

# **Die Rolle von Aufmerksamkeit im Kontext des Waffenfokus-Effekts**

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Eine gefaßte Hypothese giebt uns Luchsaugen für alles sie Bestätigende, und macht uns blind für alles ihr Widersprechende.

– Arthur Schopenhauer, *Die Welt als Wille und Vorstellung. Zweiter Band*



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# 1 EINLEITUNG

Augenzeugenaussagen sind bei polizeilichen Ermittlungen und vor Gericht ein wichtiges Beweismittel, das zur Überführung von Straftäterinnen und Straftätern beitragen kann. Dies gilt natürlich insbesondere in Fällen, in denen keine anderen Beweismittel wie Fingerabdrücke oder DNA-Spuren zur Verfügung stehen. Gleichzeitig sind fehlerhafte Identifizierungen von Verdächtigten durch Augenzeuginnen oder Augenzeugen jedoch auch einer der Hauptgründe für die Verurteilung von Unschuldigen (Huff, Rattner & Sagarin, 1986; West & Meterko, 2016). Fehlerhafte Identifizierungen treten dabei nicht nur in Fällen auf, in denen Augenzeuginnen oder Augenzeugen bewusst die Unwahrheit sagen, sondern auch aufgrund von Verzerrungen und Fehlern in der Wahrnehmung und im Gedächtnis. Selbst bei einer ehrlichen Zeugenaussage ist daher nicht sichergestellt, dass eine als Täterin oder Täter identifizierte Person auch tatsächlich schuldig ist.

Es gibt zahlreiche Beispiele aus der Kriminalgeschichte, welche die Folgen solcher Fehlfeststellungen eindrucksvoll veranschaulichen. So wurde etwa Christos Orfanidis von mehreren Augenzeuginnen und Augenzeugen als Täter eines versuchten Überfalls auf einen Elektromarkt in der Nähe von Frankfurt am Main identifiziert (Friedrichsen, 2000). Dabei beschrieben die Zeuginnen und Zeugen den Täter ursprünglich als 1,90 m großen Mann mit dunklem Teint, während Orfanidis nur 1,75 m groß war und eine helle Hautfarbe hatte. Dennoch war sich insbesondere die überfallene Kassiererin sicher, in Orfanidis den Täter wiederzuerkennen. Die Zeugenaussagen trugen maßgeblich dazu bei, dass Orfanidis in zwei Instanzen für schuldig befunden und jeweils zu einer Haftstrafe verurteilt wurde. Erst als derselbe Markt ein zweites Mal überfallen wurde, kamen Zweifel an Orfanidis' Schuld auf. Diesmal konnte der Täter gefasst werden – ein hochgewachsener Mann mit dunklem Teint. Da die ursprünglichen Täterbeschreibungen auf diesen Mann deutlich besser passten als auf Orfanidis, wurde Orfanidis nach drei Jahren der Verdächtigung schließlich freigesprochen.

Während Orfanidis einer rechtskräftigen Verurteilung somit knapp entging, hatten andere weniger Glück im Unglück. Einer Schätzung von Loeffler, Hyatt und Ridgeway (2019) zufolge sind insgesamt ca. 6 % der Häftlinge in den USA zu Unrecht verurteilt. Dabei hing der konkrete Anteil stark von der jeweiligen Straftat ab. Beispielsweise war der geschätzte Anteil der Unschuldigen bei Verurteilungen wegen Trunkenheit im Verkehr deutlich geringer als bei Verurteilungen wegen Vergewaltigung. Bei den zum Tode Verurteilten wird der Anteil der Unschuldigen auf mindestens 4 % geschätzt (Gross, O'Brien, Hu & Kennedy, 2014).

Organisationen wie das *Innocence Project* setzen sich für die Entlastung und Rehabilitation von zu Unrecht verurteilten Personen ein (West & Meterko, 2016). Dabei werden insbesondere DNA-Untersuchungen und andere forensische Verfahren, die zum Zeitpunkt der Verurteilung noch nicht zur Verfügung standen oder aus anderen Gründen nicht angewandt wurden, eingesetzt, um nachträglich die Unschuld der Verurteilten zu beweisen und so ihre Freilassung zu erwirken. Auf diese Weise konnten bereits über 375 zu Unrecht Verurteilte entlastet werden (*Innocence Project*, n. d.). Dabei konnte nachgewiesen werden, dass es in 63 % der ursprünglichen Verfahren zu fehlerhaften Identifizierungen durch Augenzeuginnen und Augenzeugen kam. Bei Betrachtung aller vom *Innocence Project* dokumentierten Fälle sind Fehlidentifizierungen damit der häufigste zu unrechtmäßigen Verurteilungen beitragende Faktor.

Andererseits sind Augenzeugenaussagen, wie oben bereits beschrieben, auch wichtige Beweismittel zur Überführung tatsächlich Schuldiger. Um die Zuverlässigkeit von Zeugenaussagen beurteilen zu können, ist es daher wichtig zu untersuchen, welche Faktoren einen Einfluss auf die Güte von Augenzeugenberichten haben. Bei diesen Einflussfaktoren wird zwischen Systemvariablen und Schätzvariablen unterschieden (Wells, 1978; für einen Überblick siehe Sporer, Sauerland & Kocab, 2014). Systemvariablen sind solche Faktoren, auf die das Rechtssystem einen direkten Einfluss hat. Ein Beispiel hierfür sind Gegenüberstellungen, bei denen der Zeugin oder dem Zeugen eine Reihe von Personen gezeigt wird, aus denen die Täterin oder der Täter identifiziert werden soll. Forschung hat gezeigt, dass weniger Fehlidentifizierungen auftreten, wenn die Person, die die Gegenüberstellung durchführt, selbst nicht weiß, welche von den gezeigten Personen die oder der Verdächtige ist (siehe Kovera & Evelo, 2017). Außerdem sollte die Gegenüberstellung fair konstruiert sein, d. h. die verdächtige Person sollte nicht aufgrund von markanten Merkmalen herausstechen oder die einzige sein, die den Täterbeschreibungen entspricht (z. B. Wells, Leippe & Ostrom, 1979).

Im Gegensatz zu Systemvariablen stehen Schätzvariablen nicht unter der Kontrolle des Rechtssystems. Ihr Einfluss auf die Güte von Zeugenaussagen kann daher nicht direkt beeinflusst, sondern nur nachträglich geschätzt werden. Unter diese Schätzvariablen fallen einerseits Merkmale der Zeuginnen und Zeugen selbst. Beispielsweise zeigen Kinder und ältere Erwachsene eine schlechtere Wiedererkennungslleistung als junge Erwachsene (siehe Fitzgerald & Price, 2015). Darüber hinaus sind Menschen grundsätzlich besser darin, Personen ihrer eigenen Ethnie (siehe Meissner & Brigham, 2001) und ihres eigenen Alters (siehe Rhodes & Anastasi, 2012) zu identifizieren. Frauen und Mädchen erkennen zudem weibliche Gesichter besser als männliche Gesichter (siehe Herlitz & Lovén, 2013). Neben solchen Zeugenmerkmalen zählen

auch Eigenschaften der Beobachtungssituation wie die Lichtverhältnisse, die Entfernung zur Zielperson und die Beobachtungsdauer zu den Schätzvariablen (siehe Sporer et al., 2014).

Eine weitere Schätzvariable, die im Zentrum der vorliegenden Arbeit steht, ist die Anwesenheit einer Waffe. Der Waffenfokus-Effekt (WFE) beschreibt das Phänomen, dass Menschen sich schlechter an das Aussehen einer Person erinnern können, wenn diese Person eine Waffe getragen hat (z. B. Carlson, Young et al., 2016; E. F. Loftus, Loftus & Messo, 1987; Pickel, 1998). Auch bei der Tat, die Christos Orfanidis zur Last gelegt wurde, hatte der Täter eine Waffe auf die Zeugin gerichtet, die später zur Hauptbelastungszeugin von Orfanidis werden sollte. Es wird allgemein angenommen, dass Beobachtende ihre Aufmerksamkeit auf die Waffe fokussieren und dabei die Person, die die Waffe hält, weniger beachten (z. B. Pickel, 2015). Demnach würde eine Person, die eine Waffe in der Hand hält, aufgrund einer Aufmerksamkeitsverschiebung hin zur Waffe weniger angeschaut werden, weswegen ihr Aussehen schlechter ins Gedächtnis enkodiert werden könne.

Die frühesten Belege für den WFE stammen aus Simulationsstudien zum Einfluss von Stress auf Augenzeugenberichte (Johnson, 1975, 1977). In diesen Untersuchungen wurden Versuchspersonen unter dem Vorwand eines Lernexperiments ins Labor eingeladen. Während sie im Empfangsbereich warteten, hörten sie durch eine Tür eine inszenierte Interaktion und sahen anschließend eine Zielperson aus dem Zimmer kommen. Die Zielperson sprach die Versuchsperson mit einem kurzen Satz an, bevor sie sich abwandte und den Empfangsbereich verließ. In der Hand hielt sie dabei entweder eine Waffe (einen Brieföffner) oder ein neutrales Objekt (einen Stift). Die Ergebnisse zeigten, dass zumindest weibliche Versuchspersonen sich in der Waffen-Bedingung schlechter an das Aussehen der Zielperson erinnerten als in der neutralen Bedingung. An die Waffe selbst erinnerten sich dagegen fast alle Versuchspersonen, während nur wenige das neutrale Objekt benennen konnten. Die Zielpersonen berichteten außerdem, dass die Versuchspersonen in der Waffen-Bedingung konzentriert auf das Objekt schauten und Blickkontakt vermieden.

Auf der Grundlage dieser Beobachtungen vermutete Johnson (1975, 1977), dass die Unterschiede im Erinnerungsvermögen auf eine Verschiebung der Aufmerksamkeit auf die Waffe zurückzuführen sein könnten. Wie E. F. Loftus (1979) kritisch anmerkte, unterschieden sich die Experimentalbedingungen in diesen Untersuchungen jedoch nicht nur hinsichtlich des Objekts, das die Zielperson in der Hand hielt. In der Waffen-Bedingung hörten die Versuchspersonen eine gestellte Interaktion, die einen Streit mit Geräuschen von zerbrechenden Flaschen und umgestoßenen Möbeln beinhaltete. Außerdem war der Brieföffner mit Blut bedeckt. In der

neutralen Bedingung war die Interaktion dagegen eine Nachstellung eines regulären experimentellen Versuchs und der Stift war statt mit Blut mit Fett beschmiert. Auch der Satz, mit dem die Versuchsperson jeweils angesprochen wurde, unterschied sich zwischen den beiden Bedingungen. Somit lassen sich die von Johnson (1975, 1977) gefundenen Unterschiede im Erinnerungsvermögen nicht eindeutig auf die Anwesenheit einer Waffe zurückführen.

E. F. Loftus et al. (1987) waren eine der ersten Forschergruppen, die den WFE in einer systematischeren Weise untersucht haben. Den Versuchspersonen wurde eine Dia-Show präsentiert, die aus einer Serie von statischen Fotografien bestand. Die Dia-Show zeigte einen Mann, der ein Fast-Food-Restaurant betritt und anschließend von einer Kassiererin Geld überreicht bekommt. Je nach Experimentalbedingung hielt er dabei entweder eine Schusswaffe oder einen Scheck in der Hand. Abgesehen von diesem kritischen Objekt unterschieden sich die Dia-Shows der beiden untersuchten Bedingungen nicht voneinander. E. F. Loftus et al. (1987) erfassten zum einen mithilfe eines Eye-Trackers, wo die Versuchspersonen beim Betrachten der Dia-Shows hinschauten. Zum anderen überprüften sie, wie gut sich die Versuchspersonen an die Zielperson erinnern konnten. Dabei sollten die Versuchspersonen einerseits Fragen zum Aussehen der Zielperson beantworten und andererseits die Zielperson in einer Gegenüberstellung identifizieren.

Die Ergebnisse von E. F. Loftus et al. (1987) bestätigten, dass Versuchspersonen die Schusswaffe tatsächlich länger und häufiger mit ihrem Blick fixierten als den Scheck. Bei den Erinnerungsdaten zeigte sich numerisch ebenfalls ein Unterschied in die erwartete Richtung: Wenn die Zielperson eine Waffe getragen hatte, beantworteten die Versuchspersonen weniger Fragen zum Aussehen der Zielperson korrekt und konnten diese auch schlechter in der Gegenüberstellung identifizieren. Diese Unterschiede waren jedoch statistisch nicht signifikant. Um den Einfluss von Waffen auf das Erinnerungsvermögen näher zu untersuchen, führten E. F. Loftus et al. (1987) ein zweites Experiment mit einer größeren Stichprobe durch. Das Vorgehen war dabei grundsätzlich das gleiche wie im ersten Experiment, mit der Ausnahme, dass die Versuchspersonen diesmal in Gruppen getestet wurden und dass ihre Blickbewegungen nicht aufgezeichnet wurden. In diesem zweiten Experiment war die Erinnerungsleistung der Versuchspersonen sowohl hinsichtlich der Fragen zum Aussehen der Zielperson als auch hinsichtlich der Gegenüberstellung in der Waffen-Bedingung signifikant schlechter als in der Scheck-Bedingung.

Insgesamt stützen die Befunde von E. F. Loftus et al. (1987) damit die Annahme, dass Waffen Aufmerksamkeit auf sich ziehen und dass die Anwesenheit einer Waffe die Erinnerung

an das Aussehen der Zielperson beeinträchtigt. E. F. Loftus et al. (1987) schlugen zwei theoretische Ansätze zur Erklärung des WFE vor. Die Bedrohlichkeitshypothese besagt, dass die Bedrohung, die von Waffen ausgeht, bei Augenzeuginnen und Augenzeugen zu einem erhöhten Erregungsniveau führt. Dabei wird angenommen, dass dieses erhöhte Erregungsniveau zu einer Verengung der Aufmerksamkeit führt, sodass andere Aspekte als die fokussierte Waffe schlechter verarbeitet werden können. Die Ungewöhnlichkeitshypothese geht ebenfalls davon aus, dass Waffen Aufmerksamkeit auf sich ziehen, jedoch nicht, weil sie bedrohlich sind, sondern weil sie ungewöhnlich sind. Hier ist die Annahme, dass Beobachtende der Waffe mehr Aufmerksamkeit widmen, weil sie überrascht sind, eine Waffe in einem Kontext zu sehen, in dem man diese nicht erwarten würde. Die Bedrohlichkeitshypothese und die Ungewöhnlichkeitshypothese werden in der Forschung bis heute untersucht und diskutiert.

## 1.1 Bedrohlichkeitshypothese

Es ist bereits lange bekannt, dass das Erregungsniveau einen Einfluss auf die Leistungsfähigkeit hat. So konnten bereits Yerkes und Dodson (1908) zeigen, dass bei Mäusen die Geschwindigkeit, mit der eine Diskriminierungsaufgabe erlernt werden konnte, in einem umgekehrt U-förmigen Zusammenhang mit dem Stressniveau stand: Bei einem mittleren Erregungsniveau lernten die Mäuse am schnellsten, während ein zu hohes oder zu niedriges Erregungsniveau das Lernen beeinträchtigte. Das optimale Erregungsniveau war dabei umso niedriger, je schwieriger die Aufgabe war. Bei einer schwierigen Aufgabe führte bereits ein moderat erhöhtes Erregungsniveau zu einem Abfall der Leistung. In nachfolgenden Studien konnte ein umgekehrt U-förmiger Zusammenhang zwischen Erregungsniveau und Leistungsfähigkeit auch für menschliche Probandinnen und Probanden nachgewiesen werden (z. B. Stennett, 1957).

Als Erklärungsansatz für dieses Yerkes-Dodson-Gesetz formulierte Easterbrook (1959) die Annahme, dass sich die Aufmerksamkeit mit zunehmendem Erregungsniveau verengt und so die Anzahl der verarbeiteten Hinweisreize abnimmt. Dabei würden zuerst solche Reize ausgeblendet (d. h. nicht mehr verarbeitet), die für die jeweilige Aufgabe irrelevant sind. Demnach steigt die Leistung mit zunehmendem Erregungsniveau an, solange nur aufgaben-irrelevante Reize ausgeblendet werden. Sobald das Erregungsniveau so hoch ist, dass auch aufgaben-relevante Reize ausgeblendet werden, fällt die Leistung hingegen ab. E. F. Loftus et al. (1987) übertrugen diese Hypothese auf den WFE. Demnach würde die Aufmerksamkeit aufgrund des hohen Erregungsniveaus stark auf die bedrohliche Waffe verengt, wodurch Merkmale der Täterin oder des Täters nur eingeschränkt verarbeitet werden könnten.

Der Einfluss des Erregungsniveaus bzw. der Bedrohlichkeit der Situation auf den WFE wurde seitdem in einer Reihe von Studien untersucht. Beispielsweise induzierten Tooley, Brigham, Maass und Bothwell (1987) Stress bei Versuchspersonen, indem sie ihnen unangenehme Geräusche (weißes Rauschen) darboten und ihnen Elektroschocks androhten, während sie Bilder von Männern sahen, die entweder eine Waffe oder ein neutrales Objekt in der Hand hielten. In der Waffen-Bedingung konnten die Versuchspersonen die Zielpersonen allgemein schlechter identifizieren als in der neutralen Bedingung. Der durch die Geräusche und die angedrohten Elektroschocks induzierte Stress hatte jedoch keine Auswirkungen auf die Erinnerungsgüte. In Simulationsstudien wurde beobachtet, dass Versuchspersonen sich schlechter an eine Zielperson erinnern konnten, wenn diese eine Spritze getragen hatte (Maass & Köhnken, 1989; Peters, 1988). Entgegen den Erwartungen zum Einfluss der Bedrohlichkeit auf den WFE trat dieser Effekt unabhängig davon auf, ob den Versuchspersonen gesagt wurde, dass ihnen die Spritze verabreicht werden sollte (Maass & Köhnken, 1989).

In einer aktuelleren Studie wurde das Erregungsniveau der Versuchspersonen durch sportliche Betätigung erhöht (Brunyé & Mahoney, 2019). Dabei führte ein erhöhtes Erregungsniveau dazu, dass bei Bildern mit Waffen zentrale Details (d. h. die Waffen selbst) besser erinnert werden konnten als vergleichbare Details in Bildern ohne Waffen. Gleichzeitig konnte der klassische WFE repliziert werden: Bei Bildern mit Waffen war die Erinnerung an periphere Details (d. h. andere, thematisch weniger relevante Aspekte) schlechter als bei Bildern ohne Waffen. Dieser Effekt trat jedoch unabhängig vom Erregungsniveau auf.

Es wurde auch untersucht, ob der WFE stärker ist, wenn die Waffe in einer bedrohlichen Art und Weise verwendet wird. Die Ergebnisse der Studien dazu sind jedoch uneinheitlich: Eine Studie (Kim, Park & Lee, 2014) fand einen stärkeren WFE, wenn die Waffe in bedrohlicher Weise verwendet wurde, wohingegen zwei andere Studien (Mitchell, Livosky & Mather, 1998; Pickel, 1999) keine Unterschiede in der Effektstärke berichteten. Weiterhin wurde gezeigt, dass der WFE auch bei stark reduzierten Stimuli beobachtet werden kann, bei denen die Zielperson mit der Waffe in der Hand lediglich einen Gang hinuntergeht und somit keine Bedrohungssituation vorliegt (Kramer, Buckhout & Eugenio, 1990). Eine mögliche Erklärung für diese Inkonsistenz in den Befunden ist die Art des verwendeten Stimulusmaterials. In den Studien, in denen kein Effekt der Bedrohlichkeit nachgewiesen werden konnte, wurden zweidimensionale Dia-Shows oder Videos am Computerbildschirm gezeigt. Kim et al. (2014) hingegen präsentierten ihre Stimuli über eine Virtual-Reality-Brille. Es ist denkbar, dass die Darbietung innerhalb einer virtuellen Realität die Immersion der Versuchspersonen erhöht, wodurch Effekte der Bedrohlichkeit verstärkt werden könnten.

Insgesamt sind die Befunde zum Einfluss der Bedrohlichkeit auf den WFE gemischt. Es konnte nachgewiesen werden, dass der WFE auch in Situationen mit geringem Erregungsniveau beobachtet werden kann. Eine Bedrohungssituation scheint damit zumindest keine notwendige Voraussetzung für das Auftreten des WFE zu sein. Gleichzeitig gibt es durchaus Hinweise darauf, dass der WFE stärker ausgeprägt ist, wenn die untersuchte Situation bedrohlich oder das Erregungsniveau hoch ist. Auch in Meta-Analysen konnte bestätigt werden, dass der WFE größer ist, wenn die Waffe in einer bedrohlichen Weise verwendet wird (Fawcett, Russell, Peace & Christie, 2013) oder wenn sie im Zusammenhang mit einer Straftat gezeigt wurde (Kocab & Sporer, 2016; Steblay, 1992).

Auch in der breiteren Literatur abseits des WFE sind die Befunde zum Einfluss von Stress auf die Erinnerung nicht eindeutig (für einen aktuellen Überblick siehe Marr, Sauerland, Otgaar, Quaedflieg & Hope, 2021). Die Widersprüchlichkeit der Befunde ist dabei vermutlich auch auf die unterschiedlichen Methoden zur Induktion von Stress zurückzuführen, die insbesondere bei Grundlagen- und Anwendungsforschung verschieden sind (Marr, Sauerland et al., 2021). So werden in der Grundlagenforschung zum Einfluss von Stress auf das Erinnerungsvermögen in der Regel etablierte Verfahren wie der *Trier Social Stress Test* (Kirschbaum, Pirke & Hellhammer, 1993) verwendet, die reliabel Stressreaktionen hervorrufen (z. B. Vogel & Schwabe, 2016). In der Anwendungsforschung zu rechtspsychologischen Phänomenen wie dem WFE werden zur Induktion von Stress dagegen häufig gewalthaltige Bilder oder Videos gezeigt. Teilweise werden zusätzlich andere Stressoren wie unangenehme Geräusche (z. B. Tooley et al., 1987) oder sportliche Betätigung (z. B. Brunyé & Mahoney, 2019) eingesetzt. Es ist unklar, inwieweit Art und Ausmaß des durch diese unterschiedlichen Manipulationen induzierten Stresses vergleichbar sind.

Deffenbacher (1994) schlug vor, dass ein erhöhtes Erregungsniveau je nach Grad der Erregung zu zwei qualitativ unterschiedlichen Reaktionen führt. Konkret stellte er die Vermutung auf, dass ein leicht erhöhtes Erregungsniveau eine zuwendende Reaktion (*orienting response*) hervorruft. Dabei würde die Aufmerksamkeit neuen und informativen Aspekten zugewandt, was dazu führe, dass zentrale Informationen besser und periphere Informationen schlechter erinnert würden. Dagegen löse starker Stress eine defensive Reaktion (*defensive response*) aus, welche zu einer Zuwendung zu redundanten Informationen und zu einer allgemeinen Verschlechterung der Erinnerung führe.

