Exploring Memory Manipulation in Extended Reality Using Scenario Construction

Elise Bonnail
LTCI, Telecom Paris, IP Paris
Palaiseau, France
elise.bonnail@telecom-paris.fr

Wen-Jie Tseng
LTCI, Telecom Paris, IP Paris
Palaiseau, France
wen-jie.tseng@telecom-paris.fr

Eric Lecolinet
LTCI, Telecom Paris, IP Paris
Palaiseau, France
eric.lecolinet@telecom-paris.fr

Samuel Huron
CNRS i3 (UMR 9217)
Telecom Paris, IP Paris
Palaiseau, France
samuel.huron@telecom-paris.fr

Jan Gugenheimer
LTCI, Telecom Paris, IP Paris
Palaiseau, France
jan.gugenheimer@telecom-paris.fr

ABSTRACT

People use digital records (e.g., photos and videos) to augment their memory and support reminiscence of positive events. Since Extended Reality (XR) technology can fully immerse a user inside a virtual environment (which could be the reconstruction of a past event), this technology might become a frequently used medium for reminiscing. However, inaccurate XR reconstructions could be confused with the memory of the original event, ending up with false memories which could impact users' future choices and behaviors. We aim to explore the potential impacts of XR technologies on users' memories and propose solutions. In this workshop submission, we focus on one type of memory flaw that results in false memories - source confusion. Using scenario construction, we demonstrate a situation in which false memories could be induced through an XR reminiscing experience. This scenario revolves around abusive advertising, where malicious actors alter virtual parts of a reconstructed memory to make users associate a positive experience with a brand that was not present in the original event. Through this scenario, we approach our research questions about how to address and mitigate risks of XR memory manipulations.

KEYWORDS

XR memory manipulation, false memory, source confusion, scenario construction

ACM Reference Format:
Elise Bonnail, Wen-Jie Tseng, Eric Lecolinet, Samuel Huron, and Jan Gugenheimer. 2022. Exploring Memory Manipulation in Extended Reality Using Scenario Construction. In *CHI Conference on Human Factors in Computing Systems (CHI '22), April 29-May 5, 2022, New Orleans, LA, USA.* ACM, New York, NY, USA, 5 pages.

CHI EA '22, Proceedings of the 1st Workshop on Novel Challenges of Safety, Security and Privacy in Extended Reality, April 29-May 5, 2022, New Orleans, LA, USA

1 INTRODUCTION

Humans have always tried to preserve their memories through different means like painting or writing. Nowadays, with the ubiquity of smartphones and data storage becoming cheaper, people can record anything at any time, a practice called lifelogging [17]. The rich contextual information of images augment the user's memory [7, 17, 35], supporting reminiscing and reflection [10], which boosts happiness and leads to a better ability to enjoy life [9].

Virtual Reality (VR) Head-Mounted Displays (HMDs) are becoming more and more accessible to a large public. It is reasonable to think that in the future, people would want to revisit their memories with more immersive media like Extended Reality (XR), as it offers a more attractive experience to reminisce [41] and enhances episodic memory performance [37]. Unlike current digital records, XR allows users to actively navigate in the scene and could provide tactile and olfactory feed backs, which improves recall [11, 14].

Instead of viewing recordings on a flat screen, those could be stored as 3D scenes that one could revisit with a VR HMD. Several companies have already presented this idea of reliving memories in VR. At the F8 conference in 2018, Facebook's head of social Rachel Franklin presented a project aimed at reconstructing 3D places from 2D photos and videos, to reactivate memories linked to these places [3]. This idea is also proposed by Memento VR, a project that offers to reconstruct memories in VR by collecting photos and videos and turning them into a 3D scene [1]. This shows that the reconstruction of places and events in 3D is realistic, and that current techniques would allow it.

However, human memory is fallible and digital records can be easily manipulated. Anybody can now remove clouds in the sky, remove unwanted objects or people from pictures only with a few touches on their smartphones. Similarly, XR memory reconstructions could be inaccurate (intentionally or not, for example if some spatial information is missing for the 3D reconstruction). Cognitive psychology research has shown that exposure to manipulated images can distort beliefs and lead to the creation of false memories (i.e., a strong confidence in the memory of an event that did not actually occur) [29, 38]. If false memories have traditionally been studied using narratives and manipulated pictures, they can also be implanted using XR [34]. Indeed, XR offers greater media richness (i.e., capacity for immediate feedback, language variety, transmitting multiple cues and capacity of the medium to have

personal focus) [34], which can lead to difficulties remembering the source of stored information (effect called source confusion) [36] and favor the creation of false memories [33]. Previous works questioned how 2D digital records could alter unmediated memories, affect psychological well-being [13, 23] and how fake records could distort beliefs [24], but there is currently no clear understanding of the impacts of memory reconstructions in XR.

