

EYEWITNESS MEMORY: HOW STRESS AND
SITUATIONAL FACTORS AFFECT EYEWITNESS RECALL

by

ANNE S. YILMAZ

A THESIS

Presented to the Department of Psychology
and the Robert D. Clark Honors College
in partial fulfillment of the requirements for the degree of
Bachelor of Science

December 2016

Abstract of the Thesis of

Anne Yilmaz for the degree of Bachelor of Science
in the Department of Psychology to be taken December 2016

Title: Eyewitness Memory: How Stress and Situational Factors Affect Eyewitness
Recall

Approved: _____

Robert Mauro

As eyewitness memory and its current admissibility as evidence in courts have come under scrutiny, numerous studies have examined variables that affect eyewitness memory. These variables are divided into system and estimator variables. System variables are factors that can be controlled by the criminal justice system; estimator variables are those which cannot be controlled by the justice system. Considerable research has demonstrated that stress can either inhibit or enhance memory depending on the level of arousal. This literature review will examine the role and effect of stress in general and in regard to other estimator variables (e.g., seriousness, weapons focus, and victim vs. bystander). Both field and laboratory studies will be examined. General trends, important caveats, and limitations will be reported. Despite the breadth of research in both eyewitness research and stress and memory, there is no recent comprehensive review of the effect of stress on eyewitness memory. This literature review will serve to bridge that gap and provide resources for those looking to continue research in the area of stress and eyewitness memory.

Acknowledgements

Thank you Dr. Robert Mauro for taking a chance on a student you had never met by agreeing to be my thesis adviser. You have guided me immensely the last 1.5 years with the entire thesis-writing process and beyond and, for that, I am incredibly grateful. I would also like to thank the rest of my thesis panel, Dr. Barbara Mossberg and Robert Rocklin, for their support and input on this document as well as Academic & Thesis Coordinator Miriam Alexis Jordan for assisting me with my endless questions and being a wealth of information.

Table of Contents

Introduction	1
The Eyewitness Testimony Problem	2
Number of cases in which eyewitness testimony is a problem	2
Known Cases of Misidentification	2
An Unknown Failure Rate for Eyewitness Identifications	2
The Unreliability and Malleability of Memory	3
Juries Believe Eyewitnesses Regardless of Accuracy	5
Confidence effects	6
System and Estimator Variables	6
General Background	7
Mechanisms of Memory	7
Attention	7
Perception	7
Encoding	8
Working memory	8
Long-term memory	10
Retrieval	10
Stress	11
Effects of stress on performance	11
Effects of Stress on Eyewitness Memory	12
High Stress Effects Due to Fear	12
Decreased encoding as stress increases	12
Field studies	14
Lab studies	19
Caveats and additional discussion	22
Narrowing of attention	29
Lab studies	30
Weapon focus	31
Caveats and additional discussion	34
Attention to central information	35
Field studies	36
Lab studies	37
Caveats and additional discussion	38
Amelioration: Accounting for System Variables in Legal Proceedings and Best Practices for Police	41
Court Cases	42
Remaining problems	44
Conclusion	46
References	48

List of Tables/Figures

Figure 1. Working memory diagram	9
Figure 2. Yerkes-Dodson model (Diamond, 2005)	11
Table 1. Studies discussed in the <i>Decreased encoding as stress increases</i> section	13
Table 2. Eyewitness recognition across type of assessment within-stress condition (Morgan et al., 2004)	16
Table 3. Means, SDs, and 95% Confidence Intervals for Correction and Incorrect Items Reported and Accuracy (Hope et al., 2016)	18
Table 4. Identification Accuracy Effect Sizes (Deffenbacher, Bornstein, Penrod, & McGorty, 2004)	23
Table 5. Meta-Analysis Effects by Type of Analysis (Deffenbacher, Bornstein Penrod, & McGorty, 2004)	25
Table 6. Studies discussed in the <i>Narrowing of attention</i> section	29
Table 7. Meta-analysis of weapon-focus studies (Stebly, 1992)	32
Table 8. Studies discussed in the <i>Attention to central information</i> section	36

Introduction

Eyewitnesses to a crime may experience extremely high levels of stress, making it important to understand stress' effects on a person's ability to recall information. This document summarizes this stress-memory literature for eyewitnesses.

This paper is divided into five sections: The Eyewitness Testimony Problem, General Background, The Effects of Stress on Eyewitness Memory, Amelioration, and Conclusion. In the first section, general problems with eyewitness testimony are discussed in order to contextualize the need for eyewitness scrutiny. This includes statistics of testimony use, error, and impact as well as descriptions of other common memory issues that eyewitnesses may experience. The General Background section contains an overview of memory processes and the nature of stress. Understanding these concepts is vital to understanding the core purpose and research in this paper. The next section, The Effects of Stress on Eyewitness Memory, will go into the heart of eyewitness stress literature. The Amelioration section will discuss ways of accounting for system variables when handling eyewitnesses. The conclusion will summarize the paper's findings and provide general opinions on how use the data on eyewitness memory.

The Eyewitness Testimony Problem

Number of Cases in Which Eyewitness Testimony Is a Problem

Eyewitness testimony is used in a large number of cases and is responsible for many false convictions. In the United States, approximately 75,000 defendants are implicated by eyewitnesses annually (Department of Justice, 1999). Inaccurate eyewitness testimony accounts for more wrongful convictions than do false confessions, problems with informants, and defective or fraudulent science combined (Innocence Project, 2005).

Known Cases of Misidentification

Of the first 150 people exonerated by DNA evidence, 70% had been incorrectly identified by an eyewitness (Innocence Project, 2005). Of the 1,905 exonerations listed in the National Registry of Exonerations database, 573 (30%) involved instances of eyewitness misidentification. Of the 333 post-conviction DNA exonerations in the United States, more than 70% of them involved eyewitness misidentification ("DNA Exonerations Nationwide," 2015; "Eyewitness Misidentification," Innocence Project).

Warden (2001) examined 86 death row cases that contained a post-conviction exoneration. Eyewitness identification played a role in 46 of the 86 (53.5%) of the improper convictions. In 33 (38.4%) of the cases, eyewitness testimony was the sole form of evidence.

An Unknown Failure Rate for Eyewitness Identifications

The above data demonstrate that problems in eyewitness identifications have contributed to numerous improper convictions. However, the true number of misidentifications (i.e. false positives; incorrectly identifying someone as the offender

when he or she is innocent) made by witnesses remains unknown. DNA evidence exists for only a small number of cases, so it is likely that there are many people who have been misidentified and inappropriately convicted of crimes and will never be exonerated.

Furthermore, eyewitnesses can be inaccurate by failing to identify a perpetrator (i.e. false negatives; incorrectly failing to identify a perpetrator). The rate of these false negatives is also unknown. Police do not keep systematic statistics regarding the number of instances in which an eyewitness could have identified a perpetrator but failed.

The Unreliability and Malleability of Memory

Memory is malleable. For example, imagining an event can cause people to create “memories” of it, even if the situation is unrealistic or impossible (Mazzoni & Memon, 2003). In one case, Braun, Ellis and Loftus (2002) used fake advertisements to convince participants that they had met and shaken hands with Bugs Bunny at a Disney resort as a child. Bugs Bunny is the property of Warner Bros., not Disney, and would not have been on Disney property. Despite that, 16% of the people who saw the Bugs Bunny advertisement believed that the event had happened to them.

Similarly, people may confuse imagination with fact and misremember the source of conjured images when interrogators ask people to imagine a crime scene (Henkel & Coffman, 2004). Imagination can even lead people to believe they are guilty of a crime they did not commit—but those cases usually involve improper interrogation techniques focusing on events that are easy to imagine, contain vivid details, and lack context on how the original memory formed (Henkel & Coffman, 2004).

Sometimes, eyewitnesses will experience *unconscious transference* — they will misidentify an individual who is unconsciously familiar to them as the perpetrator of a crime. This was the case in 1988 when Leslie Dunn, a Los Angeles judge, was attacked while jogging. Dunn picked Stephen Weible out of a police photobook and identified him as her attacker. However, Weible did not match the description of the perpetrator that she had given to the police immediately after the attack. Dunn was familiar with Weible. Four years prior, she had sentenced Weible in her own courtroom for a similar crime, a fact she had failed to recall on her own (Lerner, 1988). Even though Dunn said in court that she could “never erase his face [as her assailant] from her memory,” the case was eventually dismissed due to a lack of evidence (“Local News in Brief,” 1988).

In a study of unconscious transference, Ross, Ceci, Dunning, and Tolia (1994) found that people were three-times more likely to misidentify an innocent bystander as a perpetrator after watching footage of a bank robbery compared to participants in a control group without an innocent bystander. The chance of inaccurate memory was only eliminated in the transference group when participants were informed that the person they identified (the bystander) and perpetrator were not the same person. After receiving that cue, participants could recall where they had seen the bystander’s face, but without that cue they would have implicated the wrong person.

When it comes to identifying a suspect in a line-up, *relative judgment* can also affect the accuracy of eyewitness identifications. Using relative judgment, eyewitnesses will unconsciously choose the person most similar to the perpetrator if the perpetrator is not present in the line-up (Wells, 1984; 1993). In these cases, witnesses do not know a face well enough to determine if it is absent from a line-up.

People are particularly poor at identifying members of a different race. A meta-analysis found that people are 1.4 times more likely to correctly identify a same-race face than an other-race face and are 1.56 times more likely to misidentify an other-race face than a same-race face (Meissner & Brigham, 2001). People are better at identifying those of the same race due to attentional resource allocation (*see: Mechanisms of Memory section*). Attentional resources directed toward features that distinguish members of within-race (e.g. eye color) may not be useful for distinguishing member of other-races (Sporer, 2001). However, most crime happens within race (Wells & Olson, 2001).

Juries Believe Eyewitnesses Regardless of Accuracy

In a study that examined the power of eyewitness testimony, mock jurors heard an armed bank robbery case which resulted in two deaths (Loftus, 1975). The case had circumstantial evidence. Without eyewitness testimony, 18% of jurors convicted him. When eyewitness testimony was added, 72% of jurors convicted him. Even in conditions in which the eyewitness was discredited, 68% of jurors still voted for conviction.

The significantly higher conviction rate in Loftus (1975) is evidence for the widely held belief in the field that eyewitness testimony is the single most persuasive piece of evidence for juries—as well as the least reliable (Wells, Small, Penrod, Malpass, Fulero, Brimacombe, 1998).

The case of Calvin C. Johnson Jr. is an example of how convincing eyewitnesses are for juries. Johnson served 16 years in prison for a rape he did not commit. He had multiple alibis and, under a microscope, his hair did not match the one

found at the scene of the rape. The case hinged on the victim picking his photo out of a photo-spread (she had failed to pick him out of a live line-up). However, a separate rape victim who had been attacked around the same time and in a similar manner had identified Johnson in a line-up, but had failed to choose him in a photo-spread. The jury deliberated for only 45 minutes before convicting him (Firestone, 1999; “Calvin Johnson,” Innocence Project). For Johnson, a DNA comparison to the semen on a vaginal swab from the rape victim freed him after more than a decade of incarceration.

