Psychology of Popular Media

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What Does the Cat in the Hat Know About That? An Analysis of the Educational and Unrealistic Content of Children's Narrative Science Media

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Educational media can be a helpful supplement to early childhood education, especially for science, which is not as supported as other topics in classrooms and home environments. However, narrative educational media often contain unrealistic or fantastical elements, which may make it challenging for children to extract the target educational lessons. To document the nature of children's science educational media, we conducted a quantitative content analysis of books (n = 110) and videos (n = 142) with narrative content aimed at teaching science to children in preschool and early elementary school. We found that these media primarily teach about animals (including dinosaurs) and astronomy, leaving many science topics unexplored. In addition, 81% of these media contain at least 1 unrealistic or fantastical element, and these elements often intersect with the media's target educational material (e.g., media teaching about animals were more likely to contain anthropomorphic animals). This work provides a baseline for understanding how media teach about science and paves the way for future empirical work on this topic.

Public Policy Relevance Statement

Educational media, which are widely available to children of diverse cultural and socioeconomic backgrounds, can supplement early science education. But even though these stories are designed to be educational, they often contain unrealistic elements, such as talking animals. This study quantifies the educational and unrealistic content of stories designed to teach science, taking a first step toward understanding how such media can be used to help young children learn science.

Keywords: media, content analysis, fantasy, science education, learning

Since *Sesame Street* first aired in 1969, educational media have become increasingly important to the early childhood education landscape. Parents endorse educational media as a critical resource for preparing their children to enter formal education (Patterson, 2014; Vittrup et al., 2016), and approximately 40% of children in the United States watch educational media daily (Rideout, 2014). Furthermore, many publications aimed at teachers recommend the use of commercially available storybooks to supplement their presentation of educational material (Monhardt & Monhardt, 2006; Pennell et al., 2018; Pringle & Lamme, 2005; Rice, 2002).

Given this, we should carefully examine the type and quality of educational media that children are consuming. To help address this goal, the current study focuses specifically on educational media that are designed to teach about science. U.S. students consistently score lower than students from other countries on standardized tests of science (National Center for Education Statistics, 2018). Unfortunately, parents and early childhood educators report feeling ill-equipped to support children's science learning and being uncomfortable with teaching science topics (Banilower et al., 2013; Gerde et al., 2018; Silander et al., 2018). Science media could thus fill a crucial gap for promoting science knowledge in young children (Trundle, 2009). As a first step toward understanding children's learning of science from educational media, this study presents a quantitative content analysis of print and screen media that aim to teach science to young children.

This study specifically focuses on *narrative* media that teach science, such as *The Magic School Bus*, a series of books and TV shows in which a classroom of elementary school children explores aspects of the natural world via a magical school bus that can change its form (e.g., becoming a spaceship to allow them to explore the solar system). Unlike nonnarrative media (e.g., documentaries such as Disney's *Oceans* or factual books such as the ones published by National Geographic Kids), narrative (and especially fictional) media pose a particular challenge for

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children's learning: Stories often contain distortions to reality and/or unrealistic elements, so children cannot straightforwardly accept everything portrayed in the story as true. These unrealistic elements are often included on the assumption that they will appeal to children and increase their attention to the story and hence enhance their learning (Lepper et al., 1990; Parker & Lepper, 1992). Although some judicious use of unrealistic elements may indeed enhance children's learning (Fisch, 2000), young children may not yet understand how to separate the story's fantasy elements, which do not apply to reality (e.g., a school bus that transforms into a spaceship), from the story's target educational content, which do apply to reality (e.g., information about the asteroid belt). Because of this, the current study aims to explore the presence of unrealistic elements in children's science media to better understand how such elements might impact children's learning.

Children's Learning From Educational Media

Developmental research suggests that educational media are effective for teaching a wide range of topics (see Hopkins & Weisberg, 2017, for review). With respect to science, Ganea et al. (2011) found that 3- and 4-year-olds learned a new ecological principle (the role of color camouflage in a predator–prey system) from a brief storybook. Similarly, Kelemen et al. (2014) found that 5- to 8-year-olds' understanding of natural selection improved significantly after listening to a story that described the workings of natural selection in a fictional animal population (see also Emmons et al., 2018; Shtulman et al., 2016). Consuming science media has also been shown to improve children's motivation to learn science (Barak et al., 2011).

With respect to videos, previous work has shown that TV shows can also effectively teach children about science (Aladé & Nathanson, 2016; Bonus, 2019; Bonus & Watts, 2021). For example, a Public Broadcasting System (PBS) review found that 82% of studies investigating PBS-produced science content showed that this content had significant positive effects on learning (PBS Education, 2015). Because both print and screen science media could be used to supplement children's early science education, it is important to understand which science topics are represented in media aimed at young children. That is the first goal of this content analysis.

Impact of Unrealistic Story Elements on Learning

Recent investigations have revealed that up to 90% of children's media contain at least one unrealistic element (Bonus & Mares, 2018; Goldstein & Alperson, 2020; Marriott, 2002; Taggart et al., 2019). As noted earlier, the presence of such unrealistic elements in children's media may make it more difficult for children to parse out which aspects of the story should be learned and transferred to the real world (e.g., dinosaurs exist) and which should not (e.g., dragons do not exist). This conflict is known as the "reader's dilemma" (Hopkins & Weisberg, 2017). Although this dilemma occurs for all consumers of fiction as they decide how the information in a story interacts with real life, it may be particularly acute when children consume science media. Science information often contradicts children's naive beliefs about the way the world functions and hence may appear unrealistic even though it is true (Carey, 2000; Shtulman, 2017). For example, children often have great difficulty accepting that the Earth is round because to them it appears to be flat (Vosniadou & Brewer, 1992). Although media can accurately depict the shape of the Earth, children may not fully accept this information, especially if it is presented in concert with other events that children know to be impossible.

For example, anthropomorphism (i.e., the depiction of nonhuman animals and objects with human traits, capacities, and behaviors) is extremely common in children's media; a 2019 content analysis of popular children's media found that 75% of children's TV shows contained anthropomorphic characters (Taggart et al., 2019). But anthropomorphic depictions of animals have been shown to distort the way children think about the biological world (Bonus, 2019; Ganea et al., 2014; Kotaman & Balcı, 2017). For example, children may believe that a solitary octopus is lonely due to their inaccurate perception that octopuses are social creatures similar to humans, an error that can reduce children's ability to understand that nonhuman animals have needs and traits that are different from humans (Seattle Aquarium, 2015). Indeed, after reading stories with anthropomorphic characters, children sometimes report that trains can talk (Li et al., 2015), that animals live in houses (Ganea et al., 2014), and that rocks have feelings (Brabham et al., 2000). In addition, children demonstrate less learning of novel properties of anthropomorphic animals after hearing stories where these animals are anthropomorphized (Ganea et al., 2014; Geerdts, 2016). Although some work has found that anthropomorphism in stories can help children retain new information (Blanchard et al., 1984; Bonus & Mares, 2018; Conrad et al., 2021; Geerdts et al., 2016), the majority of studies on this topic show that anthropomorphic depictions both interfere with children's abilities to learn accurate biology information and encourage children to believe that real-life animals have the anthropomorphic characteristics depicted in these stories.

Although anthropomorphism is a common unrealistic element in children's media, it is not the only one; children's stories also contain aliens, portals to other worlds, and cartoon physics, among other things. How common are these elements? How does their presence relate to the media's target educational material? To our knowledge, only two prior content analyses have been conducted specifically on children's educational science media (Bonus & Mares, 2018; Charpentier, 2007), and both only investigated TV-based media. To build on this work, we analyze both videos and books, aiming to categorize the various unrealistic elements that these media present and to describe these elements' relation to the scientific content that these media aim to teach.

The Current Study

This study examines a set of educational media, specifically media that are designed to teach some aspect of science to children in preschool and early elementary school. More specifically, we focus here on media that is narrative in nature because these stories may pose particular challenges to young children in extracting their target educational messages. The set of media that we analyze includes both books and videos because both are commonly available to young children and commonly used in schools or at home to present information about science. The primary goals of this quantitative content analysis are (a) to characterize these stories' science educational information, (b) to categorize their unrealistic elements, and (c) to investigate the relation between these educational and unrealistic elements. This analysis provides a first step toward understanding how media can be best used to introduce the youngest learners to science.

Method

Media Selection

This study aims to explore the presentation of science in children's narrative educational media. Although some media occasionally teach science topics in addition to other educational content (e.g., *Sesame Street*), we chose to include in our set only media that were designed primarily to teach science.

For this content analysis, we define "science" as topics, processes, or skills that are typically found in university departments teaching natural or social sciences. Media teaching computer science, mathematics, engineering, or inventing were thus excluded. Finally, we restricted the media that we consider to those that are aimed at children in preschool and early elementary school (roughly 4–10 years old).

We conducted our search for relevant media in 2019 and 2020, stopping in September 2020.

Books

We used several methods to identify the books that we included in our coding set. First, we included all narrative storybooks listed in the National Science Teaching Association's annual recommendation of the best science books of the year for the years 2017 to 2019. Second, using *Magic School Bus* as a starting point, we followed the recommendations presented on online retailers such as Amazon.com to identify books with similar properties. Once a promising piece of media was identified, we read the product description and reviews; when available, we also used the "Look Inside" feature to assess the book. We added all books that met our criteria to our set. In addition to online retailers, we searched for narrative books designed to teach science through children's publishers at brick-and-mortar bookstores and at libraries. Third, we conducted informal surveys of children's librarians and parents to determine which books they used when teaching about science.

