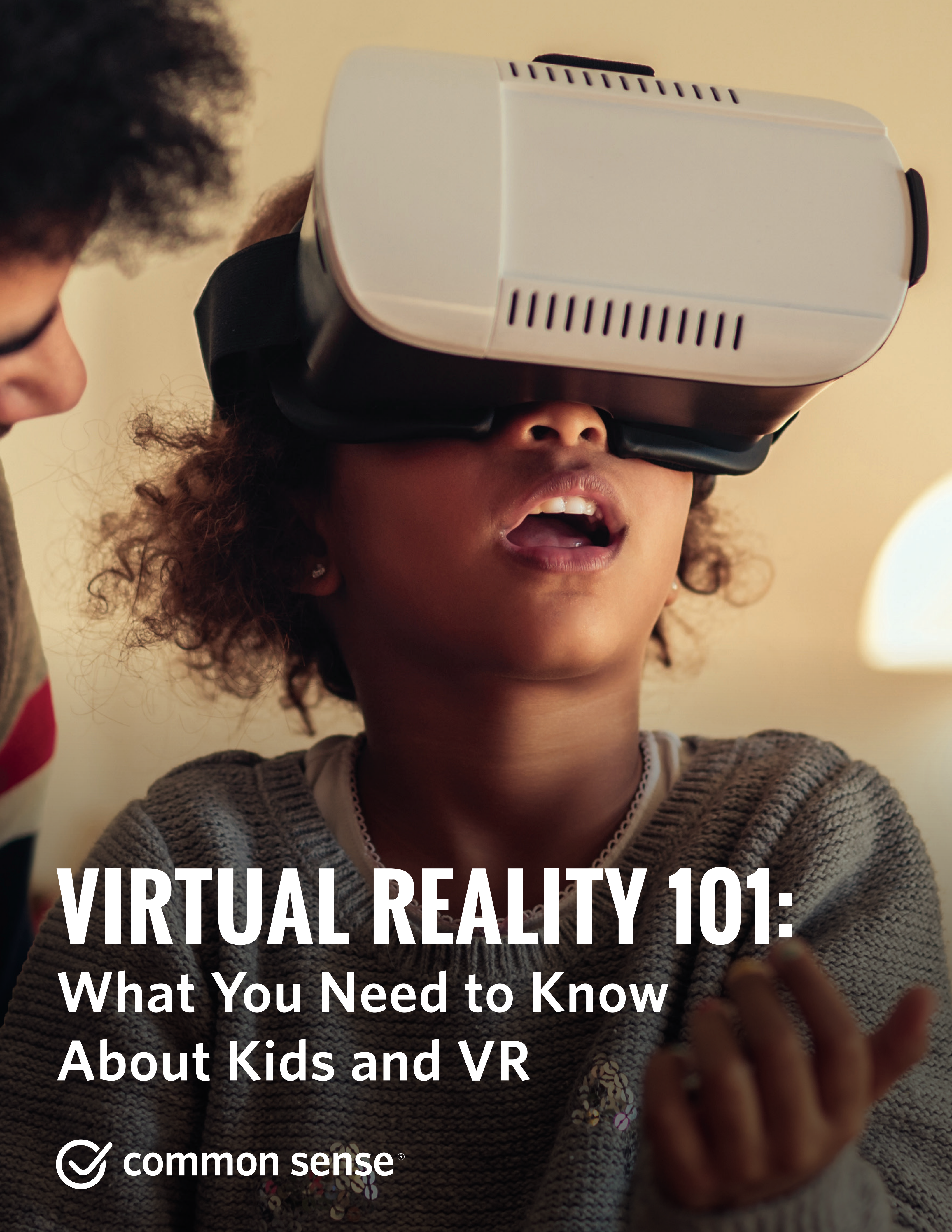

VIRTUAL REALITY 101:

What You Need to Know About Kids and VR

common sense®

Common Sense is the leading independent nonprofit organization dedicated to helping kids thrive in a world of media and technology. We empower parents, teachers, and policymakers by providing unbiased information, trusted advice, and innovative tools to help them harness the power of media and technology as a positive force in all kids' lives.

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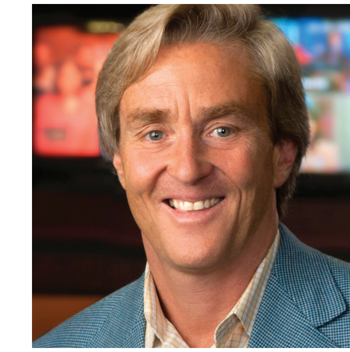
A LETTER FROM OUR FOUNDER



James P. Steyer, *founder and CEO*

Friends,

We live in a time of the most accelerated technological change, unlike anything we've seen before, with new marvels materializing every day. Today, one of those marvels is virtual reality (VR). Though nascent, VR has the potential to become a major force in entertainment, education, and health care.

Here at Common Sense, we're committed to keeping ahead of — and truly understanding — burgeoning trends like VR. This research report, which includes a survey conducted in collaboration with SurveyMonkey about parents' attitudes about VR, represents an early step in our efforts to understand its potential impact on our kids' cognitive, social, and physical well-being, as well as its potential to shape young people's perspectives.

What's unique about VR is the *intensity* of the experiences it mediates. Research — including that of this paper's co-author Jeremy Bailenson, founding director of Stanford University's Virtual Human Interaction Lab — has found that VR is one of the most intense mediums we've encountered.

As a result, many educators are excited about the potential for VR to encourage prosocial behavior among younger children, and 62 percent of parents believe that VR will enhance educational experiences for their kids. Also, research finds that, for older children who are beginning to develop the ability to understand the perspectives of others, VR can help diminish racial bias and encourage empathy. Further, clinical researchers are looking into the potential for VR experiences to help distract from pain and promote rehabilitation for treatable conditions.

It is critical for parents and educators to be aware of VR's powerful effects, as we still don't know enough about how this highly immersive medium affects the developing brain. Indeed, more than half of parents surveyed said they are at least "somewhat concerned" that their children will experience negative health effects while using VR. We also know that, based on early research on the impact of VR on children's health, there is a need for caution when it comes to its use by young children.

Because VR is in its infancy, we have a unique opportunity to stay on top of this technological wave before it overwhelms us. At Common Sense, we plan to review new VR content through our Common Sense Media platform and to guide educators on safe, appropriate, and impactful applications in the classroom. We're also committed to keeping you informed with reports, such as this one, that synthesize the most significant research on the topic to date. We hope you find useful insights in our report, and we look forward to working with you while we continue to watch VR come into better focus in the months and years ahead.

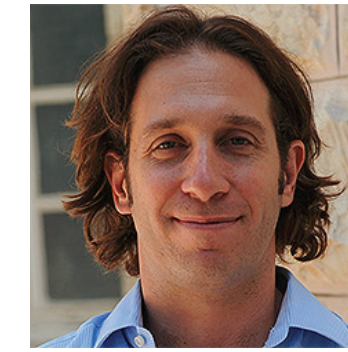
Jim Steyer

COMMON SENSE IS GRATEFUL FOR THE GENEROUS SUPPORT AND UNDERWRITING THAT FUNDED THIS RESEARCH REPORT:

Jennifer Caldwell and John H.N. Fisher

Eva and Bill Price

WHAT WE KNOW ABOUT KIDS AND VR (AND WHAT WE DON'T)



Jeremy Bailenson, *founder, Virtual Human Interaction Lab, Stanford University*

When I first started researching virtual reality in the late 1990s, we never thought about kids in their living rooms. Indeed, VR was like an MRI machine at a doctor's office: It took up a massive room, cost more than most homes, and needed a very skilled technician to operate it.

But everything has changed. The big technology companies have dedicated their brains and muscle to making VR ubiquitous, and systems that would have cost more than my car a few years back now cost less than a typical television set. That's led to a profusion of VR technology and its entry into the mainstream. Conservatively, there are more than 10 million VR systems floating around the United States, and the actual number is probably substantially higher.

This expansion of VR is creating a very real set of questions for parents: How does VR differ from other media? What effect, if any, does VR have on neurological development in children? Are there cognitive repercussions of prolonged immersion in VR experiences? How does the nature of the content presented in VR change perspectives and behaviors among kids?

These are just some of the questions I've spent the past two decades exploring as a researcher and, more recently, as a parent. I have a 6-year-old and a 3-year-old, and even though I teach about media and psychology at Stanford University, I continually struggle with questions such as, "How close is too close to the TV?" and "How many episodes of PBS programming per day is too many?" Now layer VR on top of those questions, and we find ourselves in a foreign landscape.

Since I'm the founding director of Stanford's Virtual Human Interaction Lab, parents often think I have answers to these vexing questions. The truth is, when it comes to VR and kids, we just don't know all that much. As a community, we need more research to understand these effects.

In the meantime, we do have some clues we can offer, and they are summarized in this report. One of those clues comes from Jakki Bailey, a colleague at Stanford who has dedicated her career to this topic and has run hundreds of 3- to 6-year-olds through high-end VR systems. Her preliminary finding is that the illusion of VR is more effective on young children than on adults. Also, the effects of VR tend to be magnified compared to those of traditional media such as television. An experience in VR — which perceptually surrounds people and for which people use natural body movements to interact with the scene — tends to be more impactful than a similar experience using other media.

For children, moderation should prevail. Instead of hours of use, which might apply to other screens, think in terms of minutes. Most VR is meant to be done on the five- to 10-minute scale. As far as content goes, a good rule is, if you wouldn't want your children to live with the memory of the event in the real world, then don't have them do it in VR. Traveling to the moon is fine, but scary experiences will stay with them. And think about safety. By definition, VR blocks out the real world. Watch your children around sharp edges, pets, and walls.

The good news is, VR is super fun. The vast majority of the hundreds of kids Professor Bailey has observed have been thrilled and delighted. Nobody got sick, nobody got hurt, and to date no parents have reported any ill effects. But the kids were meeting Grover from *Sesame Street*, and they were supervised in VR sessions that lasted only about five minutes.

It seems with VR, a little bit goes a long way. So, until research yields more clues on the effects of VR on children, common sense should prevail.

