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Reconstructing Witnessed Events: Sources of Error in Eyewitness Perception and Memory

Introduction

Eyewitness testimony can be a critical piece of evidence that experts, investigators, litigators and jurors consider when performing analyses and drawing conclusions about incidents and accidents. However, it has been demonstrated that the public has misperceptions about how memory functions. Simons and Chabris, 2011; *PloS One*, *6*(8), e22757. For instance, 63% of respondents agreed with the statement "human memory works like a video camera, accurately recording the events we see and hear so that we can review and inspect them later." Contrary to this belief, several decades of scientific research have shown that the human brain is not a video camera that simply records and then accurately plays back events that we have experienced. Individual and situational factors influence whether and how events are encoded into memory, and memories are reconstructed anew each time they are accessed. As such, memories of events experienced can be fallible, and subject to bias. Understanding the science of how memories are formed, stored and recalled, and when memory can fail, can assist those evaluating the reliability of witness testimony.

The Basics of Memory Science

Scientists who study memory typically distinguish between short-term and long-term storage. Short-term memory is characterized as being limited, in both time and capacity Cowan, 2010; *Current Directions in Psychological Science*, *19*(1), 51-57. For example, short-term memory is used when remembering an address or phone number just long enough to enter it into one's phone. In contrast, the storage of long-term memories—such as knowledge of state capitals or memories of one's wedding day—is thought to be essentially limitless, albeit not flawless. Eysenck & Keane, 2015; Psychology Press: New York. Asking an eyewitness to recount details of events experienced in the past is, most typically, a probing of that witness's long-term memory.

Long-term memory (LTM) is comprised of three stages: (1) Encoding: The process of getting information into LTM; (2) Storage: Maintenance of information in LTM and (3) Retrieval: The act of accessing information from LTM. When

a person witnesses an event, the details of that experience are encoded as fragments in LTM. These fragments are then integrated with other information sources, such as prior expectations, causal inferences, and facts learned after the event. When a memory is accessed from LTM, it is not played back as one might view a veridical recording of the original event. Rather, the memory is reconstructed from various fragments that represent both the experience of the original event and information from other sources. Schacter, 1995; *Memory Distortion: How Minds, Brains, and Societies Reconstruct the Past*, 1-43. While our memories generally serve us well on a day-to-day basis, a large body of scientific research has demonstrated that each stage of LTM—i.e., encoding, storage and retrieval—is susceptible to error. Understanding the ways in which memory can fail or falter can help to inform the way that eyewitness testimony is collected, evaluated and utilized in understanding past events.

Potential Sources of Error during Memory Encoding

Errors that occur at the encoding stage are critical in that they can persist through the storage and retrieval stages. A primary source of error at encoding is the quality of the information received through the senses (e.g., seeing, hearing, touching) during the experienced event. To wit, a failure to perceive is a failure to encode. Common sources of perceptual limitations and distortions include environmental conditions (e.g., weather, lighting, distance), observer states (e.g., intoxication, stress), observer characteristics (e.g., age) and situational, or task-related, factors (e.g., focus of attention). Two of these factors, environmental and situational, are discussed in greater detail below.

Environmental causes of encoding errors can arise from any quality or feature of one's surroundings that limits or distorts the ability of an observer to see (or hear, feel, etc.) a particular detail of interest. Such factors may include weather and astronomical conditions that influence visibility, the level, quality, and distribution of available lighting, partial or full obstructions to lines of sight, the distance between the observer and a detail of interest, and the loudness and/or similarity of ambient noise relative to a noise of interest. Krauss, 2015; Lawyers & Judges Publishing Company: Tucson, AZ. Because humans rely heavily on visual information to learn about the world, the influence of environmental factors on our visual processes has received considerable attention, resulting in a large body of research. For example, studies have documented, for candidate sets of circumstances, the distances at which observers can reliably recognize faces, facial expressions and the degree of illumination needed to reliably detect objects of different sizes and colors. See, Loftus & Harley, 2005; *Psychonomic Bulletin & Review*, *12*(1), 43-65; see also Smith & Schyns, 2008; *Psychological Science*, *20*(10), 1202-1208; see also Muttart et al., 2013; SAE Technical Paper No. 2013-01-0787. Studies have further documented the degree to which different viewing perspectives distort the spatial relationships among objects or people within a viewed scene. Loomis et al., 1996; *Current Directions in Psychological Science*, *5*(3), 72-77. In the auditory domain, studies have characterized how readily a particular sound can be heard against different types of background noise or localized according to where the observer is standing relative to the origin of the sound. Casali, Robinson, & Lee, 2002; In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 46*(19) pp. 1697-1701; see also Heckman, Kim, Khan, Bare, & Yamaguchi, 2011; SAE 2011-01-0086. Thus, for the interested and knowledgeable evaluator, the influence of candidate environmental features on a witness' ability to perceive, and thus encode into memory, details of interest is often an empirical question, to which there is much science that can be applied.