In total, 110 books were included in the final analysis (see Appendix A for full list). For book series (e.g., *Cat in the Hat Knows a Lot About That*), we randomly selected one title from each series to include in the final set.

Videos

First, we included all shows coded in a prior content analysis that fit our criteria (Bonus & Mares, 2018). Online sites such as Amazon.com and Common Sense Media provided recommendations based on these TV series and were used as tools to guide further selections. We also searched the offerings of common children's media distributors (e.g., PBS Kids, Netflix) for shows that matched our criteria, and we selected all narrative media sponsored by the U.S. Department of Education's Ready To Learn TV block grant from 2015 to 2020 that focused on science content.

To determine if a particular show should be included in our set, we selected a random episode from a series and watched the first 2 to 5 minutes. Using this method, we identified a total of 34 TV shows or web series. Of these, we randomly selected 5% of the episodes from each series for coding (mean number of episodes per series = 4.18). In total, 142 episodes were included in the final set (see Appendix B for full list).

Coding

Our coding focused on two main aspects of the selected media: their educational elements and their unrealistic elements. To develop our coding scheme for the media's educational elements, we began by asking research assistants to briefly describe the scientific content presented in a subset of the media. To develop our coding scheme for the media's unrealistic elements, we began with the elements used in Goldstein and Alperson (2020). These lists of educational topics and of unrealistic elements were both refined through several rounds of initial testing with a small set of media and through discussion among the authors.

Then, five research assistants were provided with a sample of eight pieces of media to code (two videos and six books). The overall agreement for this set was 81%. We then selected the three coders with the highest reliability on this set to serve as the coders for the full sample of media. The first and second author (Natasha Chlebuch and Aarti Bodas) also served as coders. Each piece of media was independently coded by at least two of these five coders. Agreement on the educational content was 85.3%, and agreement on unrealistic content was 91.0%. Discrepancies were resolved through discussions among the coders and the authors.

Coding was done via a Qualtrics survey with three sections: Media Information, Science Content, and Unrealistic Content (always in the same order).

Media Information

The first part of the survey collected descriptive information. We recorded the type of media (book or video), the episode or book title, and the series title (if any). Coders were then asked to decide whether the media was fiction or nonfiction (e.g., a biography).

For books, we recorded the media's author, illustrator, publisher, year of publication, length (in pages), and target age range. This information was collected from the book itself, from the publisher's website, or from the product page on Amazon.com.

For videos, we recorded the media's distributor (e.g., PBS Kids, Netflix). For shows that are syndicated or that were released in other countries prior to being aired in the United States (e.g., *Leo the Wildlife Ranger*), the original U.S. distributor was recorded. We also recorded the year of release, length of the episode (in minutes), and target age range. If any of this information was not clearly presented in the video itself, coders obtained information from the show's website, the Internet Movie Database, Common Sense Media, or Wikipedia.

To gain a fuller view of the different ways that these media presented their content, coders additionally categorized each book's or video's visual style as either live-action (i.e., photographs or live footage), hand-drawn (e.g., line drawings or paintings), computer-generated, other (e.g., Claymation), or a mix of visual styles (e.g., a combination of computer-generated and hand-drawn images). Coders also recorded the presence of any nonnarrative educational elements, such as informational sidebars or interstitial video clips (i.e., short clips presented during or after the main video content that directly presented educational material but that were distinct from the main narrative of the video). Finally, coders noted whether the media aimed to teach any nonscience educational material (e.g., kindness, self-acceptance), which are also common themes in children's educational media. As these variables are not related to our main analyses, we report results related to them in Appendix C.

Educational Content

To code each book's or video's educational content, coders selected whether the media aimed to teach science *content* (e.g., information from a particular science discipline, such as the size of a T. Rex) and whether the media aimed to teach an aspect of the scientific *process* (e.g., how paleontologists conduct archeology digs).

If the piece of media was coded as teaching science content, coders selected the primary science topic that it was aiming to teach from a list of 23 topics (e.g., astronomy, mechanics; Table 1). This list additionally included the option "other science not listed here," but that option was never selected and so is not included in our analyses. Coders could select additional content if more than one topic was taught, but the current analyses only focus on the primary topic. Similarly, we originally asked coders to select which science process or skill the media was teaching (e.g., observation, experimentation). However, agreement on these secondary codes was low, so we only use the coders' overall judgment of whether science process was taught. Coders additionally recorded whether any of the educational content was presented as part of an embedded story (e.g., dream sequence, pretend game) rather than in the main narrative. Finally, they noted whether the primary science content was depicted in a way that was unusual or fantastical (e.g., a video aimed to teach about sailfish but the sailfish were anthropomorphized).

Unrealistic Content

The last part of the survey aimed to categorize the unrealistic elements present in children's media. Coders were asked to indicate whether the world of the story was unrealistic in any way and to select which unrealistic elements were present from a list of 16 options (e.g., anthropomorphic animals, fantastical or unusual creatures; Table 2). The original list of unrealistic elements included two additional items: "a fantastical or sci-fi explanation is offered for an everyday event" and "a fantastical or unusual creature interacts with the main character." The first category was never selected, and the second category was later subsumed into the category of "fantastical or unusual creature," so these are not included in our analyses. In addition, the categories of "anachronisms" and "fairytale themes" were added at the end of the coding process to capture a large number of unrealistic elements that had been coded into the "other" category.

Through the process of developing the coding scheme and training coders, we created brief descriptions or examples of the 16 unrealistic elements (e.g., for cartoon physics, we provided the example, "when a cartoon character runs off a cliff and keeps running in the air for a moment before they fall"). These descriptions or examples were included within the coding survey as reminders to ensure that coders were using these categories systematically.

As in the study by Goldstein and Alperson (2020), coders were also asked to indicate whether unrealistic elements were normal in the story and whether they were viewed positively or negatively. However, as there was essentially no variance in the responses to these questions (unrealistic elements were normal within the story in all but one piece of media, and these elements were always

Table 1
List of Educational Topics, by Medium

Educational topic	Books	Videos	Total	Category
1. Natural history of a particular animal, or a small number of animals	*n* = 41; 37.2%	*n* = 51; 35.9%	*n* = 92; 36.5%	Biological sciences
2. Astronomy (stars, planets, solar system)	*n* = 6; 5.5%	*n* = 16; 11.3%	*n* = 22; 8.7%	Physical sciences
3. Natural history of a particular dinosaur or dinosaurs in general	*n* = 4; 3.6%	*n* = 17; 12.0%	*n* = 21; 8.3%	Biological sciences
4. Process	*n* = 9; 8.2%	*n* = 11; 7.7%	*n* = 20; 7.9%	Process
5. Biography of a famous scientist	*n* = 17; 15.5%	*n* = 1; 0.7%	*n* = 18; 7.1%	History
6. Other physics not listed here	*n* = 2; 1.8%	*n* = 15; 10.6%	*n* = 17; 6.7%	Physical sciences
7. Conservation	*n* = 7; 6.4%	*n* = 4; 2.8%	*n* = 11; 4.4%	Biological sciences
8. Mechanics	*n* = 3; 2.7%	*n* = 6; 4.2%	*n* = 9; 3.6%	Physical sciences
9. Plants/botany	*n* = 2; 1.8%	*n* = 7; 4.9%	*n* = 9; 3.6%	Biological sciences
10. Natural history of a particular place	*n* = 3; 2.7%	*n* = 2; 1.4%	*n* = 5; 2.0%	History
11. Historical event that relates to science	*n* = 4; 3.6%	*n* = 0; 0%	*n* = 4; 1.6%	History
12. Human body	*n* = 2; 1.8%	*n* = 2; 1.4%	*n* = 4; 1.6%	Biological sciences
13. Seasons/weather	*n* = 2; 1.8%	*n* = 1; 0.7%	*n* = 3; 1.2%	Physical sciences
14. Disease/germs	*n* = 2; 1.8%	*n* = 0; 0%	*n* = 2; 0.8%	Biological sciences
15. Evolution	*n* = 2; 1.8%	*n* = 0; 0%	*n* = 2; 0.8%	Biological sciences
16. Other biology not listed here	*n* = 1; 0.9%	*n* = 1; 0.7%	*n* = 2; 0.8%	Biological sciences
17. Psychology	*n* = 0; 0%	*n* = 2; 1.4%	*n* = 2; 0.8%	Biological sciences
18. Magnetism	*n* = 1; 0.9%	*n* = 1; 0.7%	*n* = 2; 0.8%	Physical sciences
19. Other chemistry not listed here	*n* = 0; 0%	*n* = 2; 1.4%	*n* = 2; 0.8%	Physical sciences
20. Water cycle	*n* = 2; 1.8%	*n* = 0; 0%	*n* = 2; 0.8%	Physical sciences
21. Geology	*n* = 0; 0%	*n* = 1; 0.7%	*n* = 1; 0.4%	Physical sciences
22. Ecosystems/habitats	*n* = 0; 0%	*n* = 1; 0.7%	*n* = 1; 0.4%	Biological sciences
23. States of matter	*n* = 0; 0%	*n* = 1; 0.7%	*n* = 1; 0.4%	Physical sciences
Total biological sciences	*n* = 61; 55.5%	*n* = 85; 59.9%	*n* = 146; 57.9%	
Total physical sciences	*n* = 16; 14.5%	*n* = 43; 30.3%	*n* = 59; 23.4%	
Total history	*n* = 24; 21.8%	*n* = 3; 2.1%	*n* = 27; 10.7%	
Total process	*n* = 9; 8.2%	*n* = 11; 7.7%	*n* = 20; 7.9%	