Confidence effects. Witnesses’ confidence in the accuracy of their identifications is not strongly correlated with accuracy (Garry & Polaschek, 2000; Sporer, Penrod, Read & Cutler, 1995; Leippe, 1980; Hosch, Leippe, Marchioni & Cooper, 1984; Hosch & Cooper, 1982; Buckhout, 1974). Although some studies have found a weak correlation between confidence and accuracy, it is too small to have any practical applicability. Additionally, people who are trained to recognize faces and are confident in that ability do not show significantly better accuracy than untrained people (Woodhead, Baddeley & Simmonds, 1979).

System and Estimator Variables

There are many factors that can alter eyewitness memory. These factors can be sorted into two groups: system variables and estimator variables. System variables are controllable. Often they can be moderated by the criminal justice system or other professionals involved in the case. Examples of system variables are: the use of leading questions during interviews, giving praise or punishment during suspect identification procedures, and the methods used in creating line-ups. On the other hand, estimator variables (i.e., situational factors) are out of the criminal justice system’s control. These

factors cannot be changed, but can be accounted for when evaluating eyewitness credibility (*see: Amelioration section*). Examples of estimator variables are: how dark it was during the event or visibility in general, sleep deprivation of the witness, stress level of the witness, duration of the crime and if there was a weapon present. This literature review will focus on stress as an estimator variable. Many of the effects of other estimator variables (e.g., weapon presence, being a victim versus bystander, crime seriousness, etc.) are affected by stress.

General Background

Mechanisms of Memory

Attention. Attention refers to mental concentration on a specific aspect of the environment within a perceptive field. Jonides (1983) relates the brain's attentional ability as "analogous to the body's eye." Information inside the "focus" of attention, is intensely processed; whereas information outside of this area (i.e., in the periphery) is subject to much less processing. Biologically, Eriksen and Hoffman (1972) specifically found one area of the visual field where optical acuity is at its best (about 1 degree in size) where information is processed in high-resolution and precise detail. Information outside of that region was encoded less-distinctly and as a "vague indefinite background" both spatially and in regards to how attentional resources were allocated. As more attentional resources are focused on stimulus within the area receiving more processing power, other information within the perceptive field will be tuned out.

Perception. Perception is a low-level form of sensory information processing that primarily occurs on an unconscious level. It includes recognizing shapes as certain

objects, having light hit the retina at a particular wavelength to produce the appearance of color, and recognizing certain patterns as a face. Perception can be changed through non-sensory means such as our pre-existing knowledge, expectations, and emotions; those non-sensory factors can cause people to interpret what they see in a way differently from others (Coon & Mitterer, 2010). For example, people with aggressive tendencies were quicker to identify aggression in pictures than people with low aggressive tendencies (Forest, 1962 qtd. in Hardy & Heyes, 1999). In a real-life scenario, that might mean one witness would recall a perpetrator as aggressive while another would not.

Encoding. Memory encoding is when sensory information is converted into a form that can be stored in the brain. During this process, new information is weaved together with previous, related information to form one, collective informational pool.

Working memory. Working memory refers to short-term limited-capacity memory mechanisms that can hold encoded information for limited amounts of time so that it can be manipulated. There are four systems to working memory: the central executive, the visuospatial sketchpad, the phonological loop and the episodic buffer (Baddeley & Hitch, 1974; Baddeley, 2000). The systems are shown in the figure below and their roles are explained in the subsequent paragraph.

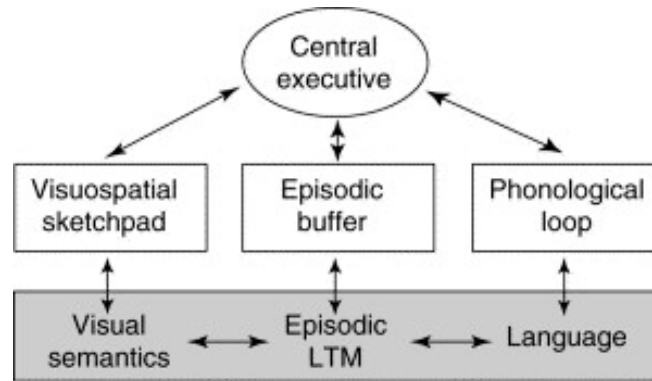


Figure 1. Working memory processes (Baddeley, 2000). The central executive directs information to the visuospatial sketchpad, phonological loop or episodic buffer.

The central executive has a few functions. It directs information to its specific “slave” systems, controls which system gets attention, and shifts between processing information and retrieving it. The visuospatial sketchpad processes visual and spatial information while the phonological loop processes auditory information (e.g. speech, sounds). Both the visuospatial sketchpad and phonological loop have limited working capacities and they can work simultaneously without interfering with each other. Even if one system of working memory (visual or auditory processing) has reached its capacity, the other can still handle information.

The episodic buffer acts as a temporary “back-up” store for information (Baddeley, 2000). It has a limited capacity and contains a mix of visual and auditory information. It is primarily discussed in reference to amnesia patients who are unable to encode information to long-term memory, but can briefly remember episodic information past the normal working capacity of the phonological loop or visuospatial sketchpad.

Long-term memory. Long-term memory is comprised of information that can be remembered for extended periods of time without rehearsal. Rehearsal and retrieval can cement a piece of information's place in long-term memory, but information can still reside for years in long-term memory without retrieval.

Some information will transfer automatically to long-term memory from working memory (as in the case of incidental learning), but information's transfer is typically dependent on control processes (e.g. attention and rehearsal) being devoted to the information (Atkinson & Shiffrin, 1968). Rehearsal is especially important for information in the phonological loop. Verbal information is lost within a few seconds without rehearsal (Baddeley, 2000).

Retrieval. Retrieval, or remembering, is when information is pulled out of storage for recall. Retrieval is both the beginning and end of the memory cycle. After information is recalled, it is re-encoded and stored in order to be retrieved at a later date. Each memory changes slightly every time it is retrieved. During the retrieval process, the brain takes the context of its retrieval into account and weaves it into the original memory itself. Therefore, when information is re-encoded, the context of the last retrieval will be encoded and stored along with the original memory; the context and the memory fuse together to form one "new" memory, changing how it will be remembered next time it is retrieved.

Stress

According to the American Psychological Association, stress is “the pattern of specific and nonspecific responses an organism makes to stimulus events that disturb its equilibrium and tax or exceed its ability to cope.” Stress is a psychological and physiological reaction to a stimulus and a form of arousal. It has been operationalized in different ways. Researchers have used heart rate measures, heart rate variability (HRV), electrodermal activity, cortisol levels, and other indicators as physiological markers of stress. Various psychological measures including self-report measures have also been used.

Effects of stress on performance. Based upon the research of Yerkes and Dodson (1908), the Yerkes-Dodson law describes an inverted-U relation between arousal and performance. It is shown below. In general, small amounts of arousal increase performance. However, after a certain point, arousal levels go past optimal levels and performance decreases.

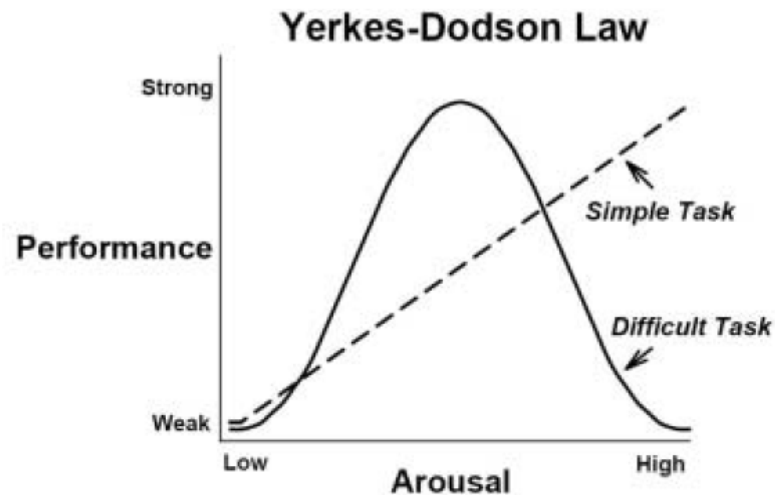


Figure 2. Yerkes-Dodson curve as shown in Diamond (2005). The point of optimal arousal for performance exists at the center of the graph. Performance goes down as arousal exceeds that point.

The model is a rough practical approximation of what happens under varying levels of arousal. It does not differentiate between types of arousal and very few studies elicit varying levels of arousal in their participants to see how their performance changes on various points of the curve, but it is still useful in understanding how arousal can affect performance.

The Yerkes-Dodson model is relevant to eyewitness memory because eyewitnesses of a crime, whether as a victim or as a bystander, are typically subjected to extreme amounts of stress and then are asked to perform a difficult task—recalling details of a crime as accurately as possible despite many factors potentially dividing their attention when the event occurred. This causes eyewitnesses to fall to the right of the curve's point of optimal arousal; the eyewitness' performance ability is harmed.

Effects of Stress on Eyewitness Memory

High Stress Effects Due to Fear

For eyewitnesses, high stress levels are typically due to fear—whether it is fear for their well-being or the well-being of others. There are two main effects of high-stress in eyewitness: decreased encoding of information in general and a narrowing of attention to specific stimuli.

Decreased encoding as stress increases. When eyewitnesses experience high levels of stress, their memory function decreases as their focus shifts to preservation of their well-being instead of processing fine details. Shown in the table below, witnesses of violent events tend to have greater levels of memory disruption. Studies that

measured memory disruption effects using field studies or a staged event found stronger evidence for the relation than laboratory studies or those without a staged event.

Researcher	Type	Witness	Stressor	Brief findings
Kuehn (1974)	Field	Real victims of crimes	Being an actual victim	Increased violence correlated with increased memory disruption
Clifford & Scott (1978)	Lab	Civilians	Violent videos	Memory was worse in the violent video condition; effect stronger in women
Leippe, Wells, & Ostrom (1978)	Lab	Civilians	Watching a theft of a calculator or cigarettes	Increased accurate identification rate if they knew worth of stolen valuable object before the crime
Clifford & Hollin (1981)	Lab	Civilians	Violent videos; increased number of menacing people	Memory was worse in the violent video condition. Memory was worse as number of men increased
Hosch & Cooper (1982)	Lab	Civilians	Victim of theft of a valuable object	Being a victim had a null effect on recall
Hosch, Leippe, Marchioni, & Cooper (1984)	Lab	Civilians	Victim of theft of a valuable object	Being a victim had a null effect on recall
Christianson & Hubinette (1993)	Field	Real witnesses of crimes	Being present during a bank robbery	Victims of the robberies had better recall than bystanders
Stanny & Johnson, exp. 1 (2000)	Lab	Police	Armed suspect with hostage	Increased violence correlated with increased memory disruption
Stanny & Johnson, exp. 2 (2000)	Lab	Police, Civilians	Armed suspect with hostage or in an argument	Increased violence correlated with increased memory disruption; officer performance was not better than civilian performance
Deffenbacher, Bornstein, Penrod, & McGorty (2004)	Meta-analysis	Varies	Varies	High-stress studies with a staged crime produced twice the effect size than those without
Morgan et al. (2004)	Field	Military personnel	Physical interrogation	Increased violence correlated with increased memory disruption
Valentine & Masout (2009)	Field	Civilians	A “scary person”	Increased fear correlated with increased memory disruption
Hope et al. (2016)	Field	Police officers	Armed suspect with a hostage	Increased stress correlated with increased memory disruption

Table 1. The studies discussed in this section that pertain to the effect of *decreased encoding as stress increases*.

