The Factors that Affect Memory and the Implications on Eyewitness Testimonies

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Abstract

Human memory is subject to psychological and social factors that can influence and distort the way events are remembered. Scientists have long since studied the effects of a variety of factors on memory, especially in relation to eyewitness testimonies, which are an integral part of the criminal justice system. However, we believe that much further study is required in this field. The aforementioned memory distortions can render eyewitness testimonies unreliable. Altered memories of a crime can derail a police investigation, lead to the false prosecution of an innocent person, and result in a guilty person going free. We must, therefore, ensure that courtroom decision-makers worldwide are aware of the multiple ways in which eyewitness testimonies can be faulty and design easily implementable measures to prevent faulty testimonies from influencing criminal cases. Here, we discuss how stress and trauma, situational factors, co-witnesses, and figures of authority affect memory.

1 Introduction

The American Psychological Association [APAb] defines memory as "the ability to retain information or a representation of past experience, based on the mental processes of learning or encoding, retention across some interval of time, and retrieval or reactivation of the memory."

Memory can be broadly categorized as either short-term "working memory" or "Long-term memory." Working memory is characterized by a limited capacity. Only a small amount of information can be processed into long-term storage (LTS) in a process known as consolidation [BH74]. Long-term memory can be further categorized as "declarative" (or explicit memory), and "procedural" (or implicit) memory [Out]. Declarative memory refers to conscious recall and consists of information that is explicitly stored and retrieved. Declarative memory

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can be further divided into "episodic memory," which stores personal experiences, and "semantic memory," which stores factual information [Ull01], [SC02]. A critical aspect of declarative memory is to detect and encode the defining features of an individual event [LR04]. Procedural memory is an implicit long-term memory that occurs due to a modification in a specialized system by reactivating the systems through which the learning first occurred. This happens without conscious thought [LR04].

Biologically, each type of memory is processed differently by different parts of the brain. The hippocampus is believed to process declarative memories [TM98]. In a seminal study by [SM00], bilateral lesions in the hippocampus caused profound memory loss in spatial/contextual and episodic memory [Hir74], [RSS$^+$00]. The amygdala is said to be involved in the processing of emotional and procedural memory [LC06], [TM98].

Memory is typically processed in three distinct stages: encoding, retention, and recall [Mel63]. Encoding is the first stage of memory processing and refers to converting sensory input into a form that can be processed and deposited into memory [APAa]. Biologically, the hippocampus plays a vital role in forming new episodic and spatial memories [CE93], [SS02], partly due to its involvement in detecting new events and places [VFBS08]. The brain has two hippocampi, one in each hemisphere. If only one hippocampus is damaged, the brain can retain near-normal memory functioning. Severe damage to the hippocampi in both hemispheres results in profound difficulties in forming new memories (anterograde amnesia) [DGQ$^+$06]. Amnesic patients with confirmed hippocampal damage often face problems remembering the recent past but can recall events that occurred a long time ago just as well as normal people [MS89], [HSS92]. The hippocampus also encodes emotional context from the amygdala [Squ92].

Retention is the second stage of memory processing and refers to the storage and maintenance of a memory [APAd]. There are many different ways of retaining information in memory. Acquiring and retaining new knowledge relies on the formation of associations to be created in memory stores [Whi09]. Retrieval is the process of recovering and locating information stored in a memory; it is the final stage of memory processing [APAe]. As mentioned earlier, hippocampal damage can impair memories of the recent past, but memories of the distant past remain untouched [MS89], [SHS89]. These findings led to the hypothesis that the hippocampus plays a temporary role in the formation and retrieval of new memories, which are permanently stored in other parts of the brain. However, recent research using functional imaging studies (fMRI) found hippocampal activation during the retrieval of both new and old episodic memories [NSH04], [PR05], [SSE06].

From these findings, the hippocampus and amygdala appear to be the significant components of the brain involved in memory. Therefore, we will focus our discussion on the two, specifically in relation to memory encoding and retrieval. Memory is prone to distortion both during the encoding process [OS05], [SWO10], [ILEM03], and during the retrieval process [MHD$^+$04], [PJH$^+$07], [SWO10], [MHRR19]. Memory distortion refers to a phenomenon wherein a person's memory of an event is altered after exposure to misinforma-

tion about it. These distortions, while usually considered an adaptive mechanism [SGJ11], [BSA18], can prove to have widespread implications, especially in the realm of criminal justice.