Table 2
List of Unrealistic Elements, by Medium

Unrealistic element	Books	Videos	Total
1. Anthropomorphized animal	*n* = 38; 34.5%	*n* = 88; 62.0%	*n* = 126; 50.0%
2. Technology that is so advanced that it's fantastical/science-fiction from the point of view of current reality	*n* = 4; 3.6%	*n* = 84; 59.2%	*n* = 88; 34.9%
3. Cartoon physics	*n* = 11; 10.0%	*n* = 76; 53.5%	*n* = 87; 34.5%
4. Fantastical or unusual creature	*n* = 8; 7.3%	*n* = 46; 32.4%	*n* = 54; 21.4%
5. Anthropomorphized object	*n* = 6; 5.5%	*n* = 27; 19.0%	*n* = 33; 13.1%
6. Magical object that is not anthropomorphized	*n* = 1; 0.9%	*n* = 29; 20.4%	*n* = 30; 11.9%
7. Alien	*n* = 4; 3.6%	*n* = 21; 14.8%	*n* = 25; 10.0%
8. Anachronisms	*n* = 1; 0.9%	*n* = 19; 13.4%	*n* = 20; 7.9%
9. An entity does something that is unlikely or impossible in the real world/does magic	*n* = 4; 3.6%	*n* = 15; 10.6%	*n* = 19; 7.5%
10. Other	*n* = 6; 5.4%	*n* = 13; 9.2%	*n* = 19; 7.5%
11. Fantastical world exists within the real world or there is a portal from the real world to a fantastical world	*n* = 2; 1.8%	*n* = 14; 9.9%	*n* = 16; 6.3%
12. A real-world experiment has gone wrong and resulted in some thing fantastical	*n* = 1; 0.9%	*n* = 5; 3.5%	*n* = 6; 2.4%
13. Fairytale themes (e.g., princesses/castles, pirates)	*n* = 3; 2.7%	*n* = 3; 2.1%	*n* = 6; 2.4%
14. Human who inherently has fantastical/magical powers	*n* = 1; 0.9%	*n* = 2; 1.4%	*n* = 3; 1.2%
15. Human who is ordinary but who acquires magic or who can do fantastical things because of a spell, a tool, or technology	*n* = 0; 0%	*n* = 1; 0.7%	*n* = 1; 0.4%
16. Characters have supernatural beliefs	*n* = 0; 0%	*n* = 1; 0.7%	*n* = 1; 0.4%

presented positively/neutrally and never negatively), we did not perform analyses on these variables.

Finally, as with the educational content, coders reported whether each unrealistic element was presented in the main narrative or in an embedded narrative.

Results

General information about the media in the coding set can be found in Table 3.

Educational Content

Each piece of media could be coded as presenting one of 23 possible science topics (see Table 1 for full list). The most common science topic was the natural history of animals in general or the natural history of a specific animal, with 36.5% of all media primarily designed to teach this kind of information (*n* = 92). The next most common topics were astronomy (*n* = 22, 8.7%), dinosaurs (*n* = 21, 8.3%), and science process (*n* = 20, 7.9%).

For ease of analysis, we categorized each of the 23 specific science topics into one of four broader categories: biological sciences, physical sciences, history (e.g., biographies of famous scientists), and science process (see bottom panel of Table 1). Biology was overwhelmingly the most popular category, followed by physics, then historical events or persons in science, and then science process.

With these four categories, there were differences between the two types of media. We found that 30.3% of videos taught a physical science topic compared with 14.5% of books (exact proportion

Table 3
Descriptive Statistics for Media

Media information	Books (*N* = 110)		Videos (*N* = 142)			
Average length	36.47 pages (*SD* = 7.55)		14.94 min (*SD* = 5.96)		Total (*N* = 252)	
Year of release or publication	*N*	%	*N*	%	*N*	%
Prior to 2000	7	6.4	7	4.9	14	5.6
2000–2005	12	10.9	7	4.9	19	7.5
2006–2010	10	9.1	26	18.3	36	14.3
2011–2015	24	21.8	52	36.6	76	30.2
2016–2020	57	51.8	50	35.2	107	42.5
Fictionality	*N*	%	*N*	%	*N*	%
Nonfictional	30	72.7	0	0	30	11.9
Fictional	80	27.3	142	100	222	88.1
Target age	*N*	%	*N*	%	*N*	%
Below 5 years	69	62.7	44	31.0	167	66.3
5 years and older	41	37.3	98	69.0	85	33.7

test, p = .006). In contrast, books more frequently taught about topics in the history of science (books = 21.8%, videos = 2.1%; exact proportion test, $p < .001$). There were no significant differences between the proportion of books and videos teaching biological science (books = 55.5%, videos = 59.9%; exact proportion test, p = .57) or science process (books = 8.2%, videos = 7.7%; exact proportion test, p = 1.00).

In addition, the media's date of release or publication had a significant effect on its educational content, $F(3) = 7.10$, $p < .001$. Post hoc tests (Bonferroni correction) showed that media teaching about science history (average year of publication = 2016; SD = 1.99) and aspects of the scientific process (average year of publication = 2015; SD = 2.86) were published significantly more recently than media teaching about biological sciences (average year of publication = 2011; SD = 7.36, both $p < .02$). Media teaching about science history were published marginally more recently than media teaching about physical sciences (average year of publication = 2012; SD = 6.02; p = .056). Indeed, 96% of the historical media and 100% of the media teaching aspects of the scientific process were published or released after 2011. We found no interaction with publication/release date and media type, $F(3, 244)$ = .32, p = .81, indicating that books and videos reflected similar types of educational content over time.

There was no overall difference in the distribution of educational topics depending on whether the target age was below 5 years or 5 years and older, $\chi^2(3, N = 252) = 3.71$, p = .29. However, biological sciences were significantly more likely to be taught to younger children (69.9%) than to older children (30.1%; exact proportion test, $p < .001$). The same was true for physical sciences (younger = 66.1%, older = 33.9%; exact proportion test, $p < .001$). There was not a similar effect for history (younger = 51.9%, older = 48.1%; exact proportion test, p = 1.00) or science process (younger = 60.0%, older = 40.0%; exact proportion test, p = .34).

We did find differences in educational content as a function of fictionality, $\chi^2(3, N = 252) = 141.13$, $p < .001$. Media designed to teach biology, physics, and process were significantly more likely to be fictional than nonfictional (biology = 95.9% fictional; physics = 100% fictional; process = 90.0% fictional; exact proportion tests, all $p < .001$). Conversely, media designed to teach about science history were significantly more likely to be nonfictional (18.5% fictional, exact proportion test, $p < .001$).

Unrealistic Elements

We found that 81.0% (n = 204) of children's science educational media contained at least one unrealistic element. The four most common fantasy elements were anthropomorphized animals (n = 126, 50.0%), advanced technology (n = 88, 34.9%), cartoon physics (n = 87, 34.5%), and fantastical or unusual creatures (n = 54, 21.4%). When counting the number of distinct types of unrealistic elements in each piece of media, we found that each piece of media contained an average of 2.12 types (SD = 1.79, range: 0–7).

Videos were significantly more likely to include an unrealistic element than books, $\chi^2(1, N = 252) = 76.54$, $p < .001$. In fact, all of the videos in our coding set contained at least one unrealistic element, whereas only 56.4% of books did. Videos also contained significantly more types of fantasy elements than books, video M = 3.13, SD = 1.63; book M = .82, SD = .94; $t(250) = -13.23$, $p < .001$.

Overall, media that contained unrealistic elements were significantly newer than media that did not, $t(250) = 2.64$, p = .009. However, this difference disappears when removing the 30 pieces of nonfiction media, which primarily aimed to teach some aspect of history and were more likely to be published within the last 10 years, $t(220) = 1.38$, p = .17. We also found a relationship between the number of different types of unrealistic elements and the media's year of release, with older media being more likely to contain more types of unrealistic elements ($r = -.14$, p = .03).

We found a marginal effect of target age on the presence of unrealistic content: 84.4% of media designed for children younger than 5 years contained at least one fantasy element, whereas 74.1% of media designed for children 5 years and older did (exact proportion test, p = .07). Media targeting younger children also contained marginally more different types of unrealistic elements than media targeting older children, M for younger children = 2.26, SD = 1.83; M for older children = 1.84, SD = 1.68; $t(250) = -1.81$, p = .07.

Perhaps unsurprisingly, fictional media were more likely to include unrealistic elements (88.7%) than nonfictional media (23.3%; exact proportion test, $p < .001$). Fictional media also contained significantly more types of unrealistic elements than nonfictional media, fictional M = 2.37, SD = 1.75; nonfictional M = .23, SD = .43; $t(250) = 6.67$, $p < .001$.

Interaction Between Educational and Unrealistic Elements

We first examined whether there were significant differences in the presence of unrealistic elements in media that aimed to teach different science topics (Table 4). Media designed to teach history of science were the least likely to contain unrealistic elements, with only 37.0% of these media containing at least one such element. In contrast, 84.9% of media designed to teach biological sciences, 94.9% of media designed to teach physical sciences, and 70.0% of media designed to teach aspects of the process of science contained at least one unrealistic element, $\chi^2(3, N = 252) = 44.29$, $p < .001$.

