .14$. Although both treatment groups performed better than the control group, only the personalized condition reached statistical significance. Specifically, toddlers who had played with a personalized interactive character performed significantly better on the subsequent seriation task that had been viewed on video than the baseline control group did ($M = 9.13$, $SD = 4.46$ vs. $M = 5.63$, $SD = 3.42$). By contrast, toddlers who had a non-personalized character ($M = 8.19$, $SD = 3.45$) that was subsequently observed demonstrating the seriation task did not perform significantly better than the control group. There were no significant differences in seriation performance between the two treatment conditions, and there were no effects of gender.

Seriation performance and survey data

For items on the surveys that were asked repeatedly throughout the study at 18, 19.5 and 21 months, we calculated an overall composite score for each of these items by finding the mean of the scores reported on the individual periodic surveys. Within the personalized character condition, toddlers who played together with their parent and their Scout or Violet interactive toy more, as indicated by their composite overall score across the 3 sessions, also had higher seriation scores ($r = .52$, $p < .05$). By contrast, there were no significant correlations within the non-personalized condition between composite scores of parent–child play with the interactive character and seriation scores. Furthermore, there were no significant correlations in either condition between seriation scores and the composite score of how often the child played with their LeapFrog toy as reported by parents in the survey.

Play session behaviors over time

Child outcomes

Growth curve analyses were conducted to assess increases in parasocial, nurturing behaviors directed at the character during play sessions. In addition, we examined other behaviors that might be related to the formation of a parasocial relationship with the character, such as saying the character's name, smiling, and pushing the character's paws. Finally, we examined the link between the slope in children's parasocial relationship development over time and seriation scores.

Table 1
Means and (standard deviations) of child seriation scores, vocabulary (CDI) scores, cup stacking experience, and attention to video demonstration by condition.

	Personalized character	Non-personalized character	No exposure control
Best seriation score	9.13 (4.46)	8.19 (3.45)	5.63 (3.42)
CDI score (18 months)	14.81 (11.88)	19.37 (12.87)	N/A
CDI score (21 months)	28.50 (20.85)	40.69 (22.60)	47.75 (20.11)
Number of children who have a set of cups at home (out of 16 per condition)	9	10	8
Proportion of time spent attending to video demonstration	.86 (.14)	.86 (.15)	N/A

Growth curve analyses revealed that for children in the personalized condition, the number of times the toddlers engaged in parasocial, nurturing behaviors directed toward their interactive character increased significantly over time ($t = 2.14$, $p < .04$). In addition, the number of times the toddlers pressed the paws of their personalized interactive character decreased significantly over time ($t = -4.47$, $p < .001$). By contrast, there were no significant changes over time for children's behaviors in the non-personalized condition.

For toddlers in the personalized condition, we followed up on these significant changes over time by calculating each child's slope in nurturing behaviors and paw pressing over the three months. Within the personalized condition, the greater the increase in children's parasocial, nurturing behaviors over time, the higher their seriation scores ($r = .50$, $p = .05$). The significant decrease over time in paw pressing, however, was not related to seriation scores.

Parent–child outcomes

Growth curve analyses were also conducted for parent–child play behaviors. In both conditions, the number of times parents encouraged their child to press the character's paws decreased significantly over time ($t = -4.06$, $p < .001$ for the personalized character condition and $t = -2.06$, $p < .05$ for the non-personalized character condition); and for smiling ($t = -2.29$, $p < .03$ for the personalized character condition, and $t = -2.33$, $p < .02$ for the non-personalized character condition). Within the personalized character condition, parents were also significantly less likely to encourage their child to say the character's name over time ($t = -2.06$, $p < .05$). However, there were no significant correlations between parent slope scores for these variables and their children's seriation scores.

Next we ran a regression analysis in the personalized condition using parent's composite smiling score as well as parental encouragement of paw pressing, nurturing parasocial behaviors, and naming the character as predictors of a parasocial relationship in their children (i.e., the nurturing behaviors their child performed with the character). Within the personalized condition, there was a significant effect for parental encouragement of paw pressing on the slope of children's parasocial, nurturing behaviors, $\beta = .47$, $p = .01$. A comparable regression analysis for the non-personalized condition yielded no significant parental predictors for changes in the slope of children's parasocial behaviors.