The criminal justice system relies heavily on eyewitness testimonies to solve crimes and prosecute criminals [WO02], [APAf], [LS13], [WMP06]. Eyewitness testimonies are accounts of an event given in a courtroom by a bystander or a victim [WMP06]. Eyewitness testimonies are convincing, but they are not accurate. Eyewitness testimonies rely heavily on how well the witness remembers an event and the level of precise details that can be gleaned from these memories [WO02], [APAf], [LS13], [WMP06], [BRB$^+$06]. However, the aforementioned memory distortions can render eyewitness testimonies unreliable. Altered memories of a crime can derail a police investigation, lead to the false prosecution of an innocent person, and result in a guilty person going free. Eyewitness memories can sometimes be incredibly accurate, but they can also be just as inaccurate. However, without more evidence, the two are virtually indistinguishable [Lof05], [BRB$^+$06]. Human memories are not stored like episodes in a tv show. Instead, they are malleable and susceptible to distortion due to various factors, including trauma or stress, environmental context, and social interaction. We must, therefore, ensure that courtroom decision-makers worldwide are aware of the multiple ways in which eyewitness testimonies can be faulty and design easily implementable measures to prevent faulty testimonies from influencing criminal cases. However, there has not been a comprehensive study on the factors affecting eyewitness memory in particular, and no studies to date have addressed both behavioral and neural findings in conjunction.

We have focused on three main factors that affect eyewitness memory: trauma or stress, environmental context, and social interaction. In Section 1, we look at various behavioral and neural studies that show how stress and trauma cause memory impairment during memory encoding and retrieval and look at the involvement of the hippocampus and amygdala. Section 2 discusses how various situational and environmental factors, namely, the "weapon focus effect," exposure duration and the number of perpetrators, affect eyewitness memory for facial recognition. We also look at the cognitive aspects that enable facial recognition. In Section 3, we address the effect of social influences like other witnesses on eyewitness memory and the impact of perceived authority and conformity on witness accounts of an event. We also consider the neural bases for conformity among eyewitnesses and the effects of social influence on a cognitive level.

2 Stress and Trauma

In the first section, we will discuss stress and trauma as potential factors that may affect eyewitness testimonies. According to the [APAg] American Psychological Association (n.d.), trauma refers to an emotional response to an event that is perceived as disturbing or threatening and is often characterized by denial, shock, and unpredictable emotions. Stress refers to a state of heightened arousal in response to a threatening experience [KD02]. Stress and

trauma can impact memory during the encoding phase as well as during the retrieval phase [MHD+04], [PJH+07], [SWO10], [MHRR19]. Therefore, stress and trauma can affect eyewitness testimonies, which depend heavily on oftentimes faulty memories. Here, we discuss how various behavioral and neural experiments show how eyewitness memories are impacted by stressful and traumatic incidents encountered during encoding and recall, leading to impaired memory of an incident, and hence, faulty testimonies.

2.1 Behavioral

Some studies have shown how stress actually enhances memory accuracy for central information about a stressful or traumatic event [Chr92]. [Chr92] Christianson (1992) focused on the Yerkes-Dodson law [YD08], which predicts that very low or very high levels of arousal (stress) cause impaired ability and motivation to perform a task and that there exists an optimal level of arousal where a person's performance is at its best. This is characterized by a typical bell-jar-shaped graph. In the study, Christianson (1992) found that they were actually retained quite clearly and mostly accurately. The study also claimed that any memory impairment that occurred could be countered with strong retrieval support. On the surface, these findings appear to suggest that eyewitness testimonies are robust against faulty memories. However, more research has shown that the conventional portrayal of the Yerkes-Dodson law as a nonlinear curve does not take into account intervening variables such as the nature and difficulty of the task [Dia05], a notion which was emphasized by Yerkes-Dodson (1908) [YD08], and Dodson (1917) [Dod17]. In the Christianson (1992) study, this aspect was addressed as a mere footnote, and only the conventional bell jar curve was used.

Indeed, research has repeatedly shown that stressful and traumatic events significantly impair memory, especially for central information. Several behavioral studies have looked at the effects of stress and trauma on eyewitness memory. A majority of these studies have concluded that stress and trauma do indeed have negative effects on both memory recall and facial recognition [DBPM04], [MHD+04], [SL78], [PNBJ12], [PAG07]. Nourkova, Bernstein, and Loftus (2004) [NBL04] also showed that traumatic memories could be experimentally altered. A sharp decline in memory accuracy can be seen for highly stressful events, especially when it comes to remembering details. Stress and trauma affect the recall of memories, especially after an hour or so after the stressor was experienced [ER05], [PAG07].

