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Virtually True: Children's Acquisition of False Memories in Virtual Reality

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Previous work on human memory has shown that prompting participants with false events and self-relevant information via different types of media such as narratives, edited 2-dimensional images, and mental imagery creates false memories. This study tested a new form of media for studying false memory formation: Immersive Virtual Environment Technology (IVET). Using this tool, we examined how memory was affected by viewing dynamic simulations of avatars performing novel actions. In the study, 55 preschool and elementary children were randomly assigned to 1 of 4 memory prompt conditions (idle, mental imagery, IVET simulation of another child, or IVET simulation of self). Each child was questioned 3 different times: once before the memory prompt, once immediately after the memory prompt, and once approximately 5 days after the memory prompt. Results showed that preschool children were equally likely to develop false memories regardless of memory prompt condition. But, for elementary children, the mental imagery and IVET self conditions caused significantly more false memories than the idle condition. Implications regarding the use of digital media in courtroom settings, clinical therapy settings, entertainment, and other applications are discussed.

Human memory is imperfect, and while most memory errors do not garner national attention, some famous memory errors have made headlines in the last 20 years (Loftus, 2002). False memories of sexual abuse (arguably planted or elicited by therapists) led to large lawsuits in the 1990s and motivated an

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acceleration of research in understanding the malleability of human memory. Numerous studies on false memory creation ensued, revealing that repeated interviewing, leading questions, and biased interviewers along with other causes can lead to memory errors in humans, and for children in particular (see Goodman & Quas, 2008, for a recent review of this work). However, as our lives become more technologically advanced and dependent on digital media, other causes of false memory elicitation emerge.

For example, Hoffman Garcia-Palacios, Thomas, and Schmidt (2001) have begun to explore the use of a particular digital medium, Immersive Virtual Environment Technology (IVET), a digital technology that allows a user to be perceptually surrounded by sights and sounds while he or she interacts with computer-simulated environments. As IVET becomes more commonplace (Reeves, Malone, & O'Driscoll, 2008), it is likely that false memory research involving IVET will grow more pertinent. IVET, which was introduced to the world of social scientists almost 20 years ago (Biocca, 1992; Loomis, 1992), makes it possible for individuals to be immersed in worlds that feel very much like their physical environments (Blascovich et al., 2002; Lanier, 2001; Loomis, Blascovich, & Beall, 1999). Today, in three-dimensional dynamic simulations, users can watch avatars (models that often resemble a user) perform acts they have never done before, such as running a marathon, skydiving, or stealing a car. Although this technology has expanded in amazing ways over the last few decades, some scholars still believe that the biggest technological revolution is yet to come (Miller, 2007).

While previous research has examined how being in a virtual world from a first-person point of view can create a false memory (Hoffman et al., 2001), the current study uses IVET in a novel manner by examining how witnessing one's avatar in the third person carrying out virtual actions that were never actually performed in physical spaces affects memory. What happens when rich forms of media, such as IVET, are used to elicit false memories?

CHILDREN'S MEMORIES

Many studies have examined source monitoring capabilities in children. For example, a recent study presented 6-, 8- and 10-year-old children with a video tape and then an audio tape about a dog named Mick (Ruffman, Rustin, Garnham, & Parkin, 2001). Some pieces of information were presented in both sources (the video and the audio tape), and some pieces were unique to one source. Afterward, the authors asked the children which sources presented specific pieces of information from the story. The 6- and 8-year-olds performed significantly worse on source monitoring questions (i.e., thought that a piece of information came from the video tape when it came from the audio tape) than the 10-year-olds.

A review of research on preschool children and memory reveals that preschoolers are in general disproportionately vulnerable to suggestive influences (Bruck & Ceci, 1999; Foley & Johnson, 1985; Foley, Santini, & Sopasakis, 1989) and experience greater difficulty than adults in making source monitoring judgments (Lindsay, 2002). Although not as frequently, older children also experience memory errors. For example, children as old as 9 years old have been shown to perform more poorly than adults on certain memory tasks (Lindsay, 2002).

Some researchers suggest that source monitoring judgments may require more deliberative or extended retrieval and reasoning processes. These mental capabilities develop gradually in humans (Flavell, 1985; Lindsay, Johnson, & Kwon, 1991) and may lead to better source monitoring capabilities over time. For these reasons, source monitoring decisions may be more difficult for children than adults.

MEDIA RICHNESS AND FALSE MEMORIES

Previous studies in the area of false memories have incorporated media stimuli ranging from simple narrative prompts to detailed edited photographs. One way to frame this previous work is in terms of varying levels of *media richness*. Daft, Lengel, and Trevino (1987) describe media richness based on four criteria: capacity for immediate feedback; capacity to transmit multiple cues such as graphic symbols or human gestures; language variety, including numbers and natural language; capacity of the medium to have a personal focus. A number of studies have examined various types of media in terms of their effect on false memory acquisition. In the following sections, we will present this work and frame it as it relates to media richness.

Narratives

Narratives are one of the most common stimuli used to study false memory formation (Hyman, Husband, & Billings, 1995; Hyman & Billings, 1998; Hyman & Pentland, 1996; Loftus & Pickrell, 1995; Pezdek, Finger, & Hodge, 1997; Pezdek & Hodge, 1999; Porter, Yuille, & Lehman, 1999). Narratives used in these studies consisted of text describing what supposedly happened to the participant from a third-person perspective. In a review of these studies (Wade, Garry, Read, & Lindsay, 2002), anywhere from 0% (Pezdek et al., 1997) to 56% (Porteret al., 1999) of participants recalled false memories from narrative stimuli with a weighted mean of about 30% across all studies.

As depicted in Table 1, narratives score relatively low on the media richness criteria. First, feedback is not delivered to the participant while reading or listening to the narrative. The narrative does not change based on the user's actions or preferences. Second, the narrative does not provide

TABLE 1 Media Richness of False Memory Prompts[a]

	Narrative	Mental imagery	Edited photo	IVET other	IVET self
Feedback		X		X	X
Multiple cues		X		X	X
Language variety	X	X		X	X
Personal focus		X	X		X

[a]The four criteria of the media richness theory (rows) as they apply to false memory stimuli (columns).

multiple cues for the participant; gestures, sounds, lights, or animation are not presented. Finally, aside from using the participant's name or the second person pronoun "you," narratives deliver very little personalized information (Nehaniv, 1999). Details such as the color of the participant's hair, his or her height or personal preferences are not conveyed through the generic narratives that all participants receive. The only category narratives score highly in is language variety since by definition narratives are linguistic.

