15th Anniversary Issue May 2023

Can Correlates of a Memory be Transferred Between Human Subjects? A New False Memory Paradigm.

Joshua Rotondo-Valentine, J. Ben Falandays, Michael J. Spivey, and Jane Wilson

ACKNOWLEDGEMENTS

University of California, Merced Department of Psychological Sciences, Department of Cognitive, Linguistic & Psychological Science, Brown University, Department of Cognitive & Information Sciences, The University of California Merced, Karen Merritt Writing Program, University of California-Merced
WRI 101: Writing in the Disciplines: Psychology

Author Note

The following paper was originally prepared in the course WRI-101: Writing in the Disciplines: Psychology, taught by Professor Jane Wilson, originally titled “Can correlates of a memory be transferred between human subjects? Proposing a new paradigm for exploring the concept of memory transfer.” Based on the input of authors Falandays and Spivey, it was adapted to a more accurate description as a paradigm for studying false memory, rather than memory transfer, and modified accordingly.

Can Correlates of a Memory be Transferred between Human Subjects? A New False Memory Paradigm.

The concept of memory transfer emerged in the mid-20th century, when conducted experiments on various specimens operationalized the theory that hypothesized-substrates of memory - ribonucleic acid (RNA) - could potentially transfer memories from a specimen having experienced a particular memory to an inexperienced specimen (Bédécarrats et al., 2018). According to Bédécarrats et al. (2018), this theory received support from research utilizing methods including forced-cannibalism and a RNA injection, though was discredited over time (McConnell, 1962; Babich et al.; 1965; Jacobson et al.; 1965; Albert, 1966; Braud, 1970). More recently, Bédécarrats et al. (2018) demonstrated the potential to transfer physiological and behavioral changes from fear-responses in conditioned *Aplysia* to *Aplysia* never experiencing the conditioning, through the utility of RNA injection, and in effect providing proof of concept for memory transfer.

This area of research involves the transfer of a specimen's actual memory to a naive specimen as a false memory (Caceres, 2019). Similar paradigms exist to study false memory inductive processes, including false feedback, imagination inflation, and memory implantation (Muschella & Schönborn, 2021). With the memory implantation paradigm, a variety of false memories have been implanted in inexperienced participants in controlled studies, including getting lost in a shopping mall (Loftus, 1997), spilling a bowl of punch at a family wedding (Hyman et al., 1995), being punched, and even punching someone else, as reported by Shaw and Porter (2015). Additionally, this paradigm has been adopted with Virtual Reality (VR) technologies, with Segovia and Bailenson (2008) managing to successfully implant a false memory in children through a VR simulation of them swimming with whales (Bonnail et al, 2022).

Motivated by historical research into the concept of memory transfer, and informed by existing paradigms studying false memory processes, this paper will propose a new paradigm for implanting false memories in controlled settings. It will be proposed that through the utility of a novel between-subjects, multimodal paradigm incorporating methodological designs from false memory, collaborative memory, and VR research, can provide insights into the phenomena of false memory production. Various measures will be discussed for their potential as measures of relevant correlates of false memories implanted in controlled settings, spanning physiological, behavioral, and survey domains.

Our Proposed Paradigm

With the research paradigms, materials, and measures outlined in this paper's literature review, we propose the between-subjects design of a new multi-modal paradigm combining these methodologically. Behavioral measures (i.e. eye-tracking) and physiological measures (i.e. skin conductance) can provide evidence for the manifestation of episodic correlates between-subjects, similar to the measures in Bédécarrats et al.'s (2018) study but without the same procedure of injection and conceptualization as memory transfer. Additionally, survey measures measuring cognitive and psychological processes can illuminate behaviors underlying the implantation of false memories.

Paradigms that study false memory production can be implemented in a between-subjects design. Controls can be participants who did experience the described memory, while participants in the experimental group can be those who did not experience the memory. The operation of this condition depends on whether the memory implantation or imagination inflation paradigm is implemented. In the former, experimental participants can hypothetically recall several actual memories described by their family and can recall a false memory from the control's recalled memories, unknowingly. Through imagination inflation, a control can be composed of participants rating a higher likelihood of experiencing the described scenario, while the experimental can be those rating in the opposite direction.

VR can standardize measures for participants' reactions to recreated memories, and instrumentalize measures of participants experiencing reconstructive processes related to memory. Additionally, collaborative memory can 'neutralize' the representations of both participants and error-correct to produce a recreated memory based on false memory-induced participants interacting with the person having experienced the described memory.

Potential Limitations to the Proposed Paradigm

Our proposed paradigm has several limitations of note. With regards to the paradigm's instrumentation of virtual reality, VR cannot recreate described memories precisely, which can likely produce more false memories (Bonnail et al., 2022). This leads to another confounding possibility, where the implanted memory is an entirely novel false memory unintentionally produced from VR recreations of actual memory. Additionally, the implementation of collaborative memory cannot be attempted for every experimental participant in the control group's memories are implanted, as the intent of the study would likely be revealed.