Jeremy Bailenson is the founding director of Stanford University's Virtual Human Interaction Lab. His lab builds and studies systems that allow people to meet in virtual space and explores the changes in the nature of social interaction. His most recent research focuses on how VR can transform education, environmental conservation, empathy, and health. In his latest book, Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do, *Bailenson provides an in-depth discussion of how to avoid the downsides of VR while maximizing its beneficial applications.*

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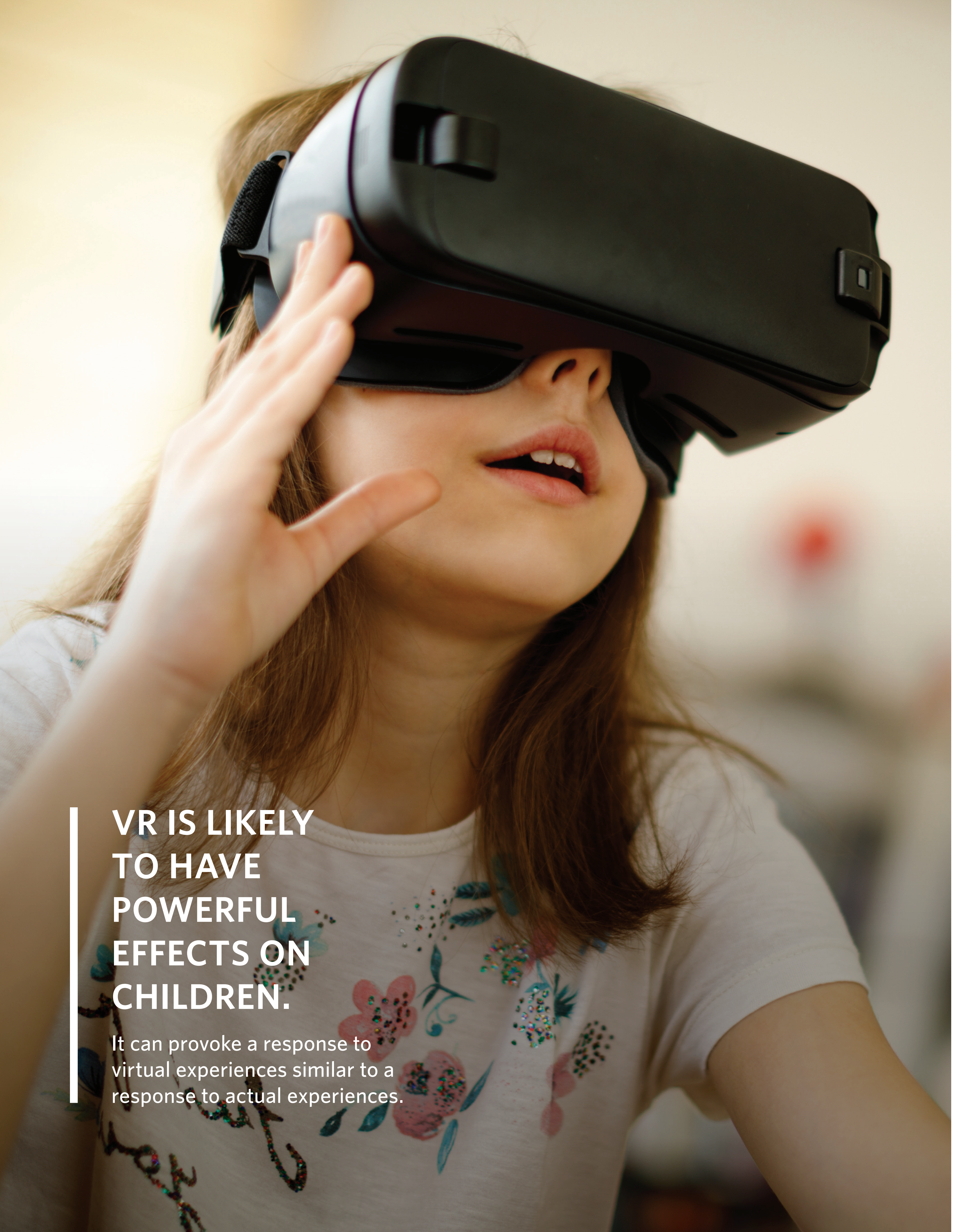

KEY FINDINGS

1. Virtual reality (VR) is likely to have powerful effects on children because it can provoke a response to virtual experiences similar to a response to *actual* experiences.

Psychological presence is the sense of "being there," occurring when users temporarily suspend the sense that an experience is mediated by technology and, instead, feel as if they are having a real experience (Lombard & Ditton, 1997). While other media technologies — even books — can create psychological presence, none is quite on the same scale as VR (e.g., Bohil, Alicea, & Biocca, 2011). To the extent that VR simulates the real world, children may face challenges discerning which components of virtual events are not real (e.g., seeing the self in VR versus seeing another person in VR) (Segovia & Bailenson, 2009). On the other hand, the psychological presence of VR can be leveraged to produce beneficial outcomes for children as well. For example, VR has clinical applications, including pain distraction and rehabilitation for treatable conditions; educational applications; and prosocial applications, such as empathy training (see Bailenson, 2018, for review).

2. The long-term effects of children's use of immersive VR on their still-developing brains and health are unknown, but most parents are concerned, and experts advocate moderation and supervision.

Sixty percent of parents say they are at least "somewhat concerned" that their children will experience negative health effects while using virtual reality (current report, see Appendix). But while most of the literature has demonstrated powerful, positive effects of VR on adults (Slater & Sanchez-Vives, 2016), fewer empirical studies have been conducted on child users. This lack of research is disconcerting, as new VR devices and software will inevitably appeal to children. Given that the development of the prefrontal cortex of the brain accelerates through middle childhood (Diamond, 2013), questions about how long-term use of VR will affect children's brain development and health are critical to investigate (Bailey & Bailenson, 2017). VR developers (Milanesi, 2016) and researchers (Mon-Williams, 2017) caution that more research on children needs to be conducted before VR can be readily recommended for children. For example, in VR, users must focus on images that appear to be far away but are drawn on screens that appear only a few centimeters from their eyes. This mismatch can confuse the brain and cause eyestrain and headaches in the short term; the long-term effects are unknown (Mon-Williams, 2017). Parents are similarly cautious, especially for young children. Only 13 percent of parents say that VR is appropriate for kids under the age of 7, which is typically the age by which children understand the plausibility of media events (e.g., Claxton & Ponto, 2013; Woolley & Ghossainy, 2013). In contrast, nearly half of parents (45 percent) say that VR is appropriate for children under the age of 13, which is the age recommendation of VR devices with more technological features (e.g., the HTC Vive, the Oculus Rift) (current report, see Appendix).

3. Only one in five U.S. parents (21 percent) today report living in a household with VR, and the majority (65 percent) are not planning to purchase VR hardware. However, the interest levels of U.S. children are high, while parent interest is mixed.

In a spring 2017 study, 70 percent of U.S. children between the ages of 8 and 15 reported being "extremely" or "fairly" interested in experiencing VR, and 64 percent of parents reported the same (Yamada-Rice et al., 2017). Despite the interest, parents appeared to need more convincing to actually purchase VR devices. In another study, among parents who have not purchased VR for their households and are not planning to, the most common reason was that they were not interested in it (56 percent), followed by: They do not know enough about VR (31 percent), it is too expensive (28 percent), and or they are

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concerned about negative health effects (20 percent) (current report, see Appendix). Still, it is probable that kids' desire for VR will drive the purchasing of VR: Two-thirds (64 percent) of parents in VR-using homes say that one or more of their children had asked them to buy a VR device. Children's enthusiasm about VR will likely drive the market for VR hardware and content in the coming years (Yamada-Rice et al., 2017). Children have been shown to adopt technology early, even when it is not designed for them (Blakemore & Mills, 2014).

4. Characters in VR may be especially influential on young children, even more so than characters on TV or computers. This can be good or bad depending on the influence.

When a virtual character behaves realistically, adult users often respond as they would to a real person (Blascovich et al., 2002). Recent research suggests this to be true of young children as well. Children age 4–6 were assigned to interact with *Sesame Street*'s Grover, either in VR or via a two-dimensional screen, and the results suggested that children in the VR condition were more likely to treat Grover as a friend than children in the screen condition (Bailey, Bailenson, Obradovic, & Aguiar, 2017). For example, they shared more stickers with him; other measures of liking demonstrated similar results. A positive implication of this finding is that the media characters in VR may help children translate skills learned in educational virtual environments to the physical world. Alternatively, the power of social influence in VR could encourage antisocial behavior, too. In VR, as with other media, parents need to be aware of the powerful influence of media characters and choose their children's interactions with them carefully.

5. Students often feel more enthusiasm for learning while using VR, but they do not necessarily learn more through VR than through video or computer games.

Many families believe in VR's educational potential; sixty-two percent of parents believe that VR will provide educational experiences for their children (current report, see Appendix). VR has been shown to facilitate learning for various skills and content areas such as visualizing fractions (Roussou, Oliver, & Slater, 2006), learning about plant growth, water, and sunlight (Roussou et al., 1999), learning about gorilla behaviors (Allison & Hodges, 2000), and learning standards-based math and science concepts (Adamo-Villani, Wilbur, & Washburn, 2008). However, when comparing learning outcomes from VR with learning outcomes from video or desktop games (Dede, 2009), some evidence suggests that VR has yet to demonstrate an increased retention of facts as compared to the non-immersive platforms (Bailenson, 2018). For example, in an assessment of a botany lesson on a desktop computer versus an immersive experience in VR, the groups did not differ in their learning outcomes — i.e., retention of information and transfer of knowledge to novel contexts (Moreno & Mayer, 2004). A primary challenge is to overcome kids' tendency to focus on the novel sensorial experiences of the virtual environment instead of the narrative information that is meant to build knowledge (Bailenson, 2018).

6. VR can potentially be an effective tool for encouraging empathy among children, though most parents are skeptical.

Parents are skeptical about the potential for VR to promote empathy; only 38 percent think it can help children empathize with people different from them (current report, see Appendix). Research shows that when users embody an avatar in VR, these perspective-taking experiences can diminish implicit racial bias (Peck, Seinfeld, Aglioti, & Slater, 2013), invoke empathy for people with colorblindness (Ahn, Le, & Bailenson, 2013), and promote prosocial responses in virtual interactions in which an avatar needs help (Ahn et al., 2013; Gillath, McCall, Shaver, & Blascovich, 2008). However, although VR can increase adult participants' empathy toward people who are different from them, the potential for VR to encourage empathy among young children might be challenging as they continue to develop the ability for perspective-taking and develop a more mature and complex ability to understand that other people may think and feel differently from them (typically developing into middle childhood and adolescence; Blakemore & Mills, 2014). It may be the case that embodied avatar experiences might not be as effective until children develop skills in social perspective-taking.