Mental Imagery

Mental imagery or imagination is another category of stimuli used in false memory research. In a typical study participants are asked to imagine actions that they may or may not have performed (such as breaking a window; see Garry & Polaschek, 2000, Hyman & Pentland, 1996, or Mazzoni & Memon, 2003, for examples and discussion). Overall, mental imagery studies show that imagining a counterfactual event can make a participant more confident that the event actually occurred. This effect has been termed *imagination inflation* and can occur even when there is no overt social pressure and when hypothetical events are imagined only briefly.

For example, in one mental imagery study, university students were given a list of 40 different events and asked to rate how certain they were that each of the events had happened during their childhoods (Garry, Manning, Loftus, & Sherman, 1996). In a follow up session, each participant was asked to imagine four of the events that were deemed least likely to have occurred in the previous session. Then all participants re-rated how confident they were that each of the 40 events had occurred. For the items that were imagined, the participant's confidence that the event had occurred in his/her childhood was inflated.

In another set of studies, college students heard simple action statements and in some conditions either performed or imagined the action as well (Goff & Roediger, 1998). In a second session, participants imagined performing actions (some of which came from the first session and some of which were new) either one, three, or five times. In the third session, participants were asked to identify actions only if they had occurred in the first session and, if identified, to tell whether the action statement had been carried out, imagined, or merely heard. The main finding was that increasing the number of imaginings during the second session caused participants to later remember that they had performed an action during the first session when in fact the participant had not.

A study very similar to that of Goff and Roediger's (1998) was conducted with college students several years later (Thomas & Loftus, 2002), but this time, the researchers included two different types of actions, familiar actions and unfamiliar actions (such as sitting on a die). Again, the authors found that as the number of imaginings in session two increased, so did the likelihood that participants would falsely remember performing the event. The unique contribution of this study, however, is that the authors found this pattern to hold across both familiar and unfamiliar events.

As depicted in Table 1, mental imagery stimuli are high in media richness criteria, as they can provide feedback, multiple cues, a variety of languages, and a personalized perspective. Mental imagery provides rapid feedback since each participant creates his or her own mental imagery and the image the participant sees responds quickly to his or her thoughts and intentions. Each moment of mental imagery is directed by the participant. Additionally, tastes (Levy, Henkin, Lin, Finley, & Schellinger, 1999), scents (Henkin & Levy, 2002), motions (Luft, Skalej, Stefanou, Klose, & Voigt, 1998), sounds (Kleber, Birbaumer, Veit, Trevorrow, & Lotze, 2007), images, and even sensations of pain (Ogino, Nemoto, Inui, Saito, Kakigi, & Goto, 2006) can provide cues during mental imagery. Mental imagery also utilizes multiple forms of language: numbers, written words, nonverbal communication and spoken words (in possibly more than one language if the participant is bilingual). Finally, since the participant is the creator of his or her own mental imagery, the situation can be extremely personal. The participant could include a favorite t-shirt, mother, pet, or childhood home in the imagery along with many other specific personal details.

Photographs

In 2002, several scholars utilized manipulated photographs to induce false childhood memories in adults (Wade et al., 2002). In the study, participants were presented with manipulated childhood photographs falsely depicting the participant riding in a hot air balloon as a child. When shown the manipulated photographs, 50% of the participants developed a false memory.

A few years later, some of the same scholars designed a study to comparatively test the power of manipulated photographs in eliciting false memories (Garry & Wade, 2005). Half of the adult participants saw a manipulated childhood photo of themselves in a hot air balloon ride and half of the participants read a false narrative about the hot air balloon ride. Eighty percent of the participants in the narrative condition reported memories of the event compared to 50% of those participants in the photo condition. The researchers offered a fluency-based account of their results, proposing that narratives made it easier than photographs for the participants to construct information about the event (information that would then be processed more fluently, feel more familiar, and be more likely to be mistaken for a real experience).

In a more recent study, 10 year olds were presented with true and false pictures from their childhoods (Strange, Hayne, & Garry, 2008). For the false pictures, half of the children saw a doctored photograph of themselves and other people in a hot air balloon while the other half of the children saw the same picture without his or her face and body depicted in the photograph. Children who saw the photograph of themselves in the balloon were more likely to develop false memories than those who saw the unedited photograph. Strange and colleagues (D. Strange, personal communication, February 16, 2009) believe that their findings give support to the model proposed by Mazzoni, Loftus, and Kirsch (2001); namely, that the personalized photographs made the false suggestion seem more plausible because they provided more details than the unedited photographs.

We believe that the manipulation explored by Strange and colleagues (2008) is important and would like to offer a complementary hypothesis to explain the reported effect. We propose that personalized photographs were more powerful stimuli because they fulfilled the personal focus criterion involved in media richness. The personal focus involved in the media richness criteria is influential in the memory process because it causes humans to self-reference; people encode more attributes when they are engaged in self-referent processing than other types of processing (Symons & Johnson, 1997). The greater the amount of information encoded the more similar the memory becomes to a memory of a physical world event, and the greater the likelihood that a source monitoring error will occur.

Digital photographs do not score exceedingly high on the media richness criteria. Photographs do not provide humans with frequent feedback or convey information in a variety of languages (few words or symbols). As well, because photographs are only small static clips of an event, the participant receives a very minimal number of cues. Lights, sounds, animation, and gestures are only minimally conveyed if at all. However, edited photographs that display an image of the participant certainly provide a personal focus (see Table 1).

SOURCE MONITORING FRAMEWORK

Memories come from a variety of sources such as television, imagination, books, and physical world events, but according to the Source Monitoring Framework (SMF; Johnson, Hashtroudi, & Lindsay, 1993, Lindsay & Johnson,

1987) memories are rarely stored with tags that identify their sources. Instead, humans utilize a process that is prone to errors to determine the sources of their memories. During this rapid and mostly nondeliberate source monitoring process, memories are evaluated and attributed to particular sources.

Each type of source yields memories with unique characteristics (Johnson et al., 1993). For example, physical world memories (that is, memories of events that actually happened to the rememberer) are extremely rich in perceptual detail. Memories developed from a book, however, usually do not contain as much detail. The amount of detail stored in a memory is one of the indicators humans use in determining a memory's source. According to Johnson and colleagues, another indicator of a memory's source is the amount of cognitive effort used to organize and store the memory. For an event in the physical world, little cognitive effort is needed to store and organize the details in memory. On the other hand, if we read about an event in the newspaper it takes substantially more cognitive effort to organize and store the details. We can differentiate memories that required high effort from ones that required low effort, and we can use this information to draw useful conclusions about sources.

The problem with digital media is that humans do not require much cognitive effort to organize and store fluent, detail-rich experiences as described by the SMF. Memories with a lot of detail that require little cognitive effort to store are generally attributed to physical world sources but could be derived from experiences with digital media as well. Consequently, we hypothesize that the possibility for a source monitoring error occurs in direct proportion to media richness.