Similarly, there was a significant difference in the number of different types of unrealistic elements included in media with different educational goals, $F(3, 248) = 14.26$, $p < .001$ (see the middle panel of Table 4). Post hoc tests (Bonferroni corrections) revealed that media designed to teach history contained significantly fewer different types of unrealistic elements than media designed to teach biology ($p < .001$) or physics ($p < .001$) and marginally fewer different types of unrealistic elements than media designed to teach science process (p = .07). In addition, media designed to teach aspects of the process of science and media designed to teach biology had significantly fewer different types of unrealistic elements than media designed to teach physics (p = .03 and $p < .001$, respectively).

Coders judged that the target educational content was portrayed unrealistically in about half of all media (47.2%; see bottom panel of Table 4). Interestingly, this tendency varied by the type of educational content, $\chi^2(3, N = 252) = 37.25$, $p < .001$. Specifically, media designed to teach biology were most likely to have a direct overlap between the educational content and the unrealistic elements (59.6%), and media designed to teach physics were similarly likely to have this overlap (47.5%). However, media

Table 4
Presence of Unrealistic Elements in Media Depending on Target Science Content and Media Type

Unrealistic content	Biology	Physics	History	Process
Contains at least one unrealistic element				
Total	*n* = 124; 84.9%	*n* = 56; 94.9%	*n* = 10; 37.0%	*n* = 14; 70.0%
Books	*n* = 39; 63.9%	*n* = 13; 81.3%	*n* = 7; 29.2%	*n* = 3; 33.3%
Videos	*n* = 85; 100%	*n* = 43; 100%	*n* = 3; 100%	*n* = 11; 100%
Average number of different types of unrealistic elements (*SD*)				
Total	2.05 (1.63)	3.07 (1.89)	0.59 (1.01)	1.85 (1.81)
Books	0.95 (1.01)	1.25 (0.86)	0.29 (0.46)	0.56 (1.01)
Videos	2.85 (1.54)	3.74 (1.72)	3.00 (1.00)	2.91 (1.64)
Primary science content is depicted unrealistically				
Total	*n* = 87; 59.6%	*n* = 28; 47.5%	*n* = 2; 7.4%	*n* = 2; 10.0%
Books	*n* = 28; 45.9%	*n* = 6; 37.5%	*n* = 1; 4.2%	*n* = 0; 0%
Videos	*n* = 59; 69.4%	*n* = 22; 51.2%	*n* = 1; 33.3%	*n* = 2; 18.2%

designed to teach history of science (7.4%) and science process (10.0%) were relatively unlikely to do so.

We also examined several more specific relations between the type of educational content and the type of unrealistic content. Based on previous work on the effects of anthropomorphism on children's learning (Ganea et al., 2014; Geerdts, 2016), we tested whether media designed to teach about animals or dinosaurs were more likely to include anthropomorphic animals (including dinosaurs). We found that 62.8% of such media contained anthropomorphic animals, compared with 39.6% of media that was designed to teach about other topics (exact proportion test, $p <$ .001). Similarly, media designed to teach about some aspect of physics were significantly more likely to use the unrealistic element of cartoon physics (47.5%) than media designed to teach another topic (30.6%; exact proportion test, $p = .03$).

In 17 pieces of media, the target science information was presented as part of an embedded story, such as a dream sequence or a pretend game. Although there are not enough such media to conduct formal analyses, 16 out of these 17 cases occurred in videos and only one occurred in a book. In addition, all 17 of these cases involved teaching a topic in the biological sciences.

Discussion

The goal of this content analysis was to examine how science is presented in narrative media aimed at children in preschool and early elementary school, specifically focusing on the interaction between these educational elements and any unrealistic elements present in these stories. Although some theoretical perspectives suggest that including unrealistic elements in educational media can be beneficial to children's learning (Fisch, 2000; Weisberg & Gopnik, 2013), empirical evidence on this issue is mixed: Some work supports this position (Bonus & Mares, 2018; Geerdts, 2016; Hopkins & Weisberg, 2021; Weisberg & Hopkins, 2020), whereas other work shows that unrealistic elements can interfere with children's learning (Ganea et al., 2011; Richert et al., 2009; Walker et al., 2015). By examining how science content is depicted in narrative educational media, the current work takes a first step toward understanding how books and videos might serve as supplements to early science education. It also highlights areas for future research on this topic that can help us to better understand whether and under what circumstances these media are effective at achieving their educational goals.

What Do These Media Aim to Teach Children?

We found that most children's media aim to teach topics within the biological sciences, specifically about the natural history of nonhuman animals and dinosaurs, and to a lesser extent about topics within the physical sciences, primarily about astronomy (e.g., the planets, phases of the moon, the day/night cycle). Although these are important topics for children to learn, there are many other science topics that young children are not being exposed to. For example, even within children's books with biological content, other work has found that negative aspects of the natural world, such as parasitism, are underrepresented (Shtulman et al., 2021). Furthermore, entire fields of science, such as geology and ecology, are neglected in children's media (Pentimonti et al., 2010). Only a single TV show in our entire set aimed to teach anything about psychology (*Floogals*). Even chemistry topics (e.g., states of matter) were massively underrepresented, despite our culture's use of chemistry as the stereotypical representation of science (as illustrated by the Draw a Scientist task; Chambers, 1983). This highlights an opportunity for content creators to broaden the range of science topics that they include in their books and videos. Parents and educators who want to expose children to the full breadth of scientific topics may also wish to be aware of this issue so that they can seek out media that focus on some of the less well-covered topics.

In addition, some of the media in our sample primarily aimed to teach aspects of the process of science, such as observation and experimentation (e.g., *Ada Twist*, *Scientist*). All of these media were published or produced within the past 10 years. This suggests a change in the landscape of children's educational science media to include more science processes and skills, perhaps as a reflection of the three-dimensional approach to science education recommended by the Next Generation Science Standards (NGSS Lead States, 2013).

Similarly, since the last decade, there has been a new focus on presenting topics within the history of science (e.g., biographies of historically important scientists). Anecdotally, many of these recent media aim to commemorate and highlight the achievements of marginalized members of the scientific community, particularly women and people of color. This effort to present all children with role models who reflect some aspect of their identity seems to be aimed at diversifying science, technology, engineering, and mathematics fields, although the contribution of such media in inspiring children to learn more about science or to enter these fields is not yet known. Previous work suggests that such efforts may be successful; children do learn better from individuals (including fictional characters) whom they trust and whom they feel resemble them in some way (Dore et al., 2017; Schlesinger et al., 2016). Future research should focus on this issue to determine whether these effects also occur for children's learning about science topics or for their reported affiliation for science. Along these lines, a current project in our lab aims to document more specifically how these books and videos depict their characters to further determine how successful these educational stories may be at conveying their intended lessons and at influencing children to feel affiliated with science fields.

What Kinds of Unrealistic Content Do These Media Contain?

Children's educational science media is highly likely to depict unrealistic entities or events, with 81.0% of all of the media in our sample containing at least one unrealistic element. This number rises to 88.7% when considering only the fictional media in our sample (i.e., excluding the biographies and depictions of historical events). These numbers are in line with previous content analyses: Goldstein and Alperson (2020) found that 92% of popular children's media contained at least one supernatural element. Similarly, Taggart et al. (2019) found that 65% of the TV shows that they analyzed contained fantastical events, and 75% contained anthropomorphism. On the whole, then, it seems that children's media are rife with unrealistic elements and that even books and videos that are explicitly educational are not immune from this trend. Furthermore, although these elements were for the most part constrained to fictional media, there were instances of unrealism in nonfiction works (e.g., the anthropomorphized robot in *Curiosity: Story of a Mars Rover*).

There were also differences by medium: Videos were more likely to contain unrealistic elements than books, and videos contained more types of unrealistic elements than books (as in Goldstein & Alperson, 2020). Indeed, all of the videos in our sample contained at least one unrealistic element; this was not true of the books. Furthermore, it was not the case that some unrealistic elements were more common in books as opposed to videos; videos were more unrealistic across the board. This might be due to the fact that the video medium inherently has more methods for presenting unrealistic content, as videos can contain unrealistic sounds and movements in addition to linguistic and visual depictions (Brodsky & Sulkin, 2020). This content analysis used identical coding categories for books and videos to facilitate direct comparisons between these two types of media, but future work should aim to characterize more precisely how unrealistic soundscapes or other aspects of a story's depiction may contribute to its overall level of unrealism.

We found that media designed for children younger than 5 years were more likely to contain unrealistic elements than media designed for older children. This likely reflects the assumptions that content creators make about what will be appealing to children at different ages, rather than any information about what kinds of media these children will learn from more effectively, as current research has not yet definitely determined which types or levels of unrealism are most likely to enhance learning in general or science learning in particular for children of various ages. Furthermore, this inclusion of higher levels of unrealism should be carefully considered, given that younger children may have more trouble than older children in distinguishing between unrealistic and educational content (Bonus & Mares, 2018). Specifically, even if the inclusion of more unrealistic elements makes the media more engaging and attractive, it is still unclear whether this outweighs the potential negative effects on the media's educational efficacy. More empirical work is needed on this issue, as is increased collaboration between researchers and content creators (Dore et al., 2018).

How Do Unrealistic Elements Interact With Educational Content?

This content analysis uncovered some interesting differences between the type of unrealistic content depending on the media's educational aims. Specifically, we found that media designed to teach a physical science topic were the most likely to contain at least one unrealistic element and contained the most different types of unrealistic elements of any of our categories of educational content.