In this workshop paper, we introduce a research plan that aims to structurally explore how XR could cause safety and security issues for users regarding memory flaws. We first introduce source confusion, one of memory flaw, and the directive memory function that guides people's choices and behaviors. Next, we construct a scenario to explore how XR technology could leverage source confusion to manipulate user memory and behaviors. We use scenario construction as a tool to explore the potential future of technologies and their ethical impacts and harms [12, 28, 39]. The scenario results in a situation of abusive XR advertising where malicious actors alter parts of a reconstructed memory to make users associate a positive experience with a brand that was not present in the original event. From this scenario, we suggest one protection mechanism (e.g., unrealistic rendering to avoid source confusion between real and virtual memories) and raise research questions around: What types of memory manipulations are possible with XR and how can we design mechanisms to prevent these manipulations.

2 BACKGROUND

In this paper, we focus on the impact of XR reconstructions of past personal events, which are part of the user's Autobiographical Memory (AM). AM contains recollected memories of personal events and experiences and general knowledge of the self [15]. It is the memory system that one would use to write their autobiography. Remembering events is a process made of three stages: encoding (the initial perception and learning of information), storage (maintaining information over time), and retrieval (accessing information when needed) [15]. However, many errors can occur at every stage, making human memory fallible. Memory flaws can lead to a strong confidence in the memory of an event that never occurred, what we call false memories. In this section, we present one of human memory flaws, the source confusion effect (when people confuse the source of their memories). We explain why XR could facilitate the creation of false memories and what impacts they could have.

2.1 Implanting False Memories

Several studies have demonstrated the possibility of intentionally implanting false memories to participants. In the "Lost in the mall" experiment, Loftus and Pickrell asked participants to recall events supplied by a close relative [27]. One of these events was a false one (i.e., that never occurred), about getting lost in a shopping mall. Some participants falsely remembered what was suggested to them. In 2002, Wade et al. created false childhood memories of flying in a hot air balloon by showing participants manipulated pictures of them as a child in a hot air balloon [38]. Segovia and colleagues showed that preschool children remembered a false experience, swimming in a virtual ocean with whales in VR, as a real memory [34]. These works show that different means can be leveraged to create new memories for events that never happened: narratives, manipulated pictures and VR. In the following, we explain what memory mechanisms are leveraged to create these false memories.

2.2 Memory flaws

To understand where false memories come from, we need to look at memory flaws. Schacter classified them into seven basic "sins" [33]. The first three sins, leading to forgetting, are: transience (decreasing accessibility of information over time), absent-mindedness (inattentive processing that contributes to weak memories) and blocking (temporary inaccessibility of information stored in memory). The next three sins, that lead to memory distortion are: misattribution (attributing a memory to the wrong source, also called source confusion), suggestibility (distortion of memories caused by new information added between encoding and retrieval), and bias (unconscious influence of current knowledge and beliefs). Finally, the seventh sin, persistence, refers to the inability to forget some memories. All of these memory flaws contribute to forgetting, distorting memories and creating new false memories. In this paper we focus only on the misattribution effect, that we refer to as source confusion. This should only demonstrate a first step towards understanding memory manipulation in XR which we are currently planing to explore in more depth in an ongoing research project.

2.3 Source Confusion: One Cause of False Memories

One reason why false memory occurs is that humans sometimes confuse the source of their memories (effect called source confusion). Indeed, a memory is not labeled with its source (where the memory comes from, what or who is at the origin of the event). Getting the source of memory is a decision process done during retrieval. These sources can be external (e.g., heard or seen events), or internal (e.g., thoughts, imagination or dreams). Confusing these sources can lead to problematic situations. Here is an example of source confusion in a daily situation: a person heard some news in a conversation. Later, they confuse the source of their memory, assuming they saw it in an official TV news show. The person then falsely remember hearing the information from a reliable source, and starts propagating potentially false news. Source confusion can even lead to more serious cases like child abuse memories induced during therapy, or cases of false witness testimonies [25, 26, 30].