Um die Auswirkungen von Stress auf das Erinnerungsvermögen von Augenzeuginnen und Augenzeugen zu untersuchen, führten Deffenbacher, Bornstein, Penrod und McGorty (2004) eine Meta-Analyse durch. Dabei wurden nur Studien berücksichtigt, in denen nachweislich

Stress induziert wurde. Ausgeschlossen wurden dagegen Studien, in denen zwar emotionales Stimulusmaterial verwendet, das Erregungsniveau der Versuchspersonen jedoch nicht erfasst wurde. Für die berücksichtigten Studien konnte in der Meta-Analyse nachgewiesen werden, dass Stress das Erinnerungsvermögen beeinträchtigt. Es ist zumindest plausibel, dass (a) die Anwesenheit einer Waffe bei tatsächlichen Straftaten bei Augenzeuginnen und Augenzeugen und insbesondere bei Opfern zu hohem Stress führt und dass (b) dieser Stress höher ist als bei vergleichbaren Situationen ohne Waffe. Unter diesen Annahmen sprechen die Ergebnisse von Deffenbacher et al. (2004) dafür, dass das durch eine Waffe erhöhte Erregungsniveau das Erinnerungsvermögen beeinträchtigen kann.

## 1.2 Ungewöhnlichkeitshypothese

Aus der Forschung zur Szenenwahrnehmung ist bekannt, dass ungewöhnlichen Objekten allgemein mehr Aufmerksamkeit gewidmet wird als solchen Objekten, die zum jeweiligen Kontext passen (für einen Überblick siehe Wu, Wick & Pomplun, 2014). Ungewöhnlichkeit meint hier eine Inkongruenz zum räumlichen Kontext. Eine der frühesten und meistzitierten Untersuchungen zum Einfluss der Ungewöhnlichkeit auf die Aufmerksamkeit stammt von G. R. Loftus und Mackworth (1978). Dabei wurden Versuchspersonen Strichzeichnungen gezeigt, bei denen experimentell variiert wurde, ob ein kritisches Objekt zum Rest der Szene passte oder nicht. Beispielsweise konnte eine Zeichnung eines Bauernhofs entweder einen Traktor enthalten (kongruent) oder aber einen Oktopus (inkongruent). Die Forscher konnten zeigen, dass Objekte, die inkongruent zu dem jeweiligen Szenenkontext waren, früher, häufiger und länger mit dem Blick fixiert wurden als solche Objekte, die zu dem Kontext passten. Der Befund, dass inkongruente Objekte häufiger und länger angeschaut werden, konnte seitdem in zahlreichen weiteren Studien bestätigt werden (z. B. Coco, Nuthmann & Dimigen, 2020; Henderson, Weeks & Hollingworth, 1999; Vö & Henderson, 2009).

Zur Erklärung ihrer Befunde schlugen G. R. Loftus und Mackworth (1978) vor, dass kontext-inkongruente Objekte für Beobachtende besonders informativ seien. Demnach hat der kontext-kongruente Traktor in der Bauernhofszene eine hohe Auftretenswahrscheinlichkeit und ist damit weitgehend redundant zu den allgemeinen Szeneninformationen. Dagegen hat der kontext-inkongruente Oktopus in dieser Szene eine niedrige Auftretenswahrscheinlichkeit und liefert somit mehr Informationen, die über den allgemeinen Szenenkontext hinausgehen.

Inspiziert von den Befunden von G. R. Loftus und Mackworth (1978) schlugen E. F. Loftus et al. (1987) vor, dass statt der Bedrohlichkeit von Waffen auch ihre Ungewöhnlichkeit für den

WFE verantwortlich sein könnte. Waffen sind in vielen Kontexten ungewöhnlich, so auch in der von E. F. Loftus et al. (1987) verwendeten Szene in einem Fast-Food-Restaurant. Wenn ungewöhnliche Objekte allgemein Aufmerksamkeit auf sich ziehen und die Waffe im untersuchten Kontext ungewöhnlich war, dann könnte auch die Fokussierung auf die Waffe auf deren Ungewöhnlichkeit zurückzuführen sein. Die Forschenden argumentierten, dass unter dieser Annahme möglicherweise die gleichen Effekte beobachtet worden wären, wenn die Zielperson statt einer Schusswaffe eine Banane hervorgeholt hätte. Nach dieser Auffassung sind Waffen somit lediglich ein Spezialfall einer breiteren Klasse an Objekten, die inkongruent zu dem jeweiligen Kontext sind.

Shaw und Skolnick (1994) waren die ersten, die diese Ungewöhnlichkeitshypothese empirisch überprüft haben. Dazu zeigten sie Versuchspersonen, ähnlich wie E. F. Loftus et al. (1987), Dia-Shows, in denen die Zielperson entweder eine Waffe, ein gewöhnliches Objekt oder eines von mehreren ungewöhnlichen Objekten in der Hand hielt. Entgegen den Vorhersagen der Ungewöhnlichkeitshypothese führten die ungewöhnlichen Objekte nicht zu einer Beeinträchtigung des Erinnerungsvermögens. Allerdings haben Shaw und Skolnick (1994) auch in der Waffen-Bedingung keine Erinnerungseinbußen festgestellt. Daher ist die Aussagekraft dieser Untersuchung hinsichtlich der Erklärungsansätze zum WFE eingeschränkt. In späteren Studien wurde gezeigt, dass nicht bedrohliche ungewöhnliche Objekte das Erinnerungsvermögen in vergleichbarem Ausmaß beeinträchtigen können wie Waffen (z. B. Mitchell et al., 1998; Pickel, 1998). Außerdem scheinen Waffen die Erinnerung nicht zu beeinträchtigen, wenn sie in dem gegebenen Kontext nicht ungewöhnlich sind (z. B. eine Schusswaffe auf einem Schießstand; Pickel, 1999).

Darüber hinaus wurde gezeigt, dass der WFE nicht nur von der Ungewöhnlichkeit im räumlichen Kontext abhängt, sondern auch von der Ungewöhnlichkeit in Relation zu der Person, die die Waffe trägt. Konkret wurde ein stärkerer WFE beobachtet, wenn die Person, die die Waffe trug, weniger mit Waffen in Verbindung gebracht wurde, sodass die Waffe in der Hand dieser Person als ungewöhnlicher wahrgenommen wurde. So beobachtete Pickel (1999), dass die Erinnerungsgenauigkeit beeinträchtigt war, wenn ein Priester eine Waffe trägt, wohingegen kein WFE auftrat, wenn die gleiche Waffe von einem Polizisten getragen wurde. Weiterhin wurde bei männlichen Tätern im Vergleich zu weiblichen Täterinnen ein schwächerer WFE beobachtet (Pickel, 2009). Die Autorin schrieb diesen Effekt geschlechterspezifischen Stereotypen zu, nach denen Männer als aggressiver eingeschätzt werden als Frauen. Pickel und Sneyd (2018) berichteten analoge Effekte für Stereotype, nach denen Schwarze Männer eher mit Waf-

fen assoziiert werden als Weiße Männer. In Übereinstimmung mit den Vorhersagen der Ungewöhnlichkeitshypothese war der WFE bei Schwarzen Tätern geringer ausgeprägt als bei Weißen Tätern. Wenn der Schwarze Täter zusätzlich Kleidung trug, die stereotyp mit Schwarzen assoziiert wird, war gar kein WFE mehr zu beobachten.

Insgesamt stützen die empirischen Befunde die Hypothese, dass die Ungewöhnlichkeit von Waffen entscheidend für das Auftreten des WFE ist. Nicht bedrohliche ungewöhnliche Objekte führen zu ähnlichen Beeinträchtigungen wie Waffen und die Stärke des WFE variiert, je nachdem als wie ungewöhnlich die Waffe in dem jeweiligen Kontext und in der Hand der jeweiligen Person wahrgenommen wird. In Meta-Analysen wurde bestätigt, dass die Erinnerungseffekte von Waffen und nicht bedrohlichen ungewöhnlichen Objekten von vergleichbarer Größe sind (Fawcett et al., 2013; Kocab & Sporer, 2016). Einige neuere Studien fanden einen WFE jedoch nur für tatsächliche Waffen und keine Erinnerungseinbußen bei nicht bedrohlichen ungewöhnlichen Objekten (Carlson, Pleasant, Weatherford, Carlson & Bednarz, 2016; Mansour, Hamilton & Gibson, 2019). Es ist daher möglich, dass Ungewöhnlichkeit nicht der einzige Faktor ist, der dem WFE zugrunde liegt. In einer Studie von Kim et al. (2014) wurden die Ungewöhnlichkeit der Waffe im jeweiligen Kontext und die Bedrohlichkeit der Situation unabhängig voneinander manipuliert. Dabei wurde festgestellt, dass Ungewöhnlichkeit und Bedrohlichkeit jeweils zu einer Beeinträchtigung der Erinnerung führten, diese Effekte aber nicht miteinander interagierten.

### **1.3 Die Rolle von Aufmerksamkeit**

Beide Erklärungsansätze zum WFE haben gemeinsam, dass die Beeinträchtigung des Erinnerungsvermögens jeweils auf eine Verschiebung der Aufmerksamkeit zurückgeführt wird. Konkret wird angenommen, dass Beobachtende ihre Aufmerksamkeit auf die Waffe fokussieren und dass die Person, die die Waffe trägt, dadurch weniger beachtet wird und folglich schlechter im Gedächtnis enkodiert wird.

Eine direkte und präzise Methode, um zu erfassen, wohin Personen ihre Aufmerksamkeit lenken, ist die Aufzeichnung der Blickbewegungen mithilfe eines Eye-Trackers (siehe Williams & Castelano, 2019). Hierbei wird mit einer Blickbewegungskamera bestimmt, zu welchem Zeitpunkt Versuchspersonen welche Orte mit ihrem Blick fixieren (Fixationsort) und wie lange ihr Blick dort jeweils verweilt (Fixationsdauer). Der Fixationsort steht wiederum in engem Zusammenhang mit der Aufmerksamkeit. Zwar gibt es auch Situationen, in denen der Ort

der Aufmerksamkeit vom fixierten Punkt abweicht (verdeckte Aufmerksamkeit; siehe Carasco, 2011); in der Regel ist die Passung zwischen Blickbewegungen und Aufmerksamkeit jedoch sehr gut (z. B. Rolfs, Jonikaitis, Deubel & Cavanagh, 2011).

Williams und Castelhana (2019) zählten vier Vorteile auf, die das Erfassen von Blickbewegungen gegenüber anderen Aufmerksamkeitsmaßen (z. B. Reaktionszeiten) hat: Blickbewegungen sind (a) natürlich und (b) schnell und sie liefern sowohl (c) räumliche als auch (d) zeitliche Informationen. Die Natürlichkeit von Blickbewegungen ergibt sich daraus, dass Menschen ihre Augen ohnehin fortwährend bewegen. Diese sogenannten Sakkaden sind notwendig, da nur Objekte, die direkt mit dem Blick fixiert werden, in voller Detailtiefe erfasst werden können. Anders als bei anderen Maßen muss Versuchspersonen beim Eye-Tracking daher keine zusätzliche Aufgabe gestellt werden, um die Aufmerksamkeit zu erfassen. Außerdem liefert das Messen von Blickbewegungen räumlich und zeitlich präzise Informationen darüber, *wo* die Versuchspersonen *wann* hingeschaut haben.

Im Kontext des WFE wurde die Aufmerksamkeitskomponente, also die Annahme einer Aufmerksamkeitsverschiebung von der Täterin oder dem Täter hin zur Waffe, deutlich weniger untersucht als der Einfluss von Waffen auf die Erinnerung. Insbesondere gibt nur wenige Studien, in denen die Aufmerksamkeit von Versuchspersonen direkt mithilfe eines Eye-Trackers erfasst wurde. Wie oben bereits beschrieben, bestätigen die Eye-Tracking-Befunde von E. F. Loftus et al. (1987) die Annahme einer Aufmerksamkeitsverschiebung zumindest teilweise: Versuchspersonen fixierten beim Betrachten einer Dia-Show eine Schusswaffe häufiger als einen Scheck. Kennwerte zu den Blickfixationen auf der Zielperson, die die jeweiligen Objekte gehalten hat, wurden von E. F. Loftus et al. (1987) jedoch nicht berichtet. Somit bleibt unklar, ob die Anwesenheit einer Waffe tatsächlich dazu geführt hat, dass Versuchspersonen weniger auf die Zielperson geachtet haben.

Eine neuere Studie von Biggs, Brockmole und Witt (2013) prüfte diese Annahme direkt. Anders als E. F. Loftus et al. (1987) präsentierten Biggs et al. (2013) ihren Versuchspersonen keine Dia-Show, die eine zusammenhängende Geschichte erzählte, sondern einzelne, unzusammenhängende Bilder, die jeweils eine einzige Person zeigten. Je nach Experimentalbedingung hielt die gezeigte Person dabei entweder eine Waffe (z. B. eine Schusswaffe oder ein Messer) oder ein neutrales Objekt (z. B. eine Fernbedienung oder einen Blumenstrauß) in der Hand. Die Blickbewegungen der Versuchspersonen wurden aufgezeichnet, um zu erfassen, wie lange sie jeweils auf das Gesicht der gezeigten Person einerseits und auf das von ihr gehaltene Objekt andererseits schauten. Wie bereits von E. F. Loftus et al. (1987) berichtet, fixierten die Versuchspersonen die Waffen länger als die neutralen Objekte. Darüber hinaus konnten Biggs

et al. (2013) zeigen, dass die Betrachtungsdauern auf dem Gesicht der gezeigten Personen kürzer waren, wenn diese statt neutraler Objekte Waffen hielten. Damit fanden die Forschenden direkte Evidenz für die von den Erklärungsansätzen zum WFE angenommene Aufmerksamkeitsverschiebung von der Täterin bzw. dem Täter hin zur Waffe.

Neben den hypothesenkonformen Befunden von E. F. Loftus et al. (1987) und Biggs et al. (2013) gibt es jedoch auch Hinweise darauf, dass Waffen zumindest nicht unter allen Umständen Aufmerksamkeit auf sich ziehen. Scrivner et al. (2019) zeichneten die Blickbewegungen von Versuchspersonen auf, während diese Bilder von gewalttätigen und nicht gewalttätigen Interaktionen betrachteten. In Übereinstimmung mit den Vorhersagen der Erklärungsansätze zum WFE schauten die Versuchspersonen bei gewalttätigen Interaktionen weniger auf die Gesichter der beteiligten Personen. Allerdings fokussierten die Versuchspersonen ihre Aufmerksamkeit bei den gewalttätigen Interaktionen stattdessen nicht auf die von den Personen gehaltenen Objekte, welche häufig Waffen waren, sondern auf die Bereiche, in denen sich die gezeigten Personen berührten (z. B. sich gegenseitig festhielten).

Da Scrivner et al. (2019) nicht direkt die Effekte von Waffen untersuchten, gibt es einige Aspekte dieser Untersuchung, die die Generalisierbarkeit auf den WFE einschränken. So waren nicht in allen gewalttätigen Interaktionen Waffen zu sehen und auch in einigen nicht gewalttätigen Szenen trugen die gezeigten Personen Waffen (im Holster). Außerdem wurden nicht alle im Bild gezeigten Waffen auch immer von den interagierenden Personen in der Hand gehalten. Somit ist die untersuchte Betrachtungsdauer auf den von den interagierenden Personen gehaltenen Objekten nicht deckungsgleich mit der Betrachtungsdauer auf den im Bild gezeigten Waffen. Die womöglich entscheidendste Einschränkung ist jedoch, dass einige der Waffen von Polizistinnen und Polizisten gehalten wurden. Wie oben bereits beschrieben, beeinträchtigte die Anwesenheit einer Waffe in einer Untersuchung von Pickel (1999) die Erinnerungsgenauigkeit nicht, wenn die Waffe von einem Polizisten gehalten wurde. Vermutlich werden Waffen in der Hand von Polizistinnen und Polizisten nicht als ungewöhnlich wahrgenommen, was auch die von Scrivner et al. (2019) beobachteten Effekte beeinflusst haben könnte.

In anderen Eye-Tracking-Studien zum WFE wurde die Aufmerksamkeitszuweisung nur für sehr kurze Darbietungszeiten (100 – 1500 Millisekunden) untersucht (Flowe, Hope & Hillstrom, 2013; Harada, Hakoda, Kuroki & Mitsudo, 2015). Dabei zeigten Flowe et al. (2013), dass eine Waffe und ein nicht bedrohliches unübliches Objekt auch automatisch und ohne Kontext mehr Aufmerksamkeit auf sich ziehen können als ein gebräuchliches Objekt. Ein unübliches (im Gegensatz zu einem ungewöhnlichen) Objekt wurde deshalb verwendet, weil die Ungewöhnlichkeit in einem bestimmten Kontext bei einer Darbietung ohne Kontext natürlich

nicht variiert werden kann. Harada et al. (2015) zeigten, dass der Aufmerksamkeitsfokus von Versuchspersonen enger war, wenn sie Bilder mit Waffen sahen, als wenn sie neutrale Bilder sahen. Bei anderen emotional erregenden Bildern, die keine Waffe enthielten, trat dieser Effekt nicht auf. Somit scheint die gefundene Verengung des Aufmerksamkeitsfokus nicht die Folge eines erhöhten Erregungsniveaus gewesen zu sein.

Schließlich gibt es auch Studien, in denen die Aufmerksamkeitskomponente des WFE ohne Eye-Tracking untersucht wurde (Erickson, Lampinen & Leding, 2014; Hope & Wright, 2007). Ähnlich wie E. F. Loftus et al. (1987) wurden in diesen Untersuchungen Dia-Shows dargeboten, die sich nur darin unterschieden, welches Objekt eine Zielperson in der Hand hielt. Hope und Wright (2007) erfassten die Aufmerksamkeit, indem sie die Reaktionszeiten bei der Bearbeitung einer Sekundäraufgabe erfassten, die unterhalb der Stimuli dargeboten wurde. Die Reaktionszeiten waren länger, wenn die Zielperson eine Waffe oder ein ungewöhnliches Objekt in der Hand hielt, als wenn sie ein neutrales Objekt in der Hand hielt. Die Forschenden interpretierten diese Befunde so, dass die Waffe und das ungewöhnliche Objekt mehr Aufmerksamkeit gebunden haben als das neutrale Objekt.

Erickson et al. (2014) verwendeten Selbstberichte, um die Verteilung der Aufmerksamkeit zu erfassen. Im Anschluss an die Präsentation der Stimuli wurden die Versuchspersonen gebeten, auf einer 10-stufigen Likert-Skala anzugeben, ob sie mehr auf das Gesicht der Zielperson oder mehr auf das Objekt in ihrer Hand geachtet hatten. In den Bedingungen, in denen die Zielperson eine Waffe oder ein ungewöhnliches Objekt in der Hand gehalten hatte, gaben die Versuchspersonen an, mehr auf das jeweilige Objekt geachtet zu haben als auf das Gesicht der Zielperson. Dagegen berichteten die Versuchspersonen in der neutralen Bedingung, dem Gesicht der Zielperson und dem Objekt jeweils gleich viel Aufmerksamkeit gewidmet zu haben. Es ist jedoch unklar, wie zuverlässig derartige Selbstberichte zur Aufmerksamkeitsverteilung sind. Einige Befunde deuten darauf hin, dass Personen Schwierigkeiten haben, Auskunft über ihre eigenen Blickbewegungen zu geben (z. B. Foulsham & Kingstone, 2013; Vö, Aizenman & Wolfe, 2016).

Insgesamt gibt es somit nur wenige Studien, in denen die Aufmerksamkeitskomponente des WFE direkt untersucht wurde. E. F. Loftus et al. (1987) waren die einzigen, die die Aufmerksamkeitseffekte von Waffen direkt und im Kontext von (inszenierten) Straftaten untersuchten. Direkte Evidenz für die Annahme, dass Personen kürzer angeschaut werden, wenn sie eine Waffe tragen, stammt aus einer einzigen Studie, in der unzusammenhängende Bilder einzelner Personen gezeigt wurden (Biggs et al., 2013). Dabei ist gerade dieser Teil der Aufmerksam-

keitskomponente des WFE zentral für den angenommenen Wirkzusammenhang: Dass die Erinnerung an das Aussehen einer Person durch eine Aufmerksamkeitsverschiebung hin zur Waffe in ihrer Hand beeinträchtigt wird, ist insbesondere dann plausibel, wenn diese Aufmerksamkeitsverschiebung auch tatsächlich dazu führt, dass der Person selbst weniger Aufmerksamkeit gewidmet wird.

## **1.4 Zielsetzung der vorliegenden Arbeit**

Das Hauptziel der vorliegenden Arbeit ist es, direkt und unter naturalistischen Betrachtungsbedingungen zu untersuchen, inwieweit die von aktuellen Theorien zum WFE aufgestellten Annahmen zu den Aufmerksamkeitseffekten von Waffen zutreffend sind. Bisherige Studien zur Aufmerksamkeitskomponente des WFE verwendeten ausschließlich statische Stimuli, entweder in Form von Dia-Shows (z. B. E. F. Loftus et al., 1987) oder unzusammenhängenden Bildern (z. B. Biggs et al., 2013). Die Verwendung statischer Stimuli vereinfacht die Analyse von Blickbewegungsdaten (vgl. Biggs et al., 2013). Reale Situationen sind jedoch selten statisch, sondern enthalten häufig bewegte Elemente. Dies gilt natürlich insbesondere für Szenen, in denen Menschen miteinander interagieren. Studien, in denen der Einfluss von elementaren Stimulusmerkmalen auf die Verteilung von Blickbewegungen untersucht wurde, haben gezeigt, dass Bewegung und Veränderungen über die Zeit starke Prädiktoren für das Blickverhalten sind (z. B. Itti, 2005). Da diese Bewegungsinformationen in statischen Stimuli nicht enthalten sind, kann ihr Einfluss auf die Aufmerksamkeitszuweisung mit dieser Art Material nicht untersucht werden.

Für die Erinnerungskomponente des WFE konnte gezeigt werden, dass Beeinträchtigungen der Erinnerung durch Waffen sowohl bei Verwendung von statischen Stimuli wie Dia-Shows (z. B. Erickson et al., 2014; Hope & Wright, 2007; Kramer et al., 1990) als auch bei Videos (z. B. Cutler, Penrod & Martens, 1987; Pickel, 1998, 1999; Pickel & Sneyd, 2018) und bei realen Interaktionen im Rahmen von Simulationsstudien (z. B. Maass & Köhnken, 1989; Peters, 1988) auftreten können. In einer Meta-Analyse wurde kein signifikanter Unterschied zwischen den Erinnerungseffekten bei Dia-Shows einerseits und Videos oder Simulationen andererseits gefunden (Kocab & Sporer, 2016). Das Vernachlässigen von Bewegungsinformationen scheint demnach keinen entscheidenden Einfluss auf die Erinnerungseffekte von Waffen zu haben. Der Einfluss von Bewegungsinformationen auf die Aufmerksamkeitskomponente des WFE ist dagegen weniger klar, da die bisherigen Untersuchungen zu den Aufmerksamkeitseffekten, wie oben beschrieben, ausschließlich mit statischen Stimuli durchgeführt wurden.