Stress inflicted before memory encoding has been shown to negatively impact later recall when recalling a neutral (not very emotional) event but can enhance memory for an arousing (or stressful) event [PJH+07]. Stress experienced during the encoding process has been shown to negatively impact memory regardless of how emotional the event was [SCO05]. Stress experienced during memory retrieval has been found to cause extensive memory impairment [KPW05], [ER05], [PAG07], especially for emotionally arousing events [KPW05].

As demonstrated by Morgan et al. (2004) [MHD+04], active-duty military

personnel showed much poorer recall during a high-stress interrogation than during a low-stress one. Also, of the 530 participants in the study, a majority of the participants were able to recognize faces better in the low-stress condition than in the high-stress one. Based on this, stress experienced both before and after the encoding process, as well as during memory retrieval, can cause memory impairment among participants.

We will now look at the effects of trauma on memory recall. Highly traumatic memories have been shown to be less likely to be recalled [FRE96], perhaps due to an evolutionary defense mechanism. In many highly traumatic cases, like sexual assault or abuse, witnesses are often unable to accurately identify the perpetrator's face, which often leads to an innocent person being falsely prosecuted [LS13]. For example, in 1984, a stranger broke into Jennifer Thompson-Canino's apartment and raped her. After the assault, in a photo lineup, she identified Ronald Cotton as her attacker. Then, she picked Cotton from a live lineup. Cotton was convicted of rape and sentenced to life in prison. Ten years later, DNA testing showed that Cotton was not a match to semen samples found at the crime scene. Based on the findings of Lacy and Stark (2013) [LS13], we can say that the high levels of trauma brought about by the incident may have impaired the witness's memory of her attacker's face and caused her to mis-identify Ronald Cotton as the perpetrator of the crime.

In such cases, eyewitness testimony is often given a lot of weight due to the long time the victims are exposed to the attacker, which should, many people assume, cause them to remember the perpetrator's face better [LS13]. However, as is evident from the aforementioned example, the traumatic nature of the incident caused impaired memory of the face of the attacker, resulting in the wrongful prosecution of an innocent man. Judges and jurors involved should be aware of this phenomenon so as to take it into account while listening to eyewitness testimonies. Thus far, we have focused on behavioral evidence, which shows that stress and trauma can negatively affect the quality of memory encoding and recall.

2.2 Neural

Stress hormones and hippocampal activity may be the biological mechanisms associated with this memory impairment. Stress is primarily characterized by the secretion of stress hormones like epinephrine, norepinephrine, and cortisol [KD02], [SM01], [SB97], [BS00]. Epinephrine and norepinephrine are responsible for a physiological fight or flight response to fear. Cortisol, a glucocorticoid secreted by the adrenal cortex, is the focus of most studies on stress [KWM$^+$96], [RSS$^+$00], [CKMS09], [RSL00], [SWO10], [Roo02], and in high concentrations, is known to impair episodic memory [PNBJ12]. Dominique J. et al. (1998) [DRM98] show how stress and glucocorticoids affect memory retrieval in rats going through a maze. High levels of cortisol have been shown to cause damage to the hippocampus, a part of the brain mainly associated with memory [SKM85], [HRJ$^+$89], [McE01], [PNBJ12].

Very high levels of glucocorticoids have been shown to impair memory [KWM$^+$96],

[RSS+00], [CKMS09], [RSL00], [SWO10], [Roo02]. The cognitive effects of acute stress on the hippocampus can last for several hours but are usually reversible and specific to the stress-causing task or event [McE01]. Collectively, studies conducted on glucocorticoids and the hippocampus have revealed that elevated levels of stress and high glucocorticoid levels disrupt normal hippocampal functioning. Very long exposure to glucocorticoids and stress may even result in a loss of hippocampal neurons [SKM85], [HRJ+89]. Since the hippocampus is heavily involved in the formation and retrieval of episodic and factual memories [CE93], [SS02], [VFBS08], damage to hippocampal neurons can severely impact witness memory of the events that took place, leading to faulty testimonies, resulting in delayed investigations and false prosecutions.

All in all, stress and trauma can cause serious impairments in memory formation, storage, and retrieval. This has numerous implications for courtroom trials as well as police lineups. The fact that memories, especially from traumatized or stressed witnesses, can be distorted can also help the police design lineups accordingly and is something jurors can keep in mind while making decisions.