Field studies. A benefit to a field study of eyewitness stress is that it creates a more realistic setting for participants and the effects produced are more likely to reflect reality. In one study, Kuehn (1974) analyzed real cases to determine if memory degraded as stress reached high levels. He examined the police reports of 2 homicide victims (taken before the victim died), 22 rapes, 15 assaults, and 61 robberies to see how much and what kind of information was reported for each type of crime. Kuehn found that victims reported more information in less-serious crimes compared to serious ones. Specifically, more details were given by robbery victims compared to rape or assault victims, and injured victims provided less information than their non-injured counterparts regardless of crime. Reported information was not checked for accuracy.

Kuehn also found an effect of sex of the eyewitness. Injured males recalled more details than injured females. Kuehn states that more research is needed to know why females in a violent situation recall less about the perpetrator, but he suggested that females may feel more “fearful, vulnerable, and less capable” in violent encounters. Also, female victims experience a higher, constant threat of being raped in any crime compared to men, which could increase the level of fear aroused in female witnesses and produce a failure to recall details as a side-effect of attempting to “ward off subsequent exposure to the anxiety-arousing content” (Janis & Feshbach, 1953).

Another study recreated the realistic high-intensity stress that a prisoner of war may experience and found a significant effect of stress on memory. Morgan et al. (2004) found that participants under high-stress conditions were significantly less likely to identify their interrogators. Researchers placed participants on the receiving end of two interrogations: a low-stress interrogation and a high-stress interrogation. Following

the interrogations, the participants were asked to identify their interrogators. Regardless of the way their interrogator was presented in a line-up, participants in the high-stress condition were less likely to correctly identify their interrogator.

The participants in Morgan et al. (2004) were 509 active military personnel enrolled in survival school training; no new or inexperienced personnel participated. Participants were placed in a mock prisoner of war camp (POWC) after 48 hours of sleep and food deprivation. Twelve hours after being placed in the POWC, they experienced the first of two 40-minute interrogations. One interrogation was “high-stress” (involving physical confrontation) and the other was “low-stress” (no physical confrontation, but with interrogators trying to “trick” participants into giving information). (*Note: Researchers could not elaborate on what constituted “real physical confrontation” due to details of the survival school course being classified, but asserted that the experience in a POWC was meant to be “highly realistic.”*) Four hours after their first interrogation, they experienced their second. Twenty-four hours after the interrogations were complete, participants received either a photo line-up or a live line-up to identify their interrogator. For 20% of the participants, the interrogator was not present in the line-up.

The table below shows performance data in Morgan et al. (2004). In the high stress condition, participants made fewer true positive identifications (accurately identifying their interrogator when the interrogator was present), more false positive identifications (saying someone was the interrogator when the real interrogator was absent), fewer false negative identifications (saying the interrogator was absent when

the interrogator was present), and more true negative identifications (saying the interrogator was absent when the interrogator was absent).

Type of assessment	Stress condition	
	High	Low
<i>True positive responses</i>		
Live line-up method	40/150 (30%)	113/182 (62%) ^a
Photo spread method	33/98 (34%)	70/92 (76%)
Sequential photo method	20/42 (49%) ^b	42/55 (76%)
<i>True negative responses</i>		
Live line-up method	21/38 (55%)	23/46 (50%)
Photo spread method	12/23 (52%)	9/23 (39%)
Sequential photo method	10/10 (100%) ^c	12/12 (100%) ^d
<i>False positive responses</i>		
Live line-up method	105/188 (56%)	87/228 (38%)
Photo spread method	77/114 (68%)	14/114 (12%) ^e
Sequential photo method	26/51 (51%) ^f	16/64 (25%)
<i>False negative responses</i>		
Live line-up method	0/150 (0%)	5/182 (3%)
Photo spread method	0/91 (0%)	15/24 (61%) ^g
Sequential photo method	0/41 (0%)	0/56 (0%)

Chi-square analyses to compare the methods within a condition (high stress, low stress) and not between the two conditions.

^a Method elicited significantly fewer true positive responses within the low-stress condition ($X^2=7.5$; $df=2$; $P<.02$).

^b Method elicited significantly more true positive responses within the high-stress condition ($X^2=8.3$; $df=2$; $P<.016$).

^c Method elicited significantly more true negative responses within the high-stress condition ($X^2=7.6$; $df=2$; $P<.02$).

^d Method elicited significantly more true negative responses within the low-stress condition ($X^2=12.5$; $df=2$; $P<.002$).

^e Method elicited significantly fewer false positive responses within the low-stress condition ($X^2=25$; $df=2$; $P<.0001$).

^f Trend for false positive responses to be lower within the high-stress condition ($X^2=5.6$; $df=2$; $P<.06$).

^g Method elicited significantly more false negative responses within the low-stress condition ($X^2=86$; $df=2$; $P<.0001$).

Table 2. Eyewitness recognition across type of assessment within stress conditions (Morgan et al., 2004). Participants in the high-stress condition had fewer true positive IDs, more false positive IDs, less false negative IDs, and more true negative IDs.

Additionally, confidence ratings did not significantly differ between accurate and inaccurate IDs in Morgan et al. (2004), implying that confidence level was not an indication of accuracy in this case. This study's finding on confidence levels supports those in other studies (e.g., Garry and Polaschek (2000) and Sporer, Penrod, Read and Cutler (1995)).

In Morgan et al. (2004), both length of exposure to their interrogator's face and previous military experience could have led to a much higher accuracy rate than would be expected of typical eyewitnesses. Each interrogation in the study lasted for approximately 40 minutes, which is a much longer exposure time to a perpetrator's face than a typical eyewitness would have in a mugging, rape, burglary or assault. Exposure duration has a strong positive correlation with ability to identify a perpetrator's face (Shapiro & Penrod, 1986; Memon, Hope & Bull, 2003). Additionally, members of the active military may have had previous training in mock-captive or interrogation situations and may have experienced less stress than civilian eyewitnesses might experience.

In another study, police officers were put into a mock hostage situation and later told to perform recall tasks (Hope et al., 2016). Seventy-six police officers of varying rank were paired and placed in heart rate monitors. One officer was designated the "Active Officer" and the other was the "Observer Officer." Both officers watched CCTV footage of the events that took place before they arrived. This was the "briefing phase." Afterward, the Active Officer was put into the hostage event role-play, armed with a training handgun loaded with blank rounds. The Active Officers were told that they were part of an initial response team and that they should "respond...as they would

normally in the course of their duty.” This was the “response phase.” During the response phase, the Observer Officer could only observe silently. Forty-five to fifty minutes after the response phase, the officers underwent recall tasks for both phases.

The officers showed no difference in quantity of reported accurate or inaccurate information during recall of the briefing phase. In the response phase, the quantity of reported inaccurate information did not vary between the two groups; however, as shown in the table below, Active Officers “reported significantly fewer correct details about the scenario than observer witnesses” during the response phase.

	Active Officers		Observer Officers	
	Mean (SD)	95% CI	Mean (SD)	95% CI
Briefing Phase				
Correct	47.46 (17.37)	[41.97, 52.68]	47.24 (16.01)	[42.32, 52.45]
Incorrect	4.72 (5.66)	[3.16, 6.86]	4.54 (4.21)	[3.25, 6.00]
Accuracy rate	.91 (.08)	[.88, .94]	.92 (.07)	[.90, .94]
Critical response phase				
Correct**	38.67 (10.17)	[35.61, 41.97]	45.84 (12.59)	[42.02, 50.03]
Incorrect	1.64 (2.18)	[1.00, 2.40]	1.29 (1.05)	[.97, 1.66]
Accuracy	.96 (.04)	[.95, .97]	.97 (.02)	[.96, .98]

**p < .01.

Table 3. Means, SDs, and 95% Confidence Intervals for Correct and Incorrect Items Reported and Accuracy Rate by Experimental Group (Hope et al., 2016). Active officers differed significantly from observer officers in the number of correct details about the response phase.

Physiological data from heart rate monitors suggest that stress may have contributed to the smaller number of correct items recalled by Active Officers compared to Observer Officers during the response phase. The Active Officers demonstrated significantly higher average maximum heart rates compared to Observer Officers, and significantly lower heart rate variability (HRV). Lower HRV is associated with increased stress (Thayer et al., 2012). The physiological and recall performance in Hope

et al. (2016) indicates that the increased stress of being engaged in a high-risk situation negatively impacts memory functioning in police officers. Also, these effects were not mediated by rank within the police force, so stress levels and memory performance cannot be attributed to lack of experience.

In another field study of the effects of fear on memory, Valentine & Masout (2009) had participants walk through the Horror Labyrinth of the London Dungeon while wearing heart rate monitors. While walking through the labyrinth, participants encountered a “scary person” who blocked their way, preventing them from proceeding further down the path. Approximately 45-minutes after exiting the labyrinth, participants were given a questionnaire that asked for details about the “scary person” and about their experiences; then, they were shown a photo line-up. People who reported a higher state of anxiety remembered fewer correct details, reported more incorrect details, and were less likely to identify the scary person in the lineup than people who reported lower levels of anxiety.

Lab studies. A benefit of laboratory studies is that researchers can closely control and vary the individual variables affecting stress levels to determine how each of these factors affects eyewitness memory. One common way to examine the relationship between stress and fear is to examine changes in memory performance as the severity or “seriousness” of a crime changes. Seriousness of a crime can refer to how dangerous the crime is, the monetary worth of objects that are stolen or damaged, or the personal stake one has in the crime (Narby, Cutler & Penrod 1996).

In a classic study of crime seriousness, Leippe, Wells, and Ostrom (1978) staged a robbery of a confederate’s pack of cigarettes or a calculator to see if value of an object

would affect a witness' ability to identify the thief. They found higher accuracy rates of identification when the witness knew the item was valuable before it was stolen. If witnesses were told that the item was valuable after the crime occurred, the information did not impact their ability to identify the perpetrator. In this case, we do not see a negative effect on memory because of an insufficient level of witness fear. Witnesses were not personally victimized, the theft was not violent in nature, and there was no chance of bodily harm. Instead, witnesses likely experienced moderate amounts of arousal (increasing their performance) or there was an attention-related effect since the witness' attention was drawn to the object by the confederate before the theft occurred—meaning they were more aware of the object as it was being stolen.

Another way that researchers can induce witness stress is to have participants view videotapes and perform recall tasks. Clifford and Scott (1978) showed violent and nonviolent videos of an interaction between a police officer and a suspect being restrained. They found that recall was significantly much less accurate for the violent video compared to the nonviolent one.

Sex of the witness played a role in recall ability in Clifford and Scott (1978). Women performed significantly worse than men in recall of the violent condition despite equal performance in the nonviolent condition. This difference in recall rates is likely due to higher levels of emotional stress; compared to men, women rated the violent condition as significantly more violent. This corroborates Kuehn's (1974) observation of a sex difference in recall rates for violent crimes.