Die Ergebnisse einer Studie von Dorr, Martinetz, Gegenfurtner und Barth (2010) legen nahe, dass sich die Aufmerksamkeitszuweisung zwischen statischen und dynamischen Szenen unterscheidet. Dorr et al. (2010) zeigten Versuchspersonen unterschiedliche Versionen des gleichen Stimulusmaterials. In einer Bedingung wurden Videos gezeigt, in denen natürliche Situationen wie Menschen in einer Fußgängerzone oder vorbeifahrende Autos zu sehen waren. Zum Vergleich wurden Einzelbilder aus diesen Videos jeweils für wenige Sekunden gezeigt. Dabei wurden die Einzelbilder in einer der Bedingungen chronologisch angeordnet, sodass sich eine Dia-Show ergab, bei der die narrative Struktur der Videos erhalten blieb (vgl. E. F. Loftus et al., 1987). In einer anderen Bedingung wurden die Einzelbilder dagegen in zufälliger Reihenfolge dargeboten, sodass der Inhalt eines Bildes nicht anhand des vorherigen Bildes vorhergesagt werden konnte und die Bilder somit inhaltlich weniger stark zusammenhingen (vgl. Biggs et al., 2013).

Dorr et al. (2010) untersuchten insbesondere, inwieweit sich die Art des Stimulusmaterials auf die Kohärenz in den Blickbewegungen zwischen unterschiedlichen Betrachtenden auswirkte, d. h. ob Versuchspersonen eher die gleichen oder eher unterschiedliche Aspekte fokussierten. Bei den Dia-Shows war die Kohärenz kurz nach der Darbietung eines neuen Einzelbildes besonders hoch und auch höher als die Kohärenz zum gleichen Zeitpunkt in der Video-Bedingung. Diese hohe Kohärenz ergab sich daraus, dass viele Versuchspersonen nach dem Einsetzen des neuen Bildes zunächst in die Bildmitte schauten. Diese Präferenz der Bildmitte ist in der Blickbewegungsforschung allgemein bekannt (z. B. Buswell, 1935) und wird *Center Bias* genannt. Nach diesem anfänglichen *Center Bias* fiel die Kohärenz in der Dia-Show-Bedingung jedoch unter die in der Video-Bedingung, bis ein neues Dia gezeigt wurde und wieder ein *Center Bias* auftrat. Insgesamt war die Kohärenz bei den Videos über die Zeit hinweg stabiler als bei den Dia-Shows.

Neben der Verwendung von statischen Stimuli ist eine weitere Gemeinsamkeit bisheriger Studien zur Aufmerksamkeitskomponente des WFE, dass ausschließlich kurze Darbietungszeiten im Bereich von wenigen Zehntelsekunden (Harada et al., 2015) bis maximal 6 Sekunden (E. F. Loftus et al., 1987) verwendet wurden. Studien zu den Erinnerungseffekten von Waffen haben gezeigt, dass ein WFE sowohl bei einer Darbietungszeit von nur wenigen Sekunden (z. B. Erickson et al., 2014) als auch bei Darbietungszeiten von über einer Minute (z. B. Cutler et al., 1987) auftreten kann. Eine Meta-Analyse ergab, dass die stärksten Erinnerungseffekte bei Darbietungszeiten zwischen 10 und 60 Sekunden auftreten (Fawcett et al., 2013). Der Einfluss der Darbietungszeit auf die Aufmerksamkeitseffekte von Waffen ist dagegen weniger

klar. Insbesondere ist offen, inwieweit die in bisherigen Studien gefundenen Effekte über längere Darbietungszeiten hinweg bestehen bleiben.

In den vorliegenden Studien wurde erstmals untersucht, inwieweit sich bisherige Befunde zu den Aufmerksamkeitseffekten von Waffen auf dynamische und damit natürlichere Stimuli generalisieren lassen. Dazu wurden Versuchspersonen Videos von inszenierten Raubüberfällen gezeigt. Die Videos unterschieden sich durch das kritische Objekt, das von der Täterin bzw. dem Täter in der Hand gehalten wurde (entweder eine Waffe oder ein anderes Objekt).

Es wurde modernes und qualitativ hochwertiges Eye-Tracking-Equipment verwendet, um die Blickbewegungen von Versuchspersonen mit einer hohen räumlichen und zeitlichen Auflösung aufzuzeichnen. Untersucht wurde, wie sich die verschiedenen kritischen Objekte darauf auswirken, wie lange die Täterin bzw. der Täter, die kritischen Objekte selbst sowie die Opfer betrachtet werden. Dabei wurden auf maschinellem Lernen basierende Methoden genutzt, um diese untersuchten Bildregionen präzise voneinander abzugrenzen. Neuartige Zeitverlaufsanalysen erlaubten es, die zeitliche Entwicklung der Aufmerksamkeitseffekte bei längeren Darbietungszeiten detailliert zu analysieren. Zusätzlich wurde untersucht, inwieweit die Anwesenheit einer Waffe das Erinnerungsvermögen an das Aussehen der Täterin bzw. des Täters beeinträchtigt, d. h. inwieweit ein erinnerungsbezogener WFE auftritt.

Das in Studie 1 verwendete Stimulusmaterial basierte auf Videos einer aktuellen US-amerikanischen Studie (Pickel & Sneyd, 2018). Da in dieser Original-Untersuchung große Erinnerungseffekte gefunden wurden, konnten so die Aufmerksamkeitseffekte von Waffen mit Material untersucht werden, das nachweislich einen starken WFE hervorrufen kann. Unerwarteterweise führte die Anwesenheit einer Waffe in Studie 1 jedoch weder zu der von aktuellen Theorien vorhergesagten Aufmerksamkeitsverschiebung noch zu einer Beeinträchtigung des Erinnerungsvermögens.

Für Studie 2 wurden daher eigene, hochauflösende Videos erstellt, die mit dem Ziel konzipiert wurden, die Auftretenswahrscheinlichkeit des WFE zu maximieren. Dazu wurden die Ausprägungen bekannter Moderatorvariablen des WFE so gewählt, dass ein möglichst starker Effekt auftreten sollte. Die Erstellung von eigenem Material hatte den zusätzlichen Vorteil, dass die Personen im Video Deutsch sprachen, was der Muttersprache der deutschen Versuchspersonen entsprach. Als weitere Vergleichsbedingung wurde zudem ein Video mit einem nicht bedrohlichen ungewöhnlichen Objekt erstellt, um die Ungewöhnlichkeitshypothese als theoretische Erklärung für den WFE zu prüfen.

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## **2 STUDIE 1 – REVISITING THE ROLE OF ATTENTION IN THE “WEAPON FOCUS EFFECT”: DO WEAPONS DRAW GAZE AWAY FROM THE PERPETRATOR UNDER NATURALISTIC VIEWING CONDITIONS?**

Körner, H. M., Faul, F. & Nuthmann, A. (2023). Revisiting the role of attention in the "weapon focus effect": Do weapons draw gaze away from the perpetrator under naturalistic viewing conditions? *Attention, Perception, & Psychophysics*, 85, 1868–1887. <https://doi.org/10.3758/s13414-022-02643-8>

## 2.1 Zusammenfassung

Im Hauptexperiment von Studie 1 wurden die Blickbewegungen von Versuchspersonen aufgezeichnet, während diese Videos eines inszenierten Raubüberfalls ansahen. Je nach Experimentalbedingung hielt der Täter dabei entweder eine Pistole oder ein Handy in der Hand. Zusätzlich gab es für jedes dieser kritischen Objekte zwei Versionen des Videos, eine mit einem Schwarzen Täter und eine mit einem Weißen Täter. Die Videos basierten auf Material aus einer US-amerikanischen Studie (Pickel & Sneyd, 2018), in der große Erinnerungseffekte festgestellt wurden.

Die gefundenen Eye-Tracking-Ergebnisse widersprechen den Vorhersagen der aktuellen Theorien zum WFE sowie den bisherigen Befunden zur Aufmerksamkeitskomponente des WFE: Die Pistole wurde nicht signifikant länger angeschaut als das Handy und beiden Objekten wurde deutlich weniger Aufmerksamkeit gewidmet als den gezeigten Personen. Auch die Betrachtungsdauer auf dem Täter hing nicht davon ab, welches Objekt er in der Hand hielt. Die Ergebnisse einer Zeitverlaufsanalyse legen jedoch nahe, dass Versuchspersonen in der Waffen-Bedingung der Interaktion der gezeigten Personen aufmerksamer folgten als in der Handy-Bedingung. Die Befunde zur Erinnerungsgüte widersprechen ebenfalls bisherigen Befunden zum WFE allgemein und insbesondere auch den Ergebnissen der Original-Studie aus den USA: Die Versuchspersonen erinnerten sich in der Waffen-Bedingung genauso gut an das Aussehen des Täters wie in der Handy-Bedingung. Diese unerwarteten Befunde wurden in zwei Folgeexperimenten untersucht. Die Hautfarbe des Täters hatte im Hauptexperiment keinen Einfluss auf die Aufmerksamkeitsverteilung oder die Erinnerungsgüte. Daher wurden in diesen Folgeexperimenten nur noch das Stimulusmaterial mit dem Weißen Täter verwendet, für das größere Effekte erwartet wurden (vgl. Pickel & Sneyd, 2018).

Für das erste Folgeexperiment wurden Dia-Shows aus den Videos erstellt. Damit wurde die Vorgehensweise der einflussreichen Studie von E. F. Loftus et al. (1987) nachgeahmt, um zu prüfen, ob die abweichenden Befunde im Hauptexperiment auf die Verwendung von dynamischen Stimuli zurückzuführen sind. Für die Dia-Shows konnte der Befund von E. F. Loftus et al. (1987) repliziert werden, dass eine Waffe länger angeschaut wird als ein neutrales Objekt. Im Gegensatz zu den Befunden für unzusammenhängende Bilder (Biggs et al., 2013) wurde der Täter jedoch nicht weniger angeschaut, wenn er die Waffe in der Hand hielt. Auch die Erinnerung an das Aussehen des Täters wurde erneut nicht durch die Anwesenheit einer Waffe beeinträchtigt.

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Das zweite Folgeexperiment diente dazu, die Erinnerungseffekte genauer zu untersuchen. Hierfür wurde eine Online-Untersuchung durchgeführt, in der eine größere Stichprobe getestet und das Vorgehen der Original-Studie möglichst genau repliziert wurde. Auch hier konnte kein Einfluss des Objekttyps auf die Erinnerungsgüte festgestellt werden.

Für Videos konnte die vorhergesagte Aufmerksamkeitsverschiebung vom Täter zur Waffe nicht nachgewiesen werden. Die Befunde für Dia-Shows legen nahe, dass entsprechende Ergebnisse aus früheren Studien auf die Verwendung von weniger natürlichem Material zurückzuführen sind. Insgesamt sprechen die Eye-Tracking-Ergebnisse dafür, dass die Aufmerksamkeitseffekte von Waffen unter natürlichen Betrachtungsbedingungen komplexer sind als bisher angenommen.

Im Gegensatz zur Original-Untersuchung von Pickel und Sneyd (2018) konnte in keinem der Experimente ein Erinnerungseffekt festgestellt werden. Da die verwendete Methode, insbesondere die des Online-Experiments, stark an der von Pickel und Sneyd (2018) orientiert war, ist diese Diskrepanz der Befunde vermutlich auf Unterschiede in der Stichprobensatzzusammensetzung zurückzuführen. Allein anhand der vorliegenden Daten lässt sich jedoch nicht mit Sicherheit feststellen, welche spezifischen Charakteristika der Betrachtenden das Auftreten des WFE beeinflussen.

## 2.2 Abstract

The presence of a weapon in a scene has been found to attract observers' attention and to impair their memory of the person holding the weapon. Here, we examined the role of attention in this weapon focus effect (WFE) under different viewing conditions. German participants viewed stimuli in which a man committed a robbery while holding a gun or a cell phone. The stimuli were based on material used in a recent U.S. study reporting large memory effects. Recording eye movements allowed us to test whether observers' attention in the gun condition shifted away from the perpetrator towards the gun, compared with the phone condition. When using videos (Experiment 1), weapon presence did not appear to modulate the viewing time for the perpetrator, whereas the evidence concerning the critical object remained inconclusive. When using slide shows (Experiment 2), the gun attracted more gaze than the phone, replicating previous research. However, the attentional shift towards the weapon did not come at a cost of viewing time on the perpetrator. In both experiments, observers focused their attention predominantly on the depicted people and much less on the gun or phone. The presence of a weapon did not cause participants to recall fewer details about the perpetrator's appearance in either experiment. This null effect was replicated in an online study using the original videos and testing more participants. The results seem at odds with the attention-shift explanation of the WFE. Moreover, the results indicate that the WFE is not a universal phenomenon.

Weapons have been shown to attract more attention and gaze than other objects (Biggs et al., 2013; E. F. Loftus et al., 1987). Moreover, the presence of a weapon in a scene can impair an observer's memory for relevant aspects of the environment, in particular for the person holding the weapon (e.g., E. F. Loftus et al., 1987; Mitchell et al., 1998; Pickel, 1998, 1999, 2009). This phenomenon is known as the weapon focus effect (WFE). While the memory effects of weapons are well established (see Fawcett et al., 2013, and Kocab & Sporer, 2016, for meta-analyses), very few studies have explicitly addressed the attention component of the WFE. The main goal of the present research was to test whether attentional effects of weapons found for slide shows (E. F. Loftus et al., 1987) and non-narrative static images (Biggs et al., 2013) generalize to more naturalistic viewing conditions (i.e., videos). Memory for the perpetrator's appearance was also assessed.

Currently, there exist two main theoretical explanations for the WFE: the arousal/threat hypothesis and the unusual item hypothesis. The arousal/threat hypothesis attributes the phenomenon to the threatening nature of weapons (e.g., Hulse & Memon, 2006; Maass & Köhnken, 1989). Based on Easterbrook's (1959) "cue utilization hypothesis," the arousal induced by a weapon is assumed to cause a narrowing of attention, leading witnesses to focus on central details (i.e., the weapon itself) at the cost of attention to peripheral ones (i.e., other aspects of the perpetrator and the scene). In contrast, the unusual item hypothesis highlights the unusualness of weapons in most situations (e.g., Mitchell et al., 1998; Pickel, 1998). Objects that are unexpected in the given context have been shown to attract more attention and eye fixations than context-congruent objects (e.g., G. R. Loftus & Mackworth, 1978). Weapons are unusual in most contexts. Therefore, according to the unusual item hypothesis, weapons often form a special case of incongruent objects (E. F. Loftus et al., 1987).

A central assumption underlying both theoretical approaches is that the weapon draws attention to itself, which leads to poorer encoding of other aspects of the scene. Eye tracking provides researchers with an excellent tool for assessing how overt attention is allocated in the scene (e.g., Foulsham, 2015; Williams & Castelhana, 2019). In particular, fixation locations reveal *where* participants attend to in a scene, whereas fixation durations indicate *how long* attention and gaze remain at a specific location (Henderson, 2003). Two eye-tracking studies on the WFE provided evidence for the assumption that weapons attract attention and gaze (Biggs et al., 2013; E. F. Loftus et al., 1987). E. F. Loftus et al. (1987) recorded the eye movements of participants who were asked to view a slide show of a man taking money from a cashier. Memory for the man was worse when he carried a gun than when he held a check.

Importantly, eye-movement data revealed that the weapon was fixated more often and for longer durations than the neutral object.

In the study by Biggs et al. (2013), participants were presented with several unrelated, non-narrative images (i.e., images involving different people and settings), each depicting a person holding either a weapon or a neutral object. On trials including a weapon, participants spent more time fixating what was being held, thereby replicating E. F. Loftus et al. (1987). In line with current theories on the WFE, Biggs et al. (2013) found that this attentional focus on the weapon came at a cost in viewing time on the face of the person. Biggs et al. (2013) further manipulated participants' action-specific potential during stimulus presentation by either arming participants with a gun or giving them a metal cylinder to hold. Holding a gun in a readily usable position led to a general bias towards faces, which did not interact with the observed attentional WFE.

Other studies that examined the attentional component of the WFE used either very short exposure durations (Flowe et al., 2013; Harada et al., 2015) or did not record participants' eye movements (Erickson et al., 2014; Hope & Wright, 2007). Erickson et al. (2014) used a self-report measure to assess observers' attentional allocation. They found that participants who saw a target person carrying a weapon or an unusual object compared with a neutral object indicated to have paid more attention to the object and less attention to the face of the person. If this self-report is accurate, these results suggest that an attentional shift due to weapon presence is consciously accessible.

In contrast to previous research, Scrivner et al. (2019) found indirect evidence that weapons do not always attract attention. In their study, the authors did not specifically examine the effects of weapons, but instead tracked subjects' eye movements while they viewed images of violent vs. nonviolent interactions. Viewing time on the objects held by the depicted people did not differ between violent and non-violent scenes. Instead, when viewing violent scenes, participants attended more to locations where the people touched each other and less to faces. There are some aspects of this study that limit the generalization to the WFE: Given the focus of the study, some of the objects in violent interactions were not weapons, and not all weapons present in the scenes were held by the interacting people. Moreover, a few of the non-violent scenes included (holstered) weapons. Perhaps more importantly, some of the stimuli depicted police officers carrying weapons, and it has been shown that the presence of a gun has no effect on memory when it is carried by a police officer (Pickel, 1999).

In studies on the WFE, the scenarios in which the weapon is presented, the control of intervening variables, and the way in which the effect is measured, vary considerably (Kocab &

Sporer, 2016). In part, this variability can be attributed to the conflicting goals arising from the applied perspective, which demands a highly realistic setting, and the basic research perspective, which places more emphasis on stimulus control. Using videos of staged criminal scenarios presents a good compromise in this regard, as videos allow researchers to depict realistic scenarios and control the stimulus on basic dimensions (e.g., Mitchell et al., 1998; Pickel, 2009; Pickel & Sneyd, 2018).

A recent meta-analysis suggests that the mode of presentation (slides vs. video/live) does not modulate the memory-related WFE (Kocab & Sporer, 2016). The effect of presentation mode on the attentional component of the WFE is less clear, because previous eye-tracking studies used slide shows (E. F. Loftus et al., 1987) or non-narrative static images only (Biggs et al., 2013). Thus, despite the complexities that arise when analyzing eye movements observers make when viewing dynamic scenes, it is important to test whether findings obtained for static scene images generalize to moving images (i.e., videos).

Research on eye-movement control during naturalistic scene viewing has shown that gaze behavior depends on both the mode of stimulus presentation and the viewing task (Dorr et al., 2010; Smith & Mital, 2013). Dorr et al. (2010) compared participants' eye movements while they watched 20-s long videos of real-world scenes containing no cuts and only minimal camera movement as opposed to random static images or stop-motion sequences (i.e., slide shows of a selection of still images taken from the respective video). When viewing stop-motion sequences or random static images, most participants focused their attention on the center of the screen at the start of the presentation of a new image or slide. This center bias (e.g., Buswell, 1935) is known to be particularly prominent shortly after stimulus onset (Tatler, 2007). Accordingly, for the first second following a new slide, observers' gaze behavior was more similar in the stop-motion sequence compared with the same point in the video condition (Dorr et al., 2010). After this initial phase, however, coherence dropped below the level observed in the video condition. Thus, the inter-observer coherence showed different time courses in videos and stop-motion sequences: stop-motion sequences led to an alternating rise and fall of coherence, whereas coherence in the video condition maintained a more stable level.

It is currently unclear whether and how the effects of weapon presence on attention change over time. In previous studies in which attention shifts towards weapons were found, the exposure duration for the critical object (i.e., the weapon or the neutral control) was relatively short (6 s in E. F. Loftus et al., 1987, and 5 s per image in Biggs et al., 2013). It is quite possible that the presence of a weapon affects the allocation of attention within the first few seconds only.

Culture may constitute another factor moderating the WFE. Most published studies on the WFE were conducted in the U.S. Gun ownership is a constitutional right in the U.S., whereas gun laws are much more restrictive in other regions, including most European countries. It seems plausible that varying “gun cultures” could affect the processing of gun-related events. The comparatively few studies that examined the effects of weapons on memory outside of the U.S. produced mixed results. Some studies found a classic WFE (Hope & Wright, 2007; Kim et al., 2014; Maass & Köhnken, 1989; Saunders, 2009), but only Hope and Wright (2007) included a gun as a weapon. In contrast, several recent European studies found that the WFE occurred only under certain conditions (Harvey & Sekulla, 2021; Mansour et al., 2019) or not at all (Harvey et al., 2020; Nyman et al., 2020). All of these more recent studies have in common that even reversed effects were found for some measures or experimental conditions.

A more specific finding potentially affected by culture is a moderating influence of the perpetrator’s race on the strength of the WFE. Pickel and Sneyd (2018) reported a weaker memory-related WFE for a Black than for a White perpetrator. The authors attributed this difference to racial stereotypes linking weapons to Black men, thus rendering them less unusual in this context. However, racial stereotypes are less universal than, for example, gender stereotypes and may differ significantly across nations (see Fiske, 2017, for a review). It is therefore unclear how well the findings by Pickel and Sneyd (2018), obtained from a Midwestern U.S. population, generalize to other cultures. Recent results by Frenken et al. (2022) suggest that similar racial stereotypes exist in Germany. Frenken et al. (2022) used a computer-based first-person shooter task (Correll et al., 2002) for which several U.S. studies have found that participants are quicker to “shoot” armed Black actors compared with White ones and slower to indicate a “don’t shoot” response for unarmed Black actors (Mekawi & Bresin, 2015). Frenken et al. (2022) found that this racial bias generalizes to German participants.

The goal of the current multi-experiment study was to investigate some of the open research questions outlined above. The purpose of Experiment 1 was to examine the effects of weapon presence on attention using dynamic stimuli and longer exposure durations. The stimuli were derived from the video footage used in Experiment 1 by Pickel and Sneyd (2018), in which a significant memory-related WFE for details of the perpetrator’s appearance was found. Eye tracking was used to explicitly test the key assumption that the memory-related WFE is caused by an impaired encoding of the perpetrator’s appearance due to a shift of the observer’s attention away from the perpetrator and towards the weapon. Moreover, conducting our study in Germany allowed us to test whether cultural differences regarding the role of weapons in society and stereotypes affect the strength of the WFE. Finding such differences would mean that

cultural specificities need to be taken into consideration when estimating the effects of weapon presence on eyewitness testimony.

To preview the results: Contrary to predictions by current theories and results from previous eye-tracking studies on the WFE (Biggs et al., 2013; E. F. Loftus et al., 1987), the weapon did not draw significantly more gaze than a neutral object, and weapon presence had no effect on viewing time for the perpetrator. Weapon presence also did not affect observers' memory performance, which means that we could not replicate the memory-related WFE.

To further investigate these unexpected results, we conducted two additional experiments. In Experiment 2, we used stop-motion versions of the videos to replicate the methodology of E. F. Loftus et al. (1987). Our eye-tracking results were compatible with their observations, but we still failed to find a memory-related WFE. In Experiment 1, we used modified versions of the videos used by Pickel and Sneyd (2018). To test whether these modifications could explain the differences regarding the memory effects, we conducted a third experiment in which the original videos were presented online. Again, no memory effect was found.

## 2.3 Experiment 1

In our main Experiment 1, German participants watched videos derived from the material of Experiment 1 in Pickel and Sneyd (2018) while their eye movements were tracked. The videos showed a man, who was either Black or White, committing a robbery. The perpetrator was holding either a weapon or a neutral (i.e., non-threatening and context-congruent) control object. After watching the video, participants were asked to fill out a questionnaire regarding the appearance of the perpetrator. Additionally, we used a self-report measure of attention to check (a) whether a potential shift of attention is consciously accessible (as the results of Erickson et al., 2014, suggest) and (b) how well self-reported eye movements match the actual gaze behavior.