IVET AS A FALSE MEMORY PROMPT

IVET gives its user the perceptual experience of being surrounded by a virtual, computer-generated environment. A combination of hardware, software, and interactive devices are used to create the IVET experience. Immersion is produced by continually tracking the user's position and rendering a location specific perspective in a head-mounted stereo three-dimensional visual display with a field of view that is wider than a desktop display. This tracking and rendering process provides immediate feedback based on the user's movements. These inherent characteristics of IVET provide greater media richness (e.g., dynamic, user-specific viewpoints and a wider field of view) than the previous forms of media used as false memory stimuli. In addition, newer IVET systems are delivering more forms of perceptual detail. Audio technology is being used to produce three-dimensional sound; haptic devices permit virtual touch (Bailenson & Yee, 2007), a scent collar emits virtual scent (Tortell et al., 2007), and a haptic interface puts pressure on the tongue to enhance virtual taste (Iwata, Yano, Uemura, & Moriya, 2004).

Such detail could not be delivered by two-dimensional photographs or even nonimmersive video recordings.

In addition, IVET environments can be personalized to include avatars or environments that reflect each user's individual appearance, behaviors, and history. Three-dimensional modeling technology now makes it possible to model three-dimensional versions of unique individuals' heads using front and profile photographs as depicted in Figure 1A (Bailenson, Blascovich, Beall, & Loomis, 2001; Bailenson, Beall, Loomis, Blascovich, & Turk, 2004; Bailenson, Blascovich, & Guadagno, 2008; Lee & Magnenat-Thalmann, 2000). For example, using IVET, an individual could sit in a virtual classroom that resembles his or her university lecture hall and interact with an avatar that looks like his or her professor from the physical world (Bailenson et al., 2008). Particularly, recent research has shown that being embodied in an avatar that looks like oneself can have powerful effects on human behavior (Fox & Bailenson, 2009). Furthermore, animation and behavioral realism of virtual humans is becoming more natural (Guadagno, Blascovich, Bailenson, & McCall, 2007; Vinayagamoorthy, Steed, & Slater, 2005). Although two-dimensional photographs can be edited to depict specific faces or objects, the unique combination of dynamic animation, immersion, situational awareness, and personalization offered by IVET make it the richer form of media (Blascovich et al., 2002; Loomis, 1992; Gillath, McCall, Shaver, & Blascovich, 2008; Van Dam, Forsberg, Laidlaw, LaViola, & Simpson, 2000).

The great amount of media richness (feedback, language variety, multiple cues, and personalization) provided by IVET can sometimes make the user feel physically present in the virtual environment. According to scholars in the field, rich mediated experiences may lead to difficulties remembering the source of stored information (Kim & Biocca, 1997; Shapiro & Lang, 1991; Shapiro & McDonald, 1995). These mediated experiences, unlike experiences with less rich media, may be encoded into memory in a manner so similar

FIGURE 1 A) Three-dimensional model of child's head constructed from two photographs (front and profile). B) Screen shot of child's avatar swimming with whales in virtual world. C) A child wearing the head-mounted display.

to physical world experiences that when they are later retrieved errors in source monitoring occur.

For example, in 1995, Hoffman, Hullfish, and Houston applied the concepts of the SMF to users' experiences in IVET in order to develop the virtual reality monitoring framework. Hoffman and colleagues state that virtual reality monitoring (an extension of SMF) is the decision process by which individuals separate memories of events experienced in mediated reality from real and imagined events.

A final characteristic of IVET is that from an experimental standpoint it allows researchers great experimental control and capability for replicating studies (Blascovich et al., 2002). The current research utilizes IVET as a new and innovative method for studying false memory elicitation and source monitoring errors.

CURRENT STUDY

This research project combined the vulnerability of children's memory and the media richness of IVET to propose a new method for studying false memories. Specifically, the current work addressed the research question, "What happens when rich forms of media, such as IVET, are used to elicit false memories?" In this study, we designed four conditions: idle, mental imagery, IVET simulation portraying another child, and IVET simulation portraying the participant. The idle and mental imagery conditions were included as a basis of comparison for the two IVET conditions. According to the media richness criteria and the SMF, we hypothesized that IVET could be powerful in eliciting false memories, especially the IVET self stimulus. In Table 1, we charted the IVET self and IVET other stimuli on the four media richness criteria. IVET is capable of providing feedback to the user through the tracking and rendering process and utilizing multiple types of cues and a variety of languages (through lights, sounds, symbols, nonverbal communication, and animation). The IVET self condition also provides a personal focus. Overall, IVET scores high on the media richness criteria.

METHOD

Participants

Given that this was an exploratory study with a special population (i.e., children), we were open to grouping participants in various manners. Previous work provided some rationale for splitting children into preschool and elementary groups (Bruck & Ceci, 1999) because preschoolers were disproportiantely vulnerable to suggestive influence. Twenty-seven preschool children (ages 4–5) and 28 young elementary children (ages 6–7) participated in the study. The mean age of the preschool group was 4.96 years (SD = 0.19), and the mean age of the elementary group was 6.46 years (SD = 0.51). There were 26 female participants and 29 male participants. Participants were randomly assigned to a condition. In the end, out of the preschoolers five were in the idle condition, eight were in the imagine condition, seven were in the IVET other condition, and seven were in the IVET self condition. And, out of the elementary group, nine were in the idle condition, seven were in the imagine condition, five were in the IVET other condition, and seven were in the IVET self condition. Each child visited the lab once for the main session (1 hour) and once about 5 days later for the follow-up interview (15 minutes). Participants were paid $20. Each parent or guardian was informed about the nature of the study and gave signed consent for their child to participate.

Design

The first session and second session for each participant were conducted in two phases. Each phase focused on one of the two events (some participants received the whale event phase first, some participants received the mouse event phase first). The whale narrative depicted the child swimming with two orca whales two years prior to the study. The mouse narrative depicted the child two years younger shrinking to dance with a stuffed mouse. Each parent confirmed their child had never experienced either of these events and was asked to describe possible confounds (e.g., trips to Sea World where the child swam with big fish, whales, or dolphins).

Following the experiment, a random sample of eight parents were polled via e-mail to rate the plausibility of each event (the whale event and the mouse event). Each parent was asked "How plausible is it that your son/daughter could have engaged in the following activity?" and then the exact same narratives that were read to the children in the lab were written in the e-mail. Surprisingly, on a scale of 1 to 10 (with 10 being the least plausible) the whale event received a mean score of 5.6 (SD = 3.2), and the mouse event received a mean score of 6.1 (SD = 3.5). This difference in plausibility scores was not significant ($F[1, 7] = .434, p = .53$, partial $\eta^2 = .06$), therefore, we averaged memory scores for the two events at each interview time (the *baseline* interview right before the stimulus; the *immediate interview* right after the stimulus, and the *delayed interview* about 5 days after the stimulus).