Furthermore, about half of the media in our sample were found to portray their target educational content in an unrealistic way. More specifically, media designed to teach physics concepts were more likely to include cartoon physics (i.e., exaggerated depictions of physical movement or object interactions) than media that were designed to teach other topics. Along the same lines, media designed to teach information about animals or dinosaurs were more likely to contain anthropomorphic animals or dinosaurs. That is, our analyses suggest that the unrealistic or fantastical elements of children's media are not randomly distributed; books and videos are more likely to use unrealistic depictions for their target educational content, at least for these two topics. Although the current study provides an interesting view into these cases of overlap between the educational and unrealistic content of these media, we did not consider here the degree of such overlap, nor whether the educational content was central to the plot of the story or incidental to it (Fisch, 2000). Future work could examine these issues to provide a fuller picture of how these media present science to young children.

This result about the overlap between educational and unrealistic content suggests that media with such overlap may make it particularly difficult for children to learn the target science material. Particularly with respect to anthropomorphism, previous work has shown that anthropomorphic depictions of animals in storybooks interfere with children's learning of new information about these animals (Bonus, 2019; Ganea et al., 2014; Kotaman & Balcı, 2017). Importantly, however, this work has only investigated cases where an animal is anthropomorphized and that very animal is the media's educational focus. But there may be a difference in children's learning depending on how the anthropomorphism is instantiated in the media. There are many commercially available stories in which an anthropomorphized animal teaches about a different topic, such as in the TV show *Nature Cat*, in which an anthropomorphic cat teaches about other animals or about nature more generally. This separation between the educational material and the unrealistic elements of the story could potentially reduce the risk of children mistakenly believing that the unrealistic elements are true of real life, which they are prone to do for depictions of anthropomorphic animals in the empirical work cited earlier. Furthermore, only two studies to our knowledge have examined children's science learning from anthropomorphic objects rather than from anthropomorphic animals: Brabham et al. (2000) showed that children were able to successfully learn about meteorites from an anthropomorphic meteorite, and Bonus and Mares (2018) showed that children were able to successfully learn about the day/night cycle from an anthropomorphic sun and Earth. In these cases, when the anthropomorphic entity is an object rather than an animal, children may find it easier to correctly reject the idea that these objects have faces or feelings because they are less likely to extend human-like characteristics to entities that do not resemble humans (Carey, 1985). Anthropomorphic objects in educational media may thus make the educational content more transparent and easier to learn than anthropomorphic animals. We are currently examining these issues in a follow-up study to gain a more nuanced view of the interaction between unrealistic elements and educational material in children's media.

Limitations and Future Directions

Although this content analysis provides an informative look at the landscape of children's narrative science media, there are several ways in which future work could improve on the current approach. We made every effort to be as inclusive as possible in the media we selected, and although it was not possible to exhaustively sample every book and TV show that fit our criteria, we believe that our sample provides a genuine reflection of the media available to children today. Nevertheless, this sample tends to contain newer media, with approximately half of the sample having been produced or published in the 5 years prior to the coding being conducted (i.e., 2015–2020). The focus on newer children's science media may genuinely reflect changes in the landscape of children's narrative science media, but it is also possible that this is a result of our sampling practices. Regardless, we believe that the trends that we uncovered have some validity, especially when considering what today's children are consuming, and thus can help us to gain a view of the nature of this kind of media.

As a reminder, we chose to only include narrative media because this kind of media is more likely to trigger the reader's dilemma. Narrative stories (particularly fictional stories) can take creative liberties with their content in a way that nonnarrative materials cannot. Furthermore, these kinds of stories are vastly more likely than expository media to include unrealistic or fantastical elements, which could add to this confusion. This potential blending of realistic content with fictional or fictionalized content requires readers or viewers to question which aspects of the material portrayed in these stories should be applied to reality, which could make it difficult to extract the educational material that these stories might contain. But there is also a good deal of expository science media aimed at children, and our findings about which topics are covered and how science is depicted do not necessarily apply to such media. Because narrative and expository media provide information differently and may also provide different types of information, both types are likely necessary for children to be exposed to a wide range of science topics.

Finally, this content analysis examined the media that are available to children. Future studies should measure the impact of these media on children's science learning to determine how the features that we identified here might affect learning. In turn, such work can allow us to construct empirically validated recommendations for content creators and for consumers.

When considering the more general issue of unrealism in children's media, many studies have shown that the presence of unrealistic or fantastical elements in stories inhibit children's ability to learn factual information (Richert & Smith, 2011; Richert et al., 2009; Sutherland & Friedman, 2013; Walker et al., 2015). These results are concerning, given the high proportion of children's educational media that include such elements. However, a small body of work has found that unrealistic elements can actually boost children's performance under certain circumstances. For example, children learn new words more readily when those words refer to fantastical events (Stahl & Feigenson, 2017) or when they are presented within fantastical story contexts (Weisberg et al., 2015). Unrealistic stories have also been shown to benefit children's learning of some kinds of scientific information, specifically about biological inheritance (Hopkins & Weisberg, 2021; see also Weisberg & Hopkins, 2020). Although this work suggests that the unrealistic elements that are so common in children's media might be beneficial, or at least not harmful, to children's learning, most of this work has used lab-created media, which may not be generalizable to commercially available media (with the notable exception of work by Bonus; e.g., Bonus, 2019; Bonus & Mares, 2018). Future work should aim to unite these two types of research to investigate children's learning from unrealistic, professionally produced books and videos.

Conclusion

This study is a first step in understanding the potential role that educational media can play in the growing efforts to support early childhood science learning. Our focus on narrative media and specifically on the unrealistic elements that are commonly present within such media allows this work to lay the foundation for future investigations of how such elements might affect children's learning. Although more work is needed to determine whether these unrealistic elements indeed interfere with children's learning of their target educational material, such media (if they are generally educationally successful) could serve as an effective way to teach science to young children. Indeed, because such media are widely available and can be constructed to reflect a wide range of role models and topics, they can potentially provide a way to ensure equitable access to high-quality science information for all children, taking a major step toward closing the achievement gap in science, technology, engineering, and mathematics fields.

References

Aladé, F., & Nathanson, A. I. (2016). What preschoolers bring to the show: The relation between viewer characteristics and children's learning from educational television. *Media Psychology*, *19*(3), 406–430. https://doi.org/10.1080/15213269.2015.1054945

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 national survey of science and mathematics education*. Horizon Research, Inc.

Barak, M., Ashkar, T., & Dori, Y. J. (2011). Learning science via animated movies: Its effect on students' thinking and motivation. *Computers and Education*, *56*(3), 839–846. https://doi.org/10.1016/j.compedu.2010.10.025

Blanchard, J., McNinch, G. E., & Blanchard, J. (1984). The effects of anthropomorphism on word learning. *The Journal of Educational Research*, *78*(2), 105–110. https://doi.org/10.1080/00220671.1984.10885582

Bonus, J. A. (2019). The impact of pictorial realism in educational science television on U.S. children's learning and transfer of biological facts. *Journal of Children and Media*, *13*(4), 433–451. https://doi.org/10.1080/17482798.2019.1646295

Bonus, J. A., & Mares, M. L. (2018). When the sun sings science, are children left in the dark? Representations of science in children's television and their effects on children's learning. *Human Communication Research*, *44*(4), 449–472. https://doi.org/10.1093/hcr/hqy009

Bonus, J. A., & Watts, J. (2021). You can['t] catch the sun in a net!: Children's misinterpretations of educational science television. *Journal of Experimental Child Psychology*, *202*, Article 105004. https://doi.org/10.1016/j.jecp.2020.105004

Brabham, E., Boyd, P., & Edgington, W. D. (2000). Sorting it out: Elementary students' responses to fact and fiction in informational storybooks as read-alouds for science and social studies. *Reading Research and Instruction*, *39*(4), 265–289. https://doi.org/10.1080/19388070009558326

Brodsky, W., & Sulkin, I. (2020). What babies, infants, and toddlers hear on Fox/Disney BabyTV: An exploratory study. *Psychology of Popular Media*, *10*(3), 330–339. https://doi.org/10.1037/ppm0000321

Carey, S. (1985). *Conceptual change in childhood*. MIT Press.

Carey, S. (2000). Science education as conceptual change. *Journal of Applied Developmental Psychology*, *21*(1), 13–19. https://doi.org/10.1016/S0193-3973(99)00046-5

Chambers, D. W. (1983). Stereotypic images of the scientist: The draw-a-scientist test. *Science Education*, *67*(2), 255–265. https://doi.org/10.1002/sce.3730670213

Charpentier, T. B. (2007). *The portrayal of science in children's television*. Louisana State University.