If the common assumptions about the attentional effects of weapons are correct, then viewing time on the weapon should be longer compared with the neutral object, which should in turn come at a cost in viewing time on the perpetrator. As a consequence of this attentional shift, the results from the memory questionnaire should reveal a reduced accuracy for details of the perpetrator's appearance, as observed in many previous studies, including Pickel and Sneyd (2018).

Moreover, Pickel and Sneyd (2018) found that the WFE was weaker for a Black perpetrator than for a White perpetrator, which they explained with racial stereotypes. If similar stereotypes

exist in Germany, the WFE should be reduced for the Black perpetrator. Under the assumption that an attentional shift towards the weapon is indeed the key mechanism underlying the memory-related WFE, the time spent looking at the weapon versus the neutral object should be more similar for the Black perpetrator than for the White one. Alternatively, if racial stereotypes linking weapons to Black men are less pronounced in Germany, no effect of perpetrator race on either attention or memory may be observed.

### **2.3.1 Methods**

#### **2.3.1.1 Design and Participants**

The experiment had a 2 (object type: gun and cell phone)  $\times$  2 (perpetrator race: Black and White) between-subjects design. We conducted an a priori power analysis to determine the sample size required to detect large effects ( $\eta^2 \geq .14$ ) with analyses of variance. In our study, most variables known to moderate the memory-related WFE (e.g., the exposure duration to the critical object) were within the ranges that produced the strongest effects in previous studies (Fawcett et al., 2013). Moreover, Pickel and Sneyd (2018), whose stimulus material we adapted, found large effects of weapon presence on memory. The power analysis yielded a required sample size of  $N = 68$  to achieve a power of at least  $1 - \beta = .90$  with a significance level of  $\alpha = .05$ . Accordingly, the sample consisted of 68 participants (52 women, 16 men) between 19 and 43 years of age ( $M = 23.9$  years,  $SD = 4.9$ ). Of these, 65 self-identified as White, whereas three reported being non-White. None self-identified as Black. Most participants were undergraduate psychology students. Subjects received either monetary compensation or course credit for their participation. The experiment was approved by the Central Ethics Committee of Kiel University, and participants gave informed consent accordingly.

#### **2.3.1.2 Stimuli**

The videos were adapted from Experiment 1 in Pickel and Sneyd (2018). The original videos were about 90 seconds long and showed a man robbing two other men while carrying an object. The perpetrator was either Black or White and was holding either a handgun or a cell phone. Thus, there were four different versions of the video. The videos subtended  $24.1^\circ$  horizontally and  $18.2^\circ$  vertically. Since they were filmed in a 4:3 format, but presented on a 16:9 monitor, the left and right edges of the screen were set to black ( $4.1^\circ$  each).

The perpetrator was visible during two separate scenes of the video. In the first scene, he walked down the corridor of an office building while looking around. No other people were visible during this part of the video. In the second scene, the perpetrator entered a room where

the two victims were working, one of them Black, the other White. He took their wallets and tablets before leaving. The perpetrator was visible for approximately 6 s in the first scene and for approximately 26 s in the second scene. The critical object was always with him and constantly visible to the observer. Each of the scenes consisted of a single medium long shot.

Compared with the study by Pickel and Sneyd (2018), two changes were made to the videos. The protagonists in the videos spoke English. Therefore, and firstly, we chose to present the videos to our German subjects without sound, because we wanted to eliminate any potential effects of varying degrees of comprehension or increased cognitive load due to processing a foreign language (Roussel et al., 2017). Importantly, numerous studies have found a WFE when presenting stimuli without sound (e.g., Mitchell et al., 1998; Pickel, 1998, 1999), suggesting that omitting the soundtrack should not matter.

Secondly, we chose to exclude a section of the video showing a close-up on the critical object. In the original version, when the perpetrator was shown for the first time, the shot started with a close-up on the object he carried. This focus was maintained for around 3 s before the camera slowly zoomed out to the medium long shot. In our experiment, the scene began with the zoomed out shot. For one, the close-up constitutes an unnatural element, thereby interfering with our goal to study the allocation of attention under naturalistic viewing conditions. Moreover, as no other objects of interest were present during the close-up, it is highly likely that participants would fixate and process the critical object during this part of the video. This could in turn reduce the need to further process the object later on, when both the perpetrator and the object become visible. Thus, the close-up potentially reduces the need for participants to choose between the critical object and the perpetrator when allocating their attention.

### **2.3.1.3 Apparatus**

A 24 in. monitor with a resolution of  $1920 \times 1080$  pixels and a refresh rate of 144 Hz was used for stimulus presentation. Eye movements were recorded using an SR Research EyeLink 1000 Desktop Mount. The 2000 Hz camera upgrade allowed for binocular tracking with 1000 Hz for each eye. A chin and forehead rest was used to minimize participants' head movements. The viewing distance was 93 cm.

### **2.3.1.4 Procedure**

Participants were instructed to pay close attention to the content of the video, without disclosing that their memory for certain aspects of the video would be tested afterwards. Before stimulus presentation, a nine-point calibration and validation of the eye tracker was performed. Moreover, the following fixation check was implemented: A fixation cross was presented at

the center of the screen for 500 ms. The video was displayed only if the participant's gaze deviated less than  $0.6^\circ$  from the cross for at least 200 ms. Immediately after participants had watched the video, they filled out the questionnaire regarding the appearance of the perpetrator.

The memory questionnaire was a German version of the questionnaire used by Pickel and Sneyd (2018). The questionnaire consisted of questions regarding the appearance of the perpetrator, both in a single choice format (e.g., "Was the perpetrator wearing a jacket?" with the response categories "yes" and "no") and in an open format (e.g., "What color was the jacket of the perpetrator?"). To increase the number of responses per subject, we added a set of questions about the perpetrator's backpack.

The awareness and endorsement of the stereotype that Black men are more likely to commit crimes involving weapons was assessed using rating scales. Participants were asked whether, according to (a) existing stereotypes (stereotype awareness) and (b) their personal beliefs (stereotype endorsement), a Black or a White man was more likely to commit a crime using a weapon.

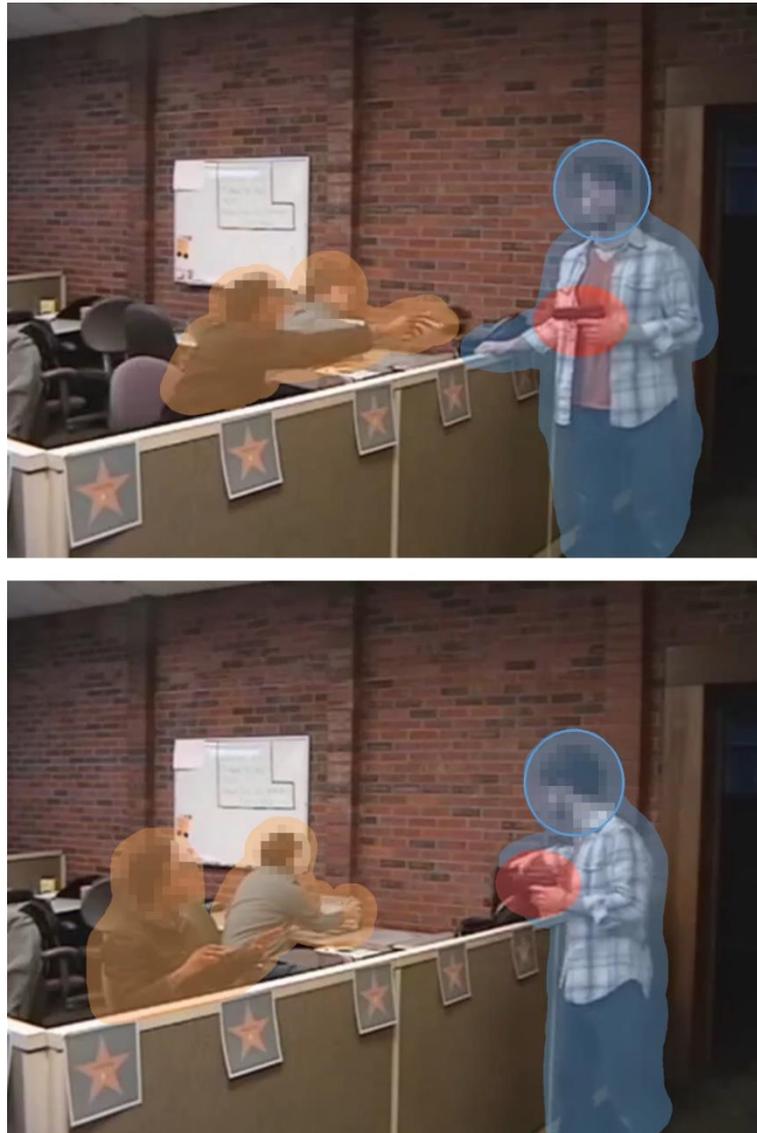
We added a new question to assess participants' introspection regarding their eye movements: The task was to indicate what percentage of time they thought they had looked at each of five predefined regions during the sequences in which the perpetrator was visible. These regions were the perpetrator, the object he held, the Black victim, the White victim, and any region outside of these categories. Note that this method differs from the unidimensional scale employed by Erickson et al. (2014), who asked participants to indicate whether they had paid more attention to the face of the target person or the object she was holding. We chose to assess the self-reported viewing time for different regions in order to be able to directly and in detail compare objectively measured and subjectively reported viewing times.

### **2.3.1.5 Data Analysis**

The data were analyzed using SR Research Data Viewer, Python, and R (see Appendix 1 for software details). Eye movements were not analyzed for the entire videos. Instead, analysis was limited to the sequences where the perpetrator was visible (i.e., the hallway scene and the robbery scene). The empirically determined quality of the eye-tracking data was high (see Appendix 2). For a given participant, the data from the eye with the lower average error during the eye-tracker validation were analyzed (cf. Hooge et al., 2019).

### **2.3.1.6 Creation of Dynamic Regions of Interest**

To analyze the allocation of attention and gaze, dynamic regions of interest (ROIs) were defined around the perpetrator, the victims, and the critical object (see Figure 2.1). The ROIs for



**Figure 2.1** Example frames for the gun and the White perpetrator with superimposed regions of interest. Top panel: The victims hand over their wallets. Bottom panel: The perpetrator takes a tablet. Transparent overlays mark the regions of interest for the perpetrator (blue), the critical object (red), and the victims (orange). The blue ellipses mark the borders of the region of interest for the perpetrator's head. Faces were pixelated for privacy protection; note that this was not the case in the experimental stimuli.

the perpetrator and each of the victims were generated automatically using the neural network module *PointRend* (Kirillov et al., 2020) with a ResNet-101 backbone. For the critical object, an elliptical ROI was created manually in SR Research Data Viewer. Given that human faces are generally known to attract attention and the eyes (e.g., Cerf et al., 2009), a separate elliptical ROI was created for the head of the perpetrator (cf. Biggs et al., 2013). For our main analyses, viewing times on the perpetrator were calculated by adding the viewing times on his head and his body. Similarly, viewing times were added up for the two victim ROIs, essentially treating

the two victim ROIs as a single ROI covering both victims. To account for inaccuracies in the eye-tracking hardware, a margin of approximately  $0.5^\circ$  was added to each ROI (cf. Orquin et al., 2016).

When generating ROIs for the critical object and the perpetrator's head in Data Viewer, instances were created manually for some of the video frames. The software then automatically interpolated the ROI coordinates with an interval of 30 ms. If necessary, further instances were added until the ROI closely matched the actual movement of the target.

Some of the created ROIs overlapped. Specifically, the ROI for the critical object always overlapped with the ROI for the perpetrator. Naturally, the ROI for the perpetrator's head also overlapped with the ROI for the entire perpetrator. The ROI for the critical object did not overlap with the victim ROI. There was also virtually no overlap between the perpetrator ROIs and the victim ROI, except for short overlaps when the victims handed over the items and when the perpetrator left.

Due to these overlaps, gaze samples could fall into more than one ROI. In these cases, samples were assigned to only one of the ROIs based on a predefined hierarchy. The ROI of the critical object took priority over the ROIs of the perpetrator. Within the perpetrator ROIs, samples were assigned primarily to the head and then to the automatically generated ROI covering the entire perpetrator. The ROI of the victims had the lowest priority.

### **2.3.1.7 Smooth Pursuit Check**

When viewing dynamic scenes, observers sometimes follow moving objects steadily with their gaze. These eye movements are known as smooth pursuit (see Goettker & Gegenfurtner, 2021, for a review). The EyeLink event parser cannot detect smooth pursuit eye movements, but instead classifies them as fixations (Smith & Mital, 2013). However, intrafixational displacements of the gaze position are expected to be larger in the presence of smooth pursuit. To check for the presence of smooth pursuit in each event classified as a fixation, we determined the Euclidian distances between the gaze coordinates of the last sample of the previous saccade and the first sample of the next saccade (cf. Hutson et al., 2017; Nuthmann & Canas-Bajo, 2022). We then compared the distances with those observed in Experiment 2 where slide shows of single frames from the videos were used. There were larger displacements for the videos ( $M = 0.65^\circ$ ,  $SD = 0.11$ ) than for the slide shows ( $M = 0.36^\circ$ ,  $SD = 0.09$ ),  $t(122) = 15.48$ ,  $p < .001$ ,  $d = 2.79$  (one-tailed test). These results indicate that the eye-movement data obtained with the videos included some smooth pursuit epochs.

For hypothesis testing, we calculated the viewing times for different ROIs rather than analyzing the durations of individual fixations. Therefore, we chose not to exclude potential smooth pursuit movements. However, the presence of smooth pursuit segments was taken into account when assigning the eye movement data to ROIs: Rather than using the mean gaze coordinates for oculomotor events classified as fixations (the default in Data Viewer), ROI matching was based on the individual gaze samples.

### **2.3.1.8 Memory Scores**

The answer key for correct responses regarding the appearance of the perpetrator was adapted from Pickel and Sneyd (2018). Participants' responses were scored independently by two raters who were unaware of the underlying hypotheses. Ratings were aggregated across both raters. For each participant, the number of correctly and incorrectly reported details was determined. When evaluating the open text questions, each new piece of information provided by the subject was counted as one detail. A detail was coded as correct if it matched the descriptions in the answer key. For example, as the Black perpetrator was wearing black jeans, both "jeans" and "black" would be counted as correct details. In contrast, if a participant reported that the pants had white stripes, this would be counted as two incorrect details, as the pants were neither white nor did they have stripes. Inter-rater reliability was high for both correct ( $r = .93$ ) and incorrect details ( $r = .85$ ). Following recommendations by Kocab and Sporer (2016), we used the proportion of correct responses (i.e., the number of correct details divided by the total number of details, correct and incorrect) as a measure of memory accuracy.

### **2.3.1.9 Details on Statistical Analyses**

For non-significant effects, we calculated Bayes factors (Jeffreys, 1935) with default priors (Rouder et al., 2012) to determine the amount of evidence in favor of the null hypothesis. The Bayes factor  $BF_{01}$  is defined as the ratio of the probability for the observed data to have arisen under the null hypothesis to the probability for them to have arisen under the alternative hypothesis. For example, a value of  $BF_{01} = 5$  would indicate that it is 5 times more likely for the observed data to have arisen under the null hypothesis than under the alternative hypothesis. Note that a value of 1 indicates equally strong evidence in favor of the null hypothesis and against it. To communicate the results, we use classifications proposed in the literature (Wagenmakers et al., 2018). Because Bayes factors account for uncertainties in the data, they can be interpreted with confidence for any sample size (cf. Dienes & McIatchie, 2018).

## 2.3.2 Results

### 2.3.2.1 Total Viewing Time

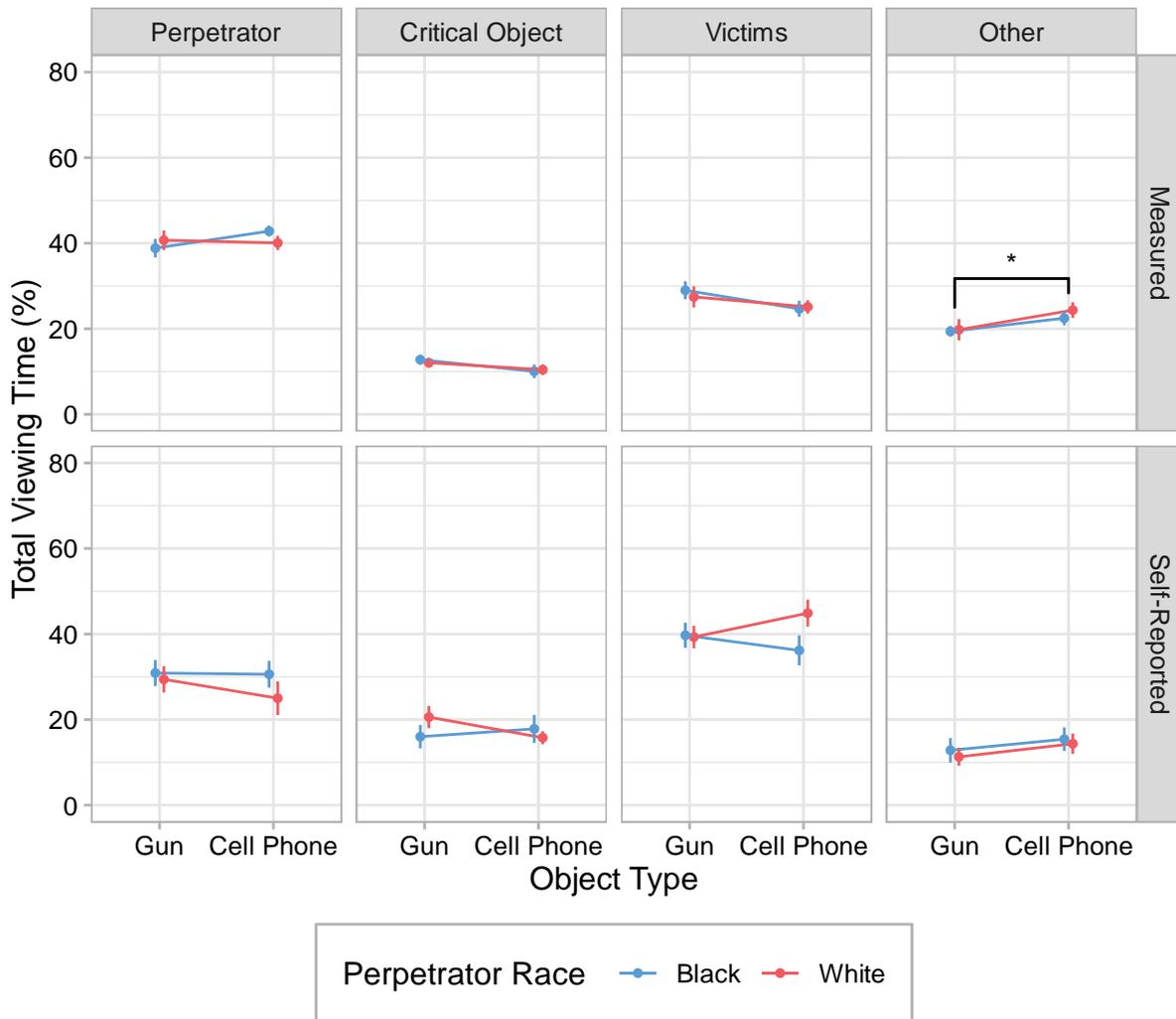
The total viewing time (TVT) is the summed duration of all fixations landing within a given ROI. TVT was standardized as the percentage of the duration of the video segments for which eye movement data were analyzed (see above). Table 2.1 and the top row of Figure 2.2 show the relative TVT on the perpetrator, the critical object, the victims, and any area outside of these ROIs as a function of the perpetrator's race and the object he carried.

TVT was longest for the perpetrator. Unexpectedly, statistical analyses yielded no significant main effect of object type on TVT for the perpetrator,  $F(1, 64) = 0.78, p = .382, BF_{01} = 2.9$  (weak to moderate evidence). The main effect of perpetrator race and the interaction were not significant either (all  $ps \geq .22$ , all  $BF_{s01} \geq 2.1$ ).

Biggs et al. (2013) found a weapon–face trade-off, with longer dwell times (i.e., TVTs) for the weapon being offset by shorter viewing times for the perpetrator's face. Therefore, we additionally analyzed the allocation of attention to the head of the perpetrator. However, there was no significant main effect of object type for the head ROI either,  $F(1, 64) = 0.01, p = .903, BF_{01} = 4.0$  (moderate evidence). The main effect of perpetrator race and the interaction were also not significant (all  $ps \geq .66$ , all  $BF_{s01} \geq 3.6$ ).

Total Viewing Time	Black Perpetrator		White Perpetrator	
	Gun	Cell Phone	Gun	Cell Phone
Measured				
Perpetrator	38.84 (8.98)	42.82 (5.30)	40.71 (9.47)	40.07 (6.90)
Critical Object	12.77 (4.70)	10.04 (6.62)	12.06 (4.59)	10.44 (5.05)
Victims	28.99 (8.63)	24.66 (7.75)	27.46 (10.16)	25.12 (6.46)
Other	19.40 (5.20)	22.47 (6.91)	19.78 (10.26)	24.37 (7.63)
Self-Reported				
Perpetrator	30.88 (12.53)	30.59 (12.98)	29.41 (12.73)	25.00 (16.20)
Critical Object	16.00 (11.32)	17.82 (13.55)	20.59 (10.74)	15.76 (6.32)
Victims	39.71 (12.18)	36.18 (14.42)	39.29 (10.88)	44.88 (13.05)
Other	12.82 (11.80)	15.41 (11.36)	11.29 (8.61)	14.35 (9.76)

**Table 2.1** Means and standard deviations for the measured and self-reported relative total viewing times (%) for each region of interest in Experiment 1. Standard deviations are presented in parentheses.  $N = 68$  ( $n = 17$  for each condition).



**Figure 2.2** Total viewing times in Experiment 1. Mean total viewing times are shown as a function of object type and perpetrator race. Each column presents the total viewing times for a different region of interest (see panel titles). The rows present objectively measured (top) and self-reported (bottom) data. Error bars are  $\pm 1 SE$ .  $*p < .05$ .

Compared with the TVT for the perpetrator, the TVT for the critical object was much shorter. As predicted, TVT on the gun was numerically longer than TVT on the phone. However, TVTs differed only by approximately 2%, and this difference was not statistically significant,  $F(1, 64) = 2.85$ ,  $p = .096$ ,  $BF_{01} = 1.2$  (inconclusive evidence). There was no significant main effect of perpetrator race and no significant interaction of object type and perpetrator race (all  $ps \geq .66$ , all  $BF_{s01} \geq 3.7$ ).

There were no significant effects for TVT on the victims (all  $ps \geq .10$ , all  $BF_{s01} \geq 1.2$ ). For the area outside of the defined ROIs, there was a significant main effect of object type,  $F(1, 64) = 4.19$ ,  $p = .045$ ,  $\eta^2 = .06$ . Specifically, participants in the gun condition spent less time looking at regions outside of the defined ROIs than participants in the phone condition.

The main effect of perpetrator race and the interaction of object type and perpetrator race were not significant (all  $ps \geq .54$ , all  $BF_{s01} \geq 3.4$ ).

