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# **What Preschoolers Bring to the Show: The Relation Between Viewer Characteristics and Children’s Learning from Educational Television**

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*The capacity model (Fisch, 2000, 2004) is one of the few existing theoretical models developed to explain how children learn from educational television, but it has yet to receive much empirical validation. The model posits that various characteristics of the viewers influence both narrative comprehension and educational content comprehension, two distinct parallel processes. While many studies of media effects and processes control for individual differences, the goal of this study was to investigate several viewer characteristics that are predicted to influence comprehension. Seventy-eight preschool-age children watched a short educational television program and completed assessments of cognitive abilities, interest in the program, prior knowledge related to the program, and comprehension of the program content. Regression analyses revealed general support for Fisch’s predictions that viewer characteristics influence narrative comprehension and educational content comprehension. Results provide an important step in theorizing about children’s learning from educational television.*

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This research was completed while F. Aladé was a graduate student at The Ohio State University School of Communication.

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For the past several decades, scholars and commercial producers alike have been increasingly interested in the various effects, both positive and negative, that television may have on society (Nabi & Oliver, 2010), especially on youth (Wartella, 1999). Sixty-five percent of American 0- to 8-year-olds watch television every day, with preschoolers being among the highest viewers (Rideout, 2013). The viewing trends of American children parallel those among children in other industrialized nations as well (Beentjes, Koolstra, Marseille, & van der Voort, 2001; Szybist, 2011). Preschool television programs that are considered “educational” are particularly popular among this age group (Rideout, 2014). American parents view this as a relatively harmless, and perhaps even beneficial, way to keep their young children entertained (Wartella, Rideout, Lauricella, & Connell, 2013). Because educational television can have a great impact on school-readiness skills, which, in turn, affect subsequent development (Anderson, Huston, Schmitt, Linebarger, & Wright, 2001), there is a great need for understanding how preschoolers learn from this popular type of television.

Although the potential for television to facilitate informal education has been well established, educational programs vary greatly in their effectiveness, especially from viewer to viewer (Anderson, 1998; Thakkar, Garrison, & Christakis, 2006; Woodard, 1999), and there is currently no agreed-upon system for rating the quality of children’s programming (Lauricella, Robb, & Wartella, 2013). Given this wide array of quality, the question remains: How can we help children navigate through the plethora of “educational” programs in a way that allows them to soak up the most knowledge? One key is to have a better understanding of what the children themselves bring to the viewing experience. Although many media effects theorists have acknowledged the importance of individual differences, very few empirical studies have taken them into account in a meaningful way. Empirical studies tend to control for individual differences in pursuit of universal effects (Valkenburg & Peter, 2013b), but in order to gain a full understanding of the media experience, researchers must consider the users as individuals. Television viewers do not just respond to the screen; they also bring their own perceptions and attributions to the viewing experience, which affects their individual experiences with the medium (Salomon, 1983). This study sought to empirically test the relationship between several viewer characteristics and preschoolers’ comprehension of an educational television program.

#### HOW CHILDREN LEARN FROM TELEVISION—A THEORETICAL MODEL

Although the existing literature highlights that children can learn from television, explanations as to *how* children learn from television are limited. In response to

the dearth of theoretical explanations available, Fisch (2000, 2004) put forth the capacity model to explain how children extract and comprehend educational content from television programs. Central to the model is the supposition that working memory is limited. The nature of working memory has been debated, with some defining it as the cognitive space that is used for temporary processing of stimuli and planning (Baddeley, 2012) and others viewing it as equal to or partially overlapping with temporary, short-term memory (Cowan, 2008). Fisch's (2000, 2004) treatment of the working memory concept appears to align with the former definition. In Fisch's (2000, 2004) model, working memory is utilized when children process television content, including selectively attending to certain aspects and integrating them. From his perspective, comprehension is impaired when the demands of processing a television program exceed the capacity of working memory.

According to the model, when children watch educational television, learning is dependent on three factors: (a) processing of the narrative, (b) processing of educational content, and (c) the distance between the educational content and the narrative. Narrative content is defined as the story or plot of the program, whereas educational content is defined as the underlying educational concept or message that the program is intended to convey. Distance refers to the degree to which the educational content is integrated with or tangential to the story. The model suggests that the distance between the narrative and educational content should be as small as possible so that resources can be allocated to both the narrative and educational content at the same time, resulting in better overall comprehension.

In addition to these factors, the capacity model operates under three governing principles. The principle of narrative dominance states that priority is given to comprehension of narrative over educational content. Because the primary purpose of watching television is usually for entertainment, and because the entertainment value of a program usually lies in the narrative, Fisch (2000, 2004) argues that children will allocate resources to processing the narrative first and foremost. The second governing principle states that the amount of resources available for processing educational content is a function of the resources being used to process the narrative. When these parallel processes are in competition with each other, the model predicts that preference will be given to narrative processing, and comprehension of the educational content will suffer. Thus, educational content comprehension is largely dependent on narrative content comprehension. The third governing principle reminds us that resources can be allocated voluntarily between the two processes. Although the default may be narrative dominance, certain motivational factors can influence viewers to allocate resources differently.