Literature Review

Defining the Phenomena of Memory

Historically, memory has been described metaphorically by representations including storage spaces, houses,and computers, among others (Roedieger, 1980). However, one definition put forth more recently describes memory as a dynamic, chemical process to store and retrieve information from interactions between one's brain, body, and environment (Zlotnik & Vansintjan, 2019). Additionally, memory in a cognitive domain describes simulative characteristics, by reconstructing recognized patterns from previously processed experiences (Lin, 2018; Wardell et al., 2022).

False Memory Research

False memory is defined as the belief that something false is a fact, and also an experienced memory (Muschalla & Schönborn, 2021). Historically, experiments have implanted a variety of false autobiographical memories, including getting lost in a shopping mall (Loftus, 1997), spilling a bowl of punch at a family wedding (Hyman et al., 1995), being punched, as well as punching someone else, as reported by Shaw and Porter (2015). A variety of cognitive, psychological, social, and linguistic mechanisms underlie false memory implantation, including imagination (Bays et al., 2015; Scoboria et al., 2017; Wardell et al., 2022), emotional intensity (Scoboria et al., 2017; Wardell et al., 2022), belief in memory (Scoboria et al., 2017;), confidence in memory (Fields & Brown, 2015; Scoboria et al., 2017), the plausibility of memory (Fields & Brown, 2015), the desirability of memory (Fields & Brown, 2015), and social interactions (Maswood & Rajaram, 2018).

Several paradigms exist for studying false memory, including imagination inflation, false feedback, and memory implantation (Muschella & Schönborn, 2021). Imagination inflation and memory implantation will be examined from both a historical and experimental viewpoint, describing the fundamentals of these two false memory paradigms as well as their application in research.

Memory Implantation

Memory implantation uses manipulated photographs and false statements to produce false memories in participants (Calado et al., 2021). Presentation of materials is typically in narrative form, using suggestive manners to implant described memories. A notable example of this paradigm in experimental research is Loftus and Pickrell's (1995) 'lost in the mall' study, by collecting childhood narratives from participants' families, and secretly included one false memory in their presentation of these described narratives as memories. Then, the participants were asked to describe all of the memories, regardless of actuality. This experiment successfully demonstrated the production of false memories by way of deliberate implantation. Similarly, Calado et al. (2021) demonstrated the potential to implant repeated false memories in participants, with three groups of participants interviewed across multiple weeks and false memories implanted as either occurring once or frequently.

Imagination-Inflation

Imagination-inflation examines how repeated imagination of a non-experienced scenario, whether guided or prompted, can lead to false memory production (Bays et al., 2015; Lindner & Echterhoff, 2015; Brewin & Andrews, 2017; Muschella & Schönborn, 2021; Wardell et al., 2022). This is the result of a source-monitoring error between one's imagination and their memory, some manage to misattribute characteristically rich imagination and related details to actual memories (Glahn et al., 2012; Bays et al., 2015). Details of perceptual, contextual, and emotional qualities within imagination can potentially produce false memories imaginatively (Glahn et al., 2012). Imagination also can manipulate memory, with there being a notable change in individuals' attitudes and preferences due to imagination (Wardell et al., 2022).

Experimentally, this paradigm involves the administration of the Life Events Inventory (LEI; Cochrane & Robertson, 1973), a multi-scenario inventory asking participants to rate on a Likert scale the likelihood they experienced the described scenario in a previous time period . Studies typically involve two LEI (Cochrane & Robertson, 1973) administrations, one before the imagination-inflation condition, and one after. Following the first LEI administration, several low-likelihood scenarios are selected into a group that will be induced in the imagination-inflation condition. During the imagination-inflation condition, participants are instructed on particular details to imagine for the low-likelihood scenarios, spanning perceptual, contextual, and emotional details (Brewin & Andrews, 2016). Either guided or prompted instructions are utilized with differing results, with the former reflecting a greater effect from the imagination-inflation condition (Bays et al., 2015). Another LEI administration is provided, and their second self-report ratings are compared to the ones collected before experiencing the imagination-inflation condition (Brewin & Andrews, 2016). Typically, confidence in the occurrence of an imagination-inflationary effect depends on whether the rating increase in the second-administered LEI is still in the lower half of the described scenario's Likert scale (Brewin & Andrews, 2016).

Mazzoni and Memon's (2003) administered participants 3 versions of the LEI (Cochrane & Robertson, 1973) describing events potentially occurring before the age of 6. In effect, Mazzoni and Memon (2003) demonstrated that imagination could lead to belief in the occurrence of an event, and subsequently produce false memories related to the described event.