Clifford and Hollin (1981) ran a similar study to Clifford and Scott (1978) and found that witnesses who viewed tapes with violent footage (a man forcibly stealing a

woman's purse) were significantly worse at accurately describing the assailant than those who watched the non-violent footage (a man asking a woman for directions). The effect became substantially more pronounced as researches increased the number of men standing "menacingly" near the female in the violent condition (Clifford & Hollin, 1981). In the non-violent condition, the increased number of men did not significantly impact memory.

Clifford and Hollin (1981) attribute the poorer memory performance in the violent condition compared to the non-violent condition to the theory that the observed violence generates arousal in the witnesses, thereby narrowing their attention to a limited amount of information and reducing the amount of information being encoded (Easterbrook, 1959; Broadbent, 1971). As for the effect of an increased number of men near the victim reducing recall in the violent condition but not in the nonviolent condition, Clifford and Hollin defer to Wall (1965) for an explanation. Wall asserted that in a "nonviolent setting, witnesses were able to cope with the extra demands on attention, perception, and memory as the number of men increased, but in a 'time of stress,' this ability decreased" (Wall, 1965 qtd. in Clifford & Hollin, 1981). In other words, under high stress, attention is narrowed and the capacity of working memory is decreased.

In a separate lab study, Stanny and Johnson (Experiment 1, 2000) ran a computerized firearms simulation to test police officers' recall under various conditions. Officers were split into a 'no-shoot' or 'shoot' scenario and into an active participant or observer role. In the no-shoot condition, an officer responded to a domestic disturbance situation and encountered a male suspect who reached into his back pocket to remove a

gun (barrel down) and set it on the ground before resuming his stance. In the shoot condition, an officer responded to an abduction call and encountered a male perpetrator holding a knife to a woman's throat before pulling out a gun and firing once at the police officers. Researchers did not find a significant difference in recall between active and observer witnesses.

Stanny and Johnson (Experiment 2, 2000) expanded their first study to measure electrodermal response (EDR) and memory differences between police and citizen witnesses, gaining physiological data to support the stress-memory link found in their first experiment. They also added a "no shoot" abduction scenario and a "shoot" domestic disturbance scenario. Both police and civilian witnesses recalled less information, reported higher levels of stress and showed higher EDR levels in the shoot conditions—showing a strong negative correlation between stress and memory performance. Additionally, both police and civilians recalled less accurate details of the abduction-shoot condition compared to its domestic disturbance counterpart, which is in line with participants rating the abduction-shoot scenario as more violent than the domestic disturbance-shoot scenario. Like in Clifford and Hollin (1981) and Clifford and Scott (1978), witnessing violent situations increased the amount of fear-related emotional distress in witnesses, decreasing their recall ability.

Caveats and additional discussion. Deffenbacher, Bornstein, Penrod and McGorty (2004) found "clear support for the hypothesis that heightened stress has a negative impact on eyewitness identification accuracy" in their recent meta-analysis on stress and eyewitness memory. These researchers found a mean effect size of $-.31$ (95% CI: $-.04$ to $-.58$) for stress across all of the studies in their meta-analysis, showing that

stress does have an effect on witness' ability to recognize faces (Deffenbacher, Bornstein, Penrod, & McGorty, 2004). The first table below shows effect sizes for each study in the meta-analysis. Effect size of about .2 are considered small effects, about .5 are considered medium effects, about .8 are considered large effects, about 1.20 are considered very large effects, and about 2.0 or greater are considered huge effects (Cohen, 1988; Sawilowky, 2009). For table below: the larger the effect size, the worse participants did in the stressful condition compared to the alternate condition in their study's facial recognition measure.

Author	Date	N	Overall (h)	TP (h)	TA (h)
Buckhout et al.	1974	48	-3.02	-3.02	
Mueller et al.	1979	96	.04	.04	
Nowicki et al., Exp. 1	1979	93	-.35	-.35	
Bailis & Mueller	1981	120	.13	.13	
Clifford & Hollin	1981	60	-.16	-.16	
Brigham et al.	1983	20	-.46	-.46	
Bothwell et al., Neurotics ^a	1987	35	-.74		
Bothwell et al., Stables ^a	1987	36	.52		
Cutler et al.	1987	165	-.08		
Tooley, Brigham, Maas, and Bothwell	1987	96	.14	.14	
Peters, TP	1988	106	-.51	-.51	
Peters, TA	1988	106	-.18		-.18
Maas & Kohnken ^b	1989	86	-.43		-.43
Hosch & Bothwell, Exp. 1 ^a	1990	39	.49		
Kramer et al., Exp. 1 ^b	1990	64	-.58	-.58	
Goodman et al., Exp. 1	1991	18	-.47	-.47	
Goodman et al., Exp. 2	1991	47	-.27	-.27	
Goodman et al., Exp. 3	1991	34	.24	.24	
Peters, Exp. 1, TP	1991	36	-.57	-.57	
Peters, Exp. 1, TA	1991	35	-.04		-.04
Peters, Exp. 2, TP	1991	34	-.61	-.61	
Peters, Exp. 2, TA	1991	33	.32		.32
Peters, Exp. 3, TP	1991	32	-1.32	-1.32	
Peters, Exp. 3, TA	1991	32	.39		.39
Peters, Exp. 4 ^a	1991	96	-.12		
Peters, Exp. 1 ^a	1997	64	-.42		
Peters, Exp. 2 ^a	1997	96	-.31		

^a Only overall proportion correct reported.

^b Weapon visibility totally confounded with anxiety level; thus reported as a stress effect.

Table 3. Identification Accuracy Effect Sizes (Deffenbacher, Bornstein, Penrod, & McGorty, 2004). The larger the effect size, the larger the gap is for recall performance between the stressful and alternate condition.

In another table below, Deffenbacher, Bornstein, Penrod, and McGorty (2004) show effect size by type of analysis. It shows that studies with a staged crime (e.g. a role-play scenario or watching video footage) produced twice the effect size than those that studied the effect of stress on memory without a staged crime in their study. Deffenbacher and colleagues' finding on larger effect size for staged-crime studies is congruent with the effects found in the video tape and field studies (Clifford & Hollin, 1981; Clifford & Scott, 1978; Stanny & Johnson, 2000) discussed in the above section. The studies without a staged crime used things such as social anxiety as their type of measured stress instead of fear-based stress. Furthermore, the table below shows an effect of line-up type on recognition tests. The greatest stress effects on memory for faces were found in target-present line-ups instead of target-absent line-ups, a result that Deffenbacher and colleagues attribute to stress. In high-stress situations, memory of perpetrator appearance would be negatively affected enough that that witness cannot make an accurate ID in a target-present line-up—lowering the overall accuracy rate. The same high-stress effect would be present in a target-absent line-up, except the suspects would only match the general verbal description given by the witness instead of the witness' higher-quality visual memory of the event—making it more likely that a witness correctly rejects target presence, maintaining a higher overall accuracy rate.

Type of Analysis	Effect size	
	<i>h</i>	<i>d</i>
Identification accuracy		
All tests ^a	-.31	
All tests ^b	.22	
TP lineups ^a	-.52	
TA lineups ^a	.01	
TP lineups ^b	.37	
TA lineups ^b	.00	
Identification paradigm ^a	-.36	
Recognition paradigm ^a	-.10	
Staged crimes ^a	-.58	
Other stressors ^a	-.28	
Adult witnesses ^a	-.34	
Child witnesses ^a	-.27	
Recall accuracy		
All tests		-.31
Interrogative recall		-.34
Narrative recall		-.20
Adult witness		-.44
Child witness		-.06
Staged crimes		-.45
Other stressors		-.16

^a Overall proportion correct, including hit and correct rejections rates

^b False alarm rate

Table 5. Meta-Analysis Effects by Type of Analysis (Deffenbacher, Bornstein, Penrod, & McGorty, 2004). TP and TA line-ups refer to target-absent and target-present scenarios. The larger the effect size, the larger the gap is for recall performance between the stressful and alternate condition.

In addition to Deffenbacher, Bornstein, Penrod, and McGorty (2004) uncovering interesting stress effects, researchers in Stanny and Johnson (Exp 2., 2000) were surprised by several of their results. Police witnesses reported higher stress levels, had significantly more pronounced EDR activity, and rated the shoot-conditions as more violent than the civilian witnesses did. Despite that, police did not differ significantly in recall accuracy from civilian witnesses even though police recalled a greater quantity of information. These researchers hypothesized that police may have a “superior ability” to recall witnessed information, but their increased stress levels may mask that effect. As for why police officers reported a higher level of stress compared to civilians, the authors suggest that police are asked to justify the use of lethal force, their decisions are

more heavily scrutinized by the public and by superiors, and they experience continuous stress knowing that their performance might be judged (Stanny & Johnson, 2000). Not discussed by the researchers is that police officers may also experience a more pronounced feeling of a constant, present threat (as discussed with Kuehn, 1974; Janis & Feshbach, 1953). Compared to civilians, police training may make officers more sensitive to and aware of the danger in an event or, at minimum, understand that there is the potential threat of it. This looming threat could increase officers' stress response thereby decreasing their recall ability.

An alternate explanation for why police remember a larger quantity of details in Stanny and Johnson (Exp. 2, 2000) is that police officers are trained to observe and may make a point to remember more details of an event compared to a civilian witness who may not make that effort. They are not better at it (as shown by the two groups having the same accuracy rate); they simply make an effort. Also, a measurement issue could explain why the accuracy rate of recalled information for civilians and police did not differ despite the physiological data showing significant differences. EDR and heart rate are sensitive forms of measurement, whereas general recall tasks are not. It is possible that an effect could appear if the performance measurement were more accurate.

Also worth discussing is the conflicting evidence on whether being a victim-witness opposed to a bystander-witness changes one's ability to remember a crime. Kuehn (1974) presented strong evidence for degradation of memory as fear increased in a victim. Even though there was no bystander group in Kuehn (1974), it seems reasonable to assume that the increased fear associated with being a victim instead of a bystander would further reduce recall ability. Two studies may offer support for that

claim: Hosch, Leippe, Marchioni and Cooper (1984) and Hosch and Cooper (1982).

Both studies found a null effect of victim-stress on memory, but the researchers may not have elicited enough stress in the victim-witnesses for them to differ significantly from bystander-witnesses. Researchers had participants witness the theft of a valuable object (an expensive watch or calculator sitting on a table) and found that witnessing one's own object being stolen had no impact on memory compared to non-victim witnesses. In this case, the lack of memory degradation found in victim-witnesses is likely because they did not experience a significantly larger amount of stress compared to bystander-witnesses. If victims do not differ significantly from bystanders in their level of stress, there is no reason to expect a difference in their memory. There was no threat of bodily harm or inherent danger associated with the event for either victim- or bystander-witnesses; witnesses simply watched confederates run out with the belongings that were located in a separate part of the room. In fact, the only time in the Hosch studies that victims performed more poorly than non-victims was when a victim felt pressure to make an identification (Hosch, Leippe, Marchioni, & Cooper, 1984).