In the Reality Monitoring framework, Johnson and Raye identify the cues used at retrieval to differentiate between external and internal events [21, 22]. Memories that have a lot of sensory characteristics (e.g., tactile, olfactory), semantic content (e.g., detailed colors, shapes) and contextual information (e.g., spatial, temporal) are more likely to be memories of external events. Memories of internal events tend to contain more information about the cognitive process that was implied to create the event (the thinking or imagining process). Prior knowledge can also help to decide if an event was real or imagined. For example, if someone remembers floating on a cloud, their knowledge of physics laws guide them to think that this is not a memory of a real event. However, an internal event that has a lot of characteristics corresponding to an external event (e.g., rich in perceptual details) is likely to be confused with an external event and result in a false memory.

2.4 XR Could Amplify Source Confusion

The Reality Monitoring framework can be completed by separating external events into real and virtual events (e.g., experienced with VR) [16, 19, 20, 32]. The cues to know that the source of a memory is a virtual event could be the limited quality of graphics (e.g., low resolution, limited field of view) and the sensory and contextual cues provided by the display (e.g., feeling the HMD weight).

However, the more XR technologies improve, the less there are cues to distinguish real and virtual events. Indeed, we can suppose that HMDs will tend to be lighter, that graphics will become more realistic and that XR devices will provide more sensory characteristics (e.g., haptic and olfactory feedback). As these cues will be reduced, confusions between real and virtual sources could become more frequent. Inducing false memories using immersive XR technology becomes more and more plausible.

2.5 Impacts of False Memories on Behavior

To understand the impacts of false memories, we should look at the role of autobiographical memory (AM). Bluck and Alea name three functions of AM: the self, the social and the directive function [8]. The self function of AM is to keep self-coherence and self-consistency over time. The social function is to develop and maintain bonds with others, and facilitate social interactions. Finally, the directive function is to guide present and future thoughts and behaviors, to solve problems and develop opinions. Modifying the memory of a personal event or inducing a new false memory could then have an impact on these three aspects.

Several papers demonstrated the effect of false memories regarding the directive function of AM: the creation of false memories can influence future choices and behaviors. In 2008, Berkowitz et al. suggested to participants that Pluto [1] had uncomfortably licked their ear when they went to Disneyland [5]. For some participants, this suggestion led to the creation of a false memory, and it had a repercussion on their future choices: they were less willing to pay for a Pluto souvenir than the others. False memories can also have an impact on preferences. In 2009, Bernstein and Loftus conducted an experiment where they induced false memories of getting sick after eating egg salad [6]. The consequence of this false memory was a lowered self-report preference for egg salad. In 2011, Rajagopal and Montgomery led participants to imagine themselves using a product that they have never used before [31]. For some participants, this imagination process created the false memory that they have already used this product, what is called the false experience effect. As a consequence, these participants tend to evaluate the product better than they did before the experiment.

As mentioned earlier, the source confusion between real and virtual memories is likely to become more frequent as technology evolves. If the simple fact of imagining using a product can create a false experience and influence behaviors, we can expect this effect to be even stronger with immersive media like XR.

3 SCENARIO

In this section, we present a scenario of how memories could be altered through XR for manipulative advertising purposes. Scenario construction is a tool to explore the potential future of technologies and analyze their ethical impacts and potential harms. It is a well-suited method to raise research questions that go beyond simple predictions [12, 28, 39]. The scenario illustrates how source confusion between reality and XR could be leveraged to provoke false memory and influence users' behavior. Other scenarios should be constructed from the other memory flaws and impacts. In the following we explain the construction process and the implications of this scenario.