Taken together, these factors and governing principles suggest that in order for children to comprehend the educational content of a program, it must be well embedded into the narrative. Many television producers have begun to take heed to these principles. Compared to children's television

years ago, most of today's popular shows for preschoolers are delivering educational content through a central, linear narrative (Akerman, Bryant, & Diaz-Wionczek, 2011). While this likely supports comprehension, it is not the full recipe for success. Summative research has shown that from one viewer to another, we still see greatly varying degrees of learning from even the most well developed programs (Fisch, 2000, 2004). Fisch posited that beyond the governing principles, there are several other features of the viewing experience that influence resource allocation and, in turn, learning.

## VIEWER CHARACTERISTICS AND THE CAPACITY MODEL

Fisch (2004) described two categories of features that influence children's processing of educational television: program characteristics (e.g., complexity of the story, need for inferences, clarity of presentation, explicitness of content, temporal organization, and use of advance organizers) and viewer characteristics (e.g., prior knowledge, story schemas, knowledge of formal features, interest, verbal reasoning ability, and short-term memory). Several studies have investigated the role of program characteristics (e.g., Calvert, Huston, & Wright, 1987; Mandler & Johnson, 1977; Nichols, 2011; van den Broek, Lorch, & Thurlow, 1996); however, research testing the viewer characteristics presented in the capacity model is sparse.

A recent study found strong support for one particular viewer characteristic: story schema skills (Piotrowski, 2014b). Story schema theory is based on the underlying assumption that there is a prototypical story grammar that is present in most narratives (Thorndyke, 1977). The more closely a story corresponds to the prototypical story structure, the more easily people are able to understand and recall the story (Mandler & Johnson, 1977). In a study of preschoolers' learning from educational television, Piotrowski (2014b) found that, as predicted by the capacity model, story schema development was positively related to comprehension of both narrative and educational content. Story schema served as an interpretive tool for understanding the story, such that children with greater story schema skills were more easily able to comprehend the narrative content, which, in turn, allowed for greater allocation of resources to processing the educational content.

The current study focused on several other viewer characteristics presented in the capacity model, with the goal of obtaining a richer understanding of the various individual differences in children that influence comprehension. There are undoubtedly many different individual differences that could affect comprehension. As a starting point, we investigated the specific viewer characteristics that Fisch (2004) mentions in his work.

## Prior Knowledge

One viewer characteristic described in the capacity model is the viewers' prior knowledge of subject matter related to the program. Familiarity with certain situations and settings can facilitate comprehension of new information that matches easily into that prior knowledge structure (Newcomb & Collins, 1979; Spilich, Vesonder, Chiesi, & Voss, 1979). Newcomb and Collins (1979) found that children's comprehension of a televised narrative was enhanced when their ethnic and social class background matched that of the characters and situations portrayed in the program, suggesting that congruence between the narrative and familiar aspects of children's lives can facilitate comprehension of the narrative.

Prior knowledge is highly related to literature on scripts and schemas, that is, organizational knowledge structures that guide encoding, storage, and retrieval (Adams & Worden, 1986). Several studies have found that very young children rely on these scripts and schemas for comprehension and inference-making (Collins & Wellman, 1982; Hudson & Slackman, 1990).

Thus, within the framework of the capacity model, the existence of prior knowledge related to some aspects of the program should allow the content to be assimilated into memory more easily, thereby reducing the demands of processing. There have also been several studies on the role of familiarity in comprehension, another similar concept to prior knowledge. In a study of preschool age children, Piotrowski (2014a) found that program familiarity was highly related to comprehension of an educational television show. Children who had previously been exposed to the stimulus program were familiar with aspects like the characters and the setting, which allowed them to allocate more resources to processing the new educational content. Other studies have also found that familiarity with the program or with the characters in the program led to increased attention (Barr, Zack, Garcia, & Muentener, 2008) and greater transfer of learning (Gola, Richards, Lauricella, & Calvert, 2013; Lauricella, Gola, & Calvert, 2011).

Importantly, Fisch (2004) predicts that prior knowledge will have an effect on both narrative processing and processing of the educational content, two distinct but parallel processes. Existing knowledge structures that are related to the narrative content of the program should facilitate the comprehension of the story events of the stimulus narrative by providing a mental model on which to map the new events. For example, Eckhardt, Wood, and Jacobvitz (1991) found that viewers' recall of the story events in a televised drama about the Underground Railroad was positively related to their prior knowledge about that topic. Therefore, we hypothesized:

H1a: Prior knowledge related to the narrative will be positively related to narrative comprehension.

Similarly, prior knowledge related to the educational content should increase comprehension of the educational material by providing a knowledge base on which to map related new information. For example, a child who has some foundational knowledge of counting and numeracy should be more able to process a simple mathematics lesson embedded in a television program than a child who does not have a basic command of numbers.

H1b: Prior knowledge related to the educational content will be positively related to educational content comprehension.

## Interest

While prior knowledge is expected to increase comprehension by reducing processing demands, Fisch (2000, 2004) predicted that viewers' interest in the program would facilitate comprehension by increasing the overall allocation of resources to processing the program. This prediction is dependent on the third governing principle of the capacity model, which states that viewers can voluntarily allocate working memory resources to processing educational and narrative content if some factor influences them to do so.

Ainley, Hidi, and Berndorff (2002) conceptualized interest as a psychological state characterized by increased attention, concentration, and affect. It is often accompanied by an enduring predisposition to reengage with a particular object, event, or idea (Hidi, 2006). Using this definition, the researchers found that for eighth and ninth grade students using science texts, topic interest was a predictor of persistence with the text, which was, in turn, a strong predictor of learning (Ainley et al., 2002). Similarly, Tobias (1994) pointed to interest as a key link between motivation and cognitive processing. He argued that the motivation to learn brought out by interest in a subject area could lead to increased learning by invoking deeper types of comprehension processes, greater use of imagery, and a more extensive network of relevant associations. Indeed, in an empirical study, Clinton and van den Broek (2012) found that topic interest was positively associated with inference generation, which, in turn, was associated with greater recall and comprehension among students.