7. When choosing VR content, parents should consider whether they would want their children to have the same experience in the real world.

While parents might deem it acceptable for children to play the role of a soldier engaged in modern warfare (e.g., in *Call of Duty*) on a traditional gaming console, playing that game in VR would likely be processed by the brain in ways more like an actual experience (Bohil et al., 2011). Even though the gamer controls the actions from the first-person perspective in both modes, the immersive nature of VR could make the experience much scarier and more anxiety-producing, especially for children. Thus, a standard for choosing content for VR could be: Would this be something you would want your child to do in real life? Would you want your child to experience real-life combat, for example? If the answer is no, then that content should likely be avoided (Bailenson, 2018).

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Parents' Views on VR for Kids

Virtual reality is just beginning to emerge in families' homes.

PERCENT OF FAMILIES WITH CHILDREN UNDER 18

- **21%** own a VR device.
- **13%** are planning to buy a VR device in the next year.

Kids don't use VR much.

PERCENT OF PARENTS OF 8- TO 17-YEAR-OLDS WHO USE VR

50% haven't used the VR device in the past week.

6% say that one or more of their children used VR every day in the past week.

It's all about the games.

PERCENT OF PARENTS OF 8- TO 17-YEAR-OLDS WHO USE VR

Percent of children who have used VR for the following:

Playing games	76%
Watching videos or movies	38%
Exploring environments	33%
Learning something	22%
Connecting with friends	9%
Doing research	7%
Medical therapy or intervention	1%

Most families who are not purchasing VR are not interested.

65% of families with children under 18 don't own and are not planning to buy a VR device.

Reasons for not purchasing VR device:

Not interested in using VR	56%
Don't know enough about VR	31%
Too expensive	28%
Concerned about health effects	20%
Think VR is a gimmick	10%
Too hard to find content	6%

VR has educational promise.

62% of parents overall believe that VR will provide educational experiences for their children.

84% of parents of 8- to 17-year-olds who use VR believe that VR will provide educational experiences for their children.

Most parents think VR is for older kids.

43% of parents say that it is appropriate for children under 13 to use VR.

Top parent VR concerns

- **70%** Sexual content, pornography, or violent content
- **67%** Too much time with VR
- **61%** Social isolation

Parents worry about VR's impact on health.

60% of parents say they are at least "somewhat concerned" that their children will experience negative health effects while using VR (**includes 30% who are "very concerned"**).

Some kids experience health issues when using VR.

PERCENT OF PARENTS OF 8- TO 17-YEAR-OLDS WHO USE VR

- **13%** Bumping into something
- **11%** Dizziness
- **10%** Headache
- **8%** Eyestrain

VR has positive potential, but most parents don't expect that kids will learn to empathize with others while using VR.

Percent of parents who agree that ...

	Parents of 8- to 17-year-olds who use VR	All parents
Virtual reality will allow children to do things they otherwise couldn't do.	76%	58%
Virtual reality will help children empathize with people different from them.	56%	38%
Virtual reality is a fun way to play together as a family.	78%	50%

Methodology: This Common Sense Media/SurveyMonkey online poll was conducted December 21–31, 2017, among a national sample of 12,148 adults. Of the adults sampled, 3,613 were the parent of at least one child under 18, and 471 indicated that they had a child between 8 and 17 years old who uses VR. Respondents for this survey were selected from the nearly 3 million people who take surveys on the SurveyMonkey platform each day. The modeled error estimate for this survey is plus or minus 1.5 percentage points. Data have been weighted to reflect the demographic composition of the United States in terms of age, race, sex, education, and geography using the Census Bureau's American Community Survey.

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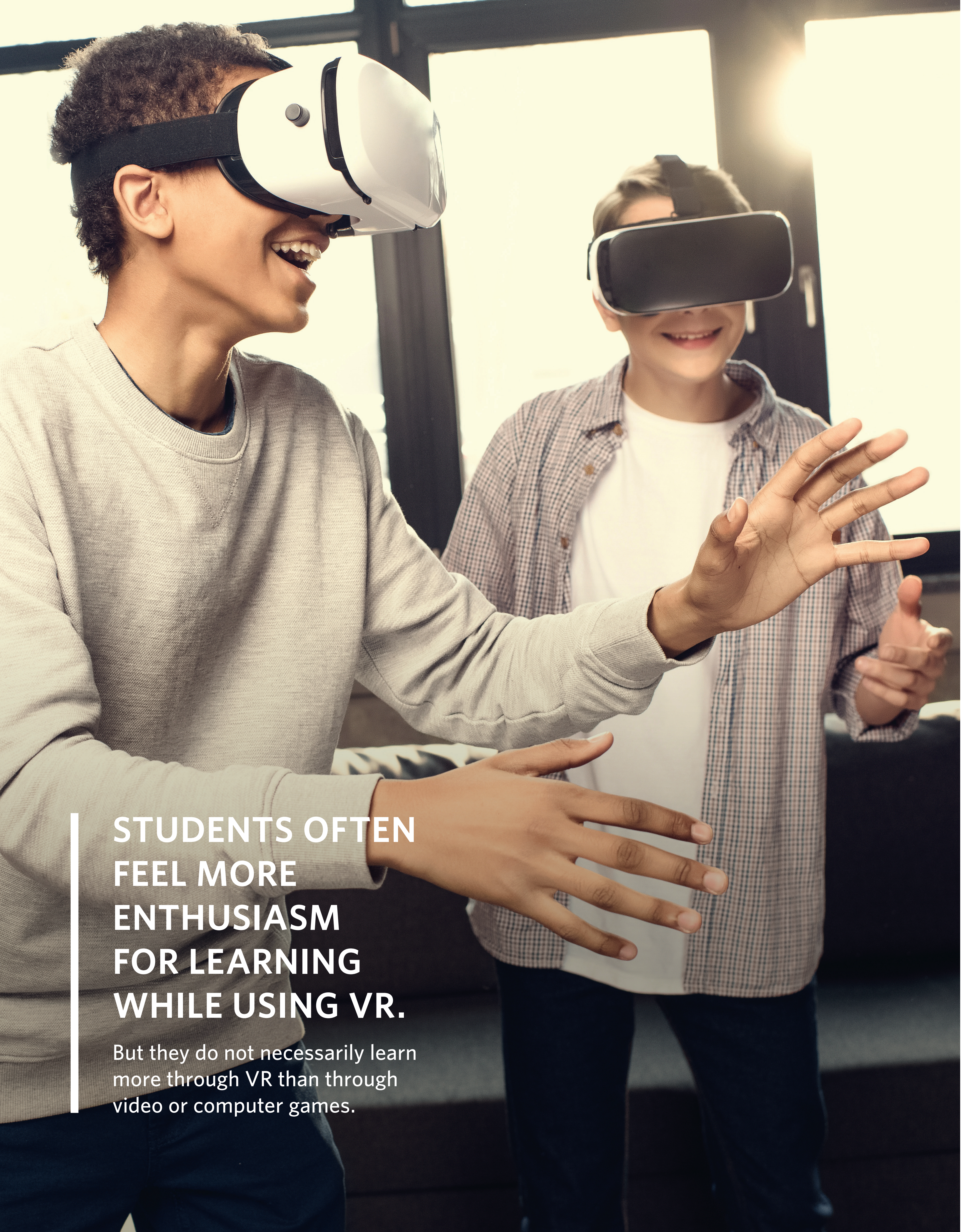

INTRODUCTION

In *Ready Player One*, a *New York Times* best-selling novel adapted to a Steven Spielberg-directed film, the year is 2044, and a generation of young people escapes to a privately controlled virtual reality universe. Wracked by an energy crisis and climate change, their physical world is in decline. In time, their virtual reality simulation becomes a "substitute for society" because life in the real world is unbearable (Krupa, 2018, para. 4). With current-day headlines like "Enter the Holodock" in the *New York Times* (O'Neil, 2018) and "The Promise of Virtual Reality" in the *Wall Street Journal* (Rose, 2018), one might wonder if *Ready Player One* is far-fetched fantasy or prophecy.

In the most basic sense, virtual reality (VR) allows users' actions in the real, physical world to merge with what they experience in a virtual world (Steuer, 1992). Given advances in technology, VR today is typically quite immersive; users are placed directly into the virtual environments by the blocking out of stimuli from the physical world, thereby creating vivid and personal experiences (Bailey & Bailenson, 2017). Technologically, the defining features of VR include tracking, rendering, and display. The tracking capability captures the movement of the user in the real world, and rendering involves updating the virtual world based on those movements. Display is the manner in which users experience the virtual environment, usually through sight, sound, and touch (and sometimes scent).

This immersive sensory experience is accomplished by using one of two main technologies: 1). Head-mounted displays (HMDs) are headsets that are worn by the user and that can show stereoscopic information, spatialize sound, and provoke tactile sensations. 2). Cave automatic virtual environments (CAVEs) are rooms in which screens covering walls, the ceiling, and the floor project virtual images to surround the user with the virtual environment. Due to limitations of room size and cost, HMDs are more common than CAVEs.

Psychologically, users of VR experience "psychological presence," the sense of "being there" (Lombard & Ditton, 1997; Riva et al., 2007), which is what distinguishes immersive virtual reality from other media technologies. Psychological presence occurs when users temporarily suspend the sense that an experience is brokered by technology and, instead, feel as if they are having a real experience. The virtual world has the ability to seamlessly match the perspective, tactile sensations, and sounds of the user's physical actions (Loomis, 1992). For example, if you walk up to an object, the object will get bigger. If you touch the object, you will feel resistance against your fingers. If the object drops from a table, the sound will get louder as your head turns toward it. This is the "secret sauce" of VR, distinguishing it from other immersive media (Bailenson, 2018, p. 54). A book or movie can certainly be engrossing, but in terms of actually "being there," these experiences pale in comparison to VR.