Christianson and Hubinette (1993) found results that appear to directly oppose the theory based on Kuehn (1974), but upon further analysis, these results actually support Kuehn's theory. Christianson and Hubinette (1993) studied the memories of 58 victims and bystanders of 22 separate post office robberies and found that victims had more accurate recall than bystanders. After the bank robberies, the victims (tellers with a gun pointed at them) and the bystanders (other employees or customers) filled out a report detailing their "emotional reactions" as well as details of event as they remembered them. The witnesses' reports were compared to information in police

reports to determine accuracy. Christianson and Hubinette found that self-reported emotional arousal did not differ significantly between victims and bystanders (supporting results in Hosch & Bothwell, 1990). As in Hosch, Leippe, Marchioni, and Cooper (1984) and Hosch and Cooper (1982), if emotional arousal does not differ between victims and bystanders, there is no reason to suspect that their memory performance will differ either. Victims' better accuracy could be due to position and distance. They were closer to the events as they unfolded and may have had a better viewing angle.

There are a few important details to note about Christianson and Hubinette (1993) before comparing their results to Kuehn (1974). First, Christianson and Hubinette exclusively studied robbery cases. Kuehn examined robberies, but also examined cases of rape, assault and homicide. It is possible that Kuehn saw much stronger fear-based effects because he was looking at significantly more serious crimes, which induced more stress. Also, examining a greater range of crimes would make it easier to find effects. Additionally, neither Kuehn nor Christianson and Hubinette checked the cases for accuracy, only for quantity of information given. Christianson and Hubinette compared testimony to police reports, but there was no way for the researchers to analyze the accuracy of the details.

Narrowing of attention. In eyewitnesses, observed violence generates arousal, thereby narrowing their attention to a limited amount of information—usually the stressor—and reducing the amount of information encoded (Easterbrook, 1959; Broadbent, 1971). The reduction of encoded information is due to focus being drawn to a specific aspect of an event, and less processing being directed toward other details (*see: Mechanisms of Memory section*).

The table below (which is continued onto the next page) shows the studies that will be discussed in this section. The general results are that attention is drawn more toward actions and away from specific descriptions and details. Also, attention is drawn to unusual, unexpected, or threatening objects.

Researcher	Type	Witness	Stressor	Brief findings
Clifford & Scott (1978)	Lab	Civilians	Violent videos	Actions were recalled more frequently than descriptions; effect more pronounced in the condition
Hosch & Cooper (1982)	Lab	Civilians	Victim of theft of a valuable object	Null effects: Attention did not narrow to perpetrator's appearance despite absence of weapon or threat of bodily harm
Hosch, Leippe, Marchioni, & Cooper (1984)	Lab	Civilians	Victim of theft of a valuable object	Null effects: Attention did not narrow to perpetrator's appearance despite absence of weapon or threat of bodily harm
Tooley, Brigham, Maas & Bothwell (1987)	Lab	Civilians	Weapon	Weapon presence decreased ability to identify a face
Stebly (1992)	Meta-analysis	Varies	Varies	Larger weapon focus effect sizes found in studies with a threatening object and high stress levels
Christianson & Hubinette (1993)	Field	Real witnesses of a crime	Being present during a bank robbery	Actions were recalled more frequently than descriptions
Mitchell, Livosky, & Mather (1998)	Lab	Civilians	Unusual object, weapons	Unusual objects and weapons decreased ability to recall perpetrator's appearance
Shaw & Skolnick (1999)	Lab	Civilians	Unusual object, gun	Unusual objects decreased ability to identify a face; effect more pronounced with a gun

Pickel (1999)	Lab	Civilians	Gun	Gun presence decreased ability to recall perpetrator appearance only when the gun was unexpected
Stanny & Johnson, exp. 1 (2000)	Lab	Police	Gun, knife	Perpetrator details were the least remembered; actions, victim, and weapon details most remembered
Stanny & Johnson, exp. 2 (2000)	Lab	Police, Civilians	Gun, knife	Perpetrator details were the least remembered; actions, victim, and weapon details most remembered
Pickel, French, & Betts (2003)	Lab	Civilians	Weapon	Weapon presence only affected auditory memory retention when it contained complex, semantic information
Deffenbacher, Bornstein, Penrod, & McGorty (2004)	Meta-analysis	Varies	Varies	High-stress more likely “debilitate” memory for human face; results not likely to be overturned
Hope et al. (2016)	Field	Police officers	Gun	Substantial memory corruption for weapon-related details

Table 6. The studies discussed in this section that pertain to the effect of *narrowed attention*.

Lab studies. Clifford and Scott (1978) showed attentional effects in their video study in addition to the previously discussed effect of general memory disruption (*see: Decreased encoding as stress increases section*). They found that actions were recalled much more frequently than descriptions in both the violent and non-violent videos, but the difference was significantly more pronounced in the violent condition (Christianson & Hubinette, 1993 found similar results).

In Stanny and Johnson (Experiments 1 and 2, 2000; *see: Decreased encoding section*) for both shoot and no-shoot scenarios, details of the perpetrator were the least-remembered type of detail, an effect that increased in the shoot situation. Details of the victim, weapon, and actions of the suspect were the most remembered (*see: Weapon focus section*). Police remembered more details of the victim compared to details of the perpetrator. This may have occurred because the officers’ focus was drawn to the victim. It is the police officer’s job to protect people with as little collateral damage as

possible. Using the study's abduction-shoot scenario as an example, the officers' focus was likely drawn to the state of the woman with a knife to her throat as they closely monitored her well-being until she was out of harm's way. As the officers' focus "tuned in" to the victim and what the weapon was doing in relation to the victim, details of the perpetrator faded into the periphery.

Deffenbacher, Bornstein, Penrod, and McGorty (2004) found that when it came to remembering necessary details (e.g. perpetrator characteristics, crime scene details, and actions of the central characters) as an eyewitness to the crime, "heightened stress is much more likely to have a debilitating effect on memory for the human face." This result supports those in Stanny and Johnson (2000) and Clifford and Scott (1978) in that attention is drawn away from descriptions, especially the appearance of a perpetrator's face, when a witness is stressed.

Weapon focus effect. Weapon focus is a special case of narrowed attention with the weapon as the stressor. If a weapon is present, attentional resources will be directed to the weapon instead of to other details in the environment and those peripheral details will not be as accurately encoded, if encoded at all.

Overall, subjects are much better at identifying a person without a weapon than a person who has one (Tooley, Brigham, Maass, & Bothwell, 1987). It is possible that the presence of a weapon causes an interaction of two variables—narrowed attention to the weapon due to fear of the object and narrowed attention due to it causing high arousal—and this interaction is what "maximizes" the effect of selective encoding (Stebly, 1992). A real-life encounter with a weapon during a crime will likely produce high levels of arousal that will accelerate the narrowing of perceptive fields to the object

that is most important in the environment—the weapon (Loftus, Loftus, & Messo, 1987; Easterbrook, 1959). In the table below of studies analyzed in Steblay (1992), the hypothesis that high stress will increase the effect of weapon focus is supported. Steblay (1992) shows the greatest weapon focus effect sizes are found in studies that have a gun or high levels of witness arousal.

Study	Date	Effect size	Z	Total N	Arousal	Mode	Weapon	Interval
Bothwell	1991	-.43	-1.11	27	Low	Video	Gun	Same day
		.00	.00	28	Low	Video	Knife	Same day
Cutler & Penrod	1988	-.14	-.91	175	Moderate	Video	Gun	Same day
Cutler et al.	1987a	.29	1.32	165	Moderate	Video	Gun	Delay
Cutler et al.	1987b	.04	.34	290	Moderate	Video	Gun	Delay
Cutler et al.	1986	.00	.00	320	Moderate	Video	Gun	Same day
		.23	1.93	287	Moderate	Video	Gun	Delay
Johnson & Scott	1976	.35	1.21	48	High	Staged	Opener	—
Kramer	1990	.04	.16	62	Low	Slides	Cleaver	Same day
Kramer et al.	1990	.61	1.64	64	Moderate	Slides	Bottle	Same day
		.06	.25	64	Low	Slides	Cleaver	Same day
		.00	.00	32	Low	Slides	Cleaver	Same day
		.43	1.50	48	Low	Slides	Cleaver	Same day
Loftus et al.	1987	-.12	-.38	42	Low	Slides	Cleaver	Same day
		.67	1.93	36	Moderate	Slides	Gun	Same day
Maass & Kohnken	1989	.47	2.06	80	Moderate	Slides	Gun	Same day
		.43	1.96	86	High	Staged	Syringe	Same day
O'Rourke et al.	1989	.22	1.28	132	Moderate	Video	Gun	Delay
Tooley et al.	1987	.08	1.65	96	Moderate	Slides	Gun	Same day

Table 7. A meta-analysis of weapon-focus studies from Steblay (1992). Studies with substantial effect sizes are those with high levels of arousal or a threatening object (including a gun), confirming the hypothesis that both high levels of witness stress and threatening objects contribute to the memory corruption associated with weapon focus.

Certain factors can increase the weapon focus effect. Pickel (1999) found that if the weapon is unexpected or surprising, there is greater memory disruption in the witness. Pickel asked individuals to watch videos of a man interacting with a woman. The man carried either a gun or a neutral object. There was no effect of the gun in situations where one was expected or normal (e.g. a shooting range or one being carried

by a police officer), but witnesses were significantly worse at describing the man in situations where the gun was unexpected (e.g. if the man and woman were at a baseball field or the man was dressed as a priest).

Furthermore, Shaw and Skolnick (1999) found that attention was diverted away from a confederate's face if the confederate carried an unusual or salient object. When the salient object was a gun, the effect was more substantial. The findings in Shaw and Skolnick support those in Mitchell, Livosky, and Mather (1998) where it was found that both weapons and novel or unusual objects would distract witnesses and negatively affect their ability to remember faces of the people carrying said objects. Mitchell, Livosky, and Mather suggest that the "weapon focus effect may be a misnomer for a more general attention effect" for salient and unusual objects. However, Shaw and Skolnick (1999) suggest that the presence of a weapon reduces identification accuracy more than other unusual objects. Overall, the findings in Pickel (1999), Shaw and Skolnick (1999) and Mitchell, Livosky, and Mather (1998) imply that unexpected or unusual objects will draw attention because witnesses are not prepared for them and that a threatening object will exacerbate this effect, perhaps through increasing stress.

The police study, Hope et al. (2016), found an exceptional level of memory corruption when it came to weapon-related information compared to other details. The captor in the hostage situation had a clearly visible weapon that remained in the waistband of their pants for the entirety of all trials. Thirty-three of the thirty-nine active officers (85%) discharged their weapons during the simulation, with 18% falsely recalling that the perpetrator pointed their weapon at them. Additionally, 15% of the Active Officers and 22% of the Observer Officers falsely reported seeing the gun in the

hands of the perpetrator. Although there was no weapon-absent group for comparison in this study, the level of memory inaccuracy for weapon-related information is substantial enough to warrant note.

While the previously discussed weapon focus articles show an effect on episodic visual memory, it seems to only affect witness' retention of auditory information under specific circumstances (*see: Working Memory section*). Pickel, French, and Betts (2003) found that the presence of a weapon did not affect the retention of vocal characteristics such as a target's vocal pitch, loudness, or speech rate as long as the auditory information was easy to understand. The presence of a weapon only worsened memory in situations where the auditory information contained semantic information that was difficult to comprehend. This is because there are different working memory stores for auditory and visual memory (*see: Working memory section*).