Like prior knowledge, Fisch (2004) predicted that interest could reduce the demands of processing both narrative and educational content. For example, if a child interested in solving mysteries comes across a mystery-themed television program, he or she will allocate more resources to processing the narrative than a child who does not have that interest. Thus, we predicted:

H2a: Interest in narrative content will be positively related to narrative comprehension.

Analogously, interest in the educational content should increase allocation of resources to processing that educational content. For example, Renninger (1998) found that among elementary school-age children, interest in mathematics resulted in greater performance on mathematical word problems.

H2b: Interest in educational content will be positively related to educational content comprehension.

### Verbal Ability

According to Fisch (2000, 2004), children's verbal ability is an important predictor of their narrative processing skills. Children with better verbal skills are able to spend fewer resources on processing verbal information, leaving more resources available for processing the narrative. Eckhardt et al. (1991) explained that verbal ability affects comprehension by facilitating word processing. Viewers low in verbal ability must allocate a large amount of resources to processing the lexical content of the program. Viewers high in verbal ability, on the other hand, benefit from automaticity of processing lexical content and, therefore, can devote more working memory resources to higher-level comprehension. Accordingly, Jacobvitz, Wood, and Albin (1991) found that 5-year-olds' expressive verbal ability accounted for 42% of the variance in their comprehension of the narrative of an age-appropriate television show. These findings are not limited to televised narratives; greater verbal ability is related to superior reading comprehension as well (Lervag & Aukrust, 2010; Song et al., 2015).

More generally, higher verbal ability is believed to reflect advanced information processing skills. Vocabulary acquisition requires children to recognize novel words, form cognitive representations of word forms, and pair word representations with conceptual or semantic information (Dollaghan, 1985; Gupta & MacWhinney, 1997). Children who acquire novel words quickly and easily should have greater facility in processing stories, both written and visual. For these reasons, we predicted:

H3a: Verbal ability will be positively related to narrative comprehension.

Fisch (2004) made specific predictions about how cognitive abilities would affect narrative processing, but he made no mention of how these abilities might directly affect the processing of educational content. Although not described in the model, there may be a direct link between verbal ability and educational content comprehension. The educational content is, after all, delivered verbally, and so reducing the demands of lexical processing should also be associated with increased comprehension of the educational content. Thus, we proposed the following as an extension of the model:



H3b: Verbal ability will be positively related to educational content comprehension.

### Short-Term Memory

In Fisch's (2000, 2004) model, short-term memory, like verbal ability, should also increase children's comprehension by facilitating more efficient use of working memory resources and, thus, allowing them to understand the story more easily. Studies in developmental psychology have found that short-term memory is a strong predictor of early learning (Alloway et al., 2005; Gathercole, Pickering, Knight, & Stegmann, 2004). Gathercole and colleagues (2004) explained that the intellectual processes required for learning academic content are constrained by the learner's short-term memory capacity. In investigating the effect of children's cognitive skills on comprehension of a televised narrative, Jacobvitz et al. (1991) found that second to verbal skills, visual short-term memory skills were the next best predictor of comprehension. Thus, the expectation here is that short-term memory skills should facilitate processing of narrative content by increasing overall capacity of available working memory and decreasing the demands of processing visual content.

H4a: Short-term memory will be positively related to narrative comprehension.

As with verbal ability, we expected that memory might also be directly related to educational content comprehension, although this possibility is not explicitly mentioned in the capacity model. Fisch (2000, 2004) did note that one way to increase educational content comprehension is to increase the overall allocation of resources to the educational material. This should be accomplished by lessening the demands of memory. Thus, we proposed:

H4b: Short-term memory will be positively related to educational content comprehension.

### Narrative Comprehension as a Mediator

As previously mentioned, the first two governing principles of the capacity model suggest that because children watch television with the primary purpose of entertainment, working memory resources are always allocated to processing narrative content before processing educational content (Fisch, 2000, 2004). Thus, when the two processes are in competition, priority is given to the processing of the narrative. Therefore, it can be argued that comprehension of the educational content is dependent on a child's understanding of the narrative. Following the logic of this principle, children who expend minimal cognitive resources processing the narrative will have a greater amount of

resources left over to process the educational content compared to their peers who have a more difficult time processing the narrative. For example, Piotrowski (2014b) found that story schema development led not only to an increase in narrative comprehension, as predicted by the capacity model, but also to an increase in educational content comprehension. For children with well-developed story schema, fewer resources were required to process the narrative, which meant that more resources were allocated to processing the educational content. One possible way to interpret this is to say that narrative comprehension mediated the relationship between story schema skills and educational content comprehension. We expected the same to occur with each of the viewer characteristics being investigated in this study.

H5: Viewer characteristics will have an indirect effect on educational content comprehension via narrative comprehension.