Collaborative Memory Research

Collaborative memory research examines how individuals, whether strangers or intimate individuals, can collaboratively encode memory and retrieve it from each individual's storage interactively (Harris et al., 2018). According to Harris et al. (2018), collaborative memory operates similarly to teaching-learning dynamics and empathy. Collaborative processes, such as disruption, error correction, and mutualized memory augmentation are also studied for their potential to transform existing memories (Maswood & Rajaram, 2018). Socially, collaborative remembering can allow for the retrieval of characteristically rich details of existing memories but also produce false memories (Maswood & Rajaram, 2018), similar to descriptive imagination potentially producing false memories (Glahn et al., 2012; Bays et al., 2015).

In collaborative remembering studies, participants typically partake in a study phase, a delay period, and a recall phase. Participants either complete memory recall tasks independently or in groups. Either ‘turn-taking’ or ‘free-for-all’ paradigms can help facilitate communication among the group, which leads to differences in memory retrieval and error correction (Maswood & Rajaram, 2018).

Virtual Reality

Virtual reality (VR) technologies project using a variety of tools, including computers, cellphones, and head-mounted displays (Kyaw et al., 2019), and are used to present a computer-generated virtual environment or 360-degree recording technology-captured real environment, effectively stimulating the human senses and creating perceptions similar to naturally experienced ones (Kalaga, 2003; Ventura, 2022). VR activates various psychological and cognitive mechanisms, including presence, self-conceptualization, interactivity, visual perception, and facial recognition, among others (Blascovich et al., 2002; Quesnel & Riecke, 2018). VR can also transfer visuospatial information from a virtual to a physical environment, leading to natural knowledge without actually experiencing it (Wilson & Foreman, 1997).

VR has also been utilized experimentally to study concepts relevant to virtual reality, including behavioral realism, the extent of realism found within VR humans and objects (Blascovich et al., 2002). Freeman et al. (2000) used VR to study stereoscopically and monoscopically presented stimuli and its relation to postural movements and subjective presence, vection, and immersion. Tessier et al. (2019) examined individuals’ emotional perception and feelings of computer-generated human avatars presented in VR. Kammler-Sucker et al. (2021) studied individuals’ voluntary motor imitation based on the observed similarity and likability of a VR-displayed avatar.

Some studies have studied false memory implantation using VR. As mentioned by Bonnail et al. (2022), one study successfully implanted a false memory in children based on a

VR simulation of them swimming with whales (Segovia & Bailenson, 2008). Additionally, Plancher et al. (2007) studied participants' true and false memories of a VR-presented town and measured their false recall and recognition.

Relevant Measures

Several measures can be used in this paradigm, and are found in various studies of false memory and VR technologies. These include survey, behavioral, and physiological measures, all of which are proposed to expose the subjective, behavioral, and physiological correlates of our proposed paradigm.

Survey Measures

Several surveys are relevant to the proposed paradigm. These include the Vividness Of Visual Imagery Questionnaire (VVIQ; Marks, 1973), the Dissociative Experiences Scale - II (DES-II; Carlson & Putman, 1993) - both of which were administered by Mazzoni and Memon (2003) in their imagination-inflation study - the Presence Questionnaire (PQ; Witmer & Singer, 1998), the Immersive Tendencies Questionnaire (ITQ; Witmer & Singer, 1998) - as the literature suggests an individual's experience of presence in a virtual environment impacts their immersion in a virtual environment (Freeman, 2000) - and the Brief Mood Introspection Scale (BMIS; Mayer & Gaschke, 1988) since emotional states can affect false memory production in controlled studies (Shaw & Porter, 2015; Scoboria et al., 2017; Shaw, 2020), impact one's VR experiences (Quesnel & Riecke, 2018; Tessier et al., 2019), and impact some physiological measures of concurrent utility, specifically skin conductance response (SCR) (Christopoulus et al., 2019).

The Vividness Of Visual Imagery Questionnaire. The VVIQ (Marks, 1973) is a 16-item questionnaire based on a 5-point Likert scale (including answers such as 1(*Perfectly clear and as vivid as normal vision*)), measuring the vividness of one's visualization of an image with their eyes both open and closed.

The Dissociative Experiences Scale - II. The DES-II (Carlson & Putman, 1993) is a 28-item scale on an 11-point, 0-100 scale, with answers ranging from 0%(*Never*) to 100%(*Always*), measuring one's frequency of dissociative experiences. Items include, "1. Some people have the experience of driving or riding in a car or bus or subway and suddenly realizing that they don't remember what has happened during all or part of the trip. Circle the number to show what percentage of the time this happens to you" (Carlson & Putman, 1993).

The Presence Questionnaire. The PQ (Witmer & Singer, 1998) is a 24-item questionnaire using a 7-point Likert scale, measuring a person's experienced presence within a VR environment, and is based on various interacting factors, including control, sensory, distraction, and realism factors (PQ; Witmer & Singer, 1998). An adapted version of the PQ (Witmer & Singer, 1998) was developed by the UQO Cyberpsychology Lab (2004). Responses to questions were on a 7-point Likert scale between *NOT AT ALL* and *COMPLETELY.* Questions include, "WITH REGARD TO THE EXPERIENCED ENVIRONMENT.. 1. How much were you able to control events?" (UQO Cyberpsychology Lab, 2004).