The unpredicted lack of difference in plausibility scores between the events may be explained by parents answering the questions from their child's perspective. Several parents requested clarification on the question regarding this issue. For example, a preschooler might still believe that shrinking to dance with a stuffed mouse would be physically possible, and the parents' answers may have reflected this perspective.

Memory prompt served as the between-participant independent variable with four levels. First, the researcher read the false event narrative to the participant (regardless of the memory prompt condition) and questioned him or her about recall in the baseline interview. Next, participants in the *idle* condition were asked to sit and wait for one minute. Participants in the *mental imagery* condition were asked to imagine themselves participating in the event for one minute. Participants in the *IVET other* condition were asked to watch a virtual reality simulation of another child participating in the false event. Participants in the *IVET self* condition were asked to watch a virtual reality simulation of themselves participating in the false event. Immediately following the memory prompt (regardless of condition) the researcher questioned the child's recall (the immediate interview). The second phase started with the other false event and proceeded through the same steps. All participants returned approximately 5 days later ($M = 5.31$, $SD = 2.04$) for the delayed interview. Neither the narrative nor the false memory stimulus was repeated again for the delayed interview. The researcher solely asked the participant if he or she remembered the whale event or the mouse event (in the same order as the events had been introduced in the first session).

Materials and IVET Hardware

The researcher took each child's digital photograph at the beginning of the first session regardless of condition or age group. If the child had been randomly assigned to the IVET self condition, a research assistant uploaded the photograph to a computer to model a three-dimensional representation of the child's head using 3DMeNow software (Figure 1A). It took approximately 20 minutes for the model of the child's head to be created. In another room, the parent and child were shown an unrelated IVET demonstration to keep the child occupied.

The three-dimensional model of the child's head was then loaded into the two virtual worlds and attached to a generic child's body of the appropriate gender using Vizard 2.5 software. Figure 1B shows a screen shot of the virtual world in which the children swam with whales.

Each child in the IVET other or self condition wore a Virtual Reality NVIS stereoscopic head-mounted display (HMD; see Figure 1C). We set the viewpoint in this experiment so the virtual simulation was always in the child's field of view regardless of head movements. Although this limited the experience of full immersion, it assured that the child focused on the stimulus of interest.

Procedure

After the parent and child were shown a demonstration of IVET, the parent left the room and the actual experiment began. The research assistant read the false event narrative to the child (regardless of condition). The whale narrative read: "[Child's name], when I was talking with your mommy/daddy earlier, he/she told me that when you were [child's age minus 2 years] years old you swam with two big fish named Fudgy and Buddy. Fudgy and Buddy were black and white and very nice fish. They liked swimming with you in the blue water. You liked swimming with them too. The water was blue with some small waves. There were green plants at the bottom of the water. After you swam with Fudgy and Buddy for a while you dried off and went back home to play. That is what your mommy/daddy remembers. Do you remember swimming with Fudgy and Buddy?" The mouse event followed the same format, but described the child shrinking to dance with a favorite stuffed animal mouse named Cheesy. Both narratives were equal in length.

The verbal narrative was given only once for each event. Every child was asked if he or she remembered the event in three separate interviews: once before the manipulation (baseline interview); once immediately after the manipulation (immediate interview); and once approximately 5 days later (delayed interview). Thus, the baseline interview showed the effect of a narrative prompt. The immediate interview showed the effect of adding one of the manipulations (idle, mental imagery, IVET other, IVET self), and the delayed interview showed the effect of those manipulations after approximately 5 days.

The manipulation was introduced to each child in the following manner depending on condition: "Maybe if you 1) sit for one minute; 2) imagine doing the event for one minute; 3) use the special glasses (HMD) to watch a special movie of another child doing the event; or 4) use the special glasses to watch a special movie of yourself doing the event it will help you to remember (or "remember more about") the event."

After the immediate interview the experimenter then repeated the process (starting with the presentation of the narrative) for the second event. The parent and child were instructed not to talk about the study between sessions.

A few days later in the delayed interview, the experimenter again asked each child if he or she remembered the event. "[Child's name], last time you were here you told me that you remembered/didn't remember swimming with Fudgy and Buddy. Now do you [still] remember swimming with Fudgy and Buddy in the real world?" The child was not presented with the narrative or memory prompt manipulation again. After the delayed interview for both events, the parent and child were fully debriefed and allowed to ask questions. If the child developed a false memory during the study, the researcher assured the child that he or she never performed the event in the physical world. All participants that developed false memories (full or partial) were able to be debriefed. Parents were present during the debriefing and helped the children understand that the memories they created were due to the memory prompt stimuli.

MEASURES

Each child's memories were coded according to four categories: no memory; no memory but trying to recall; partial memory, but little detail; memory with full detail (Hyman & Billings, 1998). Children in the first category (no memory) immediately stated that they had never completed the event. Children in the second category (no memory but trying to recall) seemed to be still searching for the memory in their minds. They stated reasons for why the event may or may not have occurred but never completely accepted the memory. Children in the third category (partial memory, but little detail) simply stated that they remembered the event but were not able to provide significant further detail. Children in the fourth category (memory with full detail) recalled the event almost immediately when questioned and went on to provide further detail about the event, such as the color of other fish.

Recall was coded by the experimenter as the response was given, and outside research assistants blind to experimental condition coded a random sample of the recorded video clips to check for inter-coder reliability (Cronbach's alpha = .87). The means mentioned in the results section are in reference to these four categories (participants who did not recall a memory were given a 1; participants who did not recall a memory but were trying were given a 2, and so forth). The larger the score/average, the closer the participant was to developing a complete false memory.

A univariate analysis of variance confirmed random assigment for the preschool and elementary children groups. As can be seen in Figures 2 and 3, there were no significant differences in baseline interview scores according to different memory prompt condition for preschoolers ($F[3, 23] = .53$, $p = .67$, partial $\eta^2 = .07$) or young elementary children ($F[3,24] = 1.66$, $p = .20$, partial $\eta^2 = .17$).

RESULTS

We segregated our data set into the two age groups and analyzed each set of data separately. We conducted a repeated measures analysis with interview time as the within participant factor (with three levels) and memory prompt as the between participant factor (with four levels).