### 2.3.2.2 Self-Reported Viewing Time

The bottom row of Figure 2.2 shows the self-reported viewing time as a function of object type and perpetrator race. The most striking difference between the self-reported and the objectively measured TVT is that subjects reported to have looked at the victims the most, followed by the perpetrator, whereas the eye-tracking data revealed the opposite; that is, that the perpetrator attracted the most attention, followed by the victims. Statistical analyses of the self-reported TVTs suggested that there were no significant main effects of object type or perpetrator race and no significant two-way interaction for any of the ROIs (all  $ps \geq .14$ , all  $BF_{s01} \geq 1.5$ ).

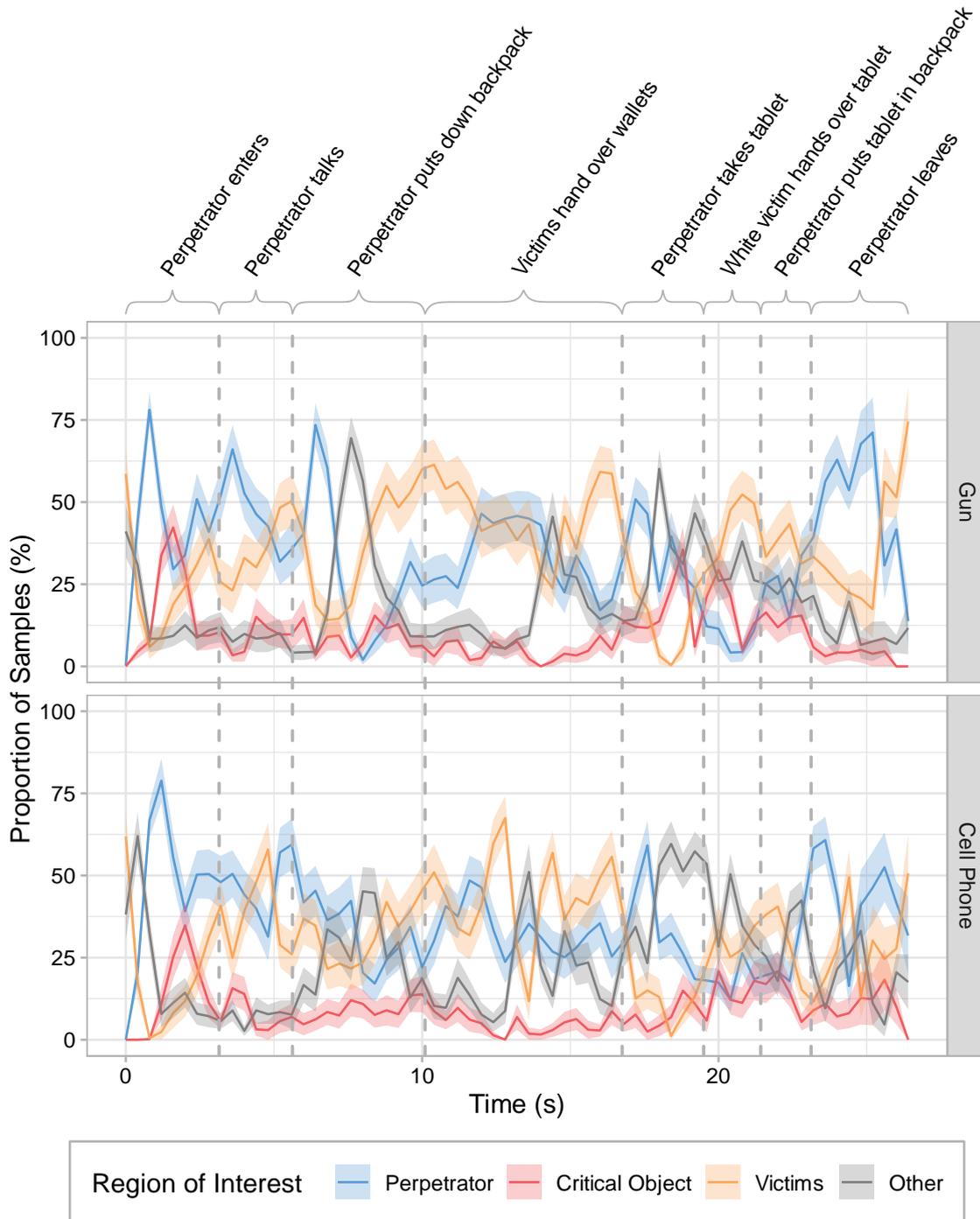
### 2.3.2.3 Time Course

Given that we used videos as stimuli, we additionally conducted a time course analysis of the proportion of gaze samples that landed within a given ROI. The eye tracker provided a new gaze sample every millisecond. For the analysis, the raw gaze samples within fixations were binned into 400-ms intervals. Moreover, the number of samples in a given ROI was divided by the total number of valid samples recorded for this interval. Because perpetrator race had no effect on TVT overall, the data were collapsed across race.

Figure 2.3 shows the proportion of samples that landed within the ROIs of the perpetrator, the critical object, the victims, and any areas outside of these ROIs separately for the gun (top panel) and the phone (bottom panel) conditions. Each graph covers the period from the moment the perpetrator enters the room where the victims are working up to the point where the perpetrator leaves (i.e., we included only the actual robbery, excluding the hallway scene). The data highlight once again that, overall, the critical object received much less attention than the perpetrator or the victims. Both the gun and the phone drew attention primarily at the beginning of the scene as the perpetrator entered the room.

Moreover, the time course analysis provides insights into the coherence of gaze behavior across different observers. For example, observing high values in one ROI and low values in the other two ROIs indicates high inter-observer coherence, in the sense that most participants were focusing on the same region. Conversely, observing similar values for multiple ROIs at a given point in time indicates a lower coherence.

For both the gun and the phone, most samples landed within the ROIs of the people involved, i.e., the perpetrator and the victims. However, when the perpetrator was carrying a gun, there was a more pronounced preference for either the perpetrator or the victims for most time



**Figure 2.3** Time course analysis for the eye-movement data in Experiment 1. The proportions of samples that landed within the regions of interest of the perpetrator, the critical object, the victims, and any areas outside of these regions of interest are shown as a function of time for the gun (top) and the cell phone (bottom). Data are shown from the moment the perpetrator enters the room where the two victims are working to the point where he leaves. Vertical lines mark the transitions between actions performed by the people depicted in the videos. Error ribbons are  $\pm 1 SE$ .

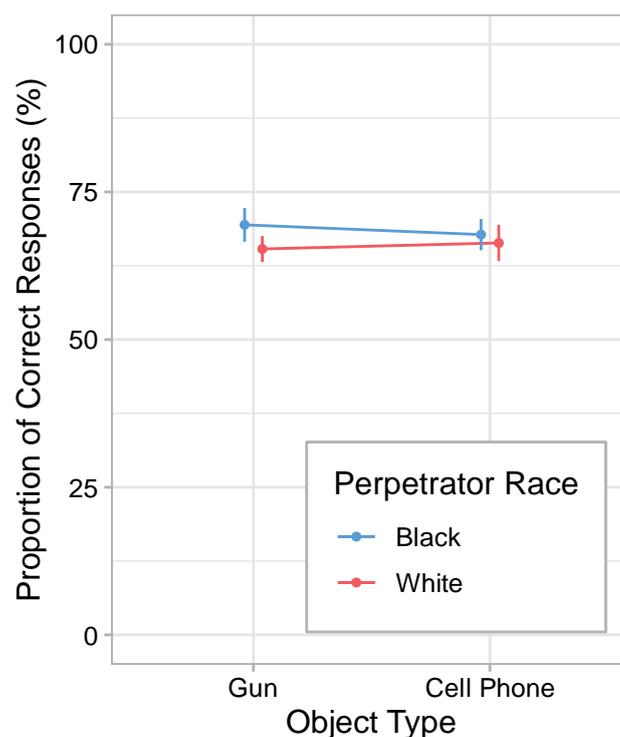
points (top panel of Figure 2.3). Specifically, between 50 and 75% of the samples landed within one of these ROIs for many bins. In the phone condition, the preference for one of the interacting parties was not as pronounced as in the gun condition.

### 2.3.2.4 Memory Questionnaire

Figure 2.4 and Table 2.2 show the proportion of correct responses as a function of object type and perpetrator race. Contrary to expectations, object type had no significant effect on memory accuracy,  $F(1, 64) = 0.01, p = .908, BF_{01} = 4.0$  (moderate evidence). The main effect of perpetrator race and the interaction of object type and perpetrator race were not significant either (all  $ps \geq .31$ , all  $BF_{s01} \geq 2.5$ ). Thus, the hypotheses regarding perpetrator race were also not confirmed. When correct and incorrect details were analyzed separately, there were no significant main effects or interactions either (all  $ps \geq .24$ , all  $BF_{s01} \geq 2.2$ ).

### 2.3.2.5 Stereotype Awareness and Endorsement

To reiterate, participants were asked whether a Black or a White man was more likely to commit a crime using a weapon according to (a) existing stereotypes and (b) their personal beliefs. The scale ranged from 0 (*White man extremely more likely*) to 10 (*Black man extremely more likely*), with 5 representing an equal likelihood for Black and White men. Results are presented



**Figure 2.4** Memory performance in Experiment 1. Mean proportions of correct responses regarding the perpetrator's appearance in the memory questionnaire are shown as a function of object type and perpetrator race. Error bars are  $\pm 1 SE$ .

Measure	Black Perpetrator		White Perpetrator	
	Gun	Cell Phone	Gun	Cell Phone
Proportion Correct	69.43 (11.79)	67.77 (10.91)	65.34 (9.02)	66.36 (12.67)
Stereotype Awareness	7.82 (1.07)	7.29 (1.31)	7.50 (2.68)	7.06 (1.64)
Stereotype Endorsement	4.59 (1.23)	4.88 (0.93)	4.94 (1.65)	4.76 (1.44)

**Table 2.2** Means and standard deviations for the memory accuracy (%) and the stereotype ratings in Experiment 1. Standard deviations are presented in parentheses.  $N = 68$  ( $n = 17$  for each condition, except for the stereotype ratings in “White Perpetrator – Gun”, for which  $n = 16$ ). Stereotype awareness and stereotype endorsement were rated on a scale from 0 to 10, with 5 indicating no difference between Black and White men.

in Table 2.2. When asked about stereotypes, participants assessed that Black men were associated more strongly with crimes involving weapons than White men ( $M = 7.42$ ,  $SD = 1.75$ ). This rating differed significantly from the midpoint of the scale,  $t(66) = 11.30$ ,  $p < .001$ ,  $d = 1.38$  (one-tailed test). There were no significant main effects of object type or perpetrator race and no interaction (all  $ps \geq .26$ , all  $BF_{s01} \geq 2.2$ ). The rating of the participants’ own personal beliefs was close to the midpoint of the scale ( $M = 4.79$ ,  $SD = 1.31$ ) and did not differ significantly from it,  $t(66) = 1.31$ ,  $p = .902$ ,  $BF_{01} = 16.2$  (one-tailed test, strong evidence). Again, there were no main effects or interactions of the independent variables (all  $ps \geq .47$ , all  $BF_{s01} \geq 3.1$ ).

### 2.3.3 Discussion

While previous investigations on the memory component of the WFE have repeatedly used dynamic stimuli (e.g., Mitchell et al., 1998; Pickel, 2009; Pickel & Sneyd, 2018), existing eye-tracking studies have used only slide shows (E. F. Loftus et al., 1987) or non-narrative images (Biggs et al., 2013). Therefore, the novel contribution of Experiment 1 was to investigate the WFE with dynamic stimuli and eye tracking.

Our results indicate that the attentional effects of weapons are more complex than current theories and previous results suggested. Specifically, we found no significant effect of weapon presence on viewing time for the perpetrator. Viewing times were numerically longer for the weapon than for the neutral object, but this effect was not statistically significant. Bayes factors indicated that the data provide equally strong evidence in favor and against such an effect. Time course analyses showed that both the weapon and the neutral object were looked at primarily at the beginning of the scene. Thus, weapons do not seem to capture attention over extended periods of time. However, the time course data also showed that participants in the weapon

condition focused more consistently on one of the interacting parties (i.e., either the perpetrator or the victims). This higher inter-observer coherence indicates that the presence of a weapon altered participants' interpretation of the scene, leading them to follow the interaction more closely. This is further supported by the fact that subjects in the weapon condition spent less time looking at regions outside of the defined ROIs. Perpetrator race had no significant effects on gaze behavior. Finally, the eye-tracking results indicate that self-reported viewing times are not a suitable substitute for objectively measured viewing times.

We did not observe reduced memory accuracy in the weapon condition, which means that we could not replicate the classic memory-related WFE (e.g., Kim et al., 2014; Pickel, 2009; Pickel & Sneyd, 2018). Perpetrator race did not significantly affect memory accuracy, which is consistent with our eye-tracking results, but contrasts findings by Pickel and Sneyd (2018).

As these results were unexpected, we conducted two additional experiments. In Experiment 2, we tracked participants' eye movements while they viewed a sequence of static stimuli resembling those used by E. F. Loftus et al. (1987). In Experiment 3, we closely replicated the methodology of Pickel and Sneyd (2018) by conducting an online experiment with unaltered stimuli.

For these follow-up experiments, we dropped perpetrator race as an independent variable. If perpetrator race has a moderating influence on the WFE, the effect should be greater for the White perpetrator than for the Black perpetrator, due to the higher perceived unusualness of the weapon (Pickel & Sneyd, 2018). To maximize the strength of a potential WFE, we therefore used the stimulus material depicting the White perpetrator only.

## **2.4 Experiment 2**

When using video stimuli in Experiment 1, we found no evidence for weapon presence having a significant effect on viewing time for either the perpetrator or the critical object, which is inconsistent with previous eye-tracking studies on the WFE (Biggs et al., 2013; E. F. Loftus et al., 1987). In a classic study, E. F. Loftus et al. (1987) presented participants with slides, which were shown for 1.5 s each. Using slides or photographs rather than videos facilitates the analysis of eye movements (Biggs et al., 2013). However, in real crime scenarios the protagonists and the objects they hold are likely to move. Recent eye-tracking research has demonstrated that motion in dynamic scenes leads to changes in viewing patterns, the degree of which depends on the viewing task (see Nuthmann & Canas-Bajo, 2022, for a review). Most relevantly, Dorr et al. (2010) found differences in gaze behavior for natural versus stop-motion movies.

To explore whether the stimulus presentation mode affects the attention component of the WFE, we conducted a second experiment in which static stimuli were used. To mimic E. F. Loftus et al. (1987), we converted the videos used in Experiment 1 to slide shows. The critical question was whether the weapon would receive more attention than the neutral object this way and whether such a potential attentional shift would come at a cost of viewing time on the perpetrator.

## **2.4.1 Methods**

### **2.4.1.1 Design and Participants**

Object type (gun vs. cell phone) was manipulated between subjects. Due to the reduced design compared with Experiment 1, we used *t* tests to analyze the data. An a priori power analysis yielded a required sample size of  $N = 56$  to detect large effects ( $d \geq 0.8$ ) with one-tailed *t* tests, a power of at least  $1 - \beta = .90$ , and a significance level of  $\alpha = .05$ . The 56 participants (41 women, 15 men) were between 19 and 50 years old ( $M = 25.5$  years,  $SD = 6.9$ ). The procedure was the same as in Experiment 1.

### **2.4.1.2 Stimuli**

Slide shows were created based on the videos depicting the White perpetrator. Given that each slide was presented for 1.5 s, there were 56 images for each slide show, leading to a total duration of 84 s. The video frames used for the slides were manually selected to ensure that (a) all important interactions between the protagonists were included and unambiguously depicted (e.g., the handover of the wallets) and (b) the slides showed the same content in the gun and the phone condition. As in Experiment 1, no soundtrack was presented.

### **2.4.1.3 Apparatus**

The stimuli were displayed on a 24.5 in. monitor with a resolution of  $1920 \times 1080$  pixels and a refresh rate of 144 Hz. An SR Research EyeLink 1000 Plus Tower Mount was used to record participants' binocular eye movements. As in Experiment 1, the viewing distance was 93 cm.

### **2.4.1.4 Data Analysis**

The ROIs for each slide were identical to those of the respective frame of the videos in Experiment 1. To ensure consistency across experiments, the assignment of eye-movement data to ROIs was again based on individual samples. As in Experiment 1, the quality of the eye-tracking data was high (see Appendix 2). Subjects' responses to the memory questionnaire were again evaluated by two naive raters. Inter-rater reliability was high for both correct ( $r = .95$ )

and incorrect ( $r = .85$ ) details. One-tailed tests were used for viewing time on the perpetrator and the critical object and for memory performance.

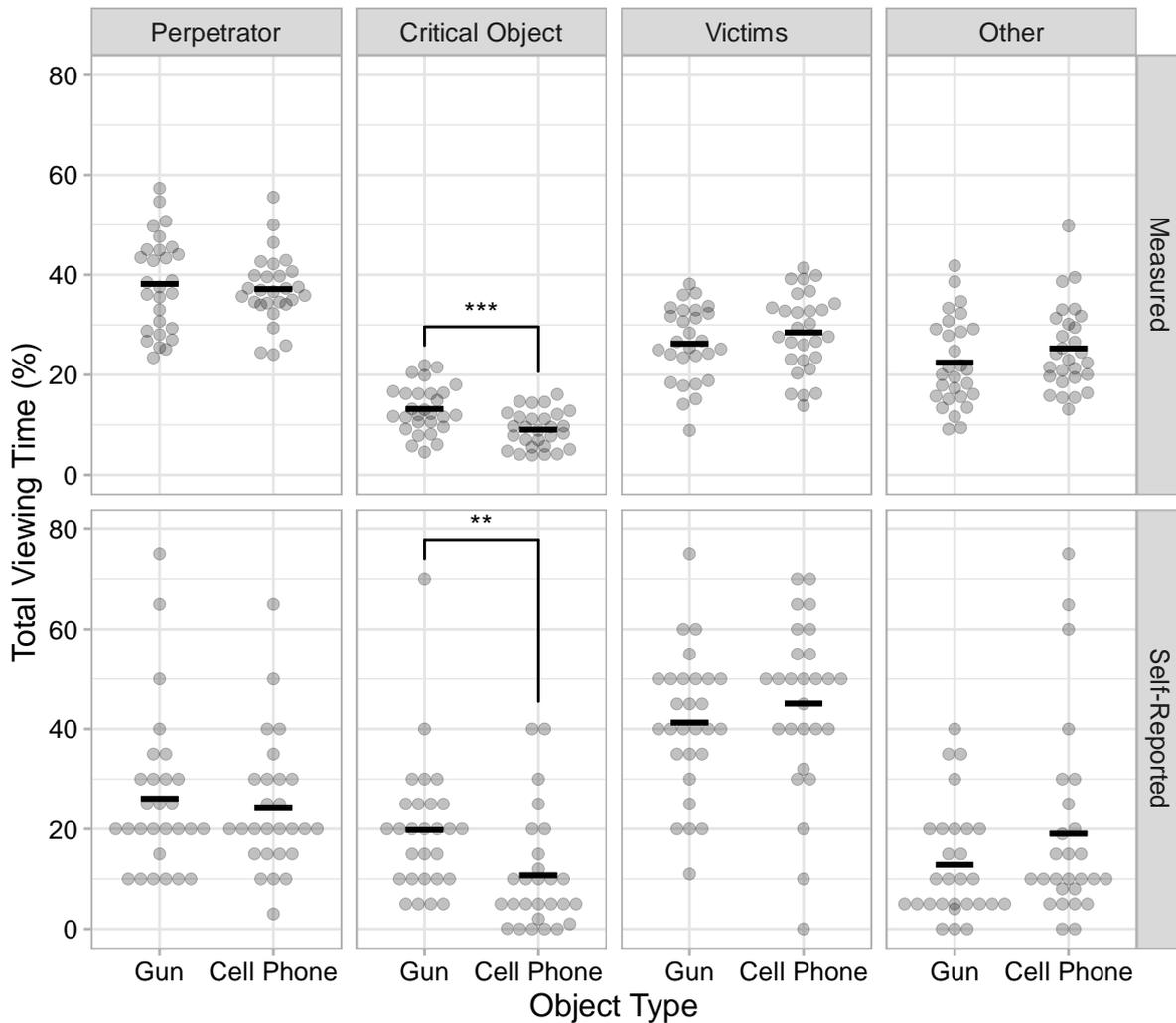
## 2.4.2 Results

### 2.4.2.1 Total Viewing Time

Table 2.3 and the top row of Figure 2.5 show the TVT on the perpetrator, the critical object, the victims, and any area outside of these ROIs for both the gun and the phone. TVT on the gun was significantly longer than TVT on the phone,  $t(54) = 3.60$ ,  $p < .001$ ,  $d = 0.96$ , replicating E. F. Loftus et al. (1987). Interestingly, this increase in looking at the gun did not come at the cost of looks to the perpetrator. Instead, there was no significant effect of object type on TVT for the perpetrator,  $t(54) = 0.48$ ,  $p = .684$ ,  $BF_{01} = 5.1$  (moderate evidence). When analyzing the TVT on the perpetrator's head in particular, there was again no significant effect of object type,  $t(54) = 1.34$ ,  $p = .907$ ,  $BF_{01} = 7.8$  (moderate evidence). In fact, the mean TVT both for the head ROI and for the entire perpetrator was numerically longer (rather than shorter) in the gun condition compared with the phone condition. There was no significant effect of object type on TVT for the victims or for regions other than the three predefined ROIs (all  $ps \geq .22$ , all  $BF_{s01} \geq 1.9$ ).

Total Viewing Time	Gun	Cell Phone
Measured		
Perpetrator	38.21 (9.53)	37.13 (6.95)
Critical Object	13.13 (4.75)	9.06 (3.64)
Victims	26.22 (7.46)	28.51 (7.90)
Other	22.44 (8.88)	25.30 (8.48)
Self-Reported		
Perpetrator	26.07 (15.95)	24.19 (13.32)
Critical Object	19.82 (13.30)	10.74 (11.53)
Victims	41.29 (14.04)	45.07 (16.98)
Other	12.82 (11.28)	19.07 (19.62)

**Table 2.3** Means and standard deviations for the measured and self-reported relative total viewing times (%) for each region of interest in Experiment 2. Standard deviations are presented in parentheses.  $N = 56$  ( $n = 28$  for each condition, except for the self-reported total viewing times in the phone condition, for which  $n = 27$ ).



**Figure 2.5** Total viewing times in Experiment 2. The data are shown as a function of object type. Each column presents total viewing times for a different region of interest (see panel titles). The rows present objectively measured (top) and self-reported (bottom) data. Each dot represents an individual participant. Horizontal lines represent the mean.  $**p < .01$ .  $***p < .001$ .