A classic demonstration of VR involves users standing on the edge of a plank that reveals a deep crevasse below, which generates the feeling that they are balancing precariously on a small shelf high in the air (Sanchez-Vives & Slater, 2005). In this context, users may logically know that they are safe in a room and wearing a headset; nevertheless, when they take the plunge in the virtual space, their hearts race, their palms sweat, and a feeling of terror overcomes them. This is a vivid example of psychological presence, which can be leveraged across many applications. VR has been used for training exercises, entertainment (i.e., video games, films, adult entertainment), emotional and empathy training, and even therapies to help users deal with pain and other treatable conditions. With the recent appearance and expansion of VR in the commercial marketplace, the full scope of what is possible with VR is still in its infancy.

Based on research on the effects of traditional (non-VR) media on kids, the effects of VR are presumed to be more intense and wide-ranging for child users than for adult users (Bailey & Bailenson, 2017). Despite little research documenting the effects of VR on child users, in the years ahead, parents, educators, and practitioners will need to know what these technological experiences mean for children and adolescents. Thus, the objectives of this report are 1). to explain the child developmental milestones that are especially important for children using VR, and 2). to summarize the potentially negative and positive effects of VR on child users.

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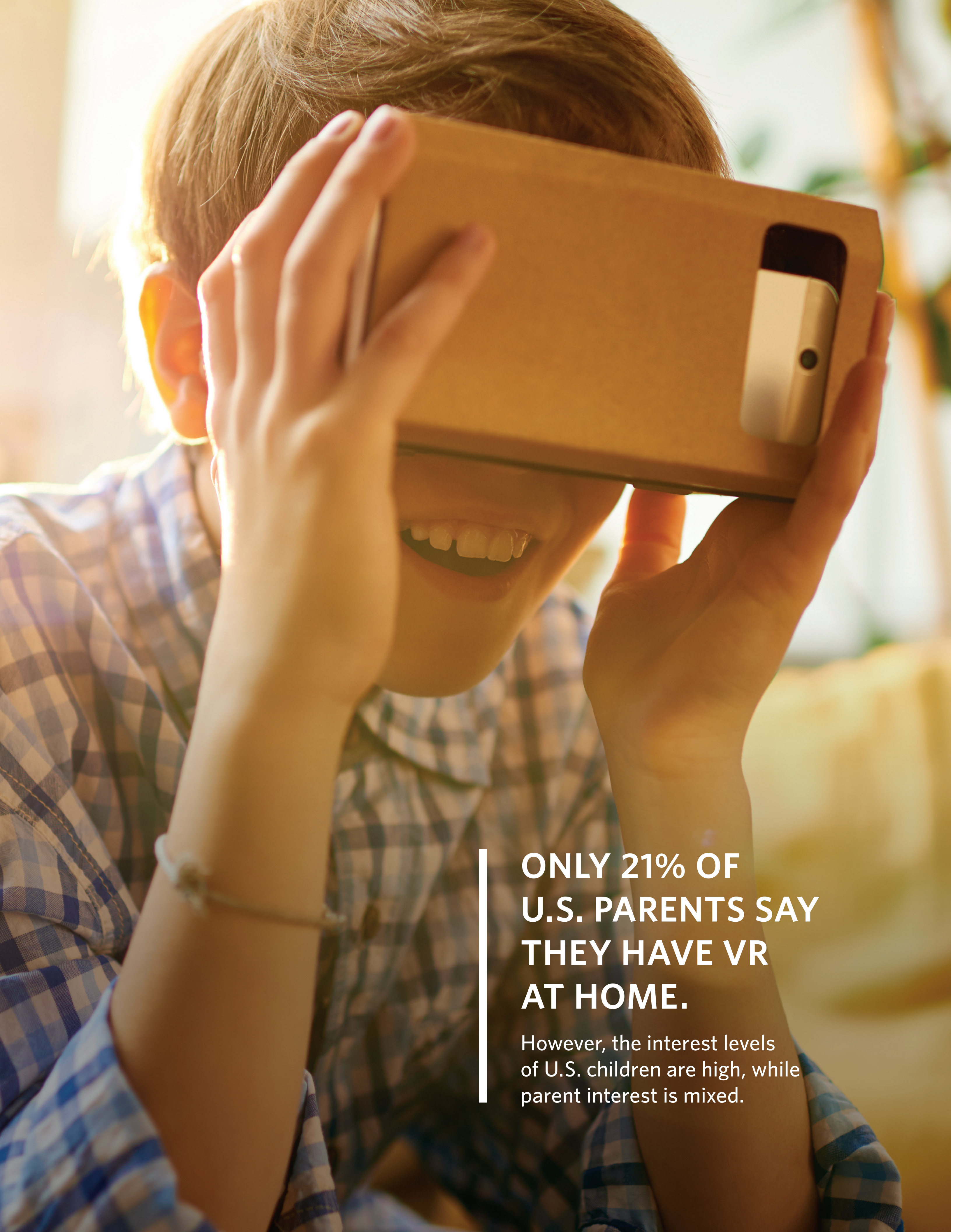

ONLY 21% OF U.S. PARENTS SAY THEY HAVE VR AT HOME.

However, the interest levels of U.S. children are high, while parent interest is mixed.

THE VR MARKETPLACE

By 2016 the technology had advanced enough, and the market competition had become fierce enough, that the price of VR devices dropped considerably to be affordable for private use (with upfront costs ranging from $15 for the low-tech Google Cardboard to $600 for the HTC Vive) (Fink, 2017). The price for VR hardware is forecasted to decrease by approximately 15 percent in the coming years (Neiger, 2016), making VR a viable option for many households. Although still in the "early adoption" phase (i.e., still approaching a critical mass of users), sales of VR devices are starting to take off. For the first time, 1 million virtual reality devices were shipped in a single quarter, just before 2017's holiday shopping season (Maggio, 2017). Sony's PlayStation VR was the most widely popular in 2017, representing nearly one half of those shipments, followed by the Oculus Rift and the HTC Vive. With dissemination of VR hardware, the next development will likely be in the production of high-quality VR content. More than $1 billion was invested in immersive entertainment projects in 2017 (Chmielewski, 2018). While 2017 was a year for experimentation, manufacturers hope to generate buzz and to build a base of users willing to invest in more expensive and sophisticated VR technology as it becomes available.

The hype has appeared to work; a spring 2017 survey of U.S. children revealed a high level of interest in VR (Yamada-Rice et al., 2017). Of 8- to 10-year-olds, 65 percent reported being "extremely" or "fairly" interested in experiencing VR, and 73 percent of 11- to 15-year-olds were "extremely" or "fairly" interested. Similarly, 64 percent of parents reported being "extremely" or "fairly" interested in experiencing VR. However, parents appear to be less excited about making the leap to purchasing VR hardware. According to Common Sense's own survey of parents of children under 18 (see Appendix), 65 percent reported "no" interest in buying VR. Only 21 percent of parents reported living in a household that already owned a VR device, and 13 percent planned to buy a VR device in the next year. Kids appear to be effective in getting access to VR: Two-thirds (64 percent) of parents in VR-using homes say that one or more of their children had asked them to buy a VR device. Together, these findings suggest that while parents might be reticent about buying VR, children's enthusiasm likely will drive the market for VR hardware and content in the coming years (Yamada-Rice et al., 2017).

A close cousin to VR is **augmented reality (AR)**. An augmented reality experience occurs when a user is engaged in the physical world but a technology augments that world with digital information (Azuma, 1997; Billinghurst, Clark, & Lee, 2015). For example, imagine that you go to an empty lot where you want to build a home. In your actual experience, you can go there and imagine in your mind what the house might look like. Through the aid of an augmented reality technology, such as an application on your smartphone or on a headset, you can virtually see your home, registered in a particular place on that lot. You can walk around the house and see it from all different viewpoints just like you could if the house were actually completed on the lot. Thus, AR technologies offer "mixed reality" experiences, combining the real with augmented virtual information. The popular Pokémon Go game is an example of an AR experience; users move through the physical world to capture virtual Pokémon characters through their smartphone application. For this report, we draw a distinction between VR and AR, and we focus on virtual reality.

Suggested Age Guidelines for VR

VR manufacturers have been careful to acknowledge that the effects of VR on children and the risks are largely unknown, and most recommend cautious age guidelines. With the exception of VR devices specifically targeted toward child users, most companies recommend that no children younger than 12 or 13 use them. However, there is no clinical rationale for this age, as it is not based on empirical evidence (Yamada-Rice et al., 2017). Sony, for instance, suggests that no one under the age of 12 should use its PlayStation VR, even though a number of the games and characters are cartoonish and child-friendly. There are some VR devices that are specifically made for children (e.g., the View-Master VR), but the lower age limits for those are still conservative (7 years old for the View-Master VR). Only 43 percent of parents believe the technology is appropriate for children younger than 13 (current report, see Appendix). However, among parents who already owned a VR device, it is clear that the industry guidelines were not supported. More than seven in 10 parents of 8- to 17-year-olds who use VR say that it is appropriate for children under 13 to use VR. The age recommendations for popular VR technologies are summarized in Table 1.

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TABLE 1. Summary of Major VR Devices as of January 2018

Brand	Make	Which Body Movements Are Allowed?	Is It Phone-Based?	Does It Track Hand Movements?	Does It Require a Computer?	Company Age Recommendation	Source
Samsung	Gear	Looking only	Yes	No	No	Should not be used by children under age 13. Adults should monitor children age 13 and up who use the headset.	https://static.oculus.com/documents/gear-vr-health-and-safety-warnings-en.pdf
Facebook	Oculus Rift CV1	Looking, leaning, a few steps	No	Yes	Yes	Should not be used by children under age 13. Adults should monitor children age 13 and up who use the headset.	https://static.oculus.com/documents/health-and-safety-warnings.pdf
Google	Cardboard	Looking only	Yes	No	No	Can be used by children with adult supervision.	https://vr.google.com/cardboard/product-safety/
Google	Daydream	Looking only	Yes	No	No	Should not be used by children under age 13.	https://support.google.com/daydream/answer/7185037?hl=en
Sony	PlayStation VR	Looking, leaning, a few steps	No	Yes	No	Should not be used by children under age 12.	https://www.playstation.com/en-us/explore/playstation-vr/
HTC	Vive	Looking, room-scale walking	No	Yes	Yes	No specific age restriction, but there is a warning that the "product was not designed to be used by children" and that if "older" children are permitted to use the product, an adult should monitor them closely.	http://dl4.htc.com/vive/safty_guide/91H02887-05M%20Rev.A.pdf
View-Master	Virtual Reality Deluxe Viewer	Looking only	Yes	No	No	Designed for children age 7 and up, with adult supervision.	http://www.view-master.com/en-us/troubleshooting

HOW WILL VR AFFECT DEVELOPMENT?