The Immersive Tendencies Questionnaire. The ITQ (Witmer & Singer, 1998) is an 18-item questionnaire using a 7-point Likert scale measuring an individual's ability to become involved or immersed. The Likert scale ranges from 1 (*Never*) to 7 (*often*), measuring the level of immersion respondents experience in books, movies, and computer games. The questionnaire comprises three subdimensions of involvement, attentional focus, and tendency to play video games (Rózsa, 2022).

The Brief Mood Introspection Scale. The BMIS (Mayer & Gaschke, 1988) is a 16-adjective open-source mood scale used to measure participants' current mood states (including questions such as, 'Are you "happy"?').

Life Events Inventory. The LEI (Cochrane & Robertson, 1973) involves a list of described scenarios respondents rate to indicate how likely it is they previously experienced said scenario. The inventory has typically been adapted in the context of themes found in the studies' subject matter, with the LEI (Cochrane & Robertson, 1973) administered as part of Mazzoni and

Memon's (2003) imagination-inflation study about events related to surgical operations on skin and teeth.

Behavioral Measures

Eye-Tracking. Eye-tracking technology can also be used in the paradigm. Kwak (2009) utilized eye-tracking when studying individuals' ability to accurately remember faces. In one of their described experiments, Kwak (2009) reported differences in eye movements tracked between participants' true and false memory recall, with more fixations and less blinking correlated with greater memory recall.

Eye-tracking technologies have also been used in studies of memory representations and mental imagery through oculomotor mechanisms. Spivey & Geng (2001) used eye-tracking demonstrating that the same perceptual-motor mechanisms activated while viewing a scene were also activated when participants imagined a scene as well as its elements of it. As reported by Ryan & Shen (2020), some eye-tracking research has found that systematic differences in eye movements could predict the novelty of a presented stimulus, despite participants' concealment of knowledge or lack thereof (Mahoney et al., 2018; Schwedes & Wentura, 2012; Schwedes & Wentura, 2016). Typically, eye tracking detects the eye position, eye movement, and pupil size of tracked individuals to create a map of what they are viewing at a particular time (Sanchez et al., 2017).

Eye-Tracking Baseline. Hypothetically, it might be relevant to determine a baseline for individual participants' movement patterns during randomized VR simulations. If details similar to the produced false memory are present in the VR simulation that is being displayed, then it can be assumed there will be an increase in fixations, as informed by Kwak's (2009) study. The sample could consist of randomly selected VR simulations, regardless of content similarities to the produced false memories. It would also be best to conduct this as part of a pre-test. ***Physiological Measures***

Skin Conductance Response. As a physiological marker of arousal, skin conductance responses (SCR) are measured through the electrodermal activity (EDA) of the human body's sympathetic and parasympathetic nervous systems. Anticipatory signals of emotionally stimulating events are detected through SCR's measurement of sweat secretion in areas greater in sweat glands. Varying sweat secretion leads to changes in skin conductance and its electrical potential, and underlies responses to present and future stimuli (Christopoulos et al., 2019). Additionally, SCR has been associated with a variety of psychological and emotional behaviors, including emotional responses, fear responses, and anxiety (Christopoulos et al., 2019).

Due to skin and its contained sweat glands containing both resistive and capacitive properties, an external source of energy is used, and thus measures the sweat glands' resistance to the presented energy while stimuli are presented. Several potential dependent variables can be measured in studies using SCR, including SCR amplitudes (difference between peak SCR response and rise to response), SCR rise (the time taken for a peak SCR response to be reached), and recovery (the phase after peak SCR response when returning to baseline skin conductance) (Christopoulos et al., 2019).

Application in Research. Both electrodermal activity (EDA) and heart rate variability (HRV) recording devices have been employed in research examining the emotional effects of viewership of 2-D, 3-D, and VR-displayed environments (Higuera-Trujillo et al., 2017;

reported by Tian et al., 2021). Additionally, research into imagery and its correlates have been conducted using SCR and HRV, focusing on preschool-aged children and imagination (Thibodeau-Nielsen et al., 2020), individuals and their responses to differentially contextualized sadness scenarios (Shirai & Suzuki, 2017), fear extinction from mental imagery tasks (Jiang & Greening, 2021), and imagery-based memories of peer-victimization in social-anxiety disordered (SAD) individuals (Sansen et al., 2015). It can be assumed that these technologies could be reasonably applied in our proposed paradigm, and thus provide a more embodied representation of memory processes examined in the study's design.