3.1 A scenario of XR advertising

Paul, like many of us, is a nostalgic person. His parents have taken thousands of photos of him since he was born. They have entire hard drives of videos: his football matches, his birthdays, his performances at school. Everything has been recorded, perhaps for fear of forgetting all these precious moments. So, you can imagine that during Paul's wedding day, they photographed and filmed everything. They were not the only one, most of the guests had the same reflex. After the wedding, Paul's parents saved these images on a hard drive. 20 years later, while tidying, Paul found this hard drive in a box. Unfortunately, today, he no longer has anything to view these images. New immersive technologies have become ubiquitous and replaced all those objects that had what was then called a "screen." Fortunately, there are free services that offer to convert old photos and videos into immersive content, to relive these moments in VR. Paul decides to convert his wedding recordings to VR to surprise his wife, Lila. Paul is fully aware that the business model of the reconstruction company revolves around advertisements but is not too concerned about the impact (similar to our current use of social media). The fact that this service is free convinces him. In 10 minutes, an artificial intelligence reconstructed the event in 3D and uploaded it to his personal VR device. The more videos provided, the more accurate the reconstruction. Then, an artificial intelligence takes care of filling in the missing points of view realistically. The next day, Paul and Lila can relive their wedding together. It is a magical moment for them. 20 years later, it is as if they were there again. Every detail is there: the dress the bridesmaid wore, the decoration, the music. They are moved to see it all again. Two weeks later, Paul and Lila are invited to a friend's party. "What could we bring for a drink? " "What do you think about Le Mimosa champagne? Remember, this is the one we had at our wedding, all the guests were very happy with it." "Yes, I remember, we should buy some Le Mimosa champagne."

In reality, Paul and Lila did have champagne at their wedding, but it was not the brand Le Mimosa. This brand was changed during the reconstruction of the scene. The bridesmaid's dress, decoration and music were also modified. Now, Paul and Lila confuse the source of their memories between the real wedding and the one they revisited in VR. A false memory of having enjoyed Le Mimosa champagne has been induced. This is the solution that the company found to be able to offer a free service: retroactive placement advertising.

3.2 Scenario Construction Process

To construct this scenario, we started with the presumption that XR technologies will become ubiquitous and widely used. We wanted it to illustrate how source confusion could be leveraged using XR, and

[1] Cartoon character created by The Walt Disney Company, https://en.wikipedia.org/wiki/Pluto_(Disney)

the impact it could have regarding the directive function of autobiographical memory. For this scenario to be as realistic as possible, we based it on an already existing use of technologies (i.e., people recording everything with their phones). The idea of reconstructing events in VR from 2D recordings is based on the Memento VR company project and is something plausible from a technological perspective [1]. Finally, the retroactive product placement advertising technique is inspired by Aza Raskin [2]. In 2010, the former creative lead of Firefox predicted a new advertising method where photos users upload on social media would be modified to include brands on it, to create false memories of experiencing a product. Previous work revealed a positive shift in attitude toward falsely experienced brands after adding them on manipulated pictures [18]. Mirriad, a digital product placement technology, announced the possibility to add targeted product placements in movies in post-production, according to a viewer's demographic and location [4]. Even though this technique has not been used with personal images yet, it might appear in a near future. Indeed, since consumers are becoming more resistant to traditional forms of advertising and can easily skip or block add contents, marketers are searching for more integrated advertising methods [40]. This technique might also appear with VR as this technology offers new opportunities and ways for marketers to promote their products [28]. We used all these building blocks and assembled them inside a realistic and potential future scenario using XR technology.

3.3 Scenario implications

In this scenario, using XR to leverage memory weaknesses results in a situation where user is being manipulated for advertising purpose. Indeed, this scenario gathers three of the five key advertising manipulation mechanisms synthesized by Mhaidli and Schaub (2021): misleading experience marketing, emotional manipulation through hyper-personalization and distorting reality [28]. Maybe the new champagne that Paul and Lila bought after being exposed to the false reconstruction is more expensive and of lower quality than the one they had at their wedding. Because of source confusion, they associate the good experience to the bad champagne, ending up purchasing products under false pretenses. Several solutions could protect XR users from these memory manipulations. A first solution would be to forbid intentional manipulation of memory. A second solution could be to ask consent to users. Then, if a user accepts that their memory reconstructions are modified, they should be explicitly notified of the changes made. For example, the modified objects like the champagne bottle could be highlighted. Using different rendering for these modified objects could provide a cue for the user to know that an object was only virtual. Then, source confusion could be reduced and false memories are less likely to occur. However, this solution is very specific to the presented scenario. Our larger goal would be to explore some more generic approach that would support the user to avoid memory pitfalls in XR. Based on prior work [19–21, 32], we are hypothesizing that if the reconstruction is not hyper-realistic it could reduce the chances of source confusion and false memories. We plan to explore different degrees of realistic rendering (e.g., low polygon vs. hyper realistic) and measure their impact on memory manipulation techniques. This could result in a general solution which would prohibit applications from having a hyper-realistic rendering of prior events, to avoid the creation of false memories.