3 Situational Factors

In the second section, we look at concerns situational factors. These refer to any aspects of the event that are influenced by the circumstances and incidents surrounding the crime. One situational factor that strongly affects memory is the "weapon focus effect."

3.1 Weapon Focus Effect

The weapon focus effect refers to a phenomenon where an eyewitness's focus on a weapon impairs their ability to remember other details of a crime, especially a perpetrator's face [LLM87], [Sau09]. Here, we discuss how the weapon focus effect depends on context [Pic99], [HW07]. Research has shown that the weapon focus effect is dependent on factors like context and that it may not be limited to weapons alone. Mitchell et al. (1998) [MLM98] showed that the human tendency to focus on novel stimuli may also play a major role. While this has been the case in other studies as well, the effect does seem to be more complex than just focusing attention on a novel object [HW07], and studies have consistently shown that the typical weapon focus effect does hold true [LLM87], [Pic99], [HW07]. The weapon focus effect may also depend on context, as demonstrated by Pickel (1999) [Pic99], where the weapon focus effect did not make an appearance when participants saw a gun with a police officer, which would be expected, and hence, would not surprise the witness. While the effect does seem to be more prominent under laboratory conditions than in real life scenarios [Ste92] (Steblay, 1992), the weapon focus effect has been found to consistently impair facial recognition [LLM87], [BHR92], [Sau09], which can make suspect identifications from a lineup less reliable. Facial recognition by witnesses after an event involving weapons should be treated with caution as

they may very well be inaccurate.

3.2 Exposure Duration

Another situational factor that could affect eyewitness memory is exposure duration. Exposure duration, or how long a witness saw an event for, can affect the accuracy of eyewitness memories, especially in regards to facial recognition [MHB03], [SP86], [BDPM12]. Typically, the longer the witness has looked at a perpetrator, the more accurate facial recognition is. Valentine, Pickering, and Darling (2003) [VPD03] found that witnesses exposed to a perpetrator for a longer duration (more than 1 minute) were more likely to identify a suspect than those exposed to the perpetrator for relatively less time (less than 1 minute). Shapiro and Penrod (1986) [SP86] found that accuracy was higher, and the number of false alarms was lower when the witnesses had been exposed to the perpetrator for a longer time. This implies that in crimes that occur very suddenly and quickly, and therefore have decreased exposure duration, eyewitness testimonies may not be very reliable. Having those witnesses identify or describe the perpetrators may lead to false facial recognition and completely derail an investigation. Lineups, too, should be designed accordingly to take that into account using procedures suggested by the APA (2004) and Steblay(2013) [APAc], [Ste13].

3.3 Number of Perpetrators

The third situational factor that influences eyewitness memory is the number of perpetrators. A study conducted by Clifford and Hollin (1981) [CH81] showed the influence of the type of incident (Violent or non-violent) and the number of perpetrators on eyewitness memory. Results indicated that eyewitness testimony was less accurate after viewing a violent crime than a non-violent one. Also, this accuracy seemed to decrease as the number of perpetrators seen increased. Hence, eyewitness testimonies from crimes committed by groups of people may be unreliable and should be verified using empirical evidence so as to conduct a successful investigation. Lineups should be designed such that only a single suspect is present at a time, even if there are multiple suspects, as per APA (2004) guidelines and Steblay(2013) [APAc], [Ste13].

We find that memories can be influenced by a large variety of situational factors, including the presence of a weapon, exposure duration, and even the number of perpetrators. As such, eyewitness testimonies can often be heavily influenced by them, and this should be kept in mind while interrogating witnesses.

4 Co-witnesses and Figures of Authority

Memories are also very easily influenced by what other people say or remember of the event in question. Discussion of an event among multiple witnesses can oftentimes influence memories of an event which leads to various inaccuracies [LW94], [SGW97], [AM06], [MTRY11], [SW08], [RHS+18]. Often, simply changing a verb in a sentence can change the way eyewitnesses remember an incident. Loftus and Palmer (1974) [LP74] found that changing the verb hit in the sentence "How fast were the cars going when they hit each other" to smashed, collided, and bumped changed participants' estimates of the speed of the cars. They were able to suggest to the witness the relative speed of the two cars and the severity of the accident. Sometimes, investigators ask leading questions, or even quote another witness's account of the event, to encourage an eyewitness to speak up. While this may improve recall for witnesses with poor memory recall, it more often than not confounds individual memories of an event [WK04], [SW08]. It has been shown that witnesses prompted as such have incorporated other witnesses' descriptions into their own, resulting in inaccuracies [LG80].