Discussion

The purpose of this study was to examine the role that personalized interactive characters play in the development of toddlers' relationships with those characters as well as their learning of subsequent cognitive tasks, in this case a seriation task presented on a video. The results suggest that interactive media characters can improve early seriation learning when they are programmed to be similar and responsive to a child. In particular, toddlers who played with interactive toy characters that were programmed to be personalized to the child, such as having the same favorite foods and songs as the child, saying the child's name, and being the same gender as the child, subsequently performed better on a video transfer task when compared to a baseline control group. By contrast, significant improvements in seriation performance did not occur for those in the non-personalized interactive character condition. Although some learning did take place for the non-personalized interactive character condition, toddlers' learning from the non-personalized interactive characters was relatively weak, with learning being significantly enhanced only by personalized interactive characters.

The personalized character matched the child in three areas: gender, personal preferences such as favorite foods and songs, and addressing the child by name. Gender does not appear to be the basis for the outcome found here because there were no differences between boys and girls in their learning from Scout and Violet, respectively. Typically, boys demonstrate a preference for male characters before girls demonstrate a preference for female characters (Calvert & Huston, 1987), though toddlers are somewhat young to demonstrate such patterns. Kohlberg (1966) argued that children do not typically identify their gender until 24 months of age, with this preference for same-sex characters emerging about ages 5 or 6 when gender constancy emerges (Luecke-Aleska, Anderson, Collins, & Schmitt, 1995; Slaby & Frey, 1975). In addition to age, it could also be that gender differences did not occur because the characters were not sufficiently gender typed for children to recognize them as a boy or a girl. In particular, voices play a key role in interactive character development (Strommen & Alexander, 1999). In the current study, both characters interacted with the child through the same boy's voice, and the color cues (a soft violet for the girl and a bright green for the boy) may have been insufficient to override the actual male voice.

Children in the personalized condition could also have learned more than the children in the non-personalized condition because the personalized character shared similar favorites with the child, such as the same favorite food or song (Fawcett & Markson, 2010). For example, one little girl's eyes 'lit up' when she discovered that Violet's favorite food was blueberries, just like hers. Fisch (2004) found that characters who were similar to children fostered more emotional investment and better learning of educational content. Perceived similarity, then, is an important area for future examination with interactive as well as non-interactive characters as an underlying reason for the development of parasocial relationships as well as for learning from media characters (see Hoffner, 2008).

Research also demonstrates that the video deficit, in which children learn better from a live than a video presentation, can be eliminated when a child is directly addressed by name (Troseth et al., 2006). Names are, in fact, a basis for personal identity (Calvert, 2002). Given our efforts to get toddlers to view Scout and Violet as persons, the character's use of the child's name may have been important. In the personalized condition, however, parents decreased their efforts to get their child to say the character's name over time, in part, we think, because of the complexity of saying these particular names at ages 18–21 months.

Another area of importance in this study was to examine how parasocial relationships develop. Growth curve analyses revealed that toddlers in the personalized condition, but not those in the non-personalized condition, increased over time in the development of nurturing, parasocial relationships with their character. Moreover, seriation scores were positively correlated with the increases in slope in the parasocial relationship scores for toddlers in the personalized condition, and parents' overall play with toddlers and their interactive toy was also associated with better seriation performance. These findings suggest that personalized interactive characters enhance learning through the formation of an emotional relationship with children. These emotional parasocial relationships are emerging, in part, through children's experiences with media characters (see also Gola et al., 2013).

The current characters, however, differed from those used in the study by Gola et al. (2013) as Scout and Violet were interactive toys that had never been seen on video by these children before the seriation test video. Moreover, Gola et al. (2013) only had one condition of children who were familiarized with the character, which prevented the comparison of children in different treatment conditions over time for the development of a parasocial relationship. In the current study, we found that the emotional relationship that developed over time with a personalized interactive toy character, not the experience of being familiarized with an interactive character over time *per se*, was the reason for improved learning.

Perhaps the illusion of perceived similarity between the child and the character results in more interest and investment with the character, thereby enhancing learning, particularly if children take the character to be real. Or perhaps cognitive resources are freed up when a character is perceived to be similar to a child, thereby allowing them

to concentrate less on who the character is and more on what the character is doing (see Fisch, 2004; Lauricella et al., 2011). Other research finds developmental differences in the believability that children ascribed to onscreen characters. In particular, 5-year-old children followed a televised computer-generated character's advice just as much as a live adult's advice, but 7- and 9-year-old children followed the live adults' advice more often (Claxton & Ponto, 2013). Moreover, the 5-year-old children believed that the computer-generated image could see them (Claxton & Ponto, 2013). These findings support developmental differences that are typically found in beliefs about animism, i.e., that inanimate objects are real (Piaget, 1954), as well as in the reality status attributed to certain media characters at young ages (Calvert & Richards, 2014; Wright, Huston, Reitz, & Piemyat, 1994).