4 CONCLUSION

In this paper, we question what could be the safety and security issues if XR technologies were used instead of current digital records, knowing that XR could make false memory induction easier. To do that, we first introduce the seven sins of memory (transience, absent-mindedness, blocking, misattribution, suggestibility, bias and persistence) to understand where false memories come from. We also present the three functions of autobiographical memory (directive, self and social functions) to understand the impacts of false memories. We explain why XR could amplify the source confusion effect and become an easy way to implant false memories and influence users' choices and behaviors. Then, we construct a scenario from one memory flaw (source confusion) and one memory function (the directive function) to illustrate how XR could be leveraged to create false memories for manipulative advertising purpose. We quickly propose one solution (i.e., unrealistic rendering) to avoid source confusion and the creation of false memories. Our goal for future work is to understand what types of memory manipulations could potentially happen in XR and how they could look like using scenario construction. Consecutively, we plan to explore and present potential protection mechanisms that are able to cover a variety of future XR memory manipulation techniques.

ACKNOWLEDGMENTS

This work was partially conducted within the HARMFULVR JCJC project (ANR-21-CE33-0013) funded by the French National Research Agency (ANR).

REFERENCES

[1] [n. d.]. Memento. https://www.mementovr.com
[2] 2010. Your Memories Will Be Rewritten: Mozilla's Raskin Says Product Placement is Coming Soon to Your Facebook Photos. https://readwrite.com/2010/10/18/facebook_product_placement/
[3] 2018. Facebook Can Reconstruct a 3D World from Your Photos and Videos. https://petapixel.com/2018/05/02/facebook-can-reconstruct-a-3d-world-from-your-photos-and-videos/
[4] 2019. You see Pepsi, I see Coke: New tricks for product placement. https://www.mirriad.com/insights/you-see-pepsi-i-see-coke-new-tricks-for-product-placement/
[5] Shari R. Berkowitz, Cara Laney, Erin K. Morris, Maryanne Garry, and Elizabeth F. Loftus. 2008. Pluto Behaving Badly: False Beliefs and Their Consequences. *The American Journal of Psychology* 121, 4 (2008), 643–660. https://doi.org/10.2307/20445490 Publisher: University of Illinois Press.
[6] Daniel M. Bernstein and Elizabeth F. Loftus. 2009. The Consequences of False Memories for Food Preferences and Choices. *Perspectives on Psychological Science* 4, 2 (March 2009), 135–139. https://doi.org/10.1111/j.1745-6924.2009.01113.x
[7] Emma Berry, Narinder Kapur, Lyndsay Williams, Steve Hodges, Peter Watson, Gavin Smyth, James Srinivasan, Reg Smith, Barbara Wilson, and Ken Wood. 2007. The use of a wearable camera, SenseCam, as a pictorial diary to improve autobiographical memory in a patient with limbic encephalitis: a preliminary report. *Neuropsychological Rehabilitation* 17, 4-5 (Oct. 2007), 582–601. https://doi.org/10.1080/09602010601029780
[8] Susan Bluck, Nicole Alea, Tilmann Habermas, and David C. Rubin. 2005. A TALE of Three Functions: The Self–Reported Uses of Autobiographical Memory. *Social Cognition* 23, 1 (Feb. 2005), 91–117. https://doi.org/10.1521/soco.23.1.91.59198
[9] Fred B. Bryant, Colette M. Smart, and Scott P. King. 2005. Using the Past to Enhance the Present: Boosting Happiness Through Positive Reminiscence. *Journal of Happiness Studies* 6, 3 (Sept. 2005), 227–260. https://doi.org/10.1007/s10902-005-3889-4
[10] Dan Cosley, Kathy Akey, Brian Alson, Jonathan Baxter, Mark Broomfield, Soyoung Lee, and Chethan Sarabu. 2009. Using technologies to support reminiscence. In *British Computer Society*. 480–484.

[11] H.Q. Dinh, N. Walker, L.F. Hodges, Chang Song, and A. Kobayashi. 1999. Evaluating the importance of multi-sensory input on memory and the sense of presence in virtual environments. In *Proceedings IEEE Virtual Reality (Cat. No. 99CB36316)*. 222–228. https://doi.org/10.1109/VR.1999.756955 ISSN: 1087-8270.