Discussion

Historically, memory has been defined by depictions of it metaphorically, such as storage spaces, houses, computers, and other physical representations (Roedieger, 1980). However, a modernized definition was recently put forth by Zlotnik & Vansintjan (2019), with memory being defined by its dynamic, chemical processes, and its nature as a representation of the relationship among one's brain, body, and environment. Research into the possibility of memory transfer - the concept of transferring a specimen's memory to a naive specimen - dates back to the 1950s and 60s when researchers first tried producing this effect using either forced cannibalism or RNA injection between specimens (Albert, 1966; Babich et al., 1965; Braud, 1970; Jacobson et al., 1965; McConnell, 1962; reported by Bédécarrats et al., 2018). Recently, this concept was experimentally supported by Bédécarrats et al.'s (2018) study utilizing extraction and injection of conditioned specimens' RNA into unconditioned specimens. Similarly, operating paradigms focus on the implantation of false memories, including operationally using VR technologies (Segovia & Bailenson, 2008; reported by Bonnail et al., 2022) and eye-tracking (Kwak, 2009). The production of false memories is underlined by various processes including imagination and imagery, as manipulated in the imagination-inflation paradigm of false memory production. Similar studies of imagination and imagery have employed SCR-recording technologies as part of their apparatuses (Thibodeau-Nielsen et al., 2020; Shirai & Suzuki, 2017; Jiang & Greening, 2021; Sansen et al., 2015), as well as emotional studies of user-interactions with VR environments (Higuera-Trujillo et al., 2017; reported by Tian et al., 2021).

With this review of existing literature, we propose the paradigm of false memory production using a between-subjects multi-modal design combining several existing paradigms with VR technologies. Motivated by Bédécarrats et al.'s (2018) measures of both behavioral (i.e. sensitization responses) and physiological nature (i.e. neuronal responses) in their memory transfer study, this paper's proposed false memory productive paradigm will include the incorporation of survey, behavioral, and physiological measures to study the potential manifestation of these correlates amid deliberate implantation, in addition to VR technologies being used to recreate self-described memories.

Potential Solutions to Our Paradigm's Limitations

As noted, there are several limitations to our proposed paradigm, including VR's lack of precision in simulating memories unintentionally producing a false memory separate from the control's actual memory implanted, and collaborative memory recall tasks being inapplicable for every control-experimental group interaction. In addition to our proposed paradigm, there are also solutions to our identified limitations that we propose.

For the first limitation identified, the utility of eye-tracking technologies could be simultaneously employed to distinguish between memory simulations that are experienced as actual memories and those that are experienced as false ones. Hypothetically, when operating under the imagination-inflation paradigm, based on Kwak's (2009) study, there would be a degree of difference present between an imagination-inflated low-likelihood scenario conditionally based on the control's memory recall, a non-inflated low-likelihood scenario, and one that is high-likelihood. This would in turn lead to a potentially more accurate and characteristically reflective basis for multivariate analysis.

For the latter, we propose that rather than having control participants partake in collaborative memory tasks with every member of the experimental group their memory is falsely implanted into, there could be one participant randomly selected for each control to participate in the collaborative memory task with. Then, as part of an additional phase to the experiment post-imagination-inflationary condition or implantation protocol, control participants can partake in a collaborative memory task with randomly selected members of the experimental groups, regardless of memory content. In effect, this would lead to a smaller sample size compared to the previous experimental phases but would provide some avenues for implementing the collaborative memory task design.

Our Proposed Paradigm's Relation to Memory Transfer

What distinguishes our proposed paradigm from existing memory transfer research is the transferral context, with our paradigm examining the transfer of memorable experiences and memory transfer examining the transfer of memory correlates in the absence of experience; additionally, the "transfer" of memory correlates in our paradigm would manifest independent of any deliberate implantation, and thus lacks the robustness of studied memory transfer procedures. While lacking the same theoretical framework as memory transfer, we propose that our paradigm could in theory achieve a transferral process analogous to memory transfer, if VR technologies could accurately and realistically recreate memories and be adopted as part of our proposed paradigm. However, to the best of our knowledge, those technologies do not currently exist, but we speculate have the potential to enhance the theoretical framework of our proposed paradigm when applied experimentally.

References

Albert, D. J. (1966). Memory in mammals: Evidence for a system involving nuclear ribonucleic acid. *Neuropsychologia*, *4*(1), 79-92.

Babich, F. R., Jacobson, A. L., Bubash, S., & Jacobson, A. (1965). Transfer of a response to naive rats by injection of ribonucleic acid extracted from trained rats. *Science*, *149*(3684), 656-657.