Certain developmental skills in childhood pose significant challenges and opportunities for VR. In the following section, we highlight several that are especially relevant to conceptualizing how children will process and experience VR.

Executive Function

The development of the prefrontal cortex of the brain accelerates from the preschool years (age 3–5) until late childhood and early adolescence (9–11 years old) and continues through the mid-20s (Diamond, 2013). As the prefrontal cortex matures, so do children's executive function skills, which refer to three self-regulatory abilities: working memory, impulse control, and cognitive flexibility. Working memory is the ability to hold information in mind and cognitively work with it even when it is not perceptually present. Impluse control reflects two related skills: 1). the ability to pay attention to certain stimuli while filtering out distractions, and 2). the ability to resist temptations. And finally, cognitive flexibility is the ability to change perspectives or approaches to a problem or a task. Together, children's developing executive function skills will influence how they experience and interact in virtual environments.

First, executive function skills are likely related to whether children can distinguish between actual and virtual experiences. Research involving interactive virtual characters has shown that young children perceive these characters as real and as having human needs and emotions (Bond & Calvert, 2014). One study showed that 5-year-old children followed the advice of a virtual character shown on a television screen as frequently as that of a live person, but 7- and 9-year-old children followed the advice of a live person more often than that of a virtual character (Claxton & Ponto, 2013). This suggests that a shift in perception typically occurs between 5 and 7 years of age. Five-year-olds were more likely than the 7- and 9-year-olds to believe that the virtual characters could see them through the screen. These differences in how interactive virtual characters are viewed could be related to an improvement in cognitive flexibility and working memory. That is, older children can simultaneously see that the virtual character is acting in a realistic way (using social cues like eye movement and pausing for responses), and they also can keep in mind that the rules of the physical world dictate that the virtual character is not actually in the room with them. VR's ability to block out the sensory experience of the physical world could make it more challenging for younger children to remember being in the physical world while simultaneously processing the rules of the virtual environment.

Second, in light of children's still developing impulse control, young children will likely have a difficult time resisting temptations in a virtual environment. In collaboration with the Sesame Workshop, the creators of *Sesame Street*, Bailey, Bailenson, Obradovic, and Aguiar (2017) programmed a simulation in which 52 children (age 4–6) interacted with furry blue monster Grover either through an immersive VR experience (i.e., virtual reality headset) or a non-immersive experience (watching on a two-dimensional television screen). Children in the VR condition showed a significant deficit in impulse-control skills, as measured by their success in playing a game of Simon Says with Grover. In the game, children who saw Grover on the television screen were better able to suppress mimicking the gesture when Grover did not say "Simon says," but in VR, the temptation to mimic Grover was harder to resist. The authors' explanation for this finding is that the more realistic and compelling the features of the character becomes, as happened with VR Grover, the more challenging it may be for children to resist the urge to imitate the character.

Reality and Fantasy Distinction

Another important cognitive skill that develops during childhood is the ability to distinguish fantasy from reality. Research has shown that by the age of 5, children can understand the difference between reality and fantasy on television, and they use their previous experience and striking violations of physical reality to determine if something is real or fantasy (Woolley & Ghossainy, 2013; Wright, Huston, Reitz, & Piemyat, 1994). Five-year-olds typically judge cartoons as not real because they feature physically impossible events and characters. Additionally, preschool children often erroneously believe that events that are out of the ordinary violate fundamental laws about the world around us (Shtulman & Carey, 2007). Thus, children can be thought of as

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"naive skeptics," tending to base their judgments on experience and thus classifying events that they have not experienced for themselves as impossible (Woolley & Ghossainy, 2013). By middle childhood (age 7–8), children learn to judge realism based on whether something is possible versus whether something is probable in the real world (Dorr, 1983). To the extent that virtual reality simulates the real world with environments and interactions that seem possible, and maybe even probable, children younger than 7 could face challenges discerning when virtual events are not real.

Because experiencing VR places users into the content, understanding the nature of the self is also an important facet of distinguishing between reality and fantasy in VR (Bailey & Bailenson, 2017). Throughout the preschool years, children develop an understanding that the self that existed in the past is the same as the one that exists in the present (and will exist in the future). At the same time, preschoolers develop autobiographical memory, which is a memory of the events of one's life, including the emotions, goals, and personal meanings attached to these events. If children's time-based understandings and their autobiographical memory are still developing, they could confuse VR experiences with actual experiences.

In support of this idea, Segovia and Bailenson (2009) tested whether preschool and elementary school-age children could differentiate virtual experiences from real ones. In a preliminary study of 55 preschool and elementary school-age children, participants were told stories of two events that did not actually take place. For one event, experimenters told the children that they had heard (from their parents) that, two years prior to the study, they had swum with whales at SeaWorld. For the other event, experimenters told children that, two years earlier, they had heard that the children had shrunk down to size to dance with a stuffed mouse. Afterward, children were assigned to one of four memory prompts: 1). idle — i.e., the participants were not prompted by experimenters, 2). mental imagery — i.e., the participants were asked to imagine themselves participating in the false events, 3). other avatar — i.e., the participants saw another child avatar participate in the false events, and 4). self-avatar — i.e., the participants watched themselves participate in the false events via a virtual doppelgänger (an avatar that looked like them but was controlled by a computer). For preschool children, the memory prompt did not affect their false memories; all conditions evoked relatively equal amounts of false memories. This is likely due to the combination of children's still developing abilities 1). to distinguish between reality and fantasy, 2). to temporally understand the self, and 3). to store autobiographical memories, no matter the type of memory prompt. For the elementary school-age children, however, seeing themselves as an avatar participating in the false events produced a high rate of false memories compared to the idle-control condition and the other-avatar condition. Thus, seeing their self-avatar participating in an activity was confusing enough to elicit false memories from elementary school-age children, who were still developing their ability to judge events based on their plausibility.

Imagination, Friendships, and Parasocial Relationships

During early childhood (around 3 years old), imagination (Singer & Singer, 2005) and the experience of first friendships develop (Hartup, 1989). These two developments often intersect, as it is common for children to have imaginary friends. Corresponding to media usage, it is also typical for children to develop one-way attachments to media characters, called parasocial relationships (Calvert, 2017). These emotionally tinged one-way relationships are experienced across the lifespan, but to children who are still developing the ability to distinguish fantasy from reality, the relationships can be perceived realistically (Bond & Calvert, 2014). For example, children tend to believe that the characters with whom they have developed a parasocial relationship are their friends, have human-like needs (e.g., hunger, sleep), and are really in their lives. Additionally, media characters often interact with children using parasocial techniques, even in non-immersive media. This occurs in television programs when characters, like Dora the Explorer and Elmo on *Sesame Street*, address the audience and pause as if waiting for a response. Likewise, interactive characters in video games typically ask the child user a question and respond in an "intelligent" way (i.e., the character responds to the child contingently based on their earlier decisions and actions). Research has shown that when children engage with these techniques, they exhibit better story comprehension, problem-solving skills, attentional skills, and other educational outcomes such as math skills (see Calvert, 2017, for review). Interactive characters can also generate a greater sense of trust from the child viewer, which increases the character's social influence on the child (Richert, Robb, & Smith, 2011).

When a character is embodied and exhibits realistic behaviors, there is an even greater potential for children to develop a parasocial relationship with the character (Bailey et al., 2017). That is, when children feel like they are sharing a space with a character and engaging in dialogue and interactive behaviors (e.g., sharing, playing games), they will likely encode these experiences in a manner similar to actual interactions. Some evidence from the Sesame Workshop study, described earlier, provides evidence for this claim. Children treated Grover in VR more along the lines of a friend than children who saw Grover on television.

VR, then, is well-suited to the creation of media character-based parasocial relationships. Children's attachments to media characters in a VR environment could be used to support learning and the development of prosocial behaviors. For example, successful VR applications in the interactive learning realm would provide personalized experiences so that children could interact with characters with whom they already had an attachment and a sense of credibility and trust (Calvert, 2017).

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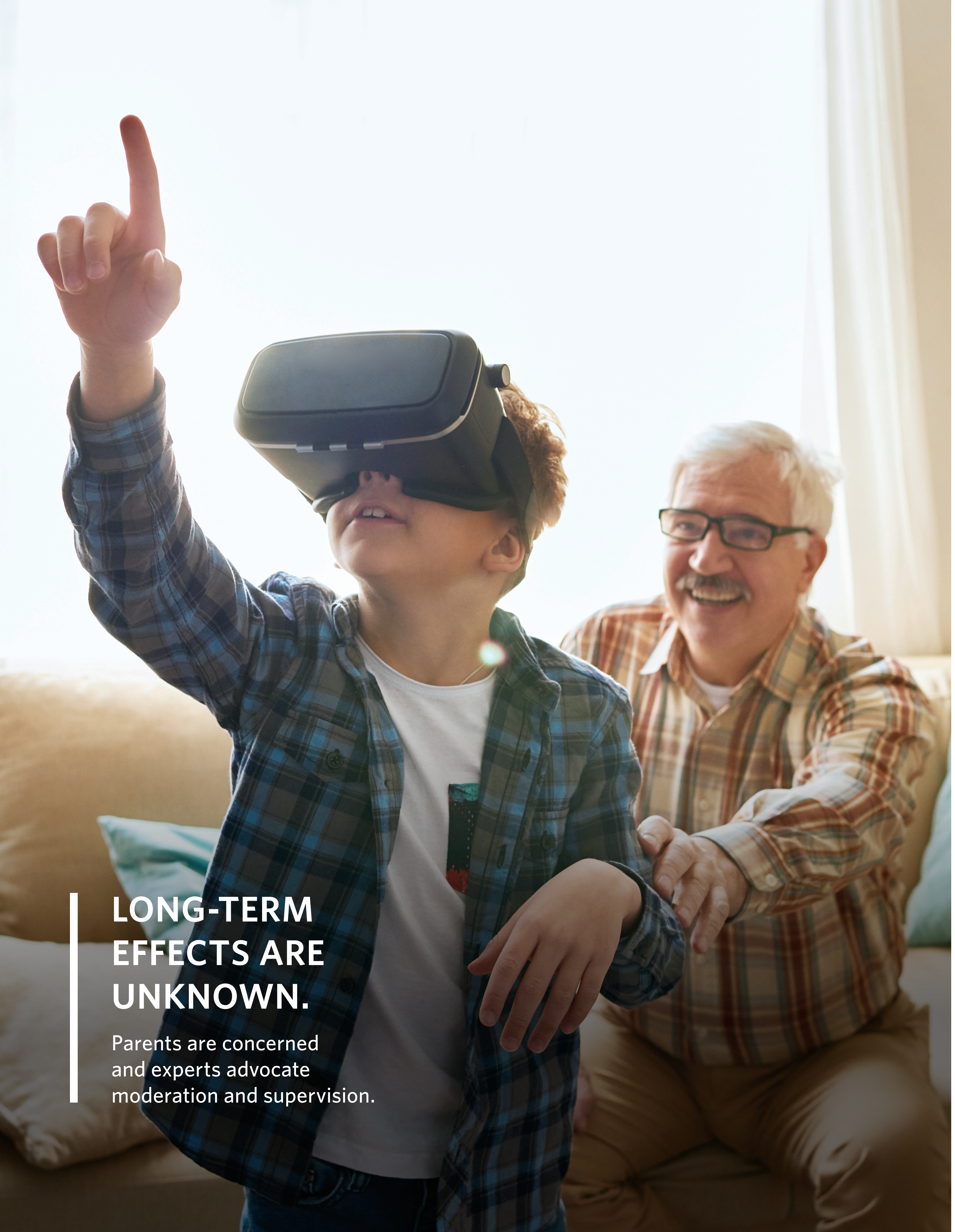