[12] Anthony Dunne and Fiona Raby. 2013. *Speculative everything: design, fiction, and social dreaming*. The MIT Press, Cambridge, Massachusetts ; London.

[13] Emmaline Drew Eliseev and Elizabeth J. Marsh. 2021. Externalizing autobiographical memories in the digital age. *Trends in Cognitive Sciences* 25, 12 (Dec. 2021), 1072–1081. https://doi.org/10.1016/j.tics.2021.08.005

[14] J. Engelkamp and H. D. Zimmer. 1989. Memory for action events: A new field of research. *Psychological Research* 51, 4 (Dec. 1989), 153–157. https://doi.org/10.1007/BF00309142

[15] Michael W. Eysenck and Mark T. Keane. 2020. *Cognitive Psychology: A Student's Handbook*. Psychology Press. Google-Books-ID: qzvCxgEACAAJ.

[16] Ajoy S. Fernandes, Ranxiao Frances Wang, and Daniel J. Simons. 2015. Remembering the physical as virtual: source confusion and physical interaction in augmented reality. In *Proceedings of the ACM SIGGRAPH Symposium on Applied Perception (SAP '15)*. Association for Computing Machinery, New York, NY, USA, 127–130. https://doi.org/10.1145/2804408.2804423

[17] Cathal Gurrin, Alan F. Smeaton, and Aiden R. Doherty. 2014. LifeLogging: Personal Big Data. *Foundations and Trends® in Information Retrieval* 8, 1 (June 2014), 1–125. https://doi.org/10.1561/1500000033 Publisher: Now Publishers, Inc..

[18] Maria V. Hellenthal, Mark L. Howe, and Lauren M. Knott. 2016. It Must Be My Favourite Brand: Using Retroactive Brand Replacements in Doctored Photographs to Influence Brand Preferences. *Applied Cognitive Psychology* 30, 6 (2016), 863–870. https://doi.org/10.1002/acp.3271 _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/acp.3271.

[19] H.G. Hoffman, K.C. Hullfish, and S.J. Houston. 1995. Virtual-reality monitoring. In *Proceedings Virtual Reality Annual International Symposium '95*. 48–54. https://doi.org/10.1109/VRAIS.1995.512479

[20] Hunter G. Hoffman, Azucena Garcia-Palacios, Ayanna K. Thomas, and Anne Schmidt. 2001. Virtual Reality Monitoring: Phenomenal Characteristics of Real, Virtual, and False Memories. *CyberPsychology & Behavior* 4, 5 (Oct. 2001), 565–572. https://doi.org/10.1089/109493101753235151

[21] Marcia K. Johnson, Shahin Hashtroudi, and D. Stephen Lindsay. 1993. Source monitoring. *Psychological Bulletin* 114, 1 (1993), 3–28. https://doi.org/10.1037/0033-2909.114.1.3 Place: US Publisher: American Psychological Association.

[22] Marcia K. Johnson and Carol L. Raye. 1981. Reality monitoring. *Psychological Review* 88, 1 (1981), 67–85. https://doi.org/10.1037/0033-295X.88.1.67 Place: US Publisher: American Psychological Association.

[23] Artie Konrad, Ellen Isaacs, and Steve Whittaker. 2016. Technology-Mediated Memory: Is Technology Altering Our Memories And Interfering With Well-Being? *ACM Transactions on Computer-Human Interaction* 23, 4 (Aug. 2016), 23:1–23:29. https://doi.org/10.1145/2934667

[24] Nadine Liv and Dov Greenbaum. 2020. Deep Fakes and Memory Malleability: False Memories in the Service of Fake News. *AJOB Neuroscience* 11, 2 (April 2020), 96–104. https://doi.org/10.1080/21507740.2020.1740351 Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/21507740.2020.1740351.

[25] Elizabeth Loftus. 2003. False memory. *Encyclopedia of cognitive science* (Jan. 2003). https://www.academia.edu/2657292/False_memory

[26] Elizabeth Loftus. 2003. Our changeable memories: legal and practical implications. *Nature Reviews Neuroscience* 4, 3 (March 2003), 231–234. https://doi.org/10.1038/nrn1054 Number: 3 Publisher: Nature Publishing Group.