## METHOD

### Participants

A total of 78 preschool-age children (51.8% male) ranging in age from 38 to 66 months ( $M = 52.16$ ,  $SD = 7.72$ ) were recruited from four childcare facilities in a large Midwestern city in the United States. After receiving approval from the university's institutional review board, we contacted directors of local preschools and daycare centers and asked if they would be interested in having their school participate. Once school directors agreed to participate, information about the research was distributed to parents. Response rates across the preschools ranged from 24% to 75%. Of the 83 children whose parents granted consent, 3 children were unable to participate due to scheduling conflicts, and 2 children did not want to complete the testing session, resulting in the final sample of 78 children. The majority of parents reported their child's race as Caucasian (72%), were very highly educated (60% reported having a graduate degree), and reported a relatively high annual household income (55% reported over \$100,000). Table 1 contains the sample's demographic information.

### Stimulus

Given the constraints of recruiting and conducting research with very young children (Boyden & Ennew, 1997; Greig, Taylor, & MacKay, 2007), we chose to use one stimulus program for this study. *The Cat in the Hat Knows A Lot About That!* is a television series designed to teach science and math concepts to preschool-age children (PBS, n.d.). In each episode, the Cat in the Hat and his friends Sally and Nick go on an adventure where they learn about science by asking questions, making observations, and discussing ideas about how the

**TABLE 1** Sample demographics

Variable	Min.	Max.	Mean ( <i>SD</i> )	Frequency	Percentage
Child's age in months	38	78	52.31 (8.10)		
Child's sex					
Males				43	51.8
Females				39	47.0
Child Race					
White				60	72.3
Black				3	3.6
Hispanic				1	1.2
Asian/Pacific Islander				11	13.3
Multiracial				8	9.6
Parent's relationship to child					
Mother				69	84.1
Father				13	15.9
Parent's age in years	20	49	36.91 (5.21)		
Parent's education					
High school/GED				1	1.2
Some college				10	12.2
College degree				18	22
Some graduate school				4	4.9
Graduate degree				49	59.8
Household Income					
25,000–49,000				7	8.5
50,000–99,000				30	36.6
100,000–149,000				23	28.0
150,000–199,000				11	13.4
200,000 or more				11	13.4

world works (PBS, *n.d.*). This program was chosen as the stimulus because it (a) targets preschool-age children, (b) includes highly integrated narrative and educational content, and (c) teaches concrete educational lessons that many preschoolers are likely to be unfamiliar with. Each half-hour episode consists of two 11-minute animated adventures that revolve around a specific science concept such as bird migration or animal camouflage.

The 11-minute adventure chosen for this study was called “I Love the Nightlife!” In it, the Cat in the Hat takes Nick and Sally on an all-night adventure, where they meet and learn about a variety of nocturnal animals. The educational objective of this adventure is to teach children that nocturnal animals sleep during the day and hunt for food at night using specialized skills (PBS, *n.d.*). In an informal survey, several parents of preschool-age children indicated that their child had not yet learned about nocturnal animals. As mentioned, the educational content was highly integrated into the narrative. For example, the overarching storyline of this adventure is that the Cat in the Hat has lost his hat, and Nick and Sally are helping him find it. When they encounter an owl in the forest, they learn that owls have special eyes that allow them to hunt for food in the dark, and so the team use special “owl eye goggles” that allow them to continue searching for the Cat’s hat even though it is very dark outside.

## Procedure

Parents of participating children completed a brief questionnaire assessing demographic information, family media habits, and other family activities. Then, children were tested individually in a quiet space at their schools. First, children completed pre-viewing assessments (verbal ability, short-term memory, interest, and prior knowledge). Then they watched the stimulus episode on a portable DVD player before, finally, completing post-viewing assessments (narrative comprehension and educational content comprehension). Each session ran approximately 30 minutes.

## Assessments and Measures: Independent Variables

### VERBAL ABILITY

The Picture Naming Individual Growth and Development Indicator (Missall & McConnell, 2004) was used as the measure of verbal ability. This expressive vocabulary measure has been shown to be sensitive to children's development and correlates with other standardized measures of language development and literacy, including the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997;  $r(88) = .56$  to  $.75$ ,  $p < .001$ ) and the Preschool Language Scale (Zimmerman, Steiner, & Pond, 1992;  $r(88) = .63$  to  $.79$ ,  $p < .001$ ; Missall & McConnell, 2004). To complete the Picture Naming task, each child was presented with flashcards of color pictures of objects (e.g., food, animals, household objects, clothing) and asked to name as many as they could in one minute. Following procedures outlined by Missall and McConnell (2004), four standard sample cards were used to demonstrate the task and confirm the child's understanding. Then the child was presented with the cards in a random order until one minute had elapsed. The number of pictures named correctly in one minute served as the child's verbal ability score ( $M = 20.49$ ,  $SD = 5.78$ , range = 6–36).

### SHORT-TERM MEMORY

It has been argued that storage processes for short-term memory should be separated into distinct verbal and visuospatial constructs (Alloway, Gathercole, & Pickering, 2006). Therefore, we measured both verbal and visuospatial short-term memory.

*Digit Recall.* The digit recall task (Pickering & Gathercole, 2001) was used to assess verbal short-term memory. For this assessment, the researcher said aloud a sequence of digits and asked the child to recall the digits in the correct order. Each level in this task consisted of three different sequences, each with the same number of digits. Each child had three chances to correctly recall one of these sequences. If a sequence was recalled correctly, the child moved on to the next level, where an additional digit was added to each sequence. Testing

continued until the child failed to recall a sequence or correctly recalled all three sequences at the highest level. For children aged 4.5 years, test–retest reliability of this assessment is 0.84 (Alloway et al., 2006). Participants received one point for every level they successfully completed, resulting in a possible range of 0 to 4 points, ( $M = 3.46$ ,  $SD = 0.66$ , range = 2–4).