HOW WILL VR AFFECT MY CHILD?

For decades, researchers have examined whether media affect children and adults differently (Strasburger, Wilson, & Jordan, 2014). These examinations factor in child development research and theory demonstrating that children have certain cognitive and psychosocial vulnerabilities that adults do not have. However, when children interact with traditional media, like television, films, and video games, they are typically aware, at least by the age of 5, that they are seeing representations of what could happen in the real world (Wright et al., 1994). For example, they understand that events on-screen happen to characters, not to themselves. This might not be the case with VR, because its immersive nature — users blocking out the physical world and interpreting virtual signals as reality — makes virtual reality feel more like actual experience (Bailenson, 2018). VR is less like a "media experience" and more like an actual experience because of how the brain interprets it (e.g., Bohil et al., 2011). It is not surprising, then, that studies on adult participants have shown that VR experiences have an impact on users and these effects do not disappear immediately.

Virtual reality is thus poised to have powerful effects, especially on children, in a variety of domains. However, there is little research that empirically supports this hypothesis. Many of the existing studies on children and VR focus on atypically developing children and/or have a clinical focus, and fewer have examined the effects of VR in non-clinical samples (Bailey et al., 2017). Much of what we can predict about the negative effects is conjecture, based largely on previous research with traditional media. With this caveat, the potentially negative outcomes of VR include impacts on children's sensory systems and vision, aggression, and unhealthy amounts of escapism and distraction from the physical world. Parents worry about this as well; sixty percent of all parents say they are at least "somewhat concerned" about VR's negative health effects, including 30 percent who are "very concerned" (current report, see Appendix).

Possible Negative Effects

Sensory and vision effects. At Stanford University's Virtual Human Interaction Laboratory (VHIL), there is a rule that adult participants use VR for no more than 20 minutes at a time without a break. When the lab studies young children, they are in VR for five minutes or less at any one time. This is to avoid "simulator sickness," which is caused by a number of factors: for example, lag, the time between a person's body movements and the virtual world updating accordingly (Bailenson, 2018). In a study (using relatively outdated technology) on the effects of VR on simulator sickness, 28 percent of adult users experienced some symptoms (Treleaven et al., 2015). To avoid it, most manufacturers encourage users to take a break from VR, even if they feel like they do not need it. For example, Oculus recommends a 10- to 15-minute break every 30 minutes for users of the Oculus Rift (LaMotte, 2017). Additionally, as VR blocks out objects in the physical environment, hazards in the physical world include bumping into things, tripping, and otherwise physically harming the self. This would be especially true for children who struggle with the representational nature of their bodies and actions in the virtual world (Bailey & Bailenson, 2017).

To examine the short-term effects of VR on children's vision and balance, a recent study of children was conducted at the University of Leeds (Yamada-Rice et al., 2017). Twenty children (age 8–12) were administered a standard eye examination, a digital test to measure stereoacuity (i.e., depth differences in binocular vision), and a test of postural stability (i.e., balance) before and after 20 minutes of VR play. The results indicated there were no effects of short-term VR play on visual acuity. Similarly, with the exception of one child, the children did not experience any effects on their binocular vision or balance as a result of gameplay.

Firm conclusions cannot be drawn from such a small study; other research studies on vision, in particular, have been similarly small in scale, yielding mixed findings. One study involving 13 subjects age 13–44 showed that headsets had no effects on vision (Neveu, Blackmon, & Stark, 1998), and another even showed that VR headsets can improve vision, including acuity, contrast sensitivity, and enhanced performance of near, intermediate, and distance tasks, among children and young adults (age 12–21) who are vision-impaired (Geruschat, Deremeik, & Whited, 1999). Another study showed that children who watched a G-rated film through an HMD experienced mild deficits in short-term near

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visual acuity (i.e., the ability to see the details of near objects) among 67 percent of participants immediately post-viewing and among 47 percent 10 minutes post-viewing (Kozulin, Ames, & McBrien, 2009). However, children who watched the same film on a high-definition television display experienced similar deficits to their near visual acuity. In a demonstration of caution, manufacturers targeting younger children, like Mattel with its View-Master line, advertise that their device has been developed under the guidance of ophthalmologists to ensure it is optically safe for children (View-Master, n.d.).

However, researchers at the University of Leeds warn that the long-term consequences for children's vision and other sensory systems taxed by VR are unknown (McKie, 2017; Mon-Williams, 2017). For example, in VR, computer-generated images are shown on two-dimensional screens, meaning that the eyes must stay focused on one location (Mon-Williams, 2017), but the presentation of three-dimensional binocular images forces the eyes to change direction as if they were gazing at a near or far object. This mismatch can cause eyestrain and headaches in the short term, but this strain might also result in long-term difficulties. This is of particular concern in young children because their developing brains might make them even more susceptible to these disruptive pressures.

Aggression. More than three decades of research suggest that violent video gameplay is a risk factor for stimulating aggressive behavior, aggressive cognitions, and aggressive affect, as well as decreases in prosocial behavior, empathy, and sensitivity to aggression (APA Task Force on Violent Media, 2015; Greitemeyer & Mügge, 2014). However, research on the effects of violence in VR is rather limited, even though it seems plausible that as the level of immersion and corresponding psychological presence into the game are increased, so too are players' aggressive feelings (Persky & Blascovich, 2008). For example, young-adult participants who played a violent video game in a VR format (with a headset) self-reported more aggressive feelings and experienced elevated heart rates compared to participants who played the same game in a traditional desktop format (Persky & Blaskovich, 2007). Similarly, young-adult participants who played the VR version of a game played the game more violently than participants on a desktop (Persky & Blascovich, 2008). Another recent study showed that when young-adult participants played a violent video game in VR, they experienced psychological presence, which, in turn, increased their levels of anger after play (Lull & Bushman, 2016).

The existing research on psychological presence implies that shooting a gun with a video game controller would be a very different experience from pointing a gun, with one's own hand, at a 3D representation of a person and pulling the trigger (Bailenson, 2018). Indeed, many video game designers have acknowledged that such visceral, gory gameplay in virtual reality is perhaps too intense for a large consumer market. Bailenson described his doubts about the mass appeal of VR violence after informally observing users participating in a demo for the HTC Vive called "Surgeon Simulator." In the game, users perform an autopsy on an alien, with a variety of medical instruments, power tools, and weapons at their disposal. From his observations, reactions fell into one of two categories. First, some people decided to not torture the alien; "it's just not their idea of fun" (p. 63). The second category of response was to actively engage in the simulation in the moment, to "have at it" (p. 64), but then to feel badly about it afterward, experiencing a sense of remorse and responsibility. Because the brain can imagine the actual experience, the recognition that one used their capabilities to perpetrate violence, even against an alien corpse, probably feels emotionally heavy.

Still, there will undoubtedly be mass-market attempts to adapt violent first-person shooter games to VR. To the extent that violent video games increase hostile tendencies and arousal, we should expect even stronger effects from VR (Lull & Bushman, 2016). This is clearly an area of concern for families as well, as 70 percent of parents of children under 18 say they are concerned about violent VR content (in addition to sexual content and pornography; current report, see Appendix). This will be a topic of study and debate in the years to come.

Escapism and distraction. Some fear that, like the VR world in *Ready Player One*, virtual experiences will be so enticing that users will retreat to the virtual world in lieu of the real world. Putting this fear into context, similar fears were associated with television, movies, and even comic books. The majority of parents (61 percent) report that they are concerned that VR would be socially isolating.

To avoid such social isolation, parents will need to be on top of managing their children's media experiences. The immersive nature of VR may represent a new concern for parents who already struggle with managing their children's attachments to screens (Rich, Bickham, & Shrier, 2015).

Harnessing the Beneficial Potential of VR

There is also considerable promise with VR applications for kids. Compared to the negative effects, more research has been done on beneficial potential. In the following, we first address the clinical applications of VR (pain distraction and clinical assessment) and then commercial applications of VR (a tool for education and an intervention to increase empathy). Finally, we discuss the benefits of fun and imaginative VR play.

Pain management. In the medical field, the most widely used application of VR is as a tool for distraction from pain during medical procedures, typically via a VR headset. To test for the effectiveness of VR in this domain, studies typically compare the effectiveness of VR as a pain-distraction tool with usual care, other distraction tools, and non-immersive VR distractions (Malloy & Milling, 2010). For example, in controlled laboratory studies, researchers have used a cold pressor task, in which children's hands are submerged in cold water, to assess when they start to feel pain and how much they can tolerate the pain. The findings have consistently demonstrated that an immersive VR experience is more effective for pain distraction than a non-VR experience, such as playing a video game without a headset (Dahlquist et al., 2007; Dahlquist et al., 2009; Law et al., 2011).