Conrad, M., Marcovitch, S., & Boseovski, J. J. (2021). The friendly fossa: The effect of anthropomorphic language on learning about unfamiliar animals through both storybooks and live animal experiences. *Journal of Experimental Child Psychology*, *201*, Article 104985. https://doi.org/10.1016/j.jecp.2020.104985

Dore, R. A., Shirilla, M., Verdine, B. N., Zimmermann, L., Golinkoff, R. M., & Hirsh-Pasek, K. (2018). Developer meets developmentalist: Improving industry–research partnerships in children's educational technology. *Journal of Children and Media*, *12*(2), 227–235. https://doi.org/10.1080/17482798.2018.1450086

Dore, R. A., Smith, E. D., & Lillard, A. S. (2017). Children adopt the traits of characters in a narrative. *Child Development Research*, *2017*, Article 6838079. https://doi.org/10.1155/2017/6838079

Emmons, N. A., Lees, K., & Kelemen, D. (2018). Young children's near and far transfer of the basic theory of natural selection: An analogical storybook intervention. *Journal of Research in Science Teaching*, *55*(3), 321–347. https://doi.org/10.1002/tea.21421

Fisch, S. M. (2000). A capacity model of children's comprehension of educational content on television. *Media Psychology*, *2*(1), 63–91. https://doi.org/10.1207/S1532785XMEP0201_4

Ganea, P. A., Canfield, C. F., Simons-Ghafari, K., & Chou, T. (2014). Do cavies talk? The effect of anthropomorphic picture books on children's knowledge about animals. *Frontiers in Psychology*, *5*, Article 283. https://doi.org/10.3389/fpsyg.2014.00283

Ganea, P. A., Ma, L., & Deloache, J. S. (2011). Young children's learning and transfer of biological information from picture books to real animals. *Child Development*, *82*(5), 1421–1433. https://doi.org/10.1111/j.1467-8624.2011.01612.x

Geerdts, M. S. (2016). (Un)real animals: Anthropomorphism and early learning about animals. *Child Development Perspectives*, *10*(1), 10–14. https://doi.org/10.1111/cdep.12153

Geerdts, M. S., Van de Walle, G. A., & LoBue, V. (2016). Learning about real animals from anthropomorphic media. *Imagination, Cognition and Personality*, *36*(1), 5–26. https://doi.org/10.1177/0276236615611798

Gerde, H. K., Pierce, S. J., Lee, K., & Van Egeren, L. A. (2018). Early childhood educators' self-efficacy in science, math, and literacy instruction and science practice in the classroom. *Early Education and Development*, *29*(1), 70–90. https://doi.org/10.1080/10409289.2017.1360127

Goldstein, T. R., & Alperson, K. (2020). Dancing bears and talking toasters: A content analysis of supernatural elements in children's media. *Psychology of Popular Media*, *9*(2), 214–223. https://doi.org/10.1037/ppm0000222

Hopkins, E. J., & Weisberg, D. S. (2017). The youngest readers' dilemma: A review of children's learning from fictional sources. *Developmental Review*, *43*, 48–70. https://doi.org/10.1016/j.dr.2016.11.001

Hopkins, E. J., & Weisberg, D. S. (2021). Investigating the effectiveness of fantasy stories for teaching scientific principles. *Journal of Experimental Child Psychology*, *203*, Article 105047. https://doi.org/10.1016/j.jecp.2020.105047

Kelemen, D., Emmons, N. A., Seston Schillaci, R., & Ganea, P. A. (2014). Young children can be taught basic natural selection using a picture-storybook intervention. *Psychological Science*, *25*(4), 893–902. https://doi.org/10.1177/0956797613516009

Kotaman, H., & Balcı, A. (2017). Impact of storybook type on kindergarteners' storybook comprehension. *Early Child Development and Care*, *187*(11), 1771–1781. https://doi.org/10.1080/03004430.2016.1188297

Lepper, M. R., Aspinwall, L. G., Mumme, D. L., & Chabay, R. W. (1990). Self-perception and social-perception processes in tutoring: Subtle control strategies of expert tutors. In J. M. Olson & M. P. Zanna (Eds.), *Self-inference processes: The Ontario symposium* (Vol. 6, pp. 217–237). Erlbaum.

Li, H., Boguszewski, K., & Lillard, A. S. (2015). The effect of anthropomorphic media on children's knowledge of trains. *Poster Presented at the Biennial Meeting of the Society for Research in Child Development, Philadelphia, PA*.

Marriott, S. (2002). Red in tooth and claw? Images of nature in modern picture books. *Children's Literature in Education*, *33*(3), 175–183. https://doi.org/10.1023/A:1019677931406

Monhardt, L., & Monhardt, R. (2006). Creating a context for the learning of science process skills through picture books. *Early Childhood Education Journal*, *34*(1), 67–71. https://doi.org/10.1007/s10643-006-0108-9

National Center for Education Statistics. (2018). *PISA 2018 science literacy results*.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. National Academies Press.

Parker, L. E., & Lepper, M. R. (1992). Effects of fantasy contexts on children's learning and motivation: Making learning more fun. *Journal of Personality and Social Psychology*, *62*(4), 625–633. https://doi.org/10.1037/0022-3514.62.4.625

Patterson, S. (2014). *PBS KIDS is a vital resource in preparing children for school*. West Virginia Public Broadcasting. https://www.wvpublic.org/about-us/2014-02-26/pbs-kids-is-a-vital-resource-in-preparing-children-for-school#stream/0

PBS Education. (2015). *PBS: Learn more: The impact of America's largest classroom on learning*. https://bento.cdn.pbs.org/hostedbento-prod/filer_public/PBSLM-EDU/docs/PBS-Learn-More-Report.pdf

Pennell, A. E., Wollak, B., & Koppenhaver, D. A. (2018). Respectful representations of disability in picture books. *The Reading Teacher*, *71*(4), 411–419. https://doi.org/10.1002/trtr.1632

Pentimonti, J. M., Zucker, T. A., Justice, L. M., & Kaderavek, J. N. (2010). Informational text use in preschool classroom read-alouds. *The Reading Teacher*, *63*(8), 656–665. https://doi.org/10.1598/RT.63.8.4

Pringle, R. M., & Lamme, L. L. (2005). Using picture storybooks to support young children's science learning. *Reading Horizons*, *46*(1), 1–15.

Rice, D. C. (2002). Using trade books in teaching elementary science: Facts and fallacies. *The Reading Teacher*, *55*(6), 552–565. https://doi.org/10.1515/IP.2007.017

Richert, R. A., Shawber, A. B., Hoffman, R. E., & Taylor, M. (2009). Learning from fantasy and real characters in preschool and kindergarten.

Journal of Cognition and Development, *10*(1–2), 41–66. https://doi.org/10.1080/15248370902966594

Richert, R. A., & Smith, E. I. (2011). Preschoolers' quarantining of fantasy stories. *Child Development*, *82*(4), 1106–1119. https://doi.org/10.1111/j.1467-8624.2011.01603.x

Rideout, V. J. (2014). *Learning at home: Media use in America*. A Report of the Families and Media Project. Bezos Family Foundation.

Schlesinger, M. A., Flynn, R. M., & Richert, R. A. (2016). U.S. preschoolers' trust of and learning from media characters. *Journal of Children and Media*, *10*(3), 321–340. https://doi.org/10.1080/17482798.2016.1162184

Seattle Aquarium. (2015). *Best practices in developing empathy toward wildlife*. https://www.informalscience.org/sites/default/files/Best%20Practices%20Briefing%202019%20FINAL.pdf

Shtulman, A. (2017). *Scienceblind: Why our intuitive theories about the world are so often wrong*. Basic Books.

Shtulman, A., Neal, C., & Lindquist, G. (2016). Children's ability to learn evolutionary explanations for biological adaptation. *Early Education and Development*, *27*(8), 1222–1236. https://doi.org/10.1080/10409289.2016.1154418

Shtulman, A., Villalobos, A., & Ziel, D. (2021). Whitewashing nature: Sanitized depictions of biology in children's books and parent-child conversations. *Child Development*, *92*(6), 2356–2374. https://doi.org/10.1111/cdev.13571

Silander, M., Grindal, T., Hupert, N., Garcia, E., Anderson, K., Vahey, P., & Pasnik, S. (2018). *What parents talk about when they talk about learning: A national survey about young children and science*. https://www.edc.org/sites/default/files/uploads/EDC_SRI_What_Parents_Talk_About.pdf

Stahl, A. E., & Feigenson, L. (2017). Expectancy violations promote learning in young children. *Cognition*, *163*, 1–14. https://doi.org/10.1016/j.cognition.2017.02.008

Sutherland, S. L., & Friedman, O. (2013). Just pretending can be really learning: Children use pretend play as a source for acquiring generic knowledge. *Developmental Psychology*, *49*(9), 1660–1668. https://doi.org/10.1037/a0030788

Taggart, J., Eisen, S., & Lillard, A. S. (2019). The current landscape of U.S. children's television: Violent, prosocial, educational, and fantastical content. *Journal of Children and Media*, *13*(3), 276–294. https://doi.org/10.1080/17482798.2019.1605916

Trundle, K. C. (2009). *Best practices in science education: Teaching science during the early childhood years*. http://ngspscience.com/profdev/Monographs/SCL22-0429A_SCI_AM_Trundle_lores.pdf.