Caveats and additional discussion. Hosch, Leippe, Marchioni, and Cooper (1984) and Hosch and Cooper (1982) both found null attentional effects in their studies, appearing to contradict other literature on narrowed attention. In both studies they found that victim-witnesses were not better at recognizing a thief than bystander-witnesses even though their increased stake in the crime (their belongings being stolen) caused them to pay more attention to it. Additionally, one might expect that victim-witnesses in these studies would have their attention narrow to the face of the perpetrator since there was no weapon nor threat of bodily harm to draw their attention to other details. However, researchers did not find that hypothesized result to be true. After obtaining their null results, Hosch and Cooper speculated that even though the victim-witnesses likely had heightened attention to the crime compared to the other witnesses, the effects

of that heightened attention may have been diminished by the stress and arousal associated with being a victim even if that stress was not high. Narby, Cutler and Penrod (1996) agreed with Hosch and Cooper that their data had been confounded by victim-witness stress since Hosch and Cooper did not measure anxiety or stress levels in their participants.

Attention to central information. There is some evidence that eyewitnesses are able to accurately and reliably recall central details of an event. The hypothesis for increased recall of central details is based off of narrowing of attention studies; in theory, if attention is narrowed to a certain aspect of an event, a witness has a better chance of remembering it. What is considered a “central detail” compared to a “peripheral detail” is not universally defined, but there are some similarities across studies. The table below shows the studies that will be discussed in this section pertaining to recall of central versus peripheral information. The general results show that actions of people are usually remembered while details about perpetrator appearance are forgotten.

Researcher	Type	Witness	Stressor	Brief findings
Kuehn (1974)	Field	Victims of crimes	Being an actual victim	Details of perpetrator appearance were the least-reported and most misremembered detail
Christianson & Loftus (1987)	Lab	Civilians	Traumatic image slides	Participants remembered key information about traumatic images over time better than non-traumatic images
Christianson & Loftus (1990)	Lab	Civilians	Recall of participants' most traumatic memory	Participants believed they recalled more central details than peripheral ones
Christianson (1992)	Meta-analysis	Varies	Varies	Emotional or traumatic events are well-retained over time
Christianson & Hubinette (1993)	Field	Real witnesses of a crime	Being present during a bank robbery	Recall of central details was more accurate than peripheral details
Stanny & Johnson exp. 1 (2000)	Lab	Police	Armed suspect with hostage	Perpetrator details were the least remembered; actions, victim, and weapon details most remembered
Stanny & Johnson, exp. 2 (2000)	Lab	Police, Civilians	Armed suspect with hostage or in an argument	Perpetrator details were the least remembered; actions, victim, and weapon details most remembered
Deffenbacher, Bornstein, Penrod, & McGorty (2004)	Meta-analysis	Varies	Varies	High-stress more likely "debilitate" memory for human face; results not likely to be overturned

Table 8. The studies discussed in this section that pertain to *attention to central information*.

Field studies. Christianson and Hubinette (1993; *see: Decreased encoding, discussion section*) found that for both victim and bystander groups, memories of peripheral details (e.g. date and time) of the robbery were less accurate than details directly related to the emotionally arousing event itself (e.g. actions and weapons). Data were taken from the statements of 58 victims and bystanders of 22 separate post office robberies which were compared to police reports for accuracy.

In a meta-analysis, Christianson (1992) hypothesized that the victim versus bystander recall results reported by Christianson and Hubinette (1993)—which was in press at the time—were a result of “flashbulb memories” formed in the minds of the

victims. Flashbulb memories are extremely “vivid” memories of an event and the circumstances surrounding it; they are formed when an event is “very surprising and consequential (or emotionally arousing)” (Brown & Kulik, 1977). Flashbulb memories “and other studies of real-life events suggest that highly emotional or traumatic events are very well retained over time, especially...detailed information directly associated to the traumatic event” (Christianson, 1992).

Lab studies. Christianson and Loftus (1987) studied recall of traumatic memories using image slides to simulate the emotional distress witnesses may experience. They found that people could remember the “essence” or “theme” of traumatic memories remarkably well, but had impaired memory for both specific and peripheral details of the traumatic event. They tested this by presenting participants with three “phases” of slides, with each phase having five image slides. Phase one and three were neutral events and were identical between the traumatic-slide group and the neutral group. Phase two was where the two groups differed. In the traumatic group, the phase two slides showed a young boy getting hit by a taxi cab and lying on the hood of the car, bleeding profusely from one eye. In the neutral group, phase two slides showed a young boy catching a taxi with his mother and going to school.

Christianson and Loftus (1987) did not explicitly define what a central or peripheral detail was before the start of the study, but did notice that there was better retention over time for the “distinguishing characteristics” of the traumatic scenario (e.g. “blood,” “eye injury,” “taxi”) compared to the neutral scenario. In a follow-up experiment, researchers determined that the results in the original slide study were not

due to the words themselves being more memorable; the details of the traumatic event were more memorable, likely due to the level of emotional arousal in the witness.

Similarly, Christianson and Loftus (1990) concluded that high emotional intensity, like the kind that would occur in a serious crime, correlates with “relatively” accurate recall for central details, but “relatively” inaccurate recall for the peripheral details of the event. Also, the more emotionally intense the event, the more participants believed that they were remembering central details.

The data in Christianson and Loftus (1990) was gathered through the use of questionnaires. They asked participants to report details of their most traumatic memory and rate the emotional intensity. Like Christianson and Loftus (1987), there were no pre-defined criteria for what made a detail central or peripheral. They left it up to the witness to categorize the type of detail they remembered. Researchers did not share what proportion of the reported details were about actions, weapons, facial features, feelings, etc., only whether or not the participant believed them to be central or peripheral to their traumatic event.

Caveats and additional discussion. There are obvious problems with a few of the studies used as evidence for this proposed effect of increased recall for central information. In Christianson and Loftus (1990), data were gathered using questionnaires; there was no way to determine how psychologically traumatic one person’s event was in comparison to another person’s event. They even cite an instance where one person in their study described the death of a parent as being an 11, the highest level of trauma possible, while another described being robbed as a 7 because,

regardless of how traumatic it felt at the time, she understood that the events could have been significantly worse and more traumatic for her.

Christianson and Loftus (1990) has another issue and it is a problem also found in Christianson and Hubinette (1993). The inherent problem with both flashbulb memory studies and studies of real-life events is that there is no baseline measure for comparison or a way to measure the accuracy of the details witnesses report remembering (Christianson, 1992).

Christianson (1992) is a meta-analysis that found that stress improved memory functioning, especially for central details. It included all of the studies mentioned in this section in their data. However, the problem with Christianson, or any of these central versus peripheral detail studies, is that there is no definition of a central detail and, more importantly, there is no discussion on how to classify a perpetrator's facial features—which are critical for an identification.

As shown by Stanny and Johnson (2000) and Kuehn (1974), the details of a perpetrator's face are simply not important enough to be encoded during times of extreme stress and fear. Across studies, the focus of stressed witnesses is drawn to information that is pertinent to their immediate well-being or the well-being of others. This includes things such as the actions of a perpetrator, the weapon used (if one was present) and, for police, information about the well-being of the victim (Stanny & Johnson, 2000; Christianson & Hubinette, 1993). In fact, memory of perpetrator details was the least remembered type of detail in Kuehn (1974) and in both experiments of Stanny and Johnson (2000). Kuehn found exceptionally bad recall for perpetrator descriptions when it came to hair color, eye color and, in violent crimes, race. Memory

of those key distinguishing features is necessary to make an accurate eyewitness identification. I argue that, although details of a perpetrator's face are important for an investigation, it is not information that will protect a witness during a crime (unlike information about a perpetrator's actions or weapon); therefore, a perpetrator's appearance should be categorized as a "peripheral detail" and the possible effect of increased attention will not apply to it.

Deffenbacher and his colleagues (2004) examined the studies that comprised Christianson's (1992) meta-analysis. They determined that the procedures used in the studies in Christianson's meta-analysis were unintentionally generating an "orienting response" in their witnesses instead of a "defensive response." An orienting response occurs when a person reacts to a change in their environment and a defensive response occurs when a person reacts to potentially threatening stimuli. In a real crime, eyewitnesses will likely experience a defensive response, so studies eliciting that defensive response are what should be examined. Additionally, Cutler (2006) says that one downfall of Christianson's meta-analysis is that it came out before some of the most compelling literature on eyewitness stress was published.

Amelioration: Accounting for System Variables in Legal Proceedings and Best Practices for Police

Although there is no official courtroom procedure or jury briefing required for eyewitness testimony nationwide, North Carolina, Minnesota and Wisconsin all have updated their police procedures to include double-blind line-ups and confidence statements during the identification process (The Justice Project, 2007). Double-blind line-ups are when neither the witness nor the line-up administrator know who the suspect is, reducing the possibility that the administrator will intentionally (or unintentionally) push a witness toward picking a certain suspect. Confidence statements are explanations given by witnesses after choosing someone out of a line-up; witnesses describe the level of confidence they have in their identification being accurate. Also, police now make disclaimers at certain points in the identification process (e.g. “The suspect may or may not be in the line-up.”) to reduce pressure on the witness in order to cut down on false identifications.

Certain groups within the legal system (particularly defense attorneys) are extremely likely to hold the belief that eyewitnesses are often inaccurate due to estimator variables and then challenge the legitimacy of eyewitness evidence in court (Brigham & WolfsKeil, 1983). Although the above police practices will not cut down on challenges of admissibility based on situational factors during a crime, following these procedures will make a judge less likely to throw out eyewitness evidence due to police error or misconduct after an attorney questions the handling of an eyewitness.

In addition to understanding the system variables that can affect an eyewitness, police can benefit from knowing the literature on stress as an estimator variable. For

example: If police are given two witnesses, one close to an armed perpetrator and another further away, it would save them time and resources to know what kind of information to pursue with each witness. With the witness close to the armed perpetrator, police should focus on weapon-related questions while being extremely wary of any perpetrator descriptions given by the witness. This is because attention would narrow to the weapon (i.e., the weapon focus effect) and extreme levels of stress caused by weapon and by being in close proximity to the perpetrator would degrade memory for perpetrator descriptions. With the witness that was further away, police can better-trust reported perpetrator descriptions since the lack of proximity to the weapon and to the perpetrator would cause that witness to have less stress compared to the one who was closer.

Court Cases

Oregon and New Jersey both considered the current work on eyewitness unreliability and have changed courtroom policy. Both *State v. Lawson/James* (2012) and *State v. Henderson* (2011) outlined stricter protocols for handling eyewitnesses in order to cut down on misidentifications caused by system variables. Amongst other things, police can only show photo-spreads in particular ways and at particular times to prevent an innocent face from being ingrained into a witness' memory. Also, they are required to ask for confidence ratings after each witness identification.

With *State v. Henderson* (2011), the New Jersey Supreme Court revamped their state's protocol on admitting eyewitness evidence. There are now more than a dozen factors that need to be considered before admitting eyewitness testimony, including things such as: the line-up being conducted using a double-blind procedure, the duration

of the crime, lighting during the incident, how stressed the witness was during the event, and if the witness is attempting a cross-racial identification. Additionally, if “disputed evidence” is admitted into the courtroom, the judge has to brief jurors—in the middle of a trial—on the factors that could lead an eyewitness to make an inaccurate identification (Weiser, 2011).