In addition to these laboratory studies, other studies have demonstrated the clinical effectiveness of VR for acute pain management in various pediatric medical procedures, including intravenous placements (Gold, Kim, Kant, Joseph, & Rizzo, 2006), cancer treatments (Gershon, Zimand, Pickering, Rothbaum, & Hodges, 2004), burn-wound cleaning (Hoffman et al., 2008), and dental work (Aminabadi, Erfanparast, Sohrabi, Oskouei, & Naghili, 2012). Although there is little research on using VR for the treatment of chronic pain in children, promising results with adults indicate that VR could be an effective therapy for children as well (see Won et al., 2017 for review).

Education. Because of its unique technological characteristics, VR is a promising tool in education. The main argument for highly immersive VR environments for educational endeavors is that they have the potential to make learning feel more real by promoting a sense of presence (Moreno & Mayer, 2004). Many families believe in VR's educational potential; sixty-two percent of parents believe that VR will provide educational experiences for their children (current report, see Appendix).

In a 10-year review of the evidence on VR in educational contexts, Mikropoulos and Natsis (2011) identified four technological capabilities that can be successfully applied to learning environments in VR: creation of three-dimensional spatial representations (i.e., allowing the user to navigate in a 3D virtual space from a first-person point of view), multisensory channels for user interaction (i.e., allowing the user to interact in the virtual space via visual, auditory, and tactile means), immersion of the user in virtual environments, and intuitive interactions through the use of specialized implements, such as special joysticks, wands, or gloves. The evidence in the review indicates that incorporating these capabilities into immersive virtual environments can contribute to positive learning outcomes.

In non-clinical child samples, VR has been shown to facilitate learning for skills and content areas such as visualizing fractions (Roussou, Oliver, & Slater, 2006), learning about plant growth, water, and sunlight (Roussou et al., 1999), learning about gorilla behaviors (Allison & Hodges, 2000), and learning standards-based math and science concepts (Adamo-Villani et al., 2008). However, when comparing learning outcomes from VR versus video or desktop games, some evidence suggests that VR fails to result in increased retention of facts as compared to the non-immersive platforms (e.g., Dede, 2009). For example, in an assessment of a technology-based lesson on botany, researchers used the same content across conditions but manipulated the mode of presentation; it was either on a desktop computer or via an immersive experience via VR. While the participants in the VR condition felt a higher level of presence than those in the desktop condition, the groups did not differ in their learning outcomes, i.e., retention of information and transfer of knowledge to novel contexts (Moreno & Mayer, 2004). According to Bailenson (2018), perhaps the critical challenge here is to overcome the students' proclivity to focus on the novel sensorial experiences of the virtual environment instead of the narrative information that is meant to build knowledge. For content developers, solutions to this challenge might be to create virtual learning environments that are completely experiential and do not require narrative, or to create virtual environments that alternate between the experiential side of the lesson and the narrative presentation of the lesson so the two sides do not compete with each other.

One exciting educational VR application that is particularly suited to children is a "reverse field trip" (Bailenson, 2018, p. 228). With VR, educators can program experiences in which students can virtually visit places, events, and even other times in history that coincide with their course lessons. For example, if students are studying the American Revolution, they might visit colonial Philadelphia, even if they are in a physical classroom in California. In his *River City Project*, Dede (2009) created an interactive simulation in which middle school students visit a 19th-century town

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and are tasked with addressing medical dilemmas, such as an outbreak of illness, using their modern knowledge of science. Students who participated in the VR experience learned more about prevention and epidemiology than those who learned the same content in a traditional school setting, and those in the VR experience had heightened self-efficacy, i.e., confidence in actually doing science. Perhaps the key component for this application is time. Through the River City Project, students can spend hours going through the simulation, offering them many opportunities to engage in multiple perspectives in a scene.

Although reverse fields trips are difficult and expensive to create, they are a worthwhile avenue for VR as a future educational tool. Once they are created, they can be disseminated on a massive scale, bringing educational opportunities to students in many contexts. Reverse field trips do not necessarily even need headsets to be experienced; the Framestore VR Studio has created an immersive experience where students board a school bus that simulates the sights and sounds of Mars. In doing so, students can share a virtual experience unmediated by headsets or earphones (Framestore VR Studio, n.d.).

Empathy. Whereas violent video games are associated with aggression, research has shown that prosocial video games are associated with positive social outcomes such as helping behaviors (Greitemeyer & Mügge, 2014). Likewise, one effect of VR on the emotional side of prosocial behavior is empathy. As an important precursor to empathy, perspective-taking can result in stereotype reduction and prosocial behaviors. With VR technology, media creators can simulate perspective-taking by having users embody an avatar that is different from them (Ahn et al., 2013). For example, a college student can see herself as an avatar of an elderly person, or a white person can see himself as an avatar of a black person (Hasler, Spanlang, & Slater, 2017; Peck et al., 2013). These are called embodied experiences (Ahn et al., 2013); they enable individuals to see, hear, and feel as if they are in another person's mind and body. Experiencing a virtual encounter while walking in someone else's shoes can be a powerful experience. A basic question of VR research, then, is: Can these embodied experiences be harnessed for good, i.e., encouraging perspective-taking that will make people more empathetic toward others' situations, positions, or backgrounds? Parents of children under 18 remain skeptical; only 38 percent think it can help children empathize with people different from them (current report, see Appendix).

However, research on adult participants has shown promising, though mixed, results. Embodied VR experiences can diminish ageism (Yee & Bailenson, 2007), invoke empathy for people with colorblindness (Ahn et al., 2013), and promote compassion and prosocial responses in virtual interactions in which an avatar needs help (Ahn et al., 2013; Gillath et al., 2008). However, there do seem to be limits on these effects. Oh, Bailenson, Weisz, and Zaki (2016) showed that the effect of an embodied avatar experience on reducing ageism was diminished when participants felt ostracized in a subsequent interaction with elderly avatars. The positive effects of VR on empathy and prosocial attitudes were limited by the perceived threat that the participants felt that the social group posed to them.

Efforts to use VR to increase empathy among kids would need to be attentive to the children's social and cognitive development. As previously mentioned, perspective-taking, an important precursor to empathy, is still developing in young children (Perner & Wimmer, 1985). This skill does not develop until later on, during middle childhood (roughly age 7–8). Thus, the potential for first-person VR to encourage empathy and prosocial behaviors might not be a realistic possibility until middle childhood.

Fun and imaginative play. One overlooked benefit is that VR can provide children with an avenue for entertainment and socializing with others. Fifty percent of parents agreed that VR would provide a fun way to play as a family (current report, see Appendix), and children are generally enthusiastic about VR, even offering creative and imaginative ways of using VR (Yamada-Rice et al., 2017). While children under 3 are reticent to put on the VR headsets because they are heavy and disorienting, by the age of 4, children love VR play, according to Ken Perlin of New York University's Future Reality Lab. And then, by the age of 8, says Perlin, "They go nuts. They feel so completely at home. They come up with their own activities the moment they put the thing on" (as quoted in Kamenetz, 2018, para. 10).

Further, VR's influence on escapism is perhaps not exclusively negative either. Researchers have coined the term "active escapism" to describe video game users' intentional escape into an immersive medium to engage fantasy and role-playing as a functional means of coping with external stressors (Kuo, Lutz, & Hiler, 2016). Thus, VR could provide opportunities for users to experience affirmation and empowerment through their VR experience.

CONCLUSION

Are we on the precipice of a revolution in VR, or will we see VR go the way of other passing technology fads, such as 3D television sets and Google Glass (Davis, 2016)? The psychological presence that is the "secret sauce" of VR needs to be seen to be believed (Bailenson, 2018), as illustrated by the parents surveyed, many of whom are uninterested in buying VR. Perhaps the game changer here will be the development of high-quality content that can only be experienced in VR (Swant, 2018). For parents, buying expensive VR rigs might seem like an unwise investment when high-quality content for children is still a ways off. These parents might instead choose to bring their children to "location-based VR" centers, similar to the arcades of the 1980s (Takahashi, 2017). Indeed, one of this report's authors accompanied NPR on a trip to an arcade in NYC in late January 2018 and observed over 100 children cycling through dozens of VR stations. The advantage to location-based VR is that the systems are maintained to function well (i.e., not to get users dizzy due to slow computers or faulty tracking systems) and safely (i.e., having "spotters" who can make sure the users are safe; Garcia-Navarro, 2018). Also, the experience itself is inherently social: Kids wait in line together and share the floor space, as opposed to being separated in their homes.

Although we have drawn conclusions about VR on children in some domains and offered conjecture in others, it is clear that, overall, the research on VR and kids is limited. With the exception of clinical applications, the effects of VR on kids is woefully understudied, which is disconcerting given the accelerating adoption of VR devices in American households. We call on researchers to continue to test and examine the interactions between VR and child development, especially as VR content evolves for child audiences. Kids are aware of this technology and excited by it (Yamada-Rice et al., 2017). Continued research efforts can help to provide answers and suggestions to parents on what they can do to minimize potentially negative effects of VR and maximize positive benefits.

Additionally, VR has many implications for children's privacy that are not addressed in this report, although we urge users to carefully read and understand a product or service's privacy policies and practices before using it. The potential for VR to collect enormous amounts of information from users, such as eye movements and other physical movements, should not be underestimated.

The research so far does suggest that because of psychological presence, experiences in virtual environment can be less like media exposure and more like actual experiences, especially for children (Bailey & Bailenson, 2017). This is even truer for children who struggle with the abstract idea that VR, although it feels real, is actually a representation of simulated events (e.g., Segovia & Bailenson, 2009). Thus, it is important that parents determine what types of actual experiences they want for their children. For example, some parents might deem that their children playing the roles of soldiers engaged in modern warfare (e.g., in *Call of Duty*) on a traditional gaming console is OK, but sending them into actual combat would be out of the question.