Vittrup, B., Snider, S., Rose, K. K., & Rippy, J. (2016). Parental perceptions of the role of media and technology in their young children's lives. *Journal of Early Childhood Research*, *14*(1), 43–54. https://doi.org/10.1177/1476718X14523749

Vosniadou, S., & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology*, *24*(4), 535–585. https://doi.org/10.1016/0010-0285(92)90018-W

Walker, C. M., Gopnik, A., & Ganea, P. A. (2015). Learning to learn from stories: Children's developing sensitivity to the causal structure of fictional worlds. *Child Development*, *86*(1), 310–318. https://doi.org/10.1111/cdev.12287

Weisberg, D. S., & Gopnik, A. (2013). Pretense, counterfactuals, and Bayesian causal models: Why what is not real really matters. *Cognitive Science*, *37*(7), 1368–1381. https://doi.org/10.1111/cogs.12069

Weisberg, D. S., & Hopkins, E. J. (2020). Preschoolers' extension and export of information from realistic and fantastical stories. *Infant and Child Development*, *29*(4), Article e2182. https://doi.org/10.1002/icd.2182

Weisberg, D. S., Ilgaz, H., Hirsh-Pasek, K., Golinkoff, R. M., Nicolopoulou, A., & Dickinson, D. K. (2015). Shovels and swords: How realistic and fantastical themes affect children's word learning. *Cognitive Development*, *35*, 1–14. https://doi.org/10.1016/j.cogdev.2014.11.001

(*Appendices follow*)

Appendix A

Table A1
Books in Coding Set

Book (series name)	Length (pages)
1. *A Moose's Morning*	32
2. *A Picture Book of Florence Nightingale*	32
3. *A Place for Pluto*	30
4. *A Platypus, Probably*	32
5. *A Round of Robins*	40
6. *Ada Twist, Scientist (The Questioneers)*	30
7. *Battle with the Bugs: An Imaginative Journey Through the Immune System (Human Body Detectives)*	38
8. *Bear Shadow*	28
9. *Beauty and the Beak*	48
10. *Bee Dance*	32
11. *Big Wolf and Little Wolf*	32
12. *Blow Your Nose, Big Bad Wolf!: A Story About Spreading Germs*	23
13. *Brainiacs: An Imaginative Journey Through the Nervous System (Human Body Detectives)*	52
14. *Cao Chong Weighs an Elephant*	32
15. *Caroline's Comets: A True Story*	40
16. *Cece Loves Science*	40
17. *Natural Processes (Chemistry in My Dreams)*	40
18. *Clang!: Ernst Chladni's Sound Experiments*	33
19. *Clara Caterpillar*	40
20. *Counting Birds: The Idea That Helped Save Our Feathered Friends*	32
21. *Coyote Moon*	32
22. *Curiosity: The Story of a Mars Rover*	56
23. *Curious Pearl Kicks Off Forces and Motion (Curious Pearl the Science Girl)*	24
24. *Diary of a Worm*	40
25. *Dinosaur Mountain*	40
26. *Earth Day-Hooray*	40
27. *Earthlets as Explained by Professor Xargle*	32
28. *Eliza and the Dragonfly*	32
29. *Equal Shmequal*	32
30. *Ethan the Raindrop*	26
31. *Every Turtle Counts*	36
32. *Fish is Fish*	32
33. *Fur and Feathers*	32
34. *Galapagos George*	40
35. *Galapagos Girl*	40
36. *Grandmother Fish*	40
37. *Green City: How One Community Survived a Tornado*	40
38. *Hawk Rising*	40
39. *How the Piloses Evolved Skinny Noses*	22
40. *I Won't Eat That*	40
41. *Is Your Mama a Llama*	28
42. *Izzy Gizmo*	32
43. *Joan Procter, Dragon Doctor*	40
44. *Just a Dream*	48
45. *Just Like My Papa*	32
46. *Karl, Get Out of the Garden!: Carolus Linnaeus and the Naming of Everything*	48
47. *Kate, Who Tamed the Wind*	40
48. *King of the Bees*	32
49. *Lance Dragon Defends His Castle with Simple Machines*	24
50. *Let's Investigate With Nate 3: Dinosaurs (Let's Investigate with Nate)*	40
51. *Lion Lessons*	32
52. *Little Penguin: The Emperor of Antarctica*	34
53. *Little Puffin's First Flight*	32
54. *Mad Margaret Experiments with the Scientific Method*	24
55. *Magic School Bus Explores the Senses (Magic School Bus)*	32
56. *Magnet Max*	24
57. *Melia and Jo*	48

(*Appendices continue*)

Table A1 (*continued*)

Book (series name)	Length (pages)
58. *Misunderstood Shark*	48
59. *Mossy*	32
60. *My Awesome Summer by P. Mantis*	40
61. *My, Oh My-A Butterfly!: All About Butterflies (Cat in the Hat Knows a Lot About That!)*	48
62. *Nefertiti the Spidernaut*	33
63. *Newton and Me*	32
64. *Newton's Rainbow*	48
65. *On a Beam of Light: A Story of Albert Einstein*	56
66. *Once I Knew a Spider*	32
67. *Once Upon a Jungle*	32
68. *One More Egg*	32
69. *Oscar and the Frog: A Book About Growing*	32
70. *Otis and Will Discover the Deep: The Record-Setting Dive of the Bathysphere*	48
71. *Out of This World (Pete the Cat)*	24
72. *Papa, Bring Me the Moon*	32
73. *Pierre the Penguin: A True Story*	32
74. *Pup and Bear*	40
75. *Robins!: How They Grow Up*	48
76. *Salamander Sky*	32
77. *Secrets of the Garden*	40
78. *Shark Lady*	40
79. *Simon and the Solar System*	34
80. *Small Wonders: Jean-Henri Fabre & His World of Insects*	48
81. *Sniffer and Tinni*	40
82. *Solving the Puzzle Under the Sea: Marie Tharp Maps the Ocean Floor*	40
83. *Spring After Spring: How Rachel Carson Inspired the Environmental Movement*	40
84. *The Dinosaur Expert (Mr. Tiffin's Classroom)*	40
85. *The Fungus That Ate My School*	32
86. *The Girl Who Thought in Pictures: The Story of Dr. Temple Grandin (Amazing Scientists)*	40
87. *The Great Kapok Tree: A Tale of the Amazon Rain Forest*	40
88. *The Inventor's Secret: What Thomas Edison Told Henry Ford*	48
89. *The Last Polar Bear*	32
90. *The Little Raindrop*	32
91. *The Most Magnificent Thing*	29
92. *The Music of Life*	48
93. *The Nutty Vulture*	32
94. *The Pebble in My Pocket*	40
95. *The Polar Bears' Home: A Story About Global Warming*	24
96. *The Problem of the Hot World*	56
97. *The Reptile Club*	32
98. *The Stuff of Stars*	40
99. *The Ugly Duckling Dinosaur*	32
100. *The Whales' Song*	32
101. *There's Nothing to Do on Mars*	32
102. *Tigress*	32
103. *Time Train*	32
104. *Turtle Trouble (Pipsie, Nature Detective)*	40
105. *Wangari Maathai: The Woman Who Planted Millions of Trees*	48
106. *What Floats In a Moat?*	48
107. *When Sparks Fly: The True Story of Robert Goddard, the Father of US Rocketry*	40
108. *When Thomas Edison Fed Someone Worms*	32
109. *Where's My Mom?*	32
110. *Whoosh!: Lonnie Johnson's Super-Soaking Stream of Inventions*	32

(*Appendices continue*)

Appendix B

Table A2
Videos in Coding Set

Series	Episode	Length (min)
1. *Annedroids*	*An Android Space Odyssey*	23
2. *Annedroids*	*Bugged Out*	23
3. *Annedroids*	*Dumpster Diving*	23
4. *Ask the Storybots*	*Where Do Planets Come From?*	28
5. *Blaze and the Monster Machines*	*Knighty Knights*	22
6. *Blaze and the Monster Machines*	*The Team Truck Challenge*	25
7. *Blaze and the Monster Machines*	*Zeg and the Egg*	23
8. *Blaze and the Monster Machines*	*Epic Sail*	25
9. *Captain Planet and the Planeteers*	*Creep from the Deep*	22
10. *Captain Planet and the Planeteers*	*Jail House Flock*	24
11. *Captain Planet and the Planeteers*	*Population Bomb*	28
12. *Captain Planet and the Planeteers*	*The Big Clam Up*	25
13. *Cat in the Hat Knows a Lot About That!*	*Amazing Eyes*	12
14. *Cat in the Hat Knows a Lot About That!*	*Babies*	12
15. *Cat in the Hat Knows a Lot About That!*	*Blue Feet Are Neat!*	13
16. *Cat in the Hat Knows a Lot About That!*	*Fast*	11
17. *Cat in the Hat Knows a Lot About That!*	*Opposites Attract*	12
18. *Cat in the Hat Knows a Lot About That!*	*Reef Magic*	13
19. *Cat in the Hat Knows a Lot About That!*	*The Talents of Balance*	11
20. *Cat in the Hat Knows a Lot About That!*	*Water Walkers*	12
21. *Dino Dan*	*Air Dino*	11
22. *Dino Dan*	*The Dino Did It*	11
23. *Dino Dan*	*Where the Dinosaurs Are*	22
24. *Dino Dan: Trek's Adventure*	*Dino Egg Hunt*	10
25. *Dino Dan: Trek's Adventure*	*Dino Footprints*	11
26. *Dino Dana*	*Dino Days of Summer*	10
27. *Dino Dana*	*Dino Defender*	10
28. *Dino Dana*	*Dino Feeder*	10
29. *Dino Dana*	*Tusk Love*	20
30. *Dino Dana*	*Tyrannosaur Test*	10
31. *Dinosaur Train*	*Butterflies*	13
32. *Dinosaur Train*	*Double-Crested Trouble*	13
33. *Dinosaur Train*	*Erma and the Conductor*	13
34. *Dinosaur Train*	*Iggy Iguanodon*	13
35. *Dinosaur Train*	*One Small Dinosaur*	13
36. *Dinosaur Train*	*Shiny Can't Sleep*	13
37. *Dinosaur Train*	*T-Rex Migration*	13
38. *Dinosaur Train*	*The Egg Stealer!*	13
39. *Dinosaur Train*	*Tiny's Fishing Friend*	13
40. *Dinosaur Train*	*To Grandparent's Nest We Go!*	13
41. *Doki!*	*Egg Experiment*	11
42. *Doki!*	*Fixed in a Flash*	11
43. *Doki!*	*Oto-Nardo Da Vinci*	11
44. *Doki*!	*The Big Picture*	11
45. *Doki!*	*Up on the Roof*	11
46. *Earth to Luna*	*Flowers and Fruits*	11
47. *Elinor Wonders Why*	*The Amazing Expandable Club House*	12
48. *Elinor Wonders Why*	*The Town Picnic*	12
49. *Elinor Wonders Why*	*Leave it to Ari*	12
50. *Elinor Wonders Why*	*Snow Friend*	12
51. *Fishtronaut*	*The Case of the day that Was Night*	12
52. *Fishtronaut*	*The Case of the End of the World*	12
53. *Fishtronaut*	*The Case of the Lurking Creature*	12
54. *Fishtronaut*	*The Case of the Seed Spreaders*	12
55. *Fishtronaut*	*The Case that Fell from the Sky*	12
56. *Floogals*	*Project Birthday Cake*	10
57. *Floogals*	*Project Clay*	10
58. *Floogals*	*Project Dusting*	10
59. *Floogals*	*Project Fear of the Dark*	10