[27] Elizabeth F. Loftus and Jacqueline E. Pickrell. 1995. The Formation of False Memories. *Psychiatric Annals* 25, 12 (Dec. 1995), 720–725. https://doi.org/10.3928/0048-5713-19951201-07 Publisher: SLACK Incorporated.

[28] Abraham Hani Mhaidli and Florian Schaub. 2021. Identifying Manipulative Advertising Techniques in XR Through Scenario Construction. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*. Association for Computing Machinery, New York, NY, USA, 1–18. https://doi.org/10.1145/3411764.3445253

[29] Robert A. Nash, Kimberley A. Wade, and D. Stephen Lindsay. 2009. Digitally manipulating memory: Effects of doctored videos and imagination in distorting beliefs and memories. *Memory & Cognition* 37, 4 (June 2009), 414–424. https://doi.org/10.3758/MC.37.4.414

[30] Richard Ofshe and Ethan Watters. 1996. *Making Monsters: False Memories, Psychotherapy, and Sexual Hysteria*. University of California Press. Google-Books-ID: flCfr4CjKP8C.

[31] Priyali Rajagopal and Nicole Votolato Montgomery. 2011. I Imagine, I Experience, I Like: The False Experience Effect. *Journal of Consumer Research* 38, 3 (Oct. 2011), 578–594. https://doi.org/10.1086/660165

[32] Marius Rubo, Nadine Messerli, and Simone Munsch. 2021. The human source memory system struggles to distinguish virtual reality and reality. *Computers in Human Behavior Reports* 4 (Aug. 2021), 100111. https://doi.org/10.1016/j.chbr.2021.100111

[33] Daniel L. Schacter. 2002. *The Seven Sins of Memory: How the Mind Forgets and Remembers*. HMH. Google-Books-ID: m8qMjPF1NYAC.

[34] Kathryn Y. Segovia and Jeremy N. Bailenson. 2009. Virtually True: Children's Acquisition of False Memories in Virtual Reality. *Media Psychology* 12, 4 (Nov. 2009), 371–393. https://doi.org/10.1080/15213260903287267 Publisher: Routledge _eprint: https://doi.org/10.1080/15213260903287267.

[35] Abigail J. Sellen, Andrew Fogg, Mike Aitken, Steve Hodges, Carsten Rother, and Ken Wood. 2007. Do life-logging technologies support memory for the past? an experimental study using sensecam. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '07)*. Association for Computing Machinery, New York, NY, USA, 81–90. https://doi.org/10.1145/1240624.1240636

[36] MICHAEL A. SHAPIRO and ANNIE LANG. 1991. Making Television Reality: Unconscious Processes in the Construction of Social Reality. *Communication Research* 18, 5 (Oct. 1991), 685–705. https://doi.org/10.1177/009365091018005007 Publisher: SAGE Publications Inc.

[37] S. Adam Smith. 2019. Virtual reality in episodic memory research: A review. *Psychonomic Bulletin & Review* 26, 4 (Aug. 2019), 1213–1237. https://doi.org/10.3758/s13423-019-01605-w

[38] Kimberley A. Wade, Maryanne Garry, J. Don Read, and D. Stephen Lindsay. 2002. A picture is worth a thousand lies: Using false photographs to create false childhood memories. *Psychonomic Bulletin & Review* 9, 3 (Sept. 2002), 597–603. https://doi.org/10.3758/BF03196318

[39] David Wright, Rachel Finn, Raphael Gellert, Serge Gutwirth, Philip Schütz, Michael Friedewald, Silvia Venier, and Emilio Mordini. 2014. Ethical dilemma scenarios and emerging technologies. *Technological Forecasting and Social Change* 87 (Sept. 2014), 325–336. https://doi.org/10.1016/j.techfore.2013.12.008

[40] Elizabeth Wright, Nile M. Khanfar, Catherine Harrington, and Lee E. Kizer. 2010. The Lasting Effects Of Social Media Trends On Advertising. *Journal of Business & Economics Research (JBER)* 8, 11 (Nov. 2010). https://doi.org/10.19030/jber.v8i11.50 Number: 11.

[41] Jiaxin Xu and Baosheng Wang. 2020. Efficacy of VR-Based Reminiscence Therapy in Improving Autobiographical Memory for Chinese Patients with AD. 339–349. https://doi.org/10.1007/978-3-030-51038-1_47