Preschool Children

For preschool children, the main effect of interview time was significant ($F[2, 46] = 4.68$, $p = .01$, partial $\eta^2 = .17$). As Figure 2 demonstrates, the false memory scores for the preschool children were higher after the experimental treatment than in the baseline interview (baseline: $M = 1.48$, $SD = .61$; immediate: $M = 2.02$, $SD = 1.11$; delayed: $M = 1.91$, $SD = 1.16$).

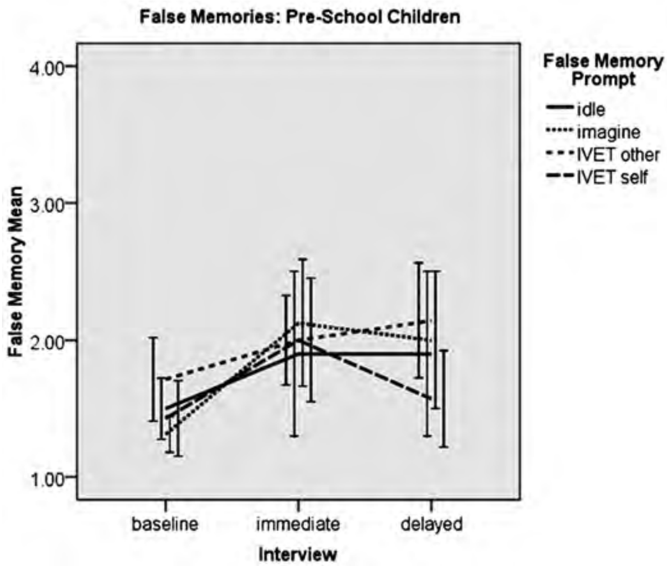

FIGURE 2 Plot of the false memory scores reported by interview and memory prompt condition for preschool participants. Error bars equal ±1 standard error.

The main effect of memory prompt was not significant for the preschool children ($F[3, 23] = .12$, $p = .95$, partial $\eta^2 = .02$) as Figure 2 demonstrates (idle: $M = 1.77$, $SD = .86$; mental imagery: $M = 1.81$, $SD = 1.00$; IVET other: $M = 1.95$, $SD = .81$; IVET self: $M = 1.67$, $SD = .88$). Additionally, there was no significant interaction between interview time and memory prompt condition ($F[6, 46] = .46$, $p = .83$, partial $\eta^2 = .06$).

Young Elementary Children

For the young elementary children, the main effect of interview time was significant ($F[2, 48] = 7.30$, $p < .01$, partial $\eta^2 = .23$), as depicted in Figure 3. The false memory scores for the elementary children were highest just after the false memory prompt in the immediate interview compared to the other two conditions (baseline: $M = 1.55$, $SD = .81$; immediate: $M = 1.93$, $SD = 1.14$; delayed: $M = 1.52$, $SD = .87$).

The main effect of memory prompt was also significant for elementary children ($F[3, 24] = 3.45$, $p = .03$, partial $\eta^2 = .30$). As Figure 3 suggests, elementary children were more likely to develop false memories in the mental imagery ($M = 2.19$, $SD = 1.12$) and IVET self ($M = 2.07$, $SD = .95$) conditions as compared to the idle ($M = 1.18$, $SD = .21$), and IVET other ($M = 1.23$, $SD = .43$) conditions in the immediate and delayed interviews. Additional tests of simple effects revealed the mental imagery condition elicited significantly more false memories than the idle condition in the

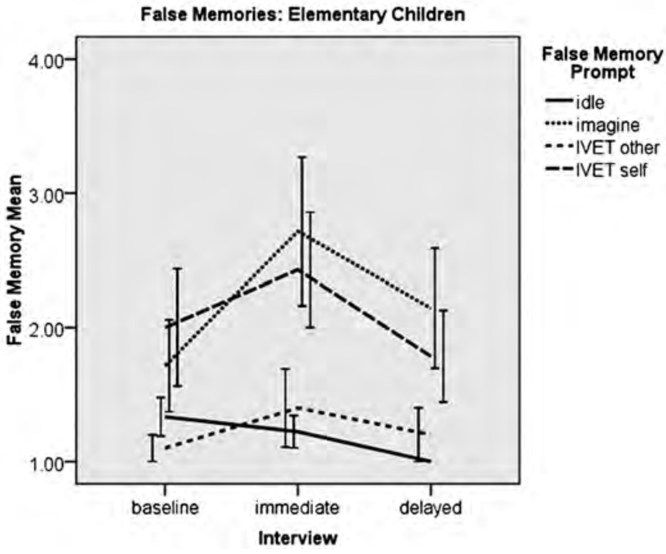

FIGURE 3 Plot of the false memory scores reported by interview and memory prompt condition for elementary school participants. Error bars equal ±1 standard error.

immediate (t[14] = −2.96, p = .01, Cohen's d = 1.58) and delayed (t[14] = −2.94, p = .01, Cohen's d = 1.57) interviews.[1] Additionally, tests of simple effects also revealed that the IVET self condition elicited significantly more false memories than the idle condition in the immediate (t[14] = −3.02, $p <$ .01, Cohen's d = 1.61) and delayed (t[14] = −2.63, p = .02, Cohen's d = 1.41) interviews.[2] Furthermore, there was a significant interaction between interview time and memory prompt condition ($F[6, 48] = 2.37, p = .04, \eta^2 = .23$). As Figure 3 demonstrates, memories changed after the treatment, but not for the baseline interview.

As a further demonstration of this effect, we divided the data from the elementary children into those children who had at least one false memory (one memory coded as greater than a two) in the four possible trials in which they were asked and those children who had no false memories in any of the four possible trials. In the IVET self condition four out of seven children had at least one false memory and in the mental imagery condition four out of seven children had at least one as well. On the other hand, zero out of nine children in the idle condition had at least one false memory, and only one out of five children in the IVET other condition had at least one false memory.

DISCUSSION

In summary, for preschool participants, we did not find a significant difference for memory prompt condition. However, there were more false memories formed after the treatment than in the baseline interview. For young elementary children, there were more false memories formed in the imagery and IVET self conditions than the idle condition. Moreover, across memory prompt condition, more false memories were reported in the immediate interview than in either the baseline or delayed interview.

False Memory Prompts

This study adds another level of digital technology to the previous chain of studies; the spectrum of false memory prompts now stretches from written narratives and mental imagery to edited digital photographs to IVET. The results from the current study do not allow direct comparisons of IVET with other forms of media, but they do confirm that the representation of the self (as seen in the IVET self memory prompt) can be a powerful factor in eliciting false memories in preschool and elementary children. More specifically, preschool children were equally likely to develop false memories across all false memory prompt conditions, while elementary children were most likely to develop false memories in the IVET self and mental imagery conditions.