(*Appendices continue*)

Table A2 (*continued*)

Series	Episode	Length (min)
60. *Floogals*	*Project Ice*	10
61. *Floogals*	*Project Piano*	10
62. *Floogals*	*Project Pillow Fort*	10
63. *Go Diego Go*	*Alicia and Whitetail to the Rescue*	19
64. *Go Diego Go*	*Alicia Saves A Crocodile*	19
65. *Go Diego Go*	*Fiercest Animals*	37
66. *Go Diego Go*	*Jorge the Hawk Learns to Migrate*	19
67. *Go Diego Go*	*Rainforest Rhapsody*	20
68. *Hero Elementary*	*Hero Hideaway*	12
69. *Hero Elementary*	*Toadal Confusion*	12
70. *Jungle Book Safari*	*Nest*	12
71. *Leo the Wildlife Ranger*	*Plantain Squirrel*	11
72. *Leo the Wildlife Ranger*	*Yellow Crested Cockatoo*	11
73. *Leo the Wildlife Ranger*	*Yellow-footed Rock-Wallaby*	10
74. *Magic School Bus*	*Flexes Its Muscles*	25
75. *Magic School Bus*	*In The Arctic*	25
76. *Magic School Bus*	*The Busasaurus*	25
77. *Magic School Bus Rides Again*	*Tim and the Talking Trees*	25
78. *Magic School Bus Rides Again*	*Waste Not, Want Not*	25
79. *Nature Cat*	*Bug Eating Plants*	11
80. *Nature Cat*	*Flight of the Firefly*	12
81. *Nature Cat*	*Lights out for Sea Turtles!*	11
82. *Nature Cat*	*Mighty Mountain Climbers*	12
83. *Nature Cat*	*Small but Big*	11
84. *Octonauts*	*Duck Billed Platypus*	11
85. *Octonauts*	*Emperor Penguins*	11
86. *Octonauts*	*Humpback Whales*	11
87. *Octonauts*	*The Giant Kelp Forest*	11
88. *Octonauts*	*The Hermit Crab*	11
89. *Octonauts*	*The Speedy Sailfish*	11
90. *Octonauts*	*The Vampire Squid*	11
91. *Octonauts*	*Tiger Shark*	11
92. *Peep and the Big Wide World*	*Give Me A Call*	11
93. *Peep and the Big Wide World*	*Night Light*	11
94. *Peep and the Big Wide World*	*Sounds Like*	11
95. *Project Mc*^{2}	*Crate Expectations*	22
96. *Ready Jet Go!*	*Freebird*	12
97. *Ready Jet Go!*	*How We Found Your Sun*	12
98. *Ready Jet Go!*	*Just the Right Distance From the Sun*	12
99. *Ready Jet Go!*	*Sean's Robotic Arm*	12
100. *Ready Jet Go!*	*Solar Power Rover*	12
101. *Ready Jet Go!*	*Tree House Observatory*	12
102. *Sid the Science Kid*	*Halloween Spooky Science Special*	26
103. *Sid the Science Kid*	*My Super Slide*	26
104. *Sid the Science Kid*	*Now That's Using Your Brain!*	26
105. *Sid the Science Kid*	*The Amazing Computer Science Tool!*	26
106. *Space Racers*	*Asteroids, Platinum Edition*	12
107. *Space Racers*	*Hawk's Day*	12
108. *Space Racers*	*Hawk's Valentine*	12
109. *Space Racers*	*Robyn's Winter Break*	12
110. *Space Racers*	*Star Signs*	12
111. *Space Racers*	*The Hawk Factor*	12
112. *Splash and Bubbles*	*Cleaner of the Kelp*	12
113. *Splash and Bubbles*	*How Bubbles Got Her Moves Back*	12
114. *Splash and Bubbles*	*Partner Pals*	12
115. *Splash and Bubbles*	*Ultimate Hide and Seek Day*	12
116. *The Deep*	*Strange Migration*	20
117. *The Zula Patrol*	*A Comet's Tale*	12
118. *The Zula Patrol*	*Blue Moon*	12
119. *The Zula Patrol*	*Egg Hunt*	12
120. *The Zula Patrol*	*Going through a Phase*	12
121. *The Zula Patrol*	*Sun Day*	12
122. *The Zula Patrol*	*Time Out*	12
123. *Thomas Edison's Secret Lab*	*Fungal Bungal*	12
124. *Thomas Edison's Secret Lab*	*Out of Memory*	12
125. *Thomas Edison's Secret Lab*	*Pizza to Go!*	12
126. *Thomas Edison's Secret Lab*	*Water Friends For?*	12

(*Appendices continue*)

Table A2 (*continued*)

Series	Episode	Length (min)
127. *Tumble Leaf*	*Cock-A-Doodle Day*	11
128. *Tumble Leaf*	*Fig Flies A Kite*	11
129. *Tumble Leaf*	*Glow In The Dark Sleepover*	11
130. *Tumble Leaf*	*Missing Muffin*	11
131. *Tumble Leaf*	*Paper Plane Messages*	11
132. *Wild Animal Baby Explorers*	*Picky Eaters*	13
133. *Wild Animal Baby Explorers*	*Pocket Protector*	13
134. *Wild Animal Baby Explorers*	*Side By Side*	12
135. *Wild Animal Baby Explorers*	*Sled Stuck*	13
136. *Wild Kratts*	*Birds of a Feather*	27
137. *Wild Kratts*	*Desert Elves*	27
138. *Wild Kratts*	*Liturgusa Krattorum*	27
139. *Wild Kratts*	*Puffin Rescue*	24
140. *Wild Kratts*	*Search for the Florida Panther*	27
141. *Wild Kratts*	*This Orca Likes Sharks*	27
142. *Wild Kratts*	*Whale of a Squid*	27

Appendix C

Additional Media Information

Visual Style

Books in this sample almost exclusively used drawings or paintings as the visual style (n = 108, 98.2%). Only two books (1.8%) used photographs.

Most screen media in this sample used either computer-generated graphics (n = 55, 38.7%) or hand-drawn animation (n = 51, 35.9%). One series used Claymation (*TumbleLeaf*, n = 5 episodes, 3.5% of the sample), another used live action (Project Mc^2, n = 1, .7% of the sample), and 21.1% of the episodes (n = 30) used a mix of styles. We did not separately consider the auditory style of the videos since there was no possible parallel coding for the books, but future work could aim to more precisely characterize how the sounds, music, language, and other auditory elements of videos are presented.

Nonscience Educational Elements

Although the focus of this content analysis was on children's media designed to teach science, 23.8% of our sample additionally aimed to teach nonscience topics (n = 60) such as languages, teamwork, or self-acceptance.

The presence of educational material on these nonscience topics differed significantly depending on the media's primary educational content, $\chi^2(3, N = 252) = 12.04$, $p = .007$. Media designed to teach science process were significantly more likely to include nonscience educational topics (55.0%) compared with media designed to teach biology (20.5%), physics (20.3%), or history (25.9%).

We did not find a significant relationship between the presence of nonscience educational material and the presence of unrealistic content; media with nonscience educational material contained at least one unrealistic element 81.7% of the time, whereas media without such material contained at least one unrealistic element 80.7% of the time (exact proportion test, $p = 1.00$). We also did not find a relationship between the presence of nonscience educational material and the number of types of fantasy content, nonscience educational material present $M = 2.03$, $SD = 1.78$; nonscience educational material absent $M = 2.03$, $SD = 1.79$; $t(250) = .42$, $p = .67$.

Presence of Nonnarrative Elements

Educational media frequently includes nonnarrative elements such as interstitials, sidebars, and glossaries. In this sample, 59.1% of our media included such nonnarrative elements (n = 149).

We found a relationship between the primary science content and the presence of nonnarrative elements, $\chi^2(1, N = 252) = 22.21$, $p < .001$. Media designed to teach physics tended not to contain such elements (37.3% of these media), whereas media designed to teach biology (61.6%), science process (65.0%), or history (88.9%) did tend to contain such elements.

Media that had nonnarrative elements were significantly less likely to contain at least one unrealistic element (72.5%) than media without such nonnarrative elements (93.2%), exact proportion test, $p < .001$. Interestingly, however, we found no difference in the number of different types of unrealistic elements in the media between media that did ($M = 2.06$, $SD = 1.97$) and did not ($M = 2.20$, $SD = 1.48$) contain nonnarrative elements, $t(250) = .63$, $p = .53$.

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