It is additionally important to consider circumstances unique to the task or situation in which the witness was engaged at the time. A common instantiation of this relates to the witness' in-the-moment focus of attention. As humans, our ability to focus and process information around us is limited—generally speaking, we can attend to only one location,

detail, or event at a time. An example of this limitation is the phenomenon of inattentional blindness—that which is not attended to is not processed and is thus, not encoded. A classic demonstration of this is the work by Simons and Chabris, in which observers were asked to watch a video of two teams passing a ball and report the number of ball passes a given team made—a task that, given the speed and frequency with which basketballs were being passed among individuals, required focused attentional resources. Simons and Chabris, 1999; *Perception*, *28*(9), 1059-1074. Partway through the video, a gorilla-suited actor, walked to the center of the scene, faced the camera, pounded its chest, and slowly walked out of the scene. *Id.* Approximately half of experimental observers failed to notice the gorilla at all—a striking finding given how obvious and out-of-place the gorilla appears when pointed out after-the-fact. *Id.* Since this seminal study, inattentional blindness effects have been replicated across a variety of more realistic circumstances See, Hyman Jr, Boss, Wise, McKenzie, & Caggiano, 2010; *Applied Cognitive Psychology*, *24*(5), 597-607; see also Chabris, Weinberger, Fontaine, & Simons, 2011; *i-Perception*, *2*(2), 150-153. These studies demonstrate that even visually conspicuous and highly salient details can go unnoticed—and thus, not encoded into memory—when an observer's attention is elsewhere. Understanding the observer's information-processing goals at the moment an event is witnessed can thus represent an important consideration in some circumstances.

Potential Sources of Error during Memory Storage

After fragments of a witnessed event are encoded into memory, those fragments must remain in LTM until they are recalled at a later time. As time passes, memories decay, and are also prone to errors as a result of experiences and information encountered subsequent to their encoding and prior to their retrieval. Eysenck & Keane, 2015; Psychology Press: New York. For example, a study by Gabbert et al. revealed that information received after the event, and before the witness is questioned or gives testimony, can distort stored memories. Gabbert et al., 2003; *Applied Cognitive Psychology, 17*(5), 533-543. The Gabbert study examined the effect of post-event conversations with co-witnesses. *Id.* In this study, pairs of witnesses watched videos of a criminal event from different perspectives; unbeknownst to the participants, each video had aspects of the event unique to that participant. *Id.* The participant pairs then discussed the event and were given recall tests about what they saw. *Id.* The authors found that 71% of the witnesses mistakenly recalled details about the event that they had not seen but had been discussed with their co-witness. *Id.* Further, of the witnesses who did not directly see the crime occur, 60% stated that the person shown in the video was guilty after discussing the event with a co-witness. *Id.* Other sources of error during memory storage include long retention intervals and knowledge of the outcome of an event. See, Roediger and Butler, 2011; *Trends in cognitive sciences*, *15*(1), 20-27; see also Remijn and Crombag, 2007; *Psychology, Crime & Law*, *13*(2), 201-211. These are yet additional potential factors that may be valuable considerations when evaluating eyewitness testimony.