Engaging in violence in VR would be a much scarier and more anxiety-producing experience than seeing it unfold on a two-dimensional screen, even if the child is controlling the actions from the first-person perspective. Some designers are opting to downplay gore and violence against people; for example, the first-person shooter *Raw Data*, one of the first VR games to make over $1 million, has players fighting robots instead of humans (Bailenson, 2018). Thus, a standard for choosing content for VR could be: Would this be something you would do in real life or would want your child to do in real life? If the answer is no, then that content should likely be avoided (Bailenson, 2018). Being aware of the content that kids are encountering in their media consumption will be as important as ever, and parents and caregivers would be wise to think carefully about a new technology with such powerful positive and negative potential.

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Seven Tips to Help You Stay Safe in Virtual Reality: Suggestions from the head of Stanford's Virtual Human Interaction Lab, Jeremy Bailenson

Adapted from *Eight Rules to Help You Stay Safe in Virtual Reality* (Bailensen, 2018, January 17)

1. Keep it to 20 minutes. Not much I've seen in VR is worth spending more than 20 minutes inside, but even if you find the most spectacular scene that boggles the mind, take a three-minute break. Have a drink of water. See some natural light. Remind yourself of where your body actually is. Unlike in the real world, that VR sunset isn't going anywhere, and it's worth taking a short break to avoid disorientation and possible simulator sickness.

2. Unless the designers of the demo made walking a critical piece of the experience, sit down. A vast majority of accidents can be prevented this way — but not all of them. I've had people smash their heads into desks. Even though the users knew the desks were there before the goggles went on, they forgot when they tried to lean closer to a virtual object on the virtual ground. Which brings us to ...

3. Remove dangerous objects from the space. Tables with corners and glass tables are the biggest offenders. Also, metal rakes, lit candles, cacti, etc. Take the time to clear the entire VR tracking space.

4. Think about your animals. You won't know if they wander into your space, and of course cats and dogs don't know you can't see them. Keep them in another room.

5. If you decide to do room-scale VR in which you walk around — which typically makes for the most engaging VR experiences — take a lap once you have the goggles on — that is, touch all four walls as the simulation starts. Give your body muscle memory of the physical constraints of the room. In my lab at Stanford, we embed this protocol into most of our experiments. Even if the exercise breaks the illusion, having a physical reminder of walls is a good thing. Virtual spaces are infinite; living rooms are not. The more you can remind yourself of this, the better off you will be.

6. Have a second person not using VR to act as a "spotter," especially for room-scale VR. I know that VR as an industry will struggle to make its way into every living room if every user needs a second person to watch and assist. By definition, good VR challenges you with wild and intense experiences you wouldn't have in the real world. Ducking, flinching, and even fleeing are all perfectly rational responses to many off-the-shelf VR experiences. Other than enlisting a vigilant friend who cares about your safety, I don't know any way around this. Like scuba diving, VR is best served by the buddy system.

7. Watch out for safety warnings. Many VR systems will issue alerts as users approach walls — but they are just accurate enough to be dangerous, as users learn to trust them unconditionally. They are correct lots of the time, probably even most of the time, but not all the time. Whether it's a failure of hardware (a camera slips), a software bug, or the ever-changing world itself (i.e., a chair just happens to fall over once you go inside), mistakes will happen. You're much better off trusting your spotter buddy and your instincts about the room itself.

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APPENDIX: COMMON SENSE MEDIA/SURVEYMONKEY VIRTUAL REALITY POLL TOPLINE

Methodology: This Common Sense Media/SurveyMonkey online poll was conducted December 21–31, 2017, among a national sample of 12,148 adults. Of the adults sampled, 3,613 were the parent of at least one child under 18, and 471 indicated that they had a child between 8 and 17 years old who uses VR. Respondents for this survey were selected from the nearly 3 million people who take surveys on the SurveyMonkey platform each day. The modeled error estimate for this survey is plus or minus 1.5 percentage points. Data have been weighted to reflect the demographic composition of the United States in terms of age, race, sex, education, and geography using the Census Bureau's American Community Survey.

Q1. Does your household currently own a virtual reality (VR) device, are you planning to purchase one in the next year, or are you not planning to purchase a VR device?

	Total	Parents of children under 18
We already own a VR device.	14%	21%
We are planning to buy a VR device in the next year.	10%	13%
We don't own and are not planning to buy a VR device.	74%	65%
No answer	2%	1%

Q2. At what age do you think it is appropriate for a child to start using VR?

	Total	Parents of children under 18
0	4%	4%
1	1%	1%
2	0%	1%
3	1%	1%
4	1%	3%
5	2%	3%
6	2%	2%
7	2%	2%
8	3%	5%
9	1%	1%
10	11%	13%
11	1%	1%
12	10%	10%
13	8%	9%
14	5%	5%
15	7%	7%
16	10%	10%
17	1%	1%
18	18%	17%
No answer	13%	8%

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Q3. ASKED OF PARENTS ONLY: Has your child or one of your children ever requested the purchase of a VR device?

	Parents of children under 18	Parents of 8- to 17-year-olds who use VR
Yes	22%	64%
No	77%	35%
No answer	1%	0%

Q4. As you think about children's use of VR, today and in the future, how concerned are you about each of the following?

Children will spend too much time with virtual reality.	Total	Parents of children under 18
Very concerned	41%	39%
Somewhat concerned	27%	28%
Not very concerned	12%	15%
Not at all concerned	5%	6%
Don't know enough to say	12%	11%
No answer	2%	1%

Children will encounter sexual content, pornography, or violent content in virtual reality.	Total	Parets of children under 18
Very concerned	45%	47%
Somewhat concerned	23%	23%
Not very concerned	12%	12%
Not at all concerned	5%	5%
Don't know enough to say	14%	13%
No answer	2%	1%

Children will experience negative health effects while using virtual reality.	Total	Parents of children under 18
Very concerned	29%	30%
Somewhat concerned	29%	30%
Not very concerned	16%	17%
Not at all concerned	6%	6%
Don't know enough to say	18%	16%
No answer	2%	1%

Virtual reality is socially isolating.	Total	Parents of children under 18
Very concerned	35%	33%
Somewhat concerned	28%	28%
Not very concerned	14%	17%
Not at all concerned	7%	6%
Don't know enough to say	14%	13%
No answer	2%	1%

Q5. As you think about children's use of VR, today and in the future, how much do you agree with each of the following?

Virtual reality will allow children to do things they otherwise couldn't do.	Total	Parents of children under 18
Strongly agree	20%	20%
Somewhat agree	38%	38%
Somewhat disagree	10%	11%
Strongly disagree	8%	10%
Don't know enough to say	21%	19%
No answer	3%	2%

Virtual reality will allow children to have educational experiences.	Total	Parents of children under 18
Strongly agree	17%	18%
Somewhat agree	43%	44%
Somewhat disagree	10%	10%
Strongly disagree	7%	7%
Don't know enough to say	20%	18%
No answer	3%	2%

Virtual reality will help children empathize with people different from them.	Total	Parents of children under 18
Strongly agree	8%	10%
Somewhat agree	28%	28%
Somewhat disagree	17%	17%
Strongly disagree	15%	16%
Don't know enough to say	29%	27%
No answer	3%	2%

Virtual reality is a fun way to play together as a family.	Total	Parents of children under 18
Strongly agree	13%	16%
Somewhat agree	32%	34%
Somewhat disagree	14%	14%
Strongly disagree	13%	13%
Don't know enough to say	21%	25%
No answer	2%	3%

Q6. AMONG HOUSEHOLDS THAT DON'T OWN A VR DEVICE: What are the reasons you are not purchasing a VR device? (Select all that apply.)

	Total	Parents of children under 18
Too expensive	24%	28%
Too hard to find content	5%	6%
Don't know enough about VR	26%	31%
Concerned about health effects	13%	20%
Think VR is a gimmick	9%	10%
Not interested in using VR	60%	56%
Other (please specify)	8%	9%
No answer	1%	2%

Q7. AMONG HOUSEHOLDS THAT OWN A VR DEVICE: Overall, how satisfied are you with your household's experiences while using VR?

	Total	Parents of children under 18
Very satisfied	16%	19%
Satisfied	37%	35%
Neither satisfied nor dissatisfied	39%	39%
Dissatisfied	5%	5%
Very dissatisfied	2%	1%
No answer	1%	2%

Q8. AMONG HOUSEHOLDS THAT OWN A VR DEVICE: Which of the following VR devices does your household own? (Select all that apply.)

	Total	Parents of 8- to 17-year-olds who use VR	Parents of children under 18
Samsung Gear VR	32%	34%	32%
Sony PlayStation VR	19%	23%	20%
HTC Vive	5%	4%	4%
Oculus Rift	9%	7%	7%
Google Daydream View	6%	6%	7%
Google Cardboard	12%	11%	12%
Other (please specify)	7%	9%	8%
Not sure	29%	30%	30%
No answer	1%	0%	1%

Q9. AMONG PARENTS WHOSE CHILDREN USE VR: To the best of your knowledge, how often did at least one of your children use a VR device in the last week?

	Parents of 8- to 17-year-olds who use VR
Every day	6%
A few times	31%
Once	13%
The VR device was not used in the last week.	50%
No answer	0%

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Q10. AMONG PARENTS WHOSE CHILDREN USE VR: Has your child or one of your children ever reported experiencing any of the following after using VR? (Select all that apply.)

	Parents of 8- to 17-year-olds who use VR
General discomfort	3%
Eyestrain	8%
Headache	10%
Nausea	5%
Dizziness	11%
Sweating	1%
Difficulty concentrating	1%
Blurred vision	5%
Bumped into something	13%
Other (please specify)	3%
None of the above	64%
No answer	2%

Q11. AMONG PARENTS WHOSE CHILDREN USE VR: Has your child or one of your children ever used VR for any of the following? (Select all that apply.)

	Parents of 8- to 17-year-olds who use VR
Playing games	76%
Connecting to friends	9%
Watching videos or movies	38%
Research	7%
Exploring environments	33%
To learn something	22%
Medical therapy or intervention	1%
Other (please specify)	2%
Don't know	6%
No answer	1%

Q12. AMONG PARENTS WHOSE CHILDREN USE VR: Which of the following BEST describes the way that the child or children in your household use VR?

	Parents of 8- to 17-year-olds who use VR
Primarily by himself/herself	47%
Primarily with people who are in the same room to friends	50%
Primarily with people who are online but not in the same room	3%
No answer	1%

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