*Block Recall.* In order to assess visuospatial short-term memory, this study utilized an adaptation of the block recall task (Archibald & Gathercole, 2006). The researcher tapped out a sequence on a two-dimensional picture of blocks and then asked the participant to “point to the same blocks, just like I did.” Testing began with a single block tap and increased by one additional block until the child failed to reproduce a series of taps. For children aged 4.5 years, test–retest reliability of this assessment is 0.83 (Alloway et al., 2006). Like the digit recall task, participants received three different trials at each level, and received one point for every level completed, ( $M = 2.22$ ,  $SD = 1.12$ , range = 0–4). Digit recall and block recall were summed to create a short-term memory index ( $M = 5.67$ ,  $SD = 1.54$ , range = 2–8).

#### PRIOR KNOWLEDGE

This assessment consisted of open-ended questions that were developed to reflect the important themes, related to both narrative and educational content, of the stimulus episode. Identified themes included: sleepover party, the Cat finding his hat, using our different senses to find things in the dark, nocturnal animals, and animals using specialized skills to find food. These themes were representative of the episode overview and educational objective provided on the show’s accompanying parents’ website (PBS, n.d.). For analysis, this assessment was separated into two subscales: a measure of prior knowledge related to the narrative content (3 items, e.g., “What kinds of things do people do at a sleepover party?”) and a measure of prior knowledge related to the educational content (4 items, e.g., “Can you name any nocturnal animals?”). Each open-ended response was awarded up to two points. Answers that demonstrated substantial familiarity with the concept (e.g., “read scary stories, eat popcorn, and sleep in a sleeping bag”; “owls and raccoons”) received two points, answers that demonstrated a very limited understanding of the concept (e.g., “sleep and that’s all”; “some types of birds”) received one point, and no answer or answers that did not demonstrate any familiarity with the concept (e.g., “hearts and flowers”; “a bear”) received zero points. Two trained researchers established inter-rater reliability for 10% of the open-ended responses (Cohen’s  $K = 0.86$ ) before the primary coder coded the rest. The three items designed to assess prior knowledge about the narrative were summed to create an index ( $M = 3.76$ ,  $SD = 1.45$ , range = 0–6), and the four items designed to assess prior knowledge related to the educational content were summed to create an index ( $M = 2.01$ ,  $SD = 2.17$ , range = 0–8).

## INTEREST

Two subscales were developed to assess interest in the narrative content and interest in the educational content, respectively. Interest in the narrative was operationalized as the participants' willingness to engage in the types of activities portrayed in the narrative (e.g., "How much would you like to have a sleepover party?"). This measure consisted of three questions with a 4-point Likert response scale. Response options included *not at all* (coded as 0), *a little* (1), *a lot* (2), and *a whole lot* (3) with corresponding hand gestures to aid in the children's understanding. The three questions were summed to create an index of interest in the narrative ( $M = 5.28$ ,  $SD = 2.81$ , range = 0–9).

Interest in the educational content was operationalized as the participants' interest in learning about the different educational themes portrayed in the episode (e.g., "How much would you like to learn about how we use our senses, like seeing, hearing, and smelling?"). Like interest in the narrative, this measure consisted of three questions with a 4-point Likert response scale ranging from *not at all* (0) to *a whole lot* (3) with corresponding hand gestures. The three questions were summed to create an index of interest in the educational content ( $M = 5.67$ ,  $SD = 3.11$ , range = 0–9).

## Assessments and Measures: Dependent Variables

## NARRATIVE COMPREHENSION

A narrative comprehension assessment was created to evaluate how much central content (i.e., that which is central to the plot) participants were able to understand and recall from the stimulus episode (Collins, Wellman, Keniston, & Westby, 1978). In order to develop an initial list of questions, one of the researchers viewed the episode and drafted as many items as possible corresponding to plot events throughout the episode. Similar to procedures developed by Collins et al. (1978), 10 adult judges viewed the program episode and were asked to rate whether they felt the questions assessed central, incidental, or inferential content. Questions that were rated as central content with a minimum agreement of 80% across judges were eligible for inclusion. An effort was made to ensure that questions were representative of the entirety of the episode.

The final assessment consisted of 10 questions in total, such as, "Which animal did Nick, Sally, and the Cat hear with their special bat ears?" For each of the questions, the child was provided with three pictorial response options. Comparative to verbal response options, pictorial response options have been shown superior when working with young children (Linebarger & Piotrowski, 2009). Several episodes of *The Cat in the Hat Knows A Lot About That* were digitally captured to create screen shots of episode scenes. These screen shots were edited to create stylistically equivalent pictorial response options. Correct answers received one point, and incorrect answers received zero points. A composite

score was created by summing responses to the ten questions, with higher composite scores reflecting greater comprehension ( $M = 7.71$ ,  $SD = 1.59$ , range = 2–10).

#### EDUCATIONAL CONTENT COMPREHENSION

An educational comprehension assessment was created to evaluate how much of the educational content presented in the episode participants were able to learn and recall. The website of *The Cat in the Hat Knows A Lot About That!* describes the educational objectives of the series and of each episode (PBS, n. d.). Using these objectives as a guide, several multiple-choice and open-ended questions assessing the educational content of the episode were developed. These questions were pretested to determine face validity by asking 10 adult judges to rate whether or not the answers could clearly be ascertained from the episode. Questions with at least 80% agreement were eligible for inclusion.