Baioui, A., Ambach, W., Walter, B., & Vaitl, D. (2012). Psychophysiology of false memories in a Deese-Roediger-McDermott paradigm with visual scenes. *PLOS ONE*, *7*(1), Article e30416. https://doi.org/10.1371/journal.pone.0030416

Bays, R. B., Zabrucky, K. M., & Foley, M. A. (2015). Imagery induction processes differentially impact imagination inflation. *Imagination, Cognition and Personality*, *35*(1), 5–25. https://doi.org/10.1177/0276236615574487

Bédécarrats, A., Chen, S., Pearce, K., Cai, D., & Glanzman, D. L. (2018). RNA from trained aplysia can induce an epigenetic engram for long-term sensitization in untrained aplysia. *ENeuro*, *5*(3). https://doi.org/10.1523/ENEURO.0038-18.2018

Ben-Shakhar, G. (2012). Current research and potential applications of the Concealed Information Test: An overview. *Frontiers in Psychology*, *3*, Article 342. https://doi.org/10.3389/fpsyg.2012.00342

Bisio, A., Stucchi, N., Jacono, M., Fadiga, L., & Pozzo, T. (2010). Automatic versus voluntary motor imitation: Effect of visual context and stimulus velocity. *PLOS ONE*, *5*(10), Article e13506. https://doi.org/10.1371/journal.pone.0013506

Blascovich, J., Loomis, J., Beall, A. C., & Swinth, K. R. Immersive virtual environment technology as a methodological tool for social psychology. (2002).

Psychological Inquiry, *13*.

Bonnail, E., Tseng, W. J., & Lecolinet, E. (2022). Exploring memory manipulation in extended reality using scenario construction. *Proceedings of the 1st Workshop on Novel Challenges of Safety, Security and Privacy in Extended Reality, USA*, 5.

Braud, W. G. (1970). Extinction in goldfish: Facilitation by intracranial injection of RNA from brains of extinguished donors. *Science*, *168*(3936), 1234-1236.

Brewin, C. R., & Andrews, B. (2017). Creating memories for false autobiographical events in childhood: A systematic review. *Applied Cognitive Psychology*, *31*(1), 2–23. https://doi.org/10.1002/acp.3220

Calado, B., Luke, T. J., Connolly, D. A., Landström, S., & Otgaar, H. (2021). Implanting false autobiographical memories for repeated events. *Memory*, *29*(10), 1320–1341. https://doi.org/10.1080/09658211.2021.1981944

Calvillo, D. P., Flores, A. N., Lara, P. M., Hawkins, W. C., Boman, L. D., & Smelter, T. J. (2019). Imagining experiencing an event in the future inflates certainty that it occurred in the past. *Imagination, Cognition and Personality*, *39*(1), 5–24. https://doi.org/10.1177/0276236618803308

Cavallaro, R. & Mayer, J. (n.d.). A review and evaluation of an open-source mood assessment, the Brief Mood Introspection Scale.

Christopoulos, G. I., Uy, M. A., & Yap, W. J. (2019). The body and the brain: Measuring skin conductance responses to understand the emotional experience. *Organizational Research Methods*, *22*(1), 394–420. https://doi.org/10.1177/1094428116681073

Constantinou, E., Georgiou, D., Karekla, M., & Panayiotou, G. (2021). Subjective distress and physiological reactivity during anxiety-evoking imagery in social anxiety. *Personality and Individual Differences*, *182*, Article 111095.

https://doi.org/10.1016/j.paid.2021.111095

Cuperus, A. A., Klaassen, F., Hagenaars, M. A., & Engelhard, I. M. (2017). A virtual reality paradigm as an analogue to real-life trauma: Its effectiveness compared with the Trauma Film Paradigm. *European Journal of Psychotraumatology*, *8*(1), Article 1338106. https://doi.org/10.1080/20008198.2017.1338106

Fields, L. M., & Brown, A. S. (2015). Occurrence, plausibility, and desirability for 124 Life Events Inventory items. *Behavior Research Methods*, *47*(2), 529–537. https://doi.org/10.3758/s13428-014-0484-9

Freeman, J., Avons, S. E., Meddis, R., Pearson, D. E., & IJsselsteijn, W. (2000). Using behavioral realism to estimate presence: A study of the utility of postural responses to motion stimuli. *Presence: Teleoperators and Virtual Environments*, *9*(2), 149–164. https://doi.org/10.1162/105474600566691

Gates, V., Suchow, J. W., & Griffiths, T. L. (2022). Memory transmission in small groups and large networks: An empirical study. *Psychonomic Bulletin & Review*, *29*(2), 581–588. https://doi.org/10.3758/s13423-021-02021-9

Glahn, N., Otani, H., Migita, M., Langford, S., & Hillard, E. (2012). What is the cause of confidence inflation in the Life Events Inventory (LEI) Paradigm? *Journal of General Psychology*, *139*, 134–154. https://doi.org/10.1080/00221309.2012.672938

Gonzalez-Sanchez, J., Baydogan, M., Chavez-Echeagaray, M. E., Atkinson, R. K., & Burleson, W. (2017). Emotions and affect in human factors and human-computer interaction. *Academic Press*, 255-288.