It appears that the less developed source monitoring capabilities in the preschool children (Flavell, 1985) caused this group of participants to report false memories across all four memory prompt conditions. The media richness of the false memory prompt (whether it was just the narrative in the idle condition or the IVET simulation of the self) did not affect the memory scores of these children.

The elementary children results, however, point to differences in source monitoring judgments by memory prompt condition. These results give support to our claim that as the media richness of the prompt increases, the more difficult it becomes to distinguish between an actual memory elicited by a physical world event and a false memory elicited by a photograph, mental image, IVET, and so forth. This difficulty in distinguishing between real and false memories is most evident in the mental imagery and IVET self conditions, the exact conditions that we claim score the highest on the media richness criteria (Table 1). The media richness of the mental imagery and IVET self memory prompts was high enough to be confused with the richness of an event in the physical world. However, more research comparing prompts of varying media richness will need to be conducted in order to test if our predictions regarding the SMF and media richness criteria are correct.

Memory Changes Over Time

The immediate interview was conducted just after the presentation of the memory prompt to capture any increase or decrease in false memory recall. More false memories were recalled in the immediate interview than in the baseline interview for both groups of participants. This trend shows that the memory prompts were successful in eliciting false memories.

The delayed interview was incorporated into the study to capture any increase or decrease in false memory recall over time. As pointed out by Ceci, Loftus, Leichtman, and Bruck (1994) and Strange, Sutherland, and Garry (2006), past research has shown mixed results regarding this variable; sometimes repeated interviewing over time causes an increase, decrease, or no change in false memory recall. Factors such as participant age, years since alleged false memory, and amount of time delay may help explain why false memory recall increases and decreases over time. In addition, in some previous work the false memory prompt has been re-administered before conducting the delayed interview (Ceci et al., 1994). In our study, however, the false memory prompt was only delivered right before the immediate interview; the prompt was not re-administered when the child visited the lab for the delayed interview. This may explain why false memory recall did not increase between the immediate and delayed interview.

Limitations

In this study, we recruited participants from a very small age range. Further work should seek to explore the effects of IVET on a more comprehensive range of ages (including adults). The IVET self and mental imagery prompts seem to have the most potential for impact on populations that are in general less susceptible to developing false memories (i.e., the elementary children in our sample). In addition, while we are presenting a new innovative method, this is only a preliminary study. For future studies, more participants would be needed to explore the robustness of these effects.

Additionally, in the designing of this study we did not separate the narrative prompt as its own condition (each condition included the reading of the narrative). Due to this design, we were not able to separate the effect of the narrative from the other conditions. In future studies, we should separate the narrative into its own condition to better compare the effects of such memory prompt stimuli. Also, if an idle condition is utilized in future studies, it would be advantageous to provide a filler task for the child to engage in during the waiting period to ensure that the participant does not use that time to imagine the false event.

Future Directions

We conducted only an introductory investigation of this topic. Future work in the field should more specifically compare IVET to other types of memory prompts. Additionally, future researchers might examine multiple IVET memory prompt conditions (with different combinations of hardware and software) within the same experiment in order to compare IVET conditions with varying levels of media richness. This parsing out of IVET affordances could better explicate the media richness of each affordance of IVET. For example, one IVET condition may deliver just the visual virtual world; the next IVET condition might add virtual sound to the visual world, and the third condition may add haptic feedback. In this way researchers could tier the amount of media richness delivered to the participant in very detailed and specific ways (Sundar, 2008).

Another aspect of media-elicited memories that future research should consider is that as photo editing software becomes more widely available, individuals will become more aware that photographs can be edited (Farid, 2006). This realization may change how individuals react to edited false memory stimuli in the future.

Conclusions

The current study provides another interesting, innovative way to elicit false memories in children. We believe that these results are uniquely interesting because they reveal that mental imagery (which must be actively initiated by the participant) and IVET self simulations (which can be completely controlled by a third party) are both powerful in eliciting false memories in children. In other words, by viewing an IVET simulation of the self a passive observer can develop false memories just as easily as a participant using cognitive energy to create mental images. This finding suggests that third parties may be able to elicit false memories without the consent or mental effort of an individual.

In addition to psychiatric clinics (Carlin, Hoffman, & Weghorst, 1997; Difede & Hoffman, 2002; Krijn, Emmelkamp, Olafsson, & Biemond, 2004; Rothbaum, Hodges, Smith, Lee, & Price, 2000), IVET may soon be utilized in court rooms (Bailenson, Blascovich, Beall, & Noveck, 2006; Feigenson, 2006) and other environments (Hoffman et al., 2001; Holden, 2005; Pridmore, Hilton, Green, Eastgate, & Cobb, 2004). Social scientists in communication and psychology, digital media activists, professionals in the field, and the general public need to be informed regarding the benefits and precautions of using digital media. The current study shows that digital media affect human memory in predictable patterns; digital media may also affect human emotion or decision making in predictable ways. Research in this area of social psychology will inform digital media users and researchers about how different forms of media may manipulate the human experience, including how humans think about their experiences while not using media.

NOTES

1. The Levene's test for equality of variances yielded a statistically significant p value. However, when we used the Welch-Satterthwaite equation to adjust for the unequal variances, the effects were still statistically significant ($p < .05$).

2. The Levene's test for equality of variances yielded a statistically significant p value. However, when we used the Welch-Satterthwaite question to adjust for the unequal variances, the difference between the idle and IVET self condition (in the immediate interview) was statistically significant ($p = .03$), and the difference between the idle and IVET self condition (in the delayed interview) was marginally significant ($p = .06$).

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REFERENCES

Bailenson, J. N., Beall, A. C., Loomis, J., Blascovich, J., & Turk, M. (2004). Transformed social interaction: Decoupling representation from behavior and form in collaborative virtual environments. *PRESENCE: Teleoperators and Virtual Environments, 13*(4), 428–441.

Bailenson, J. N., Blascovich, J., Beall, A. C., & Loomis, J. M. (2001). Equilibrium revisited: Mutual gaze and personal space in virtual environments. *PRESENCE: Teleoperators and Virtual Environments, 10*, 583–598.

Bailenson, J. N., Blascovich, J., Beall, A. C., & Noveck, G. (2006). Courtroom applications of virtual environments, immersive virtual environments, and collaborative virtual environments. *Law & Policy, 28*(2), 249–270.

Bailenson, J. N., Blascovich, J., & Guadagno, R. E. (2008). Self representations in immersive virtual environments. *Journal of Applied Social Psychology*, *38*(11), 2673–2690.