The final assessment consisted of five multiple choice questions, e.g., “Who is the best at seeing in the dark—humans, owls, or bats?” and five open-ended questions, e.g., “What does *nocturnal* mean?” For multiple-choice questions, pictorial response options were provided. Correct answers received one point, and incorrect answers received zero points. For open-ended questions, children were provided with an orienting image and asked to provide their own verbal response. Two trained researchers established inter-rater reliability for ten percent of the open-ended responses (Cohen’s  $K = 1.00$ ) before the primary coder coded the rest. Fully correct answers received two points, answers that were feasible responses but not completely accurate received one point, and no answer or answers that were irrelevant or unfeasible received zero points. A composite score was created by summing responses to the ten questions. Higher composite scores reflected greater comprehension, ( $M = 7.63$ ,  $SD = 4.19$ , range = 0–15).

## RESULTS

Two hierarchical multiple regression models were planned to test Hypotheses 1–4, one with narrative comprehension as the dependent variable and the other with educational content comprehension as the dependent variable. Because the child’s sex, the parent’s education level, and the household income were significantly correlated with at least one of the outcome variables (Pearson’s  $r$  with  $p < .05$ ), they were entered into the first block of each analysis as covariates. The main predictors were entered together at the second step of each regression equation. Model assumptions were tested and confirmed prior to analysis. A priori power analyses indicated that the sample size was sufficient to detect small effects ( $f = .15$ ) with a power of .75 (Cohen, 1988), however, post hoc power calculations indicated that the models achieved an observed power of .98 (Soper, 2015). Tables 2 and 3 summarize the results.

The overall model predicting narrative comprehension was statistically significant with 30% of variance explained ( $F(7,69) = 4.71, p = .001$ ). The block of control variables accounted for a non-significant 5% of the variance in narrative comprehension ( $F(3,73) = 1.28, p = .289$ ). At the second step, we found that prior knowledge related to the narrative ( $B = .27, \beta = .25, p = .035$ ), verbal ability ( $B = .09, \beta = .34, p = .009$ ), and short-term memory ( $B = .32, \beta = .31, p = .013$ ) were significantly related to narrative comprehension, providing support for Hypotheses 1a, 3a, and 4a. However, interest in the narrative was not a significant predictor of narrative comprehension ( $B = -.04, \beta = -.08, p = .482$ ).

The overall model predicting educational content comprehension was also statistically significant, with 63% of variance explained ( $F(7,69) = 16.86, p < .001$ ). The block of control variables accounted for a nonsignificant 6% of the variance in educational content comprehension ( $F(3,73) = 1.54, p = .212$ ). Prior knowledge related to the educational content ( $B = .77, \beta = .40, p < .001$ ),

**TABLE 2** Relation between viewer characteristics and narrative comprehension

Control variables (Block 1)	B	SE	$\beta$	$R^2$ change
Child's sex (male = 1, female = 2)	-.67	.35	-.22	
Parent's education	.07	.16	.06	
Household income	-.09	.17	-.06	
Total				.05
Independent variables (Block 2)				
Prior knowledge related to the narrative	.27*	.13	.25*	
Interest in the narrative	-.04	.06	-.08	
Verbal ability	.09*	.03	.34*	
Short-term memory	.32*	.13	.31*	
Total				.25**

Dependent variable: narrative comprehension.

\* $p < .05$ , \*\* $p < .001$ .

**TABLE 3** Relation between viewer characteristics and educational content comprehension

Control variables (Block 1)	B	SE	$\beta$	$R^2$ change
Child's sex (male = 1, female = 2)	-1.3	.92	-.16	
Parent's education	-.47	.43	-.14	
Household income	.55	.43	.16	
Total				.06
Independent variables (Block 2)				
Prior knowledge related to the educational content	1.12**	.19	.58**	
Interest in the educational content	-.04	.13	-.03	
Verbal ability	.21*	.07	.29*	
Short-term memory	1.09**	.24	.41**	
Total				.57**

Dependent variable: educational content comprehension.

\* $p < .05$ , \*\* $p < .001$ .



verbal ability ( $B = .19, \beta = .26, p = .009$ ), and short-term memory ( $B = 1.05, \beta = .39, p < .001$ ) were significantly related to educational content comprehension, providing support for Hypotheses 1b, 3b, and 4b. However, interest in the educational content was not significantly related to educational content comprehension ( $B = -.04, \beta = -.03, p = .755$ ).

To address Hypothesis 5, which predicted that the viewer characteristics would have an indirect effect on educational content comprehension through narrative comprehension, mediation analyses were conducted using PROCESS for SPSS (Hayes, 2009). PROCESS uses ordinary least squares regression to generate the direct and indirect effects of some predictor  $X$  on some outcome  $Y$  along with the linear models used to estimate these effects. This bootstrapping method is recommended for small sample sizes because it does not assume a normal distribution, and it has been shown to have greater statistical power compared to the causal steps approach to testing intervening variables (Hayes, 2009). Three separate mediation models were tested, and all analyses were based on 1,000 bootstrap samples. Table 4 summarizes the results.