Jacobson, A. L., Babich, F. R., Bubash, S., & Jacobson, A. (1965). Differential-approach tendencies produced by injection of RNA from trained rats. *Science*, *150*(3696), 636-637. Jiang, X., & Greening, S. G. (2021). Psychophysiological evidence for fear extinction learning via mental imagery. *Psychophysiology*, *58*(11), Article e13906. https://doi.org/10.1111/psyp.13906

Harden, K. P., & Koellinger, P. D. (2020). Using genetics for social science. *Nature Human Behaviour*, *4*(6), 567-576. https://doi.org/10.1038/s41562-020-0862-5

Harris, C., Barnier, A., Sutton, J., & Savage, G. (2018). Features of successful and unsuccessful collaborative memory conversations in long-married couples. *Topics in Cognitive Science*, *11*. https://doi.org/10.1111/tops.12350

Higuera-Trujillo, J., López-Tarruella Maldonado, J., & inares Millán, C. (2017) Psychological and physiological human responses to simulated and real environments: A comparison between Photographs, 360°Panoramas, and Virtual Reality[J]. *Applied Ergonomics*. *65*(398–409). pmid: 28601190

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

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

Iriye, H., & Jacques, P. (2021). Memories for third-person experiences in immersive virtual reality. *Scientific Reports*, *11*, Article 4667. https://doi.org/10.1038/s41598-021-84047-6

Kalaga, W. (2003). The trouble with the virtual. *Symplokē*, *11*(1/2), 96–103.

Kammler-Sücker, K. I., Löffler, A., Kleinböhl, D., & Herta, F. Exploring virtual doppelgangers as movement models to enhance voluntary imitation. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, *29*, 2173-2182. https://doi.org/10.1109/TNSRE.2021.3120795

Lin, Y. T. (2018). Visual perspectives in episodic memory and the sense of self. *Frontiers in Psychology*, *9*, Article 2196. https://doi.org/10.3389/fpsyg.2018.02196

Lindner, I., & Echterhoff, G. (2015). Imagination inflation in the mirror: Can imagining others' actions induce false memories of self-performance? *Acta Psychologica*, *158*, 51–60. https://doi.org/10.1016/j.actpsy.2015.03.008

Loftus, E. F. (1997). Creating childhood memories. *Applied Cognitive Psychology*, *11*, 75–86.

Loftus, E. F., & Pickrell, J. E. (1995). The formation of false memories. *Psychiatric Annals, 25*(12), 720–725. https://doi.org/10.3928/0048-5713-19951201-07

Mahoney, E. J., Kapur, N., Osmon, D. C., & Hannula, D. E. (2018). Eye tracking as a tool for the detection of simulated memory impairment. *Journal of Applied Research in Memory and Cognition*, *7*(3), 441-453. https://doi.org/10.1016/j.jarmac.2018.05.004

Maswood, R., & Rajaram, S. (2019). Social transmission of false memory in small groups and large networks. *Topics in Cognitive Science*, *11*(4), 687–709. https://doi.org/10.1111/tops.12348

Mazzoni, G., & Memon, A. (2003). Imagination can create false autobiographical memories. *Psychological Science*, *14*(2), 186–188. https://doi.org/10.1046/j.1432-1327.1999.00020.x

McConnell, J. V. (1965). Memory transfer through cannibalism in planarians. Th. E. McGill (Ed.), *Readings in Animal Behavior, New York Etc. (Holt, Rinehart And Winston)* 1965, pp. 440-446.

Muschalla, B., & Schönborn, F. (2021). Induction of false beliefs and false memories in laboratory studies—A systematic review. *Clinical Psychology & Psychotherapy*, *28*(5), 1194–1209. https://doi.org/10.1002/cpp.2567

Otgaar, H., Howe, M., & Patihis, L. (2020). What science tells us about false and repressed memories. *Memory*, *30*. https://doi.org/10.1080/09658211.2020.1870699

Otgaar, H., Wang, J., Fränken, J. P., & Howe, M.. (2018). Believing does not equal remembering: The effects of social feedback and objective false evidence on belief in occurrence, belief in accuracy, and recollection. *Acta Psychologica*, *191*. https://doi.org/10.1016/j.actpsy.2018.10.009

Plancher, G., Haupert, S., Gyselinck, V., Tardieu, H., Nicolas, S., & Piolino, P. (2007). Virtual reality for the study of true and false memory.

Quesnel, D., & Riecke, B. E. (2018). Are you awed yet? How virtual reality gives us awe and goose bumps. *Frontiers in Psychology*, *9*, Article 2158. https://doi.org/10.3389/fpsyg.2018.02158

Roediger, H. L. (1980). Memory metaphors in cognitive psychology. *Memory & Cognition*, *8*(3), 231–246. https://doi.org/10.3758/BF03197611

Ryan, J. D. & Shen, K. (2020). The eyes are a window into memory. *Current Opinion in Behavioral Sciences*, *32*, 1-6. https://doi.org/10.1016/j.cobeha.2019.12.014

Sansen, L. M., Iffland, B., & Neuner, F. (2015). The trauma of peer victimization: Psychophysiological and emotional characteristics of memory imagery in subjects with social anxiety disorder. *Psychophysiology*, *52*(1), 107–116. https://doi.org/10.1111/psyp.12291