Toddlers' paw pressing behaviors, which made the character interact with the child, decreased significantly over time in the personalized character condition, but this decrease was unrelated to seriation performance. One problem we observed was that toddlers were initially pressing paws frequently, sometimes before the character could finish their first response to the child. Perhaps over time toddlers were learning to take turns with the character, a facet of interactivity (Rafeli & Ariel, 2007), which could have made their later paw presses with the character more meaningful, though less frequent than in the beginning play sessions. Parents whose children were in the personalized condition also decreased their encouragement of paw pressing and smiled less over time. However, the slope of children's parasocial relationship development with the personalized character was predicted by the parent's encouragement of paw pressing. These findings suggest that paw pressing is a complex behavior that can have positive or negative outcomes and is in need of more study to determine not just how much, but when, children should press a character's paws to maximize their relationship and later learning from an interactive character.

By contrast, parasocial, nurturing behaviors did not significantly increase over time for toddlers in the non-personalized condition, nor were there any other significant increases or decreases in other targeted behaviors over time. In other words, mismatching what a character *does* in relation to who a child *is* created a problem for relationship building and for learning from interactive characters, even at very young ages. Like the parents in the personalized condition, parents in the non-personalized condition also decreased their encouragement of paw pressing by their children, and they too smiled less over time, suggesting that parents in both conditions reacted in a similar way to the characters. This decrease in engagement over time is similarly reported in the survey data that reveals that parents played with their child and the character together less over time. That is, the decrease in smiling and playing together over time may indicate that parents were less likely to enjoy these play sessions over time in both conditions. These results dovetail with findings that parents play less richly with their toddlers in terms of responsiveness and teaching when using interactive versus non-interactive toys (Wooldridge & Shapka, 2012). Alternatively, it is possible that parent smiling decreased over time during play sessions because parents became more accustomed to our visits and smiled as if they would have under more naturalistic circumstances. The impact of interactive toys on the quality of parent–child interaction is a question in need of additional research.

A key limitation of this study was the fact that we personalized the character for the children using several different dimensions. Thus, it is not clear what mechanism explains the improved learning from personalized characters. Future research should tease out which variables are most important for children's parasocial relationships and learning from media characters, using age, gender, personal preferences, and saying the child's name at different points in development. Our procedure also did not randomly assign toddlers to the control group; they were placed in this group when they had prior experience with LeapFrog characters. In addition, the control group had only one home visit whereas the treatment conditions had three visits, providing more opportunities for the treatment conditions than the control condition to interact with the experimenters. Ideally, children in the control condition should have had no prior exposure to the characters and have received the same number of home visits.

Additional information on play with toys beyond the interactive toys would also be useful so that play patterns could be compared for all three conditions, as pretend play is also associated with better cognitive skills (Belsky & Most, 1981). Nevertheless, our control group had significantly higher language skills, an index of cognitive development, than the personalized interactive character condition did, yet the personalized interactive condition performed better than the control group on the seriation task. The causal chain for children's eventual learning from video in the personalized condition might also include parental involvement. One possibility is that parent interest in the personalized character leads to parent interest in playing with the toy and their child, subsequently leading to the child developing a parasocial relationship with the personalized character which may ultimately result in more learning. Future research should explore these possibilities. Finally, our sample was also highly educated. Future research should include more diverse groups of children.

At an applied level, our findings shed light on how interactive media characters can be used to teach seriation skills to very young children in their homes. In particular, the use of personalized interactive toys provides a bridge to later learning from educational videos. These characters also link the home environment and the world of screens (Calvert & Richards, 2014). Educational media are often a relatively low cost way to deliver content to a mass audience of children, yet there is also a substantial cost in producing those programs. Toys are one revenue stream for these productions (Cahn, Kalagian, & Lyon, 2008), and could be viewed as a potential way to fund programs that are of educational benefit to our children when the characters present academically-oriented content onscreen.

In conclusion, this study adds to an emerging body of research which links very young children's parasocial relationships with media characters to their subsequent learning of seriation skills when presented by that character on a screen. In contrast to previous studies (Gola et al., 2013; Lauricella et al., 2011), the character was interactive without a home on a video screen beyond a transfer task. Our results suggest that the benefits of children's real favorite teachers may extend to interactive characters, with children's emotion and caring for their ubiquitous 21st century media friends serving as a basis for that early learning.

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