#### 2.4.2.2 Self-Reported Viewing Time

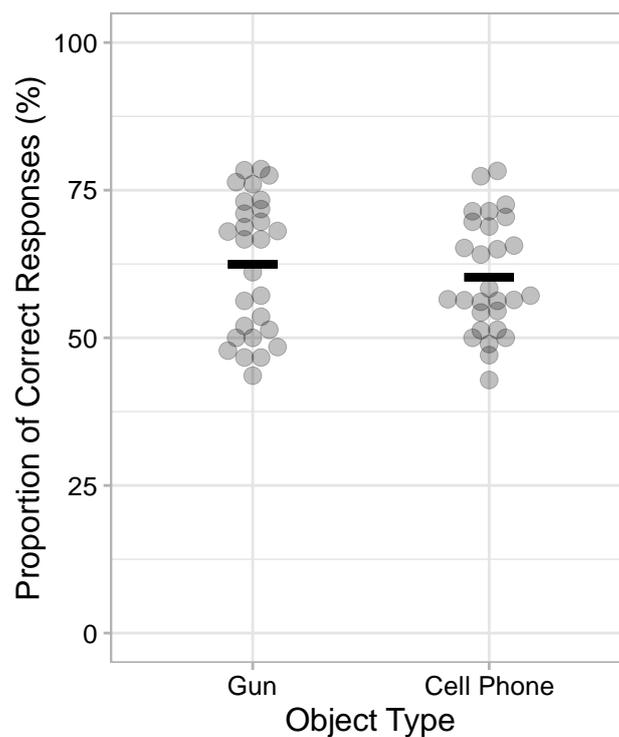
As in Experiment 1, subjects wrongly reported to have looked at the victims the most, followed by the perpetrator, whereas the eye-tracking data revealed the opposite (Figure 2.5, Table 2.3). However, in agreement with objectively measured TVTs, participants indicated that they looked longer at the gun than at the phone,  $t(53) = 2.70$ ,  $p = .005$ ,  $d = 0.73$  (see also Erickson et al., 2014). Object type did not significantly affect self-reported TVT for any of the other ROIs (all  $ps \geq .15$ , all  $BF_{s01} \geq 1.5$ ).

### 2.4.2.3 Memory Questionnaire

Figure 2.6 shows the proportion of correct responses as a function of object type. The proportion of correct responses did not significantly differ between the gun condition ( $M = 62.44\%$ ,  $SD = 11.63$ ) and the phone condition ( $M = 60.26\%$ ,  $SD = 9.64$ ),  $t(54) = 0.76$ ,  $p = .776$ ,  $BF_{01} = 5.9$  (moderate evidence). When correct and incorrect details were analyzed separately, there were no significant differences either (all  $ps \geq .39$ , all  $BF_{s01} \geq 3.0$ ).

### 2.4.3 Discussion

With Experiment 2, we followed up on the results from Experiment 1 by using slide shows instead of video stimuli. We found longer TVTs for the weapon than for the neutral object, which is in agreement with previous eye-tracking studies on the WFE (Biggs et al., 2013; E. F. Loftus et al., 1987). Contrary to predictions by current theories, however, this attention shift did not come at a cost of shorter TVTs on the perpetrator. Our experiment was modelled after E. F. Loftus et al. (1987), who did not report the TVT (or the total number of fixations) for the perpetrator. Using static images but not slide shows, Biggs et al. (2013) reported that their



**Figure 2.6** Memory performance in Experiment 2. Each dot presents an individual participant's proportion of correct responses regarding the perpetrator's appearance in the memory questionnaire as a function of object type. Horizontal lines represent the mean.

subjects spent less time looking at the faces of people holding weapons relative to neutral objects, a finding which we could not replicate. This difference in results may be due to differences in methodological details between the two studies. Biggs et al. (2013) presented non-narrative images, one by one, for 5 s apiece. Thus, stimulus processing was completely reset at regular intervals. Moreover, there was only one person in each image. In contrast, our consecutive slides told a coherent story, and, when the weapon was visible, both the perpetrator and the two victims were oftentimes competing for the observers' attention.

Even though object type was found to affect the allocation of attention in some ways, the presence of a weapon did not lead to a reduced ability to recall details about the perpetrator's appearance. Not finding an effect of object type on memory performance is consistent with Experiment 1, but inconsistent with previously published studies (e.g., Hope & Wright, 2007; Pickel, 1998; Pickel & Sneyd, 2018).

## 2.5 Experiment 3

We conducted a third experiment to explore whether our failures to replicate the memory-related WFE were due to methodological differences across studies. For the eye-tracking experiments, we made some alterations to the original stimuli used by Pickel and Sneyd (2018). Specifically, we omitted the soundtrack as well as an initial close-up on the critical object. Moreover, the videos were converted to slide shows in Experiment 2.

The goal of our final experiment was to replicate Experiment 1 reported in Pickel and Sneyd (2018) as closely as possible. As in their experiment, the video stimuli included both the close-up on the critical object and the English soundtrack. Our subject recruitment procedures ensured that potential subjects were highly proficient in English. Given that the experiment was conducted in Germany, we were unable to replicate that the first language spoken by the participants matched the language used by the protagonists in the videos. Eye movements were not recorded, and the experiment was run online, which means that we could achieve a larger sample size than in our laboratory eye-tracking experiments. Finding a memory-related WFE in Experiment 3 would suggest that methodological differences were responsible for the absence of the effect in Experiments 1 and 2.

Motivated by the eye-tracking results obtained in Experiment 1, we further extended the original memory test by including questions about the interactions between the perpetrator and the two victims. In Experiment 1, when the weapon was present, observers' preference for allocating attention to either the perpetrator or the victims changed over time (Figure 2.3).

Thus, the eye-movement data suggest that there was a particular attentional focus on the interactions among the protagonists, which may enhance observers' memory for specific actions that were performed. On the other hand, weapons have been shown to impair memory not only for the appearance of the perpetrator, but also for other details of the scene (Kim et al., 2014; Saunders, 2009). Therefore, the analyses of the questions that tested subjects' memory for the interactions were exploratory in nature.

## **2.5.1 Methods**

### **2.5.1.1 Design, Participants, and Stimuli**

Object type (gun vs. cell phone) was manipulated between subjects. Pickel and Sneyd (2018, Experiment 1) tested 266 participants in a study with a  $2 \times 2 \times 2$  design. In our Experiment 3, we chose to focus on two of these conditions, yet we tested the same number of participants as Pickel and Sneyd (2018). A sensitivity power analysis indicated that a sample size of  $N = 266$  was sufficient to detect small to medium effects ( $d \geq 0.36$ ) with one-tailed  $t$  tests, a power of at least  $1 - \beta = .90$ , and a significance level of  $\alpha = .05$ . Participants' ages ranged from 18 to 84 years ( $M = 30.7$  years,  $SD = 13.0$ ); 175 were women, and 91 were men. The original videos from Experiment 1 reported by Pickel and Sneyd (2018) were used as stimuli.

### **2.5.1.2 Procedure and Questionnaire**

The procedure was similar to that of the previous experiments, except that participants completed the experiment online with no eye tracking. Subjects could not pause or replay the video. Our additions to the questionnaire were presented only after participants had responded to the original set of questions by Pickel and Sneyd (2018).

As outlined above, we included additional questions regarding the actions performed by the perpetrator and the two victims (e.g., "In total, how many and which objects did the perpetrator take?"). Moreover, we added a number of rating items. Participants were asked to rate how threatening they perceived (a) the perpetrator and (b) the critical object to be. Moreover, subjects were asked to indicate how aroused they were while watching the video. Two more items were added to assess the perceived unusualness of the critical object. Specifically, subjects were asked to indicate how unusual they perceived the object to be (a) in general and (b) in the context of the video. Finally, subjects were asked to rate how well they understood the English dialogue. All items were rated on a scale from 0 to 10, except for the self-reported arousal, which was rated on a scale from 0 to 5.

### 2.5.1.3 Data Analysis

Responses to questions regarding the appearance of the perpetrator as well as details of the actions were evaluated by a second rater only for a subset of 104 participants (cf. Pickel & Sneyd, 2018). Inter-rater reliability was high for both correct ( $r = .98$ ) and incorrect ( $r = .87$ ) details regarding the perpetrator's appearance and correct ( $r = .97$ ) and incorrect ( $r = .79$ ) details regarding the actions. Only data from the rater who evaluated all participant responses were used for analysis, instead of aggregating across raters as in Experiments 1 and 2. Statistical tests for memory regarding the perpetrator's appearance were one-tailed, whereas two-tailed tests were used for memory regarding details of the actions. One-tailed tests were used for all rating variables except situational unusualness and linguistic comprehension.

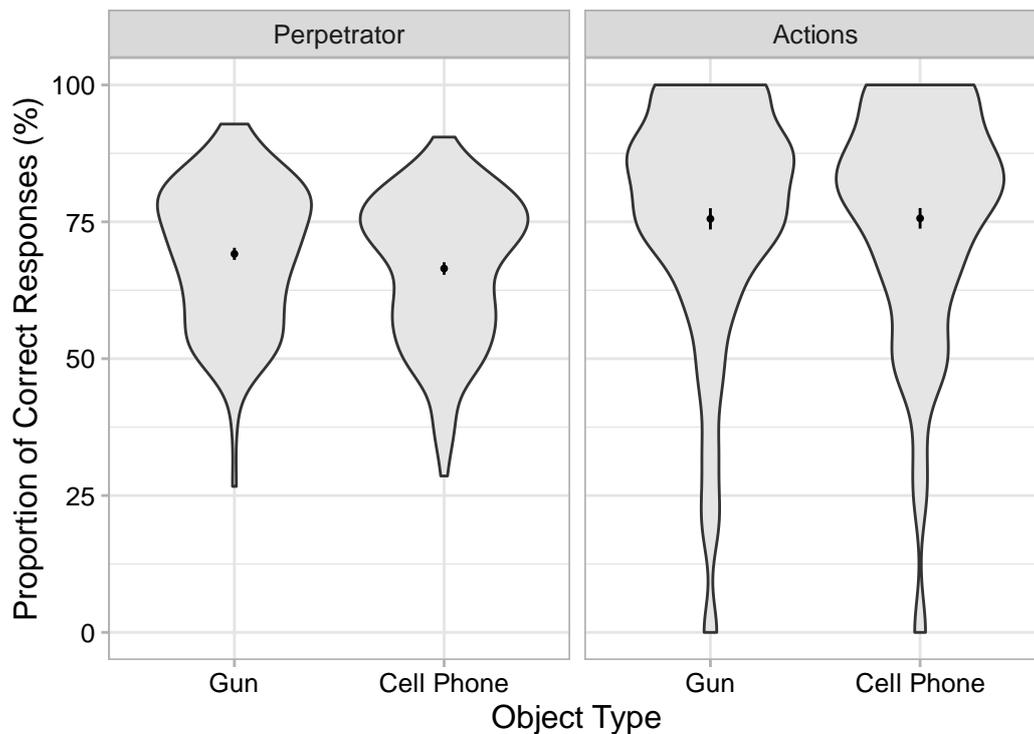
## 2.5.2 Results

### 2.5.2.1 Memory Questionnaire

Table 2.4 and Figure 2.7 show the effects of object type on memory accuracy for the perpetrator's appearance and for details of the actions of the people involved. Memory for the perpetrator's appearance was not significantly worse in the gun condition than in the phone condition,  $t(264) = 1.68$ ,  $p = .953$ ,  $BF_{01} = 19.0$  (strong evidence). In fact, memory accuracy

Measure	Gun			Cell Phone		
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
Proportion Correct						
Perpetrator	133	69.14	12.84	133	66.47	13.15
Actions	133	75.54	22.37	133	75.63	21.67
Threat						
Object	129	9.21	1.39	127	1.61	2.20
Perpetrator	132	7.10	2.08	133	2.69	1.90
Arousal	133	2.38	1.29	133	1.43	1.19
Unusualness						
General	129	7.29	2.51	127	2.20	3.12
Situational	128	3.48	3.50	126	6.83	3.03
Linguistic Comprehension	133	8.00	2.63	133	7.94	2.77

**Table 2.4** Memory accuracy (%) and ratings for threat, unusualness, and linguistic comprehension in Experiment 3. Threat, unusualness, and linguistic comprehension were rated on a scale from 0 to 10, except for arousal, which was rated on a scale from 0 to 5.



**Figure 2.7** Memory performance in Experiment 3. Mean proportion of correct responses in the memory questionnaire are shown as a function of object type. Data are shown for questions regarding the perpetrator's appearance (left) and details regarding the actions performed by the depicted people (right). Error bars are  $\pm 1 SE$ .

was numerically better rather than worse in the gun condition compared with the phone condition. Memory scores for the actions were highly similar in both conditions and did not differ significantly,  $t(264) = 0.03$ ,  $p = .973$ ,  $BF_{01} = 7.4$  (moderate evidence). When correct and incorrect details were analyzed separately, no significant differences were found either (all  $ps \geq .27$ , all  $BF_{s01} \geq 4.1$ ).

### 2.5.2.2 Ratings

Table 2.4 shows participants' ratings regarding threat, unusualness, and linguistic comprehension. Overall, the scene was rated as more threatening in the gun condition than in the phone condition (all  $ps < .001$ ).

The two items assessing the perceived unusualness of the critical object showed an interesting dissociation. When asked to assess the object's unusualness in general, the gun was judged to be more unusual than the phone,  $t(254) = 14.38$ ,  $p < .001$ ,  $d = 1.80$ . When quizzed about the situational unusualness, however, subjects rated the phone as more unusual than the gun,  $t(252) = 8.15$ ,  $p < .001$ ,  $d = 1.02$ .

Subjects judged their language comprehension to be high ( $M = 7.97$ ,  $SD = 2.69$ ), with no significant difference between the gun condition and the phone condition,  $t(264) = 0.18$ ,  $p = .856$ ,  $BF_{01} = 7.3$  (moderate evidence).

### 2.5.3 Discussion

In this experiment, we investigated the effects of weapon presence on memory with the original stimuli used by Pickel and Sneyd (2018) and in a larger sample than in Experiments 1 and 2. As in Experiments 1 and 2, memory for the perpetrator's appearance was not impaired when he was holding a weapon during the robbery depicted in the videos. Thus, we again failed to find a memory-related WFE.

Since Experiment 3 was designed to be a close replication of Pickel and Sneyd (2018), the question arises why we could not replicate their results. In our experiment, participants' first language was German and thus did not match the language used by the protagonists in the videos. However, subjects' self-reported language comprehension was high. One major difference between the study by Pickel and Sneyd (2018) and ours is the cultural background of the participants. Like most studies on the WFE, Pickel and Sneyd (2018) conducted their experiment in the U.S., whereas our data were collected in Germany. It is possible that German participants process gun-related events differently, for example due to the lower rate of homicides involving firearms (Grinshteyn & Hemenway, 2016). However, the diverging results could also be due to differences in other factors such as the heterogeneity of the sample or participant compliance. In online studies in particular, it can be difficult to obtain a balanced sample, control for potential biases, and ensure compliance. The present data alone are not sufficient to distinguish between these explanations. Our data do, however, convincingly show that the presence of a weapon does not always lead to an impairment in memory.

## 2.6 General Discussion

To explain impaired memory for a target person holding a weapon, researchers have suggested that observers shift their attention away from the target and towards the weapon (e.g., E. F. Loftus et al., 1987; Pickel, 2015). Putting this key assumption to a test, we used eye tracking to assess where and for how long observers allocate their attention when viewing a robbery scene. Our Experiment 1 is the first to systematically investigate the attentional effects of weapons using video stimuli. In Experiment 2, we converted the videos to slide-shows of static images (cf. E. F. Loftus et al., 1987) to explore how well attentional effects generalize across

different stimulus presentation modes. Experiment 3 was an online study focusing on the memory-related WFE. All stimuli were based on videos for which large effects on memory have previously been found (Pickel & Sneyd, 2018, Experiment 1). Our detailed results offer novel and surprising insights that cast doubt on the hypothesis that weapons draw attention away from the perpetrator for extended periods of time.

For dynamic scenes (Experiment 1), the attentional effects of weapons were different and more complex than previously assumed. If the allocation of attention towards the critical object (i.e., the gun or the phone) is an important condition for the WFE to emerge, we would expect observers to look at the critical object fairly extensively. However, both the weapon and the neutral object attracted only 10%–15% of observers' viewing time, which means that they were looked at for much shorter durations than the depicted people. In total, the weapon attracted slightly more gaze than the neutral object, but this difference was not significant at an alpha of 5%. The corresponding Bayes factor indicated that our data provide as much evidence in favor of such an effect as they do against it. Viewing time on the perpetrator was not significantly affected by weapon presence. Thus, we found no evidence in favor of the key assumption made by current theories that a weapon draws attention away from the perpetrator.

A novel time course analysis additionally revealed how the allocation of attention changed over time (see Figure 2.3). Both critical objects were looked at primarily at the beginning of the scene and only infrequently thereafter. Participants in the weapon condition focused their attention more consistently on either the perpetrator or the victims for most points in time. Weapon presence also led participants to spend less time looking at regions outside of the defined ROIs (i.e., the perpetrator, the critical object, and the victims). These findings indicate that participants were more involved in following the interaction of the perpetrator and the victims when the former was carrying a weapon compared with a neutral object. Scrivner et al. (2019) similarly found that violent as opposed to non-violent scenes led participants to focus more strongly on the interaction of the depicted people, with their gaze shifting towards points of contact rather than objects held by the interacting people (e.g., weapons).

To test whether the unexpected results of Experiment 1 were due to using dynamic stimuli, we turned the video material into slide shows (Experiment 2), mimicking the methodology of E. F. Loftus et al. (1987). Like E. F. Loftus et al. (1987), but in contrast to Experiment 1, we found significantly longer viewing times for the weapon than for the neutral object. Thus, the attention capturing effects of weapons may be more pronounced for (series of) static images than for dynamic stimuli. This difference in results highlights the importance of studying attentional phenomena under naturalistic circumstances. Finding differences in gaze behavior for

videos and slide shows is generally consistent with results by Dorr et al. (2010), who showed that the attentional processing of natural dynamic stimuli differs from that of series of static images and heavily edited movie trailers.

Note that in other important aspects, slide shows (Experiment 2) and videos (Experiment 1) yielded similar results. In both experiments, the weapon attracted little attention overall. Moreover, viewing time on both the perpetrator as a whole and his face in particular (cf. Biggs et al., 2013) was not significantly reduced by the presence of a weapon in either experiment. E. F. Loftus et al. (1987) did not report viewing time on the perpetrator, and the divergence with findings reported by Biggs et al. (2013) is likely due to methodological differences (see the discussion of Experiment 2).

Erickson et al. (2014) measured the allocation of attention subjectively via self-report rather than objectively via eye tracking. Therefore, a secondary objective of our study was to assess the level of agreement between the two methods. Participants correctly assessed that they allocated most of their viewing time to the depicted people (rather than the critical object or other aspects of the scene). However, subjects indicated to have spent most of their looking time on the victims, when in fact they paid most attention to the perpetrator. Moreover, between-subject variability was considerably higher for self-reported than for objectively measured data (see Figure 2.5).

In their study, Erickson et al. (2014) used interactive slide shows. With this material, they found a self-reported attentional shift towards a weapon. Similarly, when using slide shows in Experiment 2, we found that participants reported to have spent more time looking at the weapon than at the neutral object. Given that this self-reported attentional shift matches a shift in objectively measured viewing time, an attentional shift towards weapons may indeed be consciously accessible, at least for slide-show stimuli.

When considering the data for videos and slide shows together, we found that, overall, self-report measures were not very accurate representations of actual gaze behavior. These results complement previous findings suggesting that observers have only limited insight into their own eye movements (e.g., Clarke et al., 2017; Foulsham & Kingstone, 2013; Võ et al., 2016). In any case, more elaborate investigations of attentional allocation (e.g., the time course analyses presented in Figure 2.3) will always require eye-tracking data.

According to the attention-shift hypothesis, an attentional shift away from the perpetrator towards the weapon is responsible for impairing observers' ability to recall details about the person holding the weapon. In both eye-tracking experiments, the presence of a weapon did not reduce the viewing time for the perpetrator. Therefore, not finding a memory-related WFE

in these experiments is consistent with patterns of attention allocation observed in the data. Not finding the predicted memory effect is, however, inconsistent with results by Pickel and Sneyd (2018), who used similar stimulus material and reported large memory effects. Therefore, in Experiment 3, we presented the unaltered videos of Pickel and Sneyd (2018) online and replicated their sample size. Again, no memory-related WFE emerged. Bayes factors indicated that the data from all our experiments provide evidence against a memory-related WFE, with evidence being moderate for Experiments 1 and 2 and strong for Experiment 3. Moreover, several recent studies similarly found weapon presence to have no effect on or even enhance memory for at least some measures or experimental conditions (Harvey et al., 2020; Harvey & Sekulla, 2021; Mansour et al., 2019; Nyman et al., 2020).

The fact that our results diverge from findings by Pickel and Sneyd (2018) demonstrates that, even when employing very similar stimuli and methodology, the memory-related effects of weapons can differ drastically. It remains unclear whether cultural differences between German and U.S.-American participants or other differences between their sample and ours are responsible for these opposing findings. Future research is needed to identify the specific sample characteristics moderating the memory-related WFE.

Results from Experiment 2 show that an attentional focus on a weapon can be observed in a sample that does not show a memory effect. Conversely, other studies on eyewitness testimony have shown that memory effects are not always caused by attentional phenomena (Cahill et al., 2003; Echterhoff & Wolf, 2012). Therefore, future research linking the memory-related WFE to attentional processes should directly and objectively measure the allocation of attention instead of inferring an attentional effect based on differences in memory accuracy. Moreover, future studies on the attentional component of the WFE should strive to use dynamic scene stimuli, as has been done in numerous studies on the memory-related WFE (e.g., Mitchell et al., 1998; Pickel, 2009; Pickel & Sneyd, 2018).

All current experiments were based on one scene only. This is typical for studies on the WFE (e.g., Carlson et al., 2017; E. F. Loftus et al., 1987; Pickel & Sneyd, 2018), because after participants responded to questions about one particular crime scene, their viewing strategies and responses may change when shown additional similar stimuli. Strictly speaking, the inferences that can be drawn from each of these studies apply only to the particular stimulus used (see Yarkoni, 2022). Note that we adapted our stimulus material from a study in which large effects on memory were observed (Pickel & Sneyd, 2018). Therefore, the absence of a memory-related WFE in our experiments is unlikely to be due to specific stimulus properties.

However, future research should explore the degree to which attentional effects in particular generalize across populations of stimuli.

One stimulus characteristic potentially affecting the WFE may be the depiction of victims. The material used in the present study showed two men being robbed. This led to the perpetrator and the victims oftentimes competing for the observers' attention, with the victims being the second-most looked at region after the perpetrator for both the videos in Experiment 1 and the slide shows in Experiment 2. Interestingly, participants subjectively reported to have paid more attention to the victims than the perpetrator. The WFE has been found both for stimuli including victims (e.g., Kim et al., 2014; E. F. Loftus et al., 1987; Pickel, 1998) and for scenes without visible victims (e.g., Biggs et al., 2013; Carlson et al., 2016; Kramer et al., 1990). However, the depiction of victims has not yet been manipulated experimentally in the context of the WFE. It is possible that the presence vs. absence of victims as well as their characteristics (e.g., gender, race) and demeanor (e.g., emotional vs. calm) modulate the effects weapons have on attention or memory.

Finally, we compared a weapon to a neutral control object only. Non-threatening objects that do not fit into the context of the scene (i.e., unusual objects) have been shown to impair memory in a similar manner as weapons do (e.g., Mitchell et al., 1998; Pickel, 1998). However, the attentional effects of weapons and unusual objects have not yet been compared directly via eye tracking. Such a comparison could help to further evaluate whether unusualness is indeed the key factor responsible for the WFE.