Bailenson, J. N., & Yee, N. (2007). Virtual interpersonal touch: Haptics interaction and copresence in collaborative virtual environments. *International Journal of Multimedia Tools and Applications, 37*(1), 5–14.

Bailenson, J. N., Yee, N., Blascovich, J., Beall, A. C., Lundblad, N., & Jin, M. (2008). The use of immersive virtual reality in the learning sciences: Digital transformations of teachers, students, and social context. *The Journal of the Learning Sciences, 17*, 102–141.

Biocca, F. (1992). Communication within virtual reality: Creating a space for research. *Journal of Communication, 42*(4), 5–22.

Blascovich, J., Loomis, J., Beall, A., Swinth, K., Hoyt, C., & Bailenson, J. N. (2002). Immersive virtual environment technology as a methodological tool for social psychology. *Psychological Inquiry*, *13*, 103–124.

Bruck, M., & Ceci, S. J. (1999). The suggestibility of children's memory. *Annual Review of Psychology, 50*, 419–439.

Carlin, A. S., Hoffman, H. G., & Weghorst, S. (1997). Virtual reality and tactile augmentation in the treatment of spider phobia: A case report. *Behavior Research and Therapy, 35*(2), 153–158.

Ceci, S. J., Loftus, E. F., Leichtman, M. D., & Bruck, M. (1994). The possible role of source misattributions in the creation of false beliefs among preschoolers. *International Journal of Clinical and Experimental Hypnosis, 42*(4), 304–320.

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection, and manager performance: Implications for information systems. *MIS Quarterly, 11*(3), 355–366.

Difede, J., & Hoffman, H. G. (2002). Virtual reality exposure therapy for World Trade Center post-traumatic stress disorder: A case report. *CyberPsychology & Behavior, 5*(6), 529–535.

Farid, H. (2006). Digital doctoring: How to tell the real from the fake. *Significance: Statistics Making Sense, 3*(4), 162–166.

Feigenson, N. (2006). Too real? The future of virtual reality evidence. *Law & Policy, 28*(2), 271–293.

Flavell, J. H. (1985). *Cognitive Development* (2nd ed.). Englewood Cliffs, NJ: Prentice Hall.

Foley, M. A., & Johnson, M. K. (1985). Confusions between memories for performed and imagined actions: A developmental comparison. *Child Development, 56*, 1145–1155.

Foley, M. A., Santini, C., & Sopasakis, M. (1989). Discriminating between memommories: Evidence for children's spontaneous elaborations. *Journal of Experimental Child Psychology, 48*(1), 146–169.

Fox, J., & Bailenson, J. N. (2009). Virtual self-modeling: The effects of vicarious reinforcement and identification on exercise behaviors. *Media Psychology, 12*, 1–25.

Garry, M., Manning, C. G., Loftus, E. F., & Sherman, S. J. (1996). Imagination inflation: Imagining a childhood event inflates confidence that it occurred. *Psychonomic Bulletin & Review, 3*(2), 208–214.

Garry, M., & Polaschek, D. (2000). Imagination and memory. *Current Directions in Psychological Science, 9*(1), 6–10.

Garry, M., & Wade, K. A. (2005). Actually, a picture is worth less than 45 words: Narratives produce more false memories than photographs do. *Psychonomic Bulletin & Review, 12*(2), 359–366.

Gillath, O., McCall, C., Shaver, P. R., & Blascovich, J. (2008). What can virtual reality teach us about prosocial tendencies in real and virtual environments? *Media Psychology, 11*(2), 259–282.

Goff, L. M., & Roediger, III, H. L. (1998). Imagination inflation for action events: Repeated imaginings lead to illusory recollections. *Memory & Cognition, 26*(1), 20–33.

Goodman, G. S., & Quas, J. A. (2008). Repeated interviews and children's memory: It's more than just how many. *Current Directions in Psychological Science, 17*(6), 386–390.

Guadagno, R. E., Blascovich, J., Bailenson, J. N., & McCall, C. (2007). Virtual humans and persuasion: The effects of agency and behavioral realism. *Media Psychology, 10*, 1–22.

Henkin, R. I., & Levy, L. M. (2002). Functional MRI of congenital hyposmia: Brain activation to odors and imagination of odors and tastes. *Journal of Computer Assisted Tomography, 26*(1), 39–61.

Hoffman, H. G., Garcia-Palacios, A., Patterson, D. R., Jensen, M., Furness, T., & Ammons, W. F. (2001). The effectiveness of virtual reality for dental pain control: A case study. *CyberPsychology & Behavior, 4*(4), 527–535.

Hoffman, H. G., Garcia-Palacios, A., Thomas, A. K., & Schmidt, A. (2001). Virtual reality monitoring: Phenomenal characteristics of real, virtual, and false memories. *CyberPsychology & Behavior, 4*(5), 565–572.

Hoffman, H. G., Hullfish, K. C., & Houston, S. J. (1995). Virtual-reality monitoring. Paper presented at the meeting of the Virtual Reality Association International Symposium (VRAIS), Research Triangle, NC.

Holden, M. K. (2005). Virtual environments for motor rehabilitation: Review. *Cyber Psychology & Behavior, 8*(3), 187–211.

Hyman, I. E., Husband, T. H., & Billings, F. J. (1995). False memories of childhood experiences. *Applied Cognitive Psychology, 9*(3), 181–197.

Hyman, I. E., & Billings, F. J. (1998). Individual differences and the creation of false childhood memories. *Memory, 6*(1), 1–20.

Hyman, I. E., & Pentland, J. (1996). The role of mental imagery in the creation of false childhood memories. *Journal of Memory and Language, 35*(2), 101–117.

Iwata, H., Yano, H., Uemura, T., & Moriya, T. (2004). Food simulator: A haptic interface for biting. *Proc. IEEE Virtual Reality*, 51–57.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin, 114*(1), 3–28.

Kim, T., & Biocca, F. (1997). Telepresence via television: Two dimensions of telepresence may have different connections to memory and persuasion. *Journal of Computer-Mediated Communication*, *3*(2). Retrieved October 9, 2009, from http://jcmc.indiana.edu/vol3/issue2/kim.html

Kleber, B., Birbaumer, N., Veit, R., Trevorrow, T., & Lotze, M. (2007). Overt and imagined singing of an Italian aria. *NeuroImage, 36*(3), 889–900.

Krijn, M., Emmelkamp, P. M. G., Olafsson, R. P., & Biemond, R. (2004). Virtual reality exposure therapy of anxiety disorders: a review. *Clinical Psychology Review, 24*, 259–281.

Lanier, J. (2001). Virtually there. *Scientific American*, *284*(4), 66–75.

Lee, W., & Magnenat-Thalman, N. (2000). Fast head modeling for animation. *Image and Vision Computing*, *18*(4), 355–364.