The first model tested whether narrative comprehension would mediate the relation between verbal ability and educational content comprehension. The indirect effect of verbal ability on educational content comprehension through narrative comprehension was significant,  $\beta = 0.08$ , 95% confidence interval [CI] (0.02, 0.19). As predicted by Hypothesis 3b, there was also a direct effect of verbal ability on educational content comprehension, indicating partial mediation. The second model tested whether narrative comprehension would mediate the relation between short-term memory and educational content comprehension. The indirect effect of short-term memory on educational content comprehension through narrative comprehension was significant,  $\beta = 0.28$ , 95% CI (0.03, 0.65). As predicted by Hypothesis 4b, there was also evidence of a direct effect of short-term memory on educational content comprehension, indicating partial mediation. The third mediation model tested whether narrative comprehension would mediate the relation between prior knowledge related to the narrative and educational content

**TABLE 4** Direct and indirect effects of viewer characteristics on educational content comprehension

Variable	Indirect effect		Direct effect	
	$\beta$	95% CI	$\beta$	95% CI
Verbal ability	.08*	[.02, .19]	.32*	[.17, .47]
Short-term memory	.28*	[.03, .65]	1.42*	[.91, 1.93]
Prior knowledge related to the narrative	.39*	[.11, .74]	.46	[-.16, 1.08]

Dependent variable: educational content comprehension.

Intervening variable: narrative comprehension.

Note. All analyses based on 1000 bootstrap samples.

\* $p < .05$ .

comprehension. The indirect effect of prior knowledge related to the narrative on educational content comprehension through narrative comprehension was significant,  $\beta = 0.39$ , 95% CI (0.11, 0.74). There was no direct effect, which indicated complete mediation. Together, these three models provided full support for Hypothesis 5.

## DISCUSSION

The goal of this study was to empirically test several of the predictions of Fisch's (2000, 2004) capacity model, focusing on the relation between viewer characteristics and comprehension. The capacity model describes how certain viewer characteristics can influence the allocation of cognitive resources to two parallel processes: narrative comprehension and educational content comprehension. Overall, the data presented here generally provided support for the influence of viewer characteristics given a situation where educational content is well embedded into the narrative. First, we tested Fisch's (2004) predictions that verbal ability, short-term memory, prior knowledge related to the narrative, and interest in the narrative would be positively related to narrative comprehension. With the exception of interest, these hypotheses were supported. Next, we tested Fisch's (2004) predictions that prior knowledge related to the educational content and interest in the educational content would be positively related to educational content comprehension. The role of prior knowledge was supported, but here again, interest was not found to be a significant predictor. We also extended Fisch's (2004) predictions by testing whether verbal ability and memory would be directly related to educational content comprehension, and these hypotheses were supported. Finally, we used mediation analyses to begin to investigate Fisch's (2000, 2004) theoretical principle of narrative dominance. Verbal ability, short-term memory, and prior knowledge related to the narrative were found to have an indirect influence on educational content comprehension through narrative comprehension, providing some initial support for the principle. Together, these findings show strong empirical support for the important role of viewer characteristics as proposed in the capacity model. The viewer characteristics explained 30% of the variance in narrative comprehension and 63% of the variance in educational content comprehension, suggesting that Fisch's (2004) predictions about which viewer characteristics would influence comprehension were quite comprehensive.

Prior knowledge related to the narrative and to the educational content were found to be significant predictors of narrative comprehension and educational content comprehension, respectively. This represents an important extension of previous studies, which demonstrated that familiarity with the stimulus program facilitated comprehension (e.g., Barr et al., 2008; Crawley et al., 2002; Piotrowski, 2014a). The findings suggest that the importance of familiarity is not limited to familiarity with the particular program. Familiarity

with the general concepts presented in the program can also facilitate greater comprehension. This finding aligns closely with research done in the domain of scripts and schemas (Adams & Worden, 1986; Collins & Wellman, 1982; Spilich et al., 1979). Rather than learning completely novel concepts, which might require repeated exposure, children who had some prior knowledge related to the program were able to retain the concepts and information, even in a one-time exposure situation, because they had a pre-existing mental structure for storing the new information.

Conversely, interest was not found to be a significant predictor of comprehension. This is likely due to the fact that there is no clear, agreed-upon conceptualization of interest. While we operationalized interest as the child's willingness to engage in a particular activity, other scholars have defined interest in terms of attention (Ainley et al., 2002), motivation (Tobias, 1994), and engagement (Clinton & van den Broek, 2012), all operationalized in different ways. The interest assessment that we used was created especially for this study and, thus, its validity had not been established. Further, we utilized a self-report measure of interest, which may have been inappropriate given the age of the participants. Studies have shown that preschool-age children are still developing the ability to accurately report information about their own mental states (Birch & Bloom, 2004; Casey, 1993). Perhaps direct measures of attention or engagement, such as monitoring children's eye gaze or heart rate, would reveal patterns of interest that are historically difficult to capture via children's self-report. Future research should seek to refine the conceptualization of interest and come up with alternative operationalizations to be tested within the framework of the capacity model.

Looking at the cognitive abilities discussed in the capacity model, the data presented here align closely with prior research in that verbal ability and short-term memory were significantly related to narrative comprehension. Although we did not directly measure the allocation of working memory resources, these findings are consistent with Fisch's (2000, 2004) assertion that children with more highly developed cognitive skills were able to allocate fewer resources to basic vocabulary comprehension and concept recall, and were therefore able to allocate more resources to higher level comprehension. This is consistent with existing research that has shown that reduced narrative processing demands were associated with greater comprehension (e.g., Gathercole et al., 2004; Jacobvitz et al., 1991; Piotrowski, 2014b). Taken together, these findings provide evidence for Fisch's assertion that content must be presented via age-appropriate language and at levels of difficulty that are tailored to children's level of development. If children are presented with information that is too cognitively taxing, either linguistically or due to a complex storyline, it is very unlikely that they will be able to comprehend the embedded educational lesson.