### **2.6.1 Conclusion**

The main results of our study are that weapons (a) do not capture attention over extended periods of time and (b) do not necessarily draw gaze away from the perpetrator. Instead of a simple shift from the perpetrator towards the weapon, the attentional effects of weapons seem to be more complex than current theories suggest. More generally, our findings indicate that it is important to study attentional allocation under naturalistic viewing conditions. This is especially true for effects with strong practical implications, such as the WFE.

## 2.7 References

- Ahlmann-Eltze, C., & Patil, I. (2021). ggsignif: R package for displaying significance brackets for 'ggplot2'. *PsyArxiv*. Advance online publication. <https://doi.org/10.31234/osf.io/7awm6>
- Biggs, A. T., Brockmole, J. R., & Witt, J. K. (2013). Armed and attentive: Holding a weapon can bias attentional priorities in scene viewing. *Attention, Perception, & Psychophysics*, 75(8), 1715–1724. <https://doi.org/10.3758/s13414-013-0538-6>
- Bradski, G. (2000). The OpenCV library. *Dr. Dobb's Journal of Software Tools*.
- Brainard, D. H. (1997). The Psychophysics Toolbox. *Spatial Vision*, 10(4), 433–436. <https://doi.org/10.1163/156856897x00357>
- Buswell, G. T. (1935). *How people look at pictures: A study of the psychology of perception in art*. University of Chicago Press.
- Cahill, L., Gorski, L., & Le, K. (2003). Enhanced human memory consolidation with post-learning stress: Interaction with the degree of arousal at encoding. *Learning & Memory*, 10(4), 270–274. <https://doi.org/10.1101/lm.62403>
- Carlson, C. A., Dias, J. L., Weatherford, D. R., & Carlson, M. A. (2017). An investigation of the weapon focus effect and the confidence–accuracy relationship for eyewitness identification. *Journal of Applied Research in Memory and Cognition*, 6(1), 82–92. <https://doi.org/10.1016/j.jarmac.2016.04.001>
- Carlson, C. A., Pleasant, W. E., Weatherford, D. R., Carlson, M. A., & Bednarz, J. E. (2016). The weapon focus effect: Testing an extension of the unusualness hypothesis. *Applied Psychology in Criminal Justice*, 12(2), 87–100.
- Cerf, M., Frady, E. P., & Koch, C. (2009). Faces and text attract gaze independent of the task: Experimental data and computer model. *Journal of Vision*, 9(12), Article 10. <https://doi.org/10.1167/9.12.10>
- Clarke, A. D. F., Mahon, A., Irvine, A., & Hunt, A. R. (2017). People are unable to recognize or report on their own eye movements. *The Quarterly Journal of Experimental Psychology*, 70(11), 2251–2270. <https://doi.org/10.1080/17470218.2016.1231208>
- Cornelissen, F. W., Peters, E. M., & Palmer, J. (2002). The Eyelink Toolbox: Eye tracking with MATLAB and the Psychophysics Toolbox. *Behavior Research Methods, Instruments, & Computers*, 34(4), 613–617. <https://doi.org/10.3758/bf03195489>

- Correll, J., Park, B., Judd, C. M., & Wittenbrink, B. (2002). The police officer's dilemma: Using ethnicity to disambiguate potentially threatening individuals. *Journal of Personality and Social Psychology*, *83*(6), 1314–1329. <https://doi.org/10.1037//0022-3514.83.6.1314>
- Dienes, Z., & Mclatchie, N. (2018). Four reasons to prefer Bayesian analyses over significance testing. *Psychonomic Bulletin & Review*, *25*(1), 207–218. <https://doi.org/10.3758/s13423-017-1266-z>
- Dorr, M., Martinetz, T., Gegenfurtner, K. R., & Barth, E. (2010). Variability of eye movements when viewing dynamic natural scenes. *Journal of Vision*, *10*(10), Article 28. <https://doi.org/10.1167/10.10.28>
- Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review*, *66*(3), 183–201. <https://doi.org/10.1037/h0047707>
- Echterhoff, G., & Wolf, O. T. (2012). The stressed eyewitness: The interaction of thematic arousal and post-event stress in memory for central and peripheral event information. *Frontiers in Integrative Neuroscience*, *6*, Article 57. <https://doi.org/10.3389/fnint.2012.00057>
- Erickson, W. B., Lampinen, J. M., & Leding, J. K. (2014). The weapon focus effect in target-present and target-absent line-ups: The roles of threat, novelty, and timing. *Applied Cognitive Psychology*, *28*(3), 349–359. <https://doi.org/10.1002/acp.3005>
- Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G\*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. <https://doi.org/10.3758/BF03193146>
- Fawcett, J. M., Russell, E. J., Peace, K. A., & Christie, J. (2013). Of guns and geese: A meta-analytic review of the ‘weapon focus’ literature. *Psychology, Crime & Law*, *19*(1), 35–66. <https://doi.org/10.1080/1068316X.2011.599325>
- Fiske, S. T. (2017). Prejudices in cultural contexts: Shared stereotypes (gender, age) versus variable stereotypes (race, ethnicity, religion). *Perspectives on Psychological Science*, *12*(5), 791–799. <https://doi.org/10.1177/1745691617708204>
- Flowe, H. D., Hope, L., & Hillstrom, A. P. (2013). Oculomotor examination of the weapon focus effect: Does a gun automatically engage visual attention? *PloS ONE*, *8*(12), Article e81011. <https://doi.org/10.1371/journal.pone.0081011>
- Foulsham, T. (2015). Scene perception. In J. M. Fawcett, E. F. Risko, & A. Kingstone (Eds.), *The handbook of attention* (pp. 257–280). MIT Press. <https://doi.org/10.7551/mitpress/10033.003.0013>

- Foulsham, T., & Kingstone, A. (2013). Where have eye been? Observers can recognise their own fixations. *Perception*, *42*(10), 1085–1089. <https://doi.org/10.1068/p7562>
- Frenken, M., Hemmerich, W., Izydorczyk, D., Scharf, S., & Imhoff, R. (2022). Cognitive processes behind the shooter bias: Dissecting response bias, motor preparation and information accumulation. *Journal of Experimental Social Psychology*, *98*, Article 104230. <https://doi.org/10.1016/j.jesp.2021.104230>
- Goettker, A., & Gegenfurtner, K. R. (2021). A change in perspective: The interaction of saccadic and pursuit eye movements in oculomotor control and perception. *Vision Research*, *188*, 283–296. <https://doi.org/10.1016/j.visres.2021.08.004>
- Grinshteyn, E., & Hemenway, D. (2016). Violent death rates: The US compared with other high-income OECD countries, 2010. *The American Journal of Medicine*, *129*(3), 266–273. <https://doi.org/10.1016/j.amjmed.2015.10.025>
- Harada, Y., Hakoda, Y., Kuroki, D., & Mitsudo, H. (2015). The presence of a weapon shrinks the functional field of view. *Applied Cognitive Psychology*, *29*(4), 592–599. <https://doi.org/10.1002/acp.3143>
- Harris, C. R., Millman, K. J., van der Walt, S. J., Gommers, R., Virtanen, P., Cournapeau, D., Wieser, E., Taylor, J., Berg, S., Smith, N. J., Kern, R., Picus, M., Hoyer, S., van Kerkwijk, M. H., Brett, M., Haldane, A., Fernández del Río, J., Wiebe, M., Peterson, P., . . . Oliphant, T. E. (2020). Array programming with NumPy. *Nature*, *585*(7825), 357–362. <https://doi.org/10.1038/s41586-020-2649-2>
- Harvey, A. J., & Sekulla, A. (2021). Evidence of alcohol induced weapon focus in eyewitness memory. *Applied Cognitive Psychology*, *35*(5), 1263–1272. <https://doi.org/10.1002/acp.3858>
- Harvey, A. J., Shrimpton, B., Azzopardi, Z., O'Grady, K., Hicks, E., Hirst, E., & Atkinson-Cox, K. (2020). The influence of alcohol and weapon presence on eyewitness memory and confidence. *Applied Cognitive Psychology*, *34*(2), 489–503. <https://doi.org/10.1002/acp.3636>
- Henderson, J. M. (2003). Human gaze control during real-world scene perception. *Trends in Cognitive Sciences*, *7*(11), 498–504. <https://doi.org/10.1016/j.tics.2003.09.006>

- Holmqvist, K., Örbom, S. L., Hooge, I. T. C., Niehorster, D. C., Alexander, R. G., Andersson, R., Benjamins, J. S., Blignaut, P., Brouwer, A.-M., Chuang, L. L., Dalrymple, K. A., Drieghe, D., Dunn, M. J., Ettinger, U., Fiedler, S., Foulsham, T., van der Geest, J. N., Hansen, D. W., Hutton, S. B., . . . Hessels, R. S. (2022). Eye tracking: Empirical foundations for a minimal reporting guideline. *Behavior Research Methods*. Advance online publication. <https://doi.org/10.3758/s13428-021-01762-8>
- Hooge, I. T. C., Holleman, G. A., Haukes, N. C., & Hessels, R. S. (2019). Gaze tracking accuracy in humans: One eye is sometimes better than two. *Behavior Research Methods*, *51*(6), 2712–2721. <https://doi.org/10.3758/s13428-018-1135-3>
- Hope, L., & Wright, D. (2007). Beyond unusual? Examining the role of attention in the weapon focus effect. *Applied Cognitive Psychology*, *21*(7), 951–961. <https://doi.org/10.1002/acp.1307>
- Hugh-Jones, D. (2022). *huxtable: Easily create and style tables for LaTeX, HTML and other formats* (Version 5.5.0) [Computer software]. <https://CRAN.R-project.org/package=huxtable>
- Hulse, L. M., & Memon, A. (2006). Fatal impact? The effects of emotional arousal and weapon presence on police officers' memories for a simulated crime. *Legal and Criminological Psychology*, *11*(2), 313–325. <https://doi.org/10.1348/135532505X58062>
- Hutson, J. P., Smith, T. J., Magliano, J. P., & Loschky, L. C. (2017). What is the role of the film viewer? The effects of narrative comprehension and viewing task on gaze control in film. *Cognitive Research: Principles and Implications*, *2*(1), Article 46. <https://doi.org/10.1186/s41235-017-0080-5>
- Jeffreys, H. (1935). Some tests of significance, treated by the theory of probability. *Mathematical Proceedings of the Cambridge Philosophical Society*, *31*(2), 203–222. <https://doi.org/10.1017/s030500410001330x>
- Kim, K., Park, K. K., & Lee, J.-H. (2014). The influence of arousal and expectation on eyewitness memory in a virtual environment. *Cyberpsychology, Behavior, and Social Networking*, *17*(11), 709–713. <https://doi.org/10.1089/cyber.2013.0638>
- Kirillov, A., Wu, Y., He, K., & Girshick, R. (2020). PointRend: Image segmentation as rendering. *IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, 9796–9805. <https://doi.org/10.1109/cvpr42600.2020.00982>
- Kleiner, M., Brainard, D., & Pelli, D. (2007). What's new in Psychtoolbox-3? *Perception*, *36*, 14. <https://doi.org/10.1177/03010066070360S101>

- Kocab, K., & Sporer, S. L. (2016). The weapon focus effect for person identifications and descriptions: A meta-analysis. In M. K. Miller & B. H. Bornstein (Eds.), *Advances in psychology and law* (Vol. 1, pp. 71–117). Springer. [https://doi.org/10.1007/978-3-319-29406-3\\_3](https://doi.org/10.1007/978-3-319-29406-3_3)
- Kramer, T. H., Buckhout, R., & Eugenio, P. (1990). Weapon focus, arousal, and eyewitness memory: Attention must be paid. *Law and Human Behavior, 14*(2), 167–184. <https://doi.org/10.1007/BF01062971>
- Lawrence, M. A. (2016). *ez: Easy analysis and visualization of factorial experiments* (Version 4.4-0) [Computer software]. <https://CRAN.R-project.org/package=ez>
- Loftus, E. F., Loftus, G. R., & Messo, J. (1987). Some facts about "weapon focus". *Law and Human Behavior, 11*(1), 55–62. <https://doi.org/10.1007/bf01044839>
- Loftus, G. R., & Mackworth, N. H. (1978). Cognitive determinants of fixation location during picture viewing. *Journal of Experimental Psychology: Human Perception and Performance, 4*(4). <https://doi.org/10.1037/0096-1523.4.4.565>
- Maass, A., & Köhnken, G. (1989). Eyewitness identification: Simulating the "weapon effect". *Law and Human Behavior, 13*(4), 397–408. <https://doi.org/10.1007/BF01056411>
- Mansour, J. K., Hamilton, C. M., & Gibson, M. T. (2019). Understanding the weapon focus effect: The role of threat, unusualness, exposure duration, and scene complexity. *Applied Cognitive Psychology, 33*(6), 991–1007. <https://doi.org/10.1002/acp.3515>
- McKinney, W. (2010). Data structures for statistical computing in Python. *Proceedings of the 9th Python in Science Conference, 56–61*. <https://doi.org/10.25080/Majora-92bf1922-00a>
- Mekawi, Y., & Bresin, K. (2015). Is the evidence from racial bias shooting task studies a smoking gun? Results from a meta-analysis. *Journal of Experimental Social Psychology, 61*, 120–130. <https://doi.org/10.1016/j.jesp.2015.08.002>
- 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. <https://doi.org/10.1111/j.2044-8333.1998.tb00367.x>
- Morey, R. D., & Rouder, J. N. (2022). *BayesFactor: Computation of Bayes factors for common designs* (Version 0.9.12-4.4) [Computer software]. <https://CRAN.R-project.org/package=BayesFactor>
- Nuthmann, A., & Canas-Bajo, T. (2022). Visual search in naturalistic scenes from foveal to peripheral vision: A comparison between dynamic and static displays. *Journal of Vision, 22*(1), Article 10. <https://doi.org/10.1167/jov.22.1.10>

- Nyman, T. J., Antfolk, J., Lampinen, J. M., Korkman, J., & Santtila, P. (2020). Eyewitness identifications after witnessing threatening and non-threatening scenes in 360-degree virtual reality (or 2D) from first and third person perspectives. *PloS ONE*, *15*(9), Article e0238292. <https://doi.org/10.1371/journal.pone.0238292>
- Olafenwa, A. (2021). *PixelLib* (Version 0.7.1) [Computer software]. <https://pypi.org/project/pixellib>
- Orquin, J. L., Ashby, N. J. S., & Clarke, A. D. F. (2016). Areas of interest as a signal detection problem in behavioral eye-tracking research. *Journal of Behavioral Decision Making*, *29*(2-3), 103–115. <https://doi.org/10.1002/bdm.1867>
- Pelli, D. G. (1997). The VideoToolbox software for visual psychophysics: Transforming numbers into movies. *Spatial Vision*, *10*(4), 437–442. <https://doi.org/10.1163/156856897x00366>
- Pickel, K. L. (1998). Unusualness and threat as possible causes of "weapon focus". *Memory*, *6*(3), 277–295. <https://doi.org/10.1080/741942361>
- Pickel, K. L. (1999). The influence of context on the "weapon focus" effect. *Law and Human Behavior*, *23*(3), 299–311. <https://doi.org/10.1023/A:1022356431375>
- Pickel, K. L. (2009). The weapon focus effect on memory for female versus male perpetrators. *Memory*, *17*(6), 664–678. <https://doi.org/10.1080/09658210903029412>
- Pickel, K. L. (2015). Eyewitness memory. In J. M. Fawcett, E. F. Risko, & A. Kingstone (Eds.), *The handbook of attention* (pp. 485–502). MIT Press. <https://doi.org/10.7551/mitpress/10033.003.0024>
- Pickel, K. L., & Sneyd, D. E. (2018). The weapon focus effect is weaker with Black versus White male perpetrators. *Memory*, *26*(1), 29–41. <https://doi.org/10.1080/09658211.2017.1317814>
- Rouder, J. N., Morey, R. D., Speckman, P. L., & Province, J. M. (2012). Default Bayes factors for ANOVA designs. *Journal of Mathematical Psychology*, *56*(5), 356–374. <https://doi.org/10.1016/j.jmp.2012.08.001>
- Roussel, S., Joulia, D., Tricot, A., & Sweller, J. (2017). Learning subject content through a foreign language should not ignore human cognitive architecture: A cognitive load theory approach. *Learning and Instruction*, *52*, 69–79. <https://doi.org/10.1016/j.learninstruc.2017.04.007>
- Saunders, J. (2009). Memory impairment in the weapon focus effect. *Memory & Cognition*, *37*(3), 326–335. <https://doi.org/10.3758/MC.37.3.326>

- Schulz, A. (2021). *pBrackets: Plot brackets* (Version 1.0.1) [Computer software]. <https://CRAN.R-project.org/package=pBrackets>
- Scrivner, C., Choe, K. W., Henry, J., Lyu, M., Maestriperi, D., & Berman, M. G. (2019). Violence reduces attention to faces and draws attention to points of contact. *Scientific Reports*, 9, Article 17779. <https://doi.org/10.1038/s41598-019-54327-3>
- Smith, T. J., & Mital, P. K. (2013). Attentional synchrony and the influence of viewing task on gaze behavior in static and dynamic scenes. *Journal of Vision*, 13(8), Article 16. <https://doi.org/10.1167/13.8.16>
- Tatler, B. W. (2007). The central fixation bias in scene viewing: Selecting an optimal viewing position independently of motor biases and image feature distributions. *Journal of Vision*, 7(14), Article 4. <https://doi.org/10.1167/7.14.4>
- Torchiano, M. (2020). *effsize: Efficient effect size computation* (Version 0.8.1) [Computer software]. <https://CRAN.R-project.org/package=effsize>
- Vö, M. L.-H., Aizenman, A. M., & Wolfe, J. M. (2016). You think you know where you looked? You better look again. *Journal of Experimental Psychology: Human Perception and Performance*, 42(10), 1477–1481. <https://doi.org/10.1037/xhp0000264>
- Wagenmakers, E.-J., Marsman, M., Jamil, T., Ly, A., Verhagen, J., Love, J., Selker, R., Gronau, Q. F., Šmíra, M., Epskamp, S., Matzke, D., Rouder, J. N., & Morey, R. D. (2018). Bayesian inference for psychology. Part I: Theoretical advantages and practical ramifications. *Psychonomic Bulletin & Review*, 25(1), 35–57. <https://doi.org/10.3758/s13423-017-1343-3>
- Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis* (2nd ed.). Springer. <https://doi.org/10.1007/978-3-319-24277-4>
- Wickham, H., & Girlich, M. (2022). *tidyr: Tidy messy data* (Version 1.2.1) [Computer software]. <https://CRAN.R-project.org/package=tidyr>
- Wickham, H., & Pedersen, T. L. (2022). *gtable: Arrange 'grobs' in tables* (Version 0.3.1) [Computer software]. <https://CRAN.R-project.org/package=gtable>
- Wickham, H., & Seidel, D. (2022). *scales: Scale functions for visualization* (Version 1.2.1) [Computer software]. <https://CRAN.R-project.org/package=scales>
- Williams, C. C., & Castelano, M. S. (2019). The changing landscape: High-level influences on eye movement guidance in scenes. *Vision*, 3(3), Article 33. <https://doi.org/10.3390/vision3030033>
- Xie, Y. (2015). *Dynamic documents with R and knitr* (2nd). Chapman and Hall/CRC. <https://doi.org/10.1201/9781315382487>

Yarkoni, T. (2022). The generalizability crisis. *Behavioral and Brain Sciences*, 45, Article e1.  
<https://doi.org/10.1017/S0140525X20001685>

## 2.8 Appendix 1 – Software Details

Power analyses were conducted using G\*Power (Version 3.1.9.7; Faul et al., 2007). The eye-tracking experiments were implemented in MATLAB (Version R2019b) using the Psychophysics Toolbox extension (Version 3.0.16; Brainard, 1997; Kleiner et al., 2007; Pelli, 1997), which incorporates the EyeLink Toolbox (Cornelissen et al., 2002). The online experiment was implemented in LimeSurvey (Version 3.23.3). We used the SR Research Data Viewer software (Version 4.2.1) to process the raw eye-movement data and to create elliptical ROIs for the critical objects and the head of the perpetrator. The ROIs comprising the people depicted in the stimuli were created with Python (Version 3.7.9) using the libraries *NumPy* (Version 1.21.6; Harris et al., 2020), *OpenCV* (Version 4.6.0.66; Bradski, 2000), *pandas* (Version 1.3.5; McKinney, 2010), and *PixelLib* (Version 0.7.1; Olafenwa, 2021). The eye-movement data and the behavioral data were analyzed with R (Version 4.2.1) using the packages *BayesFactor* (Version 0.9.12-4.4; Morey & Rouder, 2022), *effsize* (Version 0.8.1; Torchiano, 2020), *ez* (Version 4.4-0; Lawrence, 2016), *ggplot2* (Version 3.3.6; Wickham, 2016), *ggsignif* (Version 0.6.3; Ahlmann-Eltze & Patil, 2021), *gtable* (Version 0.3.1; Wickham & Pedersen, 2022), *huxtable* (Version 5.5.0; Hugh-Jones, 2022), *knitr* (Version 1.40; Xie, 2015), *pBrackets* (Version 1.0.1; Schulz, 2021), *scales* (Version 1.2.1; Wickham & Seidel, 2022), and *tidyr* (Version 1.2.1; Wickham & Girlich, 2022).

## 2.9 Appendix 2 – Quality Assessment of the Eye-Tracking Data

Following guidelines by Holmqvist et al. (2022), we empirically assessed the quality of the eye-tracking data in Experiments 1 and 2. Specifically, we determined the accuracy as the average validation error, the precision as the root-mean-square sample-to-sample deviation, and data loss as the proportion of missing samples. Appendix Table 2.5 shows that, for both experiments, accuracy and precision were good, and data loss was low.

Experiment	Average Validation Error	RMS-S2S	Missing Samples
Experiment 1	0.32 (0.08)	0.0222 (0.0050)	1.49 (1.76)
Experiment 2	0.30 (0.07)	0.0162 (0.0039)	1.44 (1.82)

**Table 2.5** Means and standard deviations for data quality criteria for the eye-tracking data in Experiments 1 and 2. Standard deviations are presented in parentheses. RMS-S2S = root-mean-square sample-to-sample deviation. Average validation error and RMS-S2S are in degrees of visual angle; missing samples are in percentages.

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### **3 STUDIE 2 – IS A KNIFE THE SAME AS A PLUNGER? COMPARING THE ATTENTIONAL EFFECTS OF WEAPONS AND NON-THREATENING UNUSUAL OBJECTS IN DYNAMIC SCENES**

Körner, H. M., Faul, F. & Nuthmann, A. (2024). Is a knife the same as a plunger? Comparing the attentional effects of weapons and non-threatening unusual objects in dynamic scenes. *Cognitive Research: Principles and Implications*, 9, Artikel 66. <https://doi.org/10.1186/s41235-024-00579-1>

### 3.1 Zusammenfassung

Das Ziel von Studie 2 war es, die Ursachen für die unerwarteten Ergebnisse aus Studie 1 näher zu untersuchen und außerdem die Ungewöhnlichkeitshypothese zum WFE zu testen. Dazu wurden Videos eines inszenierten Raubüberfalls erstellt, bei dem die Täterin entweder eine Waffe (bedrohlich und ungewöhnlich), ein nicht bedrohliches ungewöhnliches Objekt oder ein neutrales Objekt (nicht bedrohlich und nicht ungewöhnlich) in der Hand hielt. Das Material wurde mit dem Ziel konzipiert, die Auftretenswahrscheinlichkeit des WFE zu maximieren.