Levy, L. M., Henkin, R. I., Lin, C. S., Finley, A., & Schellinger, D. (1999). Taste memory induces brain activation as revealed by function MRI. *Journal of Computer Assisted Tomography, 23*(4), 499–505.

Lindsay, D. S. (2002). Children's source monitoring. In H. L. Westcott, G. M. Davies, & R. H. C. Bull (Eds.), *Children's Testimony* (pp. 83–98). Chichester, UK: Wiley.

Lindsay, D. S., & Johnson, M. K. (1987). Reality monitoring and suggestibility: Children's ability to discriminate among memories from different sources. In S. J. Ceci, M. P. Toglia, & D. F. Ross (Eds.), *Children's Eyewitness Memory* (pp. 92–121). New York: Springer-Verlag.

Lindsay, D. S., Johnson, M. K., & Kwon, P. (1991). Developmental changes in memory source monitoring. *Journal of Experimental Child Psychology, 52*, 297–318.

Loftus, E. F. (2002). Memory faults and fixes. *Issues in Science and Technology, 18*(4), 41–50.

Loftus, E. F., & Pickrell, J. E. (1995). The formation of false memories. *Psychiatric Annals, 25*(12), 720.

Loomis, J. M. (1992). Distal attribution and presence. *Presence: Teleoperators and Virtual Environments, 1*(1), 113–119.

Loomis, J. M., Blascovich, J. J., & Beall, A. C. (1999). Immersive virtual environment technology as a basic research tool in psychology. *Behavior Research Methods, Instruments & Computers, 31*(4), 557–564.

Luft, A. R., Skalej, M., Stefanou, A., Klose, U., & Voigt, K. (1998). Comparing motion- and imagery-related activation in the human cerebellum: A function MRI study. *Human Brain Mapping, 6*(2), 105–113.

Mazzoni, G., Loftus, E. F., & Kirsch, I. (2001). Changing beliefs about implausible autobiographical events: A little plausibility goes a long way. *Journal of Experimental Psychology: Applied, 7*, 51–59.

Mazzoni, G. G., & Memon, A. A. (2003). Imagination can create false autobiographical memories. *Psychological Science, 14*(2), 186–188.

Miller, G. (2007). The promise of parallel universes. *Science, 317*(5843), 1341–1343.

Nehaniv, C. L. (1999). Narrative for artifacts: Transcending context and self (Technical Report FS-99-01). In *Proceedings of Narrative Intelligence* (pp. 101–104). North Falmouth, MA: American Association for Artificial Intelligence.

Ogino, Y., Nemoto, H., Inui, K., Saito, S., Kakigi, R., & Goto, F. (2006). Inner experience of pain: Imagination of pain while viewing images showing painful events forms subjects pain representation in human brain. *Cerebral Cortex, 17*(5), 1139–1146.

Pezdek, K., Finger, K., & Hodge, D. (1997). Planting false childhood memories. *Psychological Science, 8*, 437–441.

Pezdek, K., & Hodge, D. (1999). Planting false childhood memories in children: The role of event plausibility. *Child Development, 70*(4), 887–895.

Porter, S., Yuille, J. C., & Lehman, D. R. (1999). The nature of real, implanted, and fabricated memories for emotional childhood events: Implications for the recovered memory debate. *Law and Human Behavior, 23*(5), 517–537.

Pridmore, T., Hilton, D., Green, J., Eastgate, R., & Cobb, S. (2004, September). Mixed reality environments in stroke rehabilitation: Interfaces across the real/virtual divide. *The 5th International Conference on Disability, Virtual Reality and Associated Technologies* (pp. 11–18). Oxford, UK.

Reeves, B., Malone, T. W., & O'Driscoll, T. (2008). Leadership's online lab. *Harvard Business Review, 86*(5), 58–67.

Rothbaum, B. O., Hodges, L., Smith, S., Lee, J. H., & Price, L. (2000). A controlled study of virtual reality exposure therapy for the fear of flying. *Journal of Consulting and Clinical Psychology, 68*(6), 1020–1026.

Ruffman, T., Rustin, C., Garnham, W., & Parkin, A. J. (2001). Source monitoring and false memories in children: Relation to certainty and executive functioning. *Journal of Experimental Child Psychology, 80*, 95–111.

Shapiro, M. A., & McDonald, D. (1995). I'm not a real doctor, but I play one in virtual reality: Implications of virtual reality for judgments about reality. In F.

Biocca & M. R. (Eds.), *Communication in the age of virtual reality* (pp. 323–345). Hillsdale, NJ: Erlbaum.

Shapiro, M. A., & Lang, A. (1991). Making television reality: unconscious processes in the construction of social reality. *Communication Research 18*, 685–705.

Strange, D., Hayne, H., & Garry, M. (2008). A photo, a suggestion, a false memory. *Applied Cognitive Psychology, 22*, 587–603.

Strange, D., Sutherland, R., & Garry, M. (2006). Event plausibility does not determine children's false memories. *Memory, 14*(8), 937–951.

Sundar, S. S. (2008). The MAIN model: A heuristic approach to understanding technology effects on credibility. In M. J. Metzger & A. J. Flanagin (Eds.), *Digital media, youth, and credibility (The John D. and Catherine T. MacArthur Foundation series on digital media and learning)* (pp. 73–100). Cambridge, MA: MIT Press.

Symons, C. S., & Johnson, B. T. (1997). The self-reference effect in memory: A meta-analysis *Psychological Bulletin, 121*(3), 371–394.

Thomas, A. K., & Loftus, E. F. (2002). Creating bizarre false memories through imagination. *Memory & Cognition, 30*(3), 423–431.

Tortell, R., Luigi, D. P., Dozois, A., Bouchard, S., Morie, J. F., & Ilan, D. (2007). The effects of scent and game play experience on memory of a virtual environment. *Virtual Reality, 11*(1), 61–68.

Van Dam, A., Forsberg, A. S., Laidlaw, D. H., LaViola, J. J., & Simpson, R. M. (2000). Immersive VR for scientific visualization: A progress report. *IEEE Computer Graphics and Applications, 20*(6), 26–52.

Vinayagamoorthy, V., Steed, A., & Slater, M. (2005). Building characters: Lessons drawn from virtual environments. Paper presented at the workshop *Towards Social Mechanisms of Android Science: A CogSci 2005 Workshop*, July 25–26, 2005, Stressa, Italy.

Wade, K. A., Garry, M., Read, J. D., & Lindsay, D. S. (2002). A picture is worth a thousand lies: Using false photographs to create false childhood memories. *Psychonomic Bulletin & Review, 9*(3), 597–603.