Schöne, B., Kisker, J., Sylvester, R. S., Radtke, E. L., & Gruber, T. (2021). Library for UniversalVirtual Reality Experiments (luVRe): A standardized immersive 3D/360° picture and video database for VR based research. *Current Psychology*.

https://doi.org/10.1007/s12144-021-01841-1

Schwedes, C. & Wentura, D. (2012). The revealing glance: Eye gaze behavior to concealed information. *Memory & Cognition*, *40*, 642-651. https://doi.org/10.3758/s13421-011-0173-1

Schwedes, C. & Wentura, D. (2016). Through the eyes to memory: Fixation durations as an early indirect index of concealed knowledge. *Memory & Cognition*, *44*, 1244-1258. https://doi.org/10.3758/s13421-016-0630-y

Scoboria, A., Wade, K. A., Lindsay, D. S., Azad, T., Strange, D., Ost, J., & Hyman, I. E. (2017). A mega-analysis of memory reports from eight peer-reviewed false memory implantation studies. *Memory*, *25*(2), 146–163. https://doi.org/10.1080/09658211.2016.1260747

Shaw, J. (2020). Do false memories look real? Evidence that people struggle to identify rich false memories of committing crime and other emotional events. *Frontiers in Psychology*, *11*, Article 650. https://doi.org/10.3389/fpsyg.2020.00650

Shaw, J., & Porter, S. (2015). Constructing rich false memories of committing crime. *Psychological Science*, *26*(3), 291–301. https://doi.org/10.1177/0956797614562862

Shimmer Research. (n.d.). *Shimmer3 GSR+ Unit*. https://shimmersensing.com/product/shimmer3-gsr-unit/

Shirai, M., & Suzuki, N. (2017). Is sadness only one emotion? Psychological and physiological responses to sadness induced by two different situations: "Loss of Someone" and "Failure to Achieve a Goal." *Frontiers in Psychology*, *8*. https://www.frontiersin.org/articles/10.3389/fpsyg.2017.00288

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

Spivey, M. J., & Geng, J. J. (2001). Oculomotor mechanisms activated by imagery and memory: Eye movements to absent objects. *Psychological Research*, *65*, 235-241. https://doi.org/10.1007/s004260100059

Tessier, M. H., Gingras, C., Robitaille, N., & Jackson, P. L. (2019). Toward dynamic pain expressions in avatars: Perceived realism and pain level of different action unit orders. *Computers in Human Behavior*, *96*, 95–109. https://doi.org/10.1016/j.chb.2019.02.001

Thibodeau-Nielsen, R. B., Turley, D., DeCaro, J. A., Gilpin, A. T., & Nancarrow, A. F. (2021). Physiological substrates of imagination in early childhood. *Social Development*, *30*(3), 867–882. https://doi.org/10.1111/sode.12505

Tian, F., Hua, M., Zhang, W., Li, Y., & Yang, X. (2021). Emotional arousal in 2D versus 3D virtual reality environments. *PLOS ONE*, *16*(9), Article e0256211. https://doi.org/10.1371/journal.pone.0256211

Vasser, M., Kängsepp, M., Magomedkerimov, M., Kilvits, K., Stafinjak, V., Kivisik, T., Vicente, R., & Aru, J. (2017). VREX: An open-source toolbox for creating 3D virtual reality experiments. *BMC Psychology*, *5*(4). https://doi.org/10.1186/s40359-017-0173-4

Ventura, S., Miragall, M., Cardenas, G., & Baños, R. M. (2022). Predictors of the sense of embodiment of a female victim of sexual harassment in a male sample through 360-degree video-based virtual reality. *Frontiers in Human Neuroscience*, *16*, Article 845508. doi: 10.3389/fnhum.2022.845508

Wade, K. A., Garry, M., & Pezdek, K. (2018). Deconstructing rich false memories of committing crime: Commentary on Shaw and Porter (2015). *Psychological Science*, *29*(3), 471–476. https://doi.org/10.1177/0956797617703667

Wardell, V., Grilli, M. D., & Palombo, D. J. (2022). Simulating the best and worst of times: The powers and perils of emotional simulation. *Memory*, *30*(9), 1212–1225. https://doi.org/10.1080/09658211.2022.2088796

Wilson, P. N., Foreman, N., & Tlauka, M. (1997). Transfer of spatial information from a virtual to a real environment. *Human Factors*, *39*(4), 526–531. https://doi.org/10.1177/001872089703900401

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence: Teleoperators and Virtual Environments*, *7*(3), 225–240. https://doi.org/10.1162/105474698565686

Zlotnik, G., & Vansintjan, A. (2019). Memory: An extended definition. *Frontiers in Psychology*, *10*. https://www.frontiersin.org/articles/10.3389/fpsyg.2019.02523