Concerningly, Shaw, Garven and Wood (1997) [SGW97] found that a combination of co-witness discussion and questions that suggested an incorrect response led to a sharp decline in the accuracy of eyewitness recounts. This implies that using leading questions to facilitate the memory of a witness may not be the best course of action and may contribute to significantly biased results. Collaborative memories should be treated with due caution as distorted memories could mislead a police investigation. Due to the weight eyewitness testimonies carry in court, this could cause an innocent person to be persecuted or a guilty one to walk free.

It is well known from the Milgram obedience studies [Mil63], that people in authority positions can influence human behavior. The same has been shown to apply to memory as well [DF96], [RS02], [KD05]. The research shows conflicting results; some studies have not shown any significant correlation between perceived authority and eyewitness testimony [KD05]. Devenport and Fisher (1996) [DF96] found that participants shown a lineup administered by a policeman (authority figure) were more likely to identify a potential suspect than participants viewing a lineup administered by a civilian (non-authority figure). However, no significant correlation was found between the presence of an authority figure and the accuracy of eyewitness testimony.

Conversely, Roper and Shewan (2002) [RS02] have shown that eyewitnesses modified their original accounts and showed higher suggestibility to leading questions when a so-called figure of authority labels them as "poor eyewitnesses." Those labeled as "good eyewitnesses" showed an increase in accuracy and have improved eyewitness observation scores. This may imply that further research is required in this field to determine the exact effects of perceived authority on eyewitness accounts so as to set up safeguards to it. The study conducted by Roper and Shewan (2002) [RS02] may suggest that labels that seem more personal (e.g., the labels of good and poor witness could be seen as

a comment on participants' individual abilities as eyewitnesses) assigned to the witnesses by a perceived authority figure may actually impair eyewitness accounts in order to remove a negative label (e.g., poor eyewitness) and to retain a positive one (e.g., good eyewitness).

From a neural standpoint, Edelson et al. (2011) [MTRY11] examined how memory errors caused by the influence of other people are generated in the brain. Participants in the study tended to conform to incorrect recollections of others, even when their initial account was accurate. Specifically, brain imaging showed that social influence enhanced amygdala activity as well as the amygdala-hippocampus connectivity in the case of long-term memory alterations. Elevated activation of the amygdala was seen to be associated with persistent errors in memory recollections after influence by other people. This provides further evidence for the fact that social influences play a significant role in eyewitness memory and shows that the effects of social influences on memory may be more than just psychological.

5 Discussion

In this paper, we discussed how encoding and recall may be compromised by a variety of psychological and social factors including, stress and trauma, situational components like the weapon focus effect, exposure duration and number of perpetrators, and social influence by other witnesses and figures of authority. These altered memories negatively affect eyewitness testimonies. We found that eyewitness memories and facial recognition are significantly impaired by each of the aforementioned factors. We have looked at both behavioral and neural studies for each of the factors to individually describe their impact on eyewitness memory, and we thus far conclude that eyewitness memory distortions occur due to a complex interaction between a multitude of psychological, social, and contextual factors.

Specifically, we discussed how these factors affect memory in the context of eyewitness testimonies. Given that eyewitness testimonies are often used in our criminal justice system [WO02], [APAf], [LS13], [WMP06], it is very important to discuss what factors need to be mitigated to ensure that our society progresses toward being more fair and just. To our knowledge, this review was the first to comprehensively investigate both neural and behavioral facets of the impact that stress and trauma, situational components like the weapon focus effect, exposure duration and number of perpetrators, and social influence by other witnesses and figures of authority have on memory and therefore the eyewitness testimony. This paper aims to provide a starting point for further consolidation of the complexities of eyewitness memory and how they can be altered. However, this study is limited in the fact that not all the factors that influence eyewitness memory have been addressed in this paper. Much further research in this field is needed to gain a concrete understanding of how eyewitness memories are shaped. Furthermore, in order to aim to make eyewitness testimonies more reliable, we must understand how we may be able to alleviate the negative effects of the

factors we discussed on memory. However, the methods we can use to reduce the impact of these factors were out of the scope of our paper. We believe that our results can serve as a foundation upon which future researchers can explore direct changes with which we can make to make a real impact in the criminal justice system.

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