Importantly, these data also provided some initial support for the concept of narrative dominance, one of the governing principles of the capacity

model. The significant mediation effects suggested that narrative comprehension acted as the mechanism through which several viewer characteristics affected comprehension of the educational content. Although not a direct test of narrative dominance, these mediation effects are consistent with Fisch's (2000, 2004) prediction that when fewer resources are necessary for processing the narrative, more resources can be allocated to processing the educational content, resulting in greater comprehension of the educational material. In this study, verbal ability, short-term memory, and prior knowledge related to the narrative successfully facilitated narrative comprehension in such a way as to produce this effect. These helpers of narrative processing allowed a greater proportion of the cognitive resource pool to be allocated to processing of the educational content.

## Implications

Despite the increasing presence of media in young children's lives (Rideout, 2013) and a growing concern about the effects of media on children (Anderson, Levin, & Lorch, 1977; Mares & Woodard, 2005; Paik & Comstock, 1994; Strasburger, Jordan, & Donnerstein, 2010; Thakkar et al., 2006), few scholars have attempted to theorize about how children process media content. This study offers an important theoretical contribution by adding to the small but growing body of empirical evidence that supports the idea that narrative comprehension and educational content comprehension are two distinct processes worthy of individual attention. Moreover, while previous studies testing the capacity model have alluded to the importance of narrative dominance (Linebarger & Piotrowski, 2010; Piotrowski, 2014b), this is the first study to formally investigate this principle by using a statistical mediation model. This study also represents an important move towards research that focuses on individual differences rather than simply controlling for them, an idea that has recently been gaining traction in the communication field (Valkenburg & Peter, 2013a, 2013b).

In addition to its theoretical contributions, this research has several practical implications. Our findings can help to inform parents and educators about the most effective ways to incorporate educational television into children's daily routines. For example, the effect of prior knowledge on comprehension suggests that educational television shows might be useful in supplementing in-school learning. If a child views a television show that focuses on content similar to what is being taught in school, the child will be more likely to learn and retain the information. While the idea of educational technology as a supplement to classroom learning is certainly not new, previous school-based media interventions have seen varying levels of success (Jennings, Hooker, & Linebarger, 2009; Linebarger, Kosanic, Greenwood, & Doku, 2004; Linebarger & Piotrowski, 2009; Penuel et al., 2012). In a study by Linebarger and Piotrowski (2009), classroom teachers were told not to discuss

any of the information being presented in the stimuli because the researchers were investigating the impact of the educational television programs alone. Although they did see moderate effects of repeated viewing, our study suggests that media will be most effective when it comes after classroom instruction, once children have had the opportunity to develop a mental schema on which to map the information presented in the program.

There are also several key takeaway points for producers of educational television. In continuing to think about the importance of prior knowledge, our findings suggest that, whenever possible, programs should present new material within structures that are familiar to children. This aligns closely with prior research that has found that content delivered by familiar, socially relevant characters is more easily processed than content delivered by unfamiliar characters (Gola et al., 2013; Lauricella et al., 2011; Troseth, Saylor, & Archer, 2006). Also concurrent with previous work (Linebarger & Piotrowski, 2010; Mott, Callaway, Zettlemoyer, Lee, & Lester, 1999; Piotrowski, 2014b), support for the principle of narrative dominance indicates that no matter how well developed the educational content of a show is, children will not be able to process and learn that content fully if they are not able to easily process the narrative. Our findings suggest that producers of educational television should make every effort to ensure that educational content is built into an entertaining and easy to understand narrative.

### Limitations and Areas for Future Research

Future research should test the capacity model in a more economically diverse, nationally representative sample and with various stimuli in order to see if the tenets of the capacity model are applicable to all children and all programs. It must also be noted that although we used established scales wherever possible, the measures for prior knowledge and interest were developed specifically for this study, and, therefore, we do not have information about the construct validity or test-retest reliability of these measures. Finally, given the debates surrounding the conceptualization of working memory, we must acknowledge that other interpretations of our findings are viable. Fisch (2000) views working memory and short-term memory as distinct, with short-term memory skills reducing the processing burdens of working memory. However, other scholars view short-term memory and working memory as at least partially overlapping. Until more clarity on the distinction between working memory and short-term memory is achieved, we can only say for certain that memory capacity of some sort affects children's understanding of educational television. Future research should build on this work to examine the unique influences of short-term memory and working memory on children's comprehension of educational television.

## Conclusion

Overall, this study provides a significant contribution to the children and media literature as it supports the use of Fisch's (2000, 2004) capacity model as a framework for understanding how children learn from educational television. Although there is a large body of research on the effects of media on children, less work has been done to understand the causal mechanisms through which these effects occur. Guided by developmental theory (Bandura, 1986) and information processing theory (Lang, 2000), the capacity model offers a nuanced understanding of young children's experiences with educational television. The findings here provide encouraging support for the explanatory power of the capacity model, especially in the context of individual differences, and for the continued study of the educational potential of well-made, age-appropriate media for children.

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