The Oregon Supreme Court published their verdict in *State v. Lawson/James* (2012), a unanimous, consolidated opinion on two cases that primarily hinged on eyewitness testimony. *State v. Lawson/James* reformed previous eyewitness policy that had been established in *State v. Classen* (1979). In *Lawson/James*, the Court outlines the importance of evaluating estimator variables (specifically witness stress, viewing conditions, and exposure time to the perpetrator) before determining the reliability of the witness. The court then shifted the burden of responsibility to the prosecutor to prove that the witness is reliable instead of having the jury discern witness credibility once the witness was on the stand. With *Lawson/James*, the prosecutor has to prove to a judge that the witness is credible and the judge determines whether or not that witness’ testimony will be allowed in the courtroom.

Even though both *State v. Lawson/James* and *State v. Henderson* list stress as a factor that needs to be considered before admitting eyewitness evidence, there is no guide for judges on how to determine if a witness was stressed nor is there a guide delineating all of the factors that can cause witness stress. As discussed throughout this paper, stress can be elicited through visually perceptible (e.g. weapon presence, physical violence) and non-perceptible means (e.g. for women—the potential threat of being raped; for officers—the potential threat of scrutiny by superiors). *State v.*

Lawson/James and *State v. Henderson* are steps in the right direction, but those in the judicial sphere should be equipped with better, up-to-date information on the relation of stress to other variables and effects of stress in all of those cases.

Remaining problems. Although the aforementioned changes in courtroom and police procedures are positive, they primarily focus on system variables and do not have a clear, concise way of handling and evaluating relevant estimator variables. Dr. Brian Cutler, a specialist in eyewitness research and former editor-in-chief of *Law and Human Behavior*, wrote that there are a few estimator variables that are reliable predictors of identification accuracy: own-race bias, exposure duration, masking of hair and hairline cues, weapon focus, eyewitness stress, and the passage of time (Cutler, 2006). In legal proceedings, eyewitness evaluations should have these specific factors examined—although Cutler qualifies that any of the effects of these estimator variables can be altered by other factors. However, similar to what was described with stress in *State v. Lawson/James* (2012) and *State v. Henderson* (2011), there is no guide for law enforcement on how and to what extent various estimator variables can affect eyewitnesses, just that there is an effect.

Another problem is that the stress-memory data that exists are relatively recent. Fifteen years ago, a survey of opinions of researchers in psychology showed that 81-90% of psychologists believed that data on weapon focus, own-race bias, exposure duration, and passage of time were all reliable enough to present as expert testimony in a court, but only 50% of them believed that the information on stress was reliable enough to present as expert testimony (Cutler, 2006; Kassin, Tubb, Hosch & Memon, 2001). The 2001 survey came out before the publishing of some of the most influential

stress-memory articles in the field. Specifically, Cutler singles out the meta-analysis of Deffenbacher, Bornstein, Penrod, and McGorty (2004) and the military study Morgan et al. (2004) as having “compelling evidence” and believes that those studies would have greatly altered the results of Kassin, Tubb, Hosch, and Memon’s 2001 survey (Cutler, 2006). The field of psychology needs a more recent survey of expert opinions on stress in order to convince those in the criminal justice and legal system that policy changes need to be implemented.

Conclusion

There is strong evidence that stress negatively impacts eyewitness memory. High stress disrupts memory encoding and also causes attention to narrow, limiting the amount of information being accurately stored. In field and video studies, there was a strong trend of witnesses performing worse in the violent (i.e., high stress) condition compared to the neutral one. High stress levels in witnesses are typically caused by fear.

In stressful conditions, peripheral details of the event (such as perpetrator details) were the least-remembered piece of information while distinguishing characteristics that are important to the witness at the time of the event (such as information about the weapon and the actions of the perpetrator) were the most-remembered type of information. Furthermore, if there is a weapon or threatening object present, attention is drawn to it and the ability to recall information about other details goes down—especially if the weapon is unexpected or surprising. If the weapon is expected, like at a gun range, the effects of narrowed attention to the weapon are diminished.

Additionally, there is some evidence for increased attention to central details due to a narrowing of attention as stress increases, but more research is needed on how accurate those memories are and if they change over time. Also, it is likely that the effect of increased recall ability that is associated with increased attention would not apply to eyewitness identifications since a perpetrator's face likely qualifies as a "peripheral detail." Either way, understanding how various factors affect stress and eyewitness recall will allow the criminal justice system to account for and predict the type of errors a witness may make.

Finally, although there have been strides in the criminal justice system with handling eyewitness evidence, improvements need to be made. Not only do more states need to adopt courtroom policy like Oregon and New Jersey did with *State v. Lawson/James* (2012) and *State v. Henderson* (2011), but *Lawson/James* and *Henderson* can still be improved. Both could benefit from clearer explanations of stress and its effects under specific circumstances as well as factors that can contribute to witness stress. Police officers can also benefit from understanding social science literature. Understanding what lines of questioning are likely to produce useful information instead of no information (or worse, misinformation) based on the situational factors that the witness experienced during the crime can save them important time and resources in the long-run.

Despite more research being needed in a few areas of eyewitness stress and memory, the current evidence of stress' negative effect on memory performance is overwhelming and convincing. Knowing that, there should be a push for reform in the criminal justice sector in order to minimize the amount eyewitness misinformation being used in the legal system.

References

- Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. *The Psychology of Learning and Motivation*, 2, 89-195. [http://dx.doi.org/10.1016/S0079-7421\(08\)60422-3](http://dx.doi.org/10.1016/S0079-7421(08)60422-3)
- Baddeley, A. (2000). The episodic buffer: A new component to working memory? *Trends in Cognitive Science*, 4(11), 417-423.
- Baddeley, A. D., & Hitch, G. (1974). Working memory. *Psychology of Learning and Motivation*, 8, 47-89. [http://dx.doi.org/10.1016/S0079-7421\(08\)60452-1](http://dx.doi.org/10.1016/S0079-7421(08)60452-1)
- Braun, K. A., Ellis, R., & Loftus, E. F. (2002). Making my memory: How advertising can change our memories of the past. *Psychology and Marketing*, 19(1), 1-23.
- Brigham, J. C., & WolfsKeil, M. P. (1983). Opinions of attorneys and law enforcement personnel on the accuracy of eyewitness identifications. *Law and Human Behavior*, 7(4), 337-349. <http://dx.doi.org/10.1007/BF01044736>
- Broadbent, D. E. (1971). *Decision and stress*. London: Academic Press.
- Brown, R., & Kulik, J. (1977). Flashbulb memories. *Cognition*, 5(1), 73-99. [http://dx.doi.org/10.1016/0010-0277\(77\)90018-X](http://dx.doi.org/10.1016/0010-0277(77)90018-X)
- Buckhout, R. (1974). Eyewitness testimony. *Scientific American*, 231(6), 23-31.
- Calvin Johnson. (n.d.). Retrieved October 16, 2015, from Innocence Project website: <http://www.innocenceproject.org/cases-false-imprisonment/calvin-johnson>
- Christianson, S.-A. (1992). Emotional stress and eyewitness memory: A critical review. *Psychological Bulletin*, 112(2), 284-309. <http://dx.doi.org/10.1037//0033-2909.112.2.284>
- Christianson, S.-A., & Hubinette, B. (1993). Hands up! A study of witnesses' emotional reactions and memories associated with bank robberies. *Applied Cognitive Psychology*, 7(5), 365-379. <http://dx.doi.org/10.1002/acp.2350070502>
- Christianson, S.-A., & Loftus, E. F. (1987). Memory for traumatic events. *Applied Cognitive Psychology*, 1(4), 225-239. <http://dx.doi.org/10.1002/acp.2350010402>
- Christianson, S.-A., & Loftus, E. F. (1990). Some characteristics of people's traumatic memories. *Bulletin of the Psychonomic Society*, 28(3), 195-198. <http://dx.doi.org/10.3758/BF03334001>

- Clifford, B. R., & Hollin, C. R. (1981). Effects of the type of incident and the number of perpetrators on eyewitness memory. *Journal of Applied Psychology*, 66(3), 364-370. <http://dx.doi.org/10.1037/0021-9010.66.3.364>
- Clifford, B. R., & Scott, J. (1978). Individual and situational factors in eyewitness testimony. *Journal of Applied Psychology*, 63(3), 352-359. <http://dx.doi.org/10.1037/0021-9010.63.3.352>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: L. Erlbaum Associates. <http://dx.doi.org/10.1037/h0045186>
- Coon, D., & Mitterer, J. O. (2010). *Introduction to psychology: Gateways to mind and behavior* (12th ed.). Belmont, CA: Wadsworth Cengage Learning.
- Cutler, B. L. (2006). A sample of witness, crime, and perpetrator characteristics affecting eyewitness identification accuracy. *Cardozo Public Law, Policy & Ethics Journal*, 4(2), 327-240.
- Deffenbacher, K. A., Bornstein, B. H., Penrod, S. D., & McGorty, E. K. (2004). A meta-analytic review of the effects of high stress on eyewitness memory. *Law and Human Behavior*, 28(6), 687-706. <http://dx.doi.org/10.1007/s10979-004-0565-x>
- Department of Justice. (1999, October). *Eyewitness evidence: A guide for law enforcement* [PDF]. Retrieved from <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&sqi=2&ved=0CB0QFjAAahUKEwivtOaNzMbIAhVL92MKHRzvDLM&url=https%3A%2F%2Fwww.ncjrs.gov%2Fpdffiles1%2Fnij%2F178240.pdf&usq=CNFuyqYLBQPJitL5IR-d5VaqxIXnIQ&sig2=QdjbH9Ajpy3REtD7fq0dqg&bvm=bv.105039540,d.cGc&cad=rja>
- Diamond, D. M. (2005). Cognitive, endocrine and mechanistic perspectives on non-linear relationship between arousal and brain function. *Nonlinearity in Biology, Toxicology, and Medicine*, 3(1), 1-7. <http://dx.doi.org/10.2201/nonlin.003.01.001>
- DNA exonerations nationwide. (2015, October 26). Retrieved December 10, 2015, from Innocence Project website: <http://www.innocenceproject.org/free-innocent/improve-the-law/fact-sheets/dna-exonerations-nationwide>
- Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review*, 66(3), 183-201. <http://dx.doi.org/10.1037/h0047707>