Potential Sources of Error during Memory Retrieval

Lastly, following the encoding and storage of memories, memory fragments are reconstructed each time an event is recalled, such as when a witness provides a recounting through testimony. Each resultant reconstruction is susceptible to error—based not only on the circumstances under which the event was originally experienced and encoded, the natural processes of degradation over time, and information received during the intervening storage, but also the circumstances

under which the fragments are accessed and pieced together. Factors such as biased or leading questions are just some of many that can affect memory retrieval in this regard. For example, the way that a witness is questioned can affect what he or she recalls. See, Loftus and Palmer, *Journal of Verbal Learning and Verbal Behavior*, *13*(5), 585-589 (1974). In this experiment, witnesses to a simulated car accident were asked to estimate an involved vehicle's speed. *Id.* All witnesses watched the same video but were asked slightly different questions to probe their memories for the event– e.g. "About how fast were the cars going when they *contacted* each other?" versus "About how fast were the cars going when they *smashed* into each other?" *Id.* Witnesses presented with the word "smashed" estimated the vehicle speed to be an average of 9 mph higher compared to witnesses presented with the word "contacted." *Id.* Another study found that early questions of a witness can affect later answers, and can plant "false" memories. Loftus, *Cognitive Psychology*, *7*(4), 560-572 (1975). In this experiment, witnesses were shown a video of a car accident on a country road. *Id.* Different groups of these witnesses were then asked either (1) how fast a car was going when it passed the barn while traveling down the road, or (2) how fast the car was going while traveling down the road. *Id.* When asked later if they saw a barn (in reality there was no barn), 17% of witnesses in group one said they had seen a barn, compared to only 3% of witnesses in group two. *Id.* These studies illustrate the importance of using open-ended, non-leading questions when probing a witness' memory to result in an unbiased account.

Conclusion

While our memory generally serves us well on a day-to-day basis, the studies and examples discussed above illustrate a small sample of the complex and various ways in which errors can be introduced during memory encoding, storage, and retrieval. Based on these scientific principles and findings we suggest obtaining detailed information about the environmental, observer, and situational factors present when the witness experienced the event, as well as details about their memory storage and retrieval (e.g., did they discuss their observations with other witnesses or investigators, who questioned them about the event and when, etc.). Such information can prove valuable when evaluating witness memory and testimony. Human information processing and memory are nuanced and complex processes in the context of eyewitness recall and testimony. Applying the science of human factors and human performance can assist in the understanding and evaluation of these issues.

About the Authors

Dr. Christina Cloninger received her Ph.D. in Neurobiology and Anatomy for the University of Rochester. She has a background in cognitive and behavioral neuroscience investigating human motor behavior, motion processing and sensory perception using eye-tracking, behavioral measurements, and computational methods.

Dr. David Cades specializes in human factors investigations of vehicle and aircraft operator behavior, including perception response time, visual perception, nighttime visibility, and distractions and has investigated the effects of advanced driver assistance systems (ADAS) and highly automated vehicles (HAVs) on driver behavior. He also has expertise in the evaluation and development of warnings and instructions for a wide range of consumer and industrial products. He received his Ph.D. in Human Factors and Applied Cognition from George Mason University in 2011.

Prior to joining *Exponent*, **Dr. Genevieve Nauhaus** completed a B.A. in psychology, with honors, from Wake Forest University and a Ph.D. in psychology, with specialization in cognitive neuroscience, at the University of California, Los Angeles. Using her specialized knowledge of human sensory, motor, and cognitive processes, Dr. Nauhaus focuses on human factors and human performance issues in everyday and accident situations. Her work evaluates issues related to visual and auditory perception, lighting and illumination, balance and movement control, reaction time, attention and distraction, memory, and decision-making.

Prior to joining *Exponent*, **Dr. Erin Harley** completed a Ph.D. in cognitive psychology at the University of Washington. Her expertise includes the analysis of visibility, lighting, reaction time, eyewitness memory and bias, attention and distraction, driver behavior, gait and loss of balance, performance in sports and recreational activities, and warning design and compliance. Dr. Harley has published scientific research related to visual perception, hindsight bias, perceptual abilities in medical professionals, warning compliance, driver gear-shifting behaviors and errors, skier perception and reaction, and analyses of store-related injuries.

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