- Eriksen, C. W., & Hoffman, J. E. (1972). Temporal and spatial characteristics of selective encoding from visual displays. *Perception & Psychophysics*, *12*(2-B), 201-204.
- Eyewitness misidentification. (n.d.). Retrieved December 10, 2015, from Innocence Project website: <http://www.innocenceproject.org/causes-wrongful-conviction/eyewitness-misidentification>
- Firestone, D. (1999, June 16). DNA test brings freedom, 16 years after conviction. *The New York Times*. Retrieved from <http://www.nytimes.com/1999/06/16/us/dna-test-brings-freedom-16-years-after-conviction.html>
- Garry, M., & Polaschek, D. L.L. (2000). Imagination and memory. *Current Directions in Psychological Science*, *9*(1), 6-10. <http://dx.doi.org/10.1111/1467-8721.00048>
- Greene, E., Heilbrun, K., Fortune, W., & Nietzel, M. (2007). *Wrightsmen's psychology and the legal system* (6th ed.). Belmont, CA: Thomson/Wadsworth.
- Hardy, M., & Heyes, S. (1999). *Beginning psychology* (5th ed.). Oxford: Oxford University Press.
- Henkel, L. A., & Coffman, K. J. (2004). Memory distortions in coerced false confessions: A source monitoring framework analysis. *Applied Cognitive Psychology*, *18*(5), 567-588. <http://dx.doi.org/10.1002/acp.1026>
- Hope, L., Blocksidge, D., Gabbert, F., Sauer, J. D., Lewinski, W., Mirashi, A., & Atuk, E. (2016). Memory and the operational witness: Police officer recall of firearms encounters as a function of active response role. *Law and Human Behavior*, *40*(1), 23-35. <http://dx.doi.org/10.1037/lhb0000159>
- Hosch, H. M., & Bothwell, R. K. (1990). Arousal, description and identification accuracy of victims and bystanders. *Journal of Social Behavior and Personality*, *5*(5), 481-488.
- Hosch, H. M., & Cooper, D. S. (1982). Victimization as a determinant of eyewitness accuracy. *Journal of Applied Psychology*, *67*(5), 649-652. <http://dx.doi.org/10.1037/0021-9010.67.5.649>
- Hosch, H. M., Leippe, M. R., Marchioni, P. M., & Cooper, D. S. (1984). Victimization, self-monitoring, and eyewitness identification. *Journal of Applied Psychology*, *69*(2), 280-288. <http://dx.doi.org/10.1037/0021-9010.69.2.280>
- Innocence Project*. (2005). Retrieved from <http://www.innocenceproject.org/news-events-exonerations/reports-publications>
- Janis, I. L., & Feshbach, S. (1953). Effect of fear-arousing communications. *Journal of Abnormal and Social Psychology*, *48*(1), 78-92.

- Jonides, J. (1983). Further toward a model of the mind's eye movement. *Bulletin of the Psychonomic Society*, 21(4), 247-250.
- The Justice Project. (2007). *Eyewitness identification: A policy review* [PDF].
- Kassin, S. M., Tubb, V. A., Hosch, H. M., & Memon, A. (2001). On the "general acceptance" of eyewitness testimony research: A new survey of the experts. *American Psychologist*, 56(5), 405-416. <http://dx.doi.org/10.1037/0003-066X.56.5.405>
- Kuehn, L. L. (1974). Looking down a gun barrel: Person perception and violent crime. *Perceptual and Motor Skills*, 39(3), 1159-1164. <http://dx.doi.org/10.2466/pms.1974.39.3.1159>
- Leippe, M. R. (1980). Effects of integrative memorial and cognitive processes on the correspondence of eyewitness accuracy and confidence. *Law and Human Behavior*, 4(4), 261-274. <http://dx.doi.org/10.1007/BF01040618>
- Leippe, M. R., Wells, G. L., & Ostrom, T. M. (1978). Crime seriousness as a determinant of accuracy in eyewitness identification. *Journal of Applied Psychology*, 63(3), 345-351. <http://dx.doi.org/10.1037/0021-9010.63.3.345>
- Lerner, P. K. (1988, June 10). 2 hung juries: Charges dropped in attack on judge. *Los Angeles Times*. Retrieved from http://articles.latimes.com/1988-06-10/local/me-4956_1_hung-juries
- Local news in brief: Judge testifies on attack. (1988, January 13). *Los Angeles Times*. Retrieved from http://articles.latimes.com/1988-01-13/local/me-23866_1_attack-judge-testifies
- Loftus, E. F. (1975). Reconstructing memory: The incredible eyewitness [PDF]. *Jurimetrics Journal*, 15(3), 188-193. <http://dx.doi.org/10.2307/29761487>
- Loftus, E. F., Loftus, G. R., & Messo, J. (1987). Some facts about "weapon focus". *Law and Human Behavior*, 11(1), 55-62. <http://dx.doi.org/10.1007/BF01044839>
- Mazzoni, G., & Memon, A. (2003). Imagination can create false autobiographical memories. *Psychological Science*, 14(2), 186-188. <http://dx.doi.org/10.1046/j.1432-1327.1999.00020.x>
- Memon, A., Hope, L., & Bull, R. (2003). Exposure duration: Effects on eyewitness accuracy and confidence. *British Journal of Psychology*, 94(3), 339-354. <http://dx.doi.org/10.1348/000712603767876262>

- Meissner, C. A., & Brigham, J. C. (2001). Thirty years of investigating the own-race bias in memory for faces: A meta-analytic review. *Psychology, Public Policy, and Law*, 7(1), 3-35.
- Mitchell, K. J., Livosky, M., & Mather, M. (1998). The weapon focus effect revisited: The role of novelty. *Legal and Criminological Psychology*, 3(2), 287-303. <http://dx.doi.org/10.1111/j.2044-8333.1998.tb00367.x>
- Morgan, C. A., Hazlett, G., Doran, A., Garrett, S., Hoyt, G., Thomas, P., . . . Southwick, S. M. (2004). Accuracy of eyewitness memory for persons encountered during exposure to highly intense stress. *International Journal of Law and Psychiatry*, 27, 265-279. <http://dx.doi.org/10.1016/j.ijlp.2004.03.004>
- Narby, D. J., Cutler, B. L., & Penrod, S. D. (1996). The effects of witness, target, and situational factors on eyewitness identifications. In S. L. Sporer, R. S. Malpass, & G. Koehnken (Eds.), *Psychological issues in eyewitness identification* (pp. 23-52). Mahwah, NJ: Lawrence Erlbaum Associates.
- National registry of exonerations. (n.d.). Retrieved October 27, 2016, from National Registry of Exonerations website:
<https://www.law.umich.edu/special/exoneration/Pages/browse.aspx>
 This is a compilation of exonerations since 1989 run by the Newkirk Center for Science & Society at University of California Irvine, the University of Michigan Law School and Michigan State University College of Law. It was founded in conjunction with Northwestern University School of Law.
- Pickel, K., French, T., & Betts, J. (2003). A cross-modal weapon focus effect: The influence of a weapon's presence on memory for auditory information. *Memory*, 11(3), 277-292. <http://dx.doi.org/10.1080/09658210244000036>
- Pickel, K. L. (1999). The influence of context on the 'weapon focus' effect. *Law and Human Behavior*, 23(3), 299-311. <http://dx.doi.org/10.1023/A:1022356431375>
- Ross, D. F., Ceci, S. J., Dunning, D., & Togliani, M. P. (1994). Unconscious transference and mistaken identity: When a witness misidentifies a familiar with innocent person. *Journal of Applied Psychology*, 79(6), 918-930. <http://dx.doi.org/10.1037/0021-9010.79.6.918>
- Sawilowsky, S. S. (2009). New effect sizes rule of thumb. *Journal of Modern Applied Statistical Methods*, 8(2), 597-599. Retrieved from http://digitalcommons.wayne.edu/coe_tbf/4/
- Shapiro, P. N., & Penrod, S. (1986). Meta-analysis of facial identification studies. *Psychological Bulletin*, 100(2), 139-156. <http://dx.doi.org/10.1037/0033-2909.100.2.139>

- Shaw, J. I., & Skolnick, P. (1999). Weapon focus and gender differences in eyewitness accuracy: Arousal versus salience. *Journal of Applied Social Psychology*, 29(11), 2328-2341. <http://dx.doi.org/10.1111/j.1559-1816.1999.tb00113.x>
- Sporer, S. L. (2001). Recognizing faces of other ethnic groups: An integration of theories. *Psychology, Public Policy, and Law*, 7(1), 36-97. <http://dx.doi.org/10.1037/1076-8971.7.1.36>
- Sporer, S. L., Penrod, S., Read, D., & Cutler, B. (1995). Choosing, confidence, and accuracy: A meta-analysis of the confidence-accuracy relation in eyewitness identification studies. *Psychological Bulletin*, 118(3), 315-327. <http://dx.doi.org/10.1037/0033-2909.118.3.315>
- State of New Jersey v. Henderson, 27 A.3d 872 (2011).
- State of Oregon v. Classen, 590 P.2d 1198 (1979). Retrieved from http://www.leagle.com/decision/19791788590P2d1198_11719/STATE%20v.%20CLASSEN
- State of Oregon v. Lawson/James, 291 P.3d 673 (2012). Retrieved from <https://www.courtlistener.com/opinion/834780/state-v-lawsonjames/>
- Stebly, N. M. (1992). A meta-analytic review of the weapon focus effect. *Law and Human Behavior*, 16(4), 413-424. <http://dx.doi.org/10.1007/BF02352267>
- Thayer, J. F., Åhs, F., Fredrikson, M., Sollers, J. J., III, & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. *Neuroscience and Biobehavioral Reviews*, 36(2), 747-756. <http://dx.doi.org/10.1016/j.neubiorev.2011.11.009>
- Tooley, V., Brigham, J. C., Maass, A., & Bothwell, R. K. (1987). Facial recognition: Weapon effect and attentional focus. *Journal of Applied Social Psychology*, 17(10), 845-859. <http://dx.doi.org/10.1111/j.1559-1816.1987.tb00294.x>
- Valentine, T., & Mesout, J. (2009). Eyewitness identification under stress in the London Dungeon. *Applied Cognitive Psychology*, 23(2), 151-161. <http://dx.doi.org/10.1002/acp.1463>
- Wall, P. M. (1965). *Eye-witness identification in criminal cases*. Springfield, IL: Charles C. Thomas.
- Warden, R. (2001, May 2). How mistaken and perjured eyewitness identification testimony put 46 innocent Americans on death row. *Center on Wrongful Convictions. Northwestern University School of Law*.
 Rob Warden is the Executive Director of the Center on Wrongful Convictions at Northwestern University's School of Law.

- Weiser, B. (2011, August 24). In New Jersey, rules are changed on witness IDs. *The New York Times*. Retrieved from http://www.nytimes.com/2011/08/25/nyregion/in-new-jersey-rules-changed-on-witness-ids.html?_r=0
- Wells, G. L. (1984). The psychology of lineup identifications. *Journal of Applied Social Psychology, 14*(2), 89-103. <http://dx.doi.org/10.1111/j.1559-1816.1984.tb02223.x>
- Wells, G. L. (1993). What do we know about eyewitness identification? *American Psychologist, 48*(5), 553-571. <http://dx.doi.org/10.1037/0003-066X.48.5.553>
- Wells, G. L., & Olson, E. A. (2001). The other-race effect in eyewitness identification: What do we do about it? *Psychology, Public Policy, and Law, 7*(1), 230-246. <http://dx.doi.org/10.1037//1076-8971.7.1.230>
- Wells, G. L., Small, M., Penrod, S., Malpass, R. S., Fulero, S. M., & Brimacombe, C. E. (1998). Eyewitness identification procedures: Recommendations for lineups and photospreads. *Law and Human Behavior, 22*(6), 603-647. <http://dx.doi.org/10.1023/A:1025750605807>
- Woodhead, M. M., Baddeley, A., & Simmonds, D. (1979). On training people to recognize faces. *Ergonomics, 22*, 333-343.
- Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology, 18*(5), 459-482. <http://dx.doi.org/10.1002/cne.920180503>