Die erhobenen Blickbewegungsdaten zeigten, dass weder die Waffe noch das nicht bedrohliche ungewöhnliche Objekt länger angeschaut wurden als das neutrale Objekt. Die Betrachtungsdauer auf der Täterin war reduziert, wenn sie das ungewöhnliche Objekt in der Hand hielt, aber nicht, wenn sie die Waffe in der Hand hielt. Allerdings beeinflusste die Waffe, *wie* die Versuchspersonen auf die Täterin schauten: Im Vergleich zu der Kontrollbedingung schauten sie weniger auf das Gesicht der Täterin, dafür jedoch mehr auf ihren Körper. Zeitverlaufsanalysen ergaben zudem, dass die Unterschiede in der Aufmerksamkeitsverteilung zwischen den Experimentalbedingungen zu Beginn der Szene stärker ausgeprägt waren.

Insgesamt widersprechen die Ergebnisse den Annahmen der aktuellen Theorien zum WFE. Sowohl die Waffe als auch das ungewöhnliche Objekt wurden insgesamt nur wenig beachtet. Beide Objekte wurden insbesondere nicht länger angeschaut als das neutrale Kontrollobjekt. Zwar war die Betrachtungsdauer auf der Täterin, wie von der Ungewöhnlichkeitshypothese vorhergesagt, verringert, wenn sie das nicht bedrohliche ungewöhnliche Objekt in der Hand hielt. Eine entsprechende Verringerung trat bei der Waffe jedoch nicht auf, obwohl diese im gegebenen Kontext ebenfalls ungewöhnlich war. Stattdessen waren, wie bereits in Studie 1, komplexere Effekte des Objekttyps auf die Aufmerksamkeitsverteilung zu beobachten.

Die Erinnerung an das Aussehen der Täterin war nicht beeinträchtigt, wenn diese die Waffe oder das nicht bedrohliche ungewöhnliche Objekt in der Hand hielt. Es trat also kein WFE auf. In einem online durchgeführten Folgeexperiment wurden die Erinnerungseffekte näher untersucht und zusätzlich geprüft, welche Auswirkungen das Darbieten bzw. Weglassen der Tonspur der Videos hat. Dabei wurde in der Bedingung mit Ton ein WFE festgestellt, ohne Ton trat dagegen kein Erinnerungseffekt auf. Da die Videos im Hauptexperiment ebenfalls mit Ton dargeboten wurden, widersprechen sich die Befunde aus den beiden Experimenten. Die plausibelsten Erklärungen für diese Inkonsistenz sind entweder (a) ein Einfluss der unterschiedlichen Stichprobenzusammensetzungen zwischen den Experimenten oder (b) ein falsch-positives Ergebnis im Folgeexperiment.

### 3.2 Abstract

Observers' memory for a person's appearance can be compromised by the presence of a weapon, a phenomenon known as the weapon-focus effect (WFE). According to the unusual-item hypothesis, attention shifts from the perpetrator to the weapon because a weapon is an unusual object in many contexts. To test this assumption, we monitored participants' eye movements while they watched a mock-crime video. The video was presented with sound and featured a female perpetrator holding either a weapon, a non-threatening unusual object, or a neutral object. Contrary to the predictions of current theories, there were no significant differences in total viewing times for the three objects. For the perpetrator, total viewing time was reduced when she held the non-threatening unusual object, but not when she held the weapon. However, weapon presence led to an attentional shift from the perpetrator's face toward her body. Detailed time-course analyses revealed that the effects of object type were more pronounced during early scene viewing. Thus, our results do not support the idea of extended attentional shifts from the perpetrator toward the unusual objects, but instead suggest more complex attentional effects. Contrary to previous research, memory for the perpetrator's appearance was not affected by object type. Thus, there was no WFE. An additional online experiment using the same videos and methodology produced a WFE, but this effect disappeared when the videos were presented without sound.

### **3.3 Significance Statement**

Eyewitness misidentifications are a major cause of wrongful convictions. Therefore, it is important to understand the factors affecting the accuracy of eyewitness testimony. The presence of a weapon seems to be one such factor. Research has shown that observers' memory for a perpetrator's appearance is worse when the attacker carried a weapon. The unusual-item hypothesis attributes this effect to weapons being unusual objects, causing an attentional shift from the perpetrator to the weapon. Most previous studies investigating the attentional effects of weapons relied on static stimuli. However, static images neglect the fact that actual situations change dynamically, making them incomplete depictions of the real world. Recent research has shown that the attentional effects of weapons differ between static and more naturalistic stimuli. We expand upon these findings by comparing the attentional effects of a weapon and a non-threatening unusual object using video stimuli. For both the weapon and the unusual object, we found some evidence for the predicted attentional shift away from the perpetrator toward the objects within the first few seconds after the perpetrator came into view. However, these effects were generally short-lived. Regarding the effects on memory for the perpetrator's appearance, we found mixed results. Memory was impaired by the presence of a weapon or an unusual object in one experiment, but not in the other. This inconsistency could suggest that the effects of weapons depend on the setting or on observer characteristics, in which case these factors would need to be accounted for when evaluating eyewitness testimony.

The weapon-focus effect (WFE) describes a phenomenon in which eyewitnesses to a crime recall the appearance of the perpetrator less accurately if the perpetrator was carrying a weapon. Currently, the theory with the most empirical support posits that the WFE occurs because weapons are unusual objects in many contexts (e.g., E. F. Loftus et al., 1987; Pickel, 2015). Objects which are not threatening in nature (i.e., not weapons) have been found to impair memory to a similar degree if they are also unusual in the given context (e.g., Mitchell et al., 1998; Pickel, 1998, 1999). Both weapons and non-threatening unusual objects are assumed to draw attention away from the perpetrator. Although this attention component of the WFE is an integral part of current theories, it has rarely been directly investigated. Results from our recent eye-tracking study on this topic (Körner et al., 2023) suggest that the attentional effects of weapons are actually more complex than previously assumed. The primary aim of the present study was to compare the attentional effects of weapons with those of non-threatening unusual objects using eye tracking and naturalistic dynamic stimuli (i.e., videos). Recall for the perpetrator's appearance was also assessed.

E. F. Loftus et al. (1987) formulated two hypotheses to explain the WFE. The arousal/threat hypothesis proposes that the WFE occurs due to the threat posed by weapons. Specifically, weapons are assumed to heighten the level of arousal or stress of eyewitnesses. Based on Easterbrook's (1959) cue-utilization hypothesis, this elevated arousal is assumed to in turn narrow eyewitnesses' focus of attention, with witnesses focusing extensively on the weapon at the cost of attention paid to other aspects of the scene such as the perpetrator's appearance.

In contrast, the unusual-item hypothesis attributes the WFE to the unusualness or unexpectedness of weapons in many contexts. Unusualness here refers to an incongruity with the spatial context (i.e., the scene). The unusual-item hypothesis was inspired by findings by G. R. Loftus and Mackworth (1978). In this widely cited study, participants viewed a set of line drawings for 4 s each. The authors manipulated the contextual congruency of a critical object. For example, a scene of a farm could contain either a tractor (context-congruent) or an octopus (context-incongruent). Results showed that incongruent objects were fixated earlier, more often, and for longer durations than congruent objects. Based on these findings by G. R. Loftus and Mackworth (1978), E. F. Loftus et al. (1987) suggested that the WFE may occur because eyewitnesses do not expect to see a weapon in a context in which it is unusual.

Since then, there has been a whole body of literature devoted to studying the attentional effects of context-incongruent objects (for a review, see Wu et al., 2014). Several studies replicated the finding that incongruent objects are fixated more often and for longer durations

compared with congruent objects (e.g., Coco et al., 2020; Henderson et al., 1999; Vö & Henderson, 2009). Whether incongruent objects are also fixated earlier is less clear, with some studies finding such an effect (e.g., Coco et al., 2020; Underwood et al., 2008), whereas others found no differences between congruent and incongruent objects (e.g., Henderson et al., 1999; Vö & Henderson, 2009).

There are some methodological aspects of this basic scene-perception research that limit the generalization to the WFE. For one, all of these studies used static images such as line drawings (e.g., G. R. Loftus & Mackworth, 1978), computer renderings (e.g., Vö & Henderson, 2009), or photos of real-world scenes (e.g., Coco et al., 2020). Dorr et al. (2010) compared participants' eye movements while they watched natural scenes in the form of either videos or stop-motion sequences (i.e., slide shows, in which still images sampled from the respective video were presented for a few seconds each). The patterns of results depended on the mode of presentation, demonstrating that findings for (series of) static scenes do not necessarily generalize to dynamic scenes. Secondly, research on incongruent objects has used only comparatively short exposure durations (ranging from 4 to 15 s) and has focused primarily on measures of extrafoveal and first-pass foveal processing (i.e., the first time that objects are fixated). It is therefore not entirely clear to what extent the effects of context-congruency persist over time. However, there is some evidence that an attentional bias toward incongruent objects can be observed in overall gaze behavior during scene viewing for up to 15 s (e.g., Henderson et al., 1999).

In the context of the WFE, research investigating the role of unusualness has focused almost exclusively on memory effects. For example, it has been found that unusual objects like a whole raw chicken (Pickel, 1998) or a stalk of celery (Mitchell et al., 1998) lead to similar memory impairments as weapons do. Moreover, the extent to which weapons reduce memory accuracy seems to depend on how unusual they are in the given context. For example, weapons have been shown not to impair memory when they are congruent to the surrounding scene (e.g., a gun at a shooting range; Pickel, 1999). Similarly, weapon presence has been found not to reduce memory accuracy when the person carrying the weapon can be expected to be armed (e.g., a police officer; Pickel, 1999).

Conversely, memory impairments tend to be greater when the person carrying the weapon has characteristics that are less associated with weapons. Pickel (2009) found that the memory-related WFE was stronger for a female perpetrator than for a male perpetrator. By contrast, a knitting needle caused a greater memory impairment than a knife for a male perpetrator, whereas the opposite was true for a female perpetrator. The author attributed these results to

gender stereotypes influencing the associations of certain objects with different gender roles and, consequently, the perceived unusualness of the given objects. Similar effects have since been reported for racial stereotypes (Pickel & Sneyd, 2018). Meta-analyses on the WFE (Fawcett et al., 2013; Kocab & Sporer, 2016) confirmed that non-threatening unusual objects impair memory to a similar degree as weapons do.

While these findings support the hypothesis that the unusualness of weapons in many contexts is a key reason why weapons impair memory accuracy, there is some evidence that threat also plays a role. For example, Kim et al. (2014) varied both threat and unusualness and found that both factors impaired memory independently of each other. Similarly, some studies have reported larger memory effects for weapons, which are both unusual and threatening, than for non-threatening unusual objects (Hope & Wright, 2007; Mansour et al., 2019). Meta-analyses have found the WFE to be stronger when the weapon is used in a threatening manner (Fawcett et al., 2013) or in the context of a crime (Kocab & Sporer, 2016).

In the broader literature on the effects of stress on eyewitness memory, stress has been shown to negatively impact memory in studies that successfully induced stress (Deffenbacher et al., 2004). It is important to note that ethical constraints limit the degree of arousal that can be induced in experimental research. It is possible that the effects of threat are exacerbated under the presumably extreme levels of stress experienced by eyewitnesses to real crimes, especially by victims. Since the arousal/threat hypothesis and the unusual-item hypothesis are not mutually exclusive, both threat and unusualness may contribute to the WFE.

In contrast to the memory effects of weapons, their attentional effects are less well understood. So far, the commonly accepted explanation has been that weapons capture eyewitnesses' attention, and that this attentional focus leads to a poorer encoding of the perpetrator's appearance. For example, Pickel (2015) defined the WFE as follows: "The *weapon-focus effect* is that witnesses tend to direct their attention toward a weapon held by a perpetrator, which causes them to remember the perpetrator's physical features and clothing less accurately than they would have without the weapon's presence" (p. 490). However, this attention component of the WFE has been studied far less extensively than the memory component.

The most direct evidence supporting the assumption that eyewitnesses focus their attention on the weapon stems from an eye-tracking study by E. F. Loftus et al. (1987). In this study, participants watched a slide show depicting a staged interaction between a man and a cashier at a restaurant. Depending on the experimental condition, the man held either a gun or a check. Eye-tracking results revealed that participants fixated the gun more often and for longer durations compared with the check. A subsequent study by Biggs et al. (2013) investigated the

attentional effects of weapons using a different paradigm. Here, the authors presented participants with individual, non-narrative images each depicting a single person holding either a weapon or a neutral object. Results showed that participants spent more time looking at the weapons than at the neutral objects, thereby corroborating the findings of E. F. Loftus et al. (1987). Importantly, this increased viewing time on the weapons came at the cost of viewing time on the faces of the people holding them. Thus, these results provide evidence for an attentional shift from the person holding a weapon to the weapon itself (E. F. Loftus et al., 1987, did not report fixations on the depicted people).

There is also evidence that non-threatening unusual objects bind attention to a similar degree as weapons do. Similar to E. F. Loftus et al. (1987), Hope and Wright (2007) presented participants with a slide show of a staged robbery. For the slide involving the critical object, participants were slower to react to a secondary task when the scene included a weapon or an unusual object than when it included a neutral object. In a study by Flowe et al. (2013), participants were instructed to look either toward or away from a target object, which appeared in the periphery and without a broader context. The authors recorded participants eye movements and used the saccade reaction time to measure the degree to which the objects engaged participants' attention. Results showed that an uncommon object engaged attention to a greater extent than a neutral object. Results for the weapon were mixed, with the weapon attracting more attention than the neutral object in only one of the two experiments.

All of these studies on the attentional effects of weapons used static stimuli, in the form of either slide shows (Hope & Wright, 2007; E. F. Loftus et al., 1987) or non-narrative images (Biggs et al., 2013; Flowe et al., 2013). As noted above, attention allocation can be different for static stimuli compared with more naturalistic viewing conditions such as videos (Dorr et al., 2010). Relatedly, viewing behavior for highly-edited dynamic stimuli such as motion pictures has been shown to be strongly shaped by bottom-up factors, which seem to override many top-down influences typically observed for static stimuli (e.g., Hutson et al., 2017; Loschky et al., 2015). This strong influence of bottom-up factors leads to a high inter-observer attentional synchrony, a phenomenon Loschky et al. (2015) coined the tyranny of film. Recent findings suggest that the high attentional synchrony observed for movies is largely due to moving elements capturing the observers' attention (Hutson et al., 2022; also see Itti, 2005). However, there is research suggesting that the tyranny of film is less pronounced for other types of dynamic scenes such as unedited real-world scenes (Dorr et al., 2010) or screen-captured instructional videos (Levin et al., 2021).

In our recent study (Körner et al., 2023), we used eye tracking to investigate whether weapons also attract attention in video stimuli. Contrary to previous findings, participants did not spend significantly more time looking at a gun than at a cell phone. Viewing time on the perpetrator was also not affected by the type of object he held. Moreover, both the weapon and the neutral object were looked at for much shorter durations compared with the depicted people. Instead of a simple attentional shift away from the perpetrator and toward the weapon, weapon presence seems to have led participants to focus more closely on the interaction of the depicted people.

To explore whether these unexpected results were due to the use of video stimuli, our previous study included a second eye-tracking experiment in which we converted the videos to slide shows, mimicking the methodology of E. F. Loftus et al. (1987). For these slide shows, we were able to replicate the attentional bias toward a weapon reported by E. F. Loftus et al. (1987). However, this increased focus on the weapon did not come at a cost in viewing time on the perpetrator, and viewing time on the weapon was still quite low overall. Finally, weapon presence did not impair memory in either eye-tracking experiment, nor in an additional online study with a larger sample size.

The current study expands upon these previous findings on the attentional effects of weapons. In our previous study (Körner et al., 2023), we compared a weapon to a neutral control object only. In such a design, it remains unclear whether any effects the weapon may induce are a result of its threatening nature or its unusualness in the given context. A central aim of the current study was to directly test these competing explanations by additionally including a non-threatening unusual object.

The stimuli used in Körner et al. (2023) were based on material from a recent U.S. study (Pickel & Sneyd, 2018). The fact that Pickel and Sneyd (2018) found large memory effects for these videos allowed us to conclude that the absence of a WFE was unlikely to be due to specific stimulus characteristics. However, adapting the material from another study also had disadvantages. Most notably, the English soundtrack did not match the first language of our German participants. To account for this mismatch, we chose to omit the soundtrack in our previous eye-tracking experiments. For the current study, we created our own material, in which the protagonists spoke German.

Due to our unexpected, but consistent previous failures to replicate the memory-related WFE, we also designed the stimuli to elicit a maximum effect by choosing optimal values for known moderator variables. These moderator variables include (a) the gender of the perpetrator, (b) the weapon type, (c) the exposure duration of the weapon and the perpetrator, and (d)

the demeanor of the perpetrator. Finally, we directly investigated the effects that including versus omitting the soundtrack has on the memory-related WFE (Experiment 2).

### **3.4 Experiment 1**

Participants watched a video of a staged robbery while their eye movements were recorded. There were three versions of the video, which differed only with regard to the critical object held by the perpetrator. Depending on the experimental condition, the perpetrator carried either a weapon, a non-threatening and context-congruent object, or a non-threatening unusual object. After watching the video, participants completed a questionnaire about the appearance of the perpetrator.

If the unusualness of weapons is indeed a key factor underlying the WFE, then weapons and non-threatening objects should have similar effects on both attention and memory. If, on the other hand, effects differ for weapons and unusual objects, this would suggest that other characteristics of weapons, such as their threatening nature (cf. Easterbrook, 1959; E. F. Loftus et al., 1987), are more relevant for the WFE.

#### **3.4.1 Methods**

##### **3.4.1.1 Design and Participants**

Object type (knife, water bottle, and plunger) was manipulated between-subjects. The sample consisted of  $N = 162$  participants (123 women, 39 men) between 18 and 53 years of age ( $M = 24.0$  years,  $SD = 5.6$ ). Most participants were undergraduate psychology students. Subjects received either monetary compensation or course credit for their participation.

##### **3.4.1.2 Stimuli**

The stimuli were designed to elicit a maximum effect based on known moderator variables of the (memory-related) WFE. One such moderator variable is the gender of the perpetrator. The memory-related WFE has been shown to be stronger for a female than for a male perpetrator (Pickel, 2009). Therefore, and firstly, the perpetrator in our videos was portrayed by a woman. Secondly, a knife was used as the weapon. In their meta-analysis, Kocab and Sporer (2016) found that studies using weapons other than guns (mostly knives, but also other objects such as a meat cleaver or a screwdriver) reported larger effects than those using guns. Kocab and Sporer (2016) had originally expected to find the opposite effect (i.e., a larger WFE for guns than for other weapons). To explain their findings, the authors hypothesized that because knives potentially cause more gruesome injuries than guns, knives may appear more frightening to the

observer. Thirdly, both the perpetrator and the critical object were in view for a duration of approximately 12 s. A meta-analysis by Fawcett et al. (2013) has shown that the memory effects of weapons were strongest for exposure durations between 10 and 60 s. The main reason why we chose an exposure duration close to the lower end of this apparently optimal range was that in our previous study (Körner et al., 2023), the critical objects attracted attention primarily at the beginning of the scene. If there are differences between viewing times on the different objects, they are presumably most pronounced during this initial period. For shorter exposure durations, such initial differences have a greater impact on the overall effect, as the first few seconds make up a larger proportion of the total scene duration. Thus, the attentional WFE should be strongest for comparatively short exposure durations. Moreover, a recent study by Erickson et al. (2022) found that weapon presence impaired the recognizability of facial composites only at an exposure duration of 10 s, with no WFE observed at 30 s. Finally, the perpetrator in our videos used the weapon in a threatening manner, which should also increase the strength of the WFE (see Fawcett et al., 2013).

Thus, we created videos depicting a female perpetrator robbing a male victim. Depending on the experimental condition, the perpetrator held either a knife, a filled plastic water bottle, or a plunger. Both the perpetrator and the victim were White and in their late 20s. The videos were approximately 50 s long and contained no cuts or camera movements. They had a resolution of  $1920 \times 1080$  pixels at 25 frames per second and subtended  $47.5^\circ$  degrees horizontally and  $27.8^\circ$  vertically.

Figure 3.1 illustrates key sections of the videos with example frames and detailed timestamps. The videos started with a shot of a room containing a table, two chairs, and a cabinet. After a short while, the victim entered the room holding a cash box. He sat down at the table, opened the box, and started counting the money inside. Then the perpetrator entered, carrying the critical object and a backpack. She demanded that the victim hand over the money. When the victim did not immediately comply, the perpetrator urged him to hurry. After the victim had put the money in the backpack, the perpetrator left, and the videos ended. The victim remained calm throughout the video. The perpetrator was visible for about 12 s (from second 34 to second 46). During this period, the critical object was also constantly in view.

### **3.4.1.3 Apparatus and Procedure**

The stimuli were presented on a 24.5-in. monitor with a resolution of  $1920 \times 1080$  pixels and a refresh rate of 144 Hz. Binocular eye movements were recorded using an SR Research



**Figure 3.1** Screenshots illustrating key interactions from the video stimuli. The panel titles describe the actions performed and the words spoken (translated from German to English) during the various sections of the videos. The timestamps within the screenshots indicate the time in seconds during which the respective actions took place, relative to the beginning of the sequence for which eye movements were analyzed (i.e., the time during which the perpetrator was visible). The example frames are taken from the knife condition, but the timestamps are aggregated across object conditions. The panel at the top left (gray background) illustrates the actions taking place before the analyzed sequence. Faces were pixelated for privacy protection; note that this was not the case in the experimental stimuli.

EyeLink 1000 Plus Tower Mount, which includes a chin-and-forehead rest to minimize participants' head movements. The viewing distance was 62 cm. The soundtrack of the videos was played through loudspeakers.

Participants were instructed to pay close attention to the content of the video. They were not informed that their memory for certain aspects of the video would be tested afterward. Before stimulus presentation, a nine-point calibration and validation of the eye tracker was performed. Moreover, the following fixation check was implemented: A fixation cross was presented at the center of the screen for 500 ms. The video was displayed only if the participant's gaze remained within an area of  $0.6^\circ \times 0.6^\circ$  around the cross for at least 200 ms.

Immediately after participants had watched the video, they filled out a questionnaire regarding the appearance of the perpetrator. The questions pertained both to the perpetrator's clothing (e.g., jacket, shirt, and pants) and to her physical characteristics (e.g., age, height, and hair style). There were both questions with predefined response categories (e.g., "Was the perpetrator wearing any headgear?" with the alternatives "yes" and "no") and open-ended questions (e.g., "What type of headgear was it?"). When creating the stimulus material, care was taken to ensure that there were many details about the perpetrator's appearance that subjects could potentially report. For example, the shirt of the perpetrator had both a complex pattern and a lettering, and she wore multiple accessories. Both the fact that we asked participants to recall details of the perpetrator's appearance rather than to identify her in a line-up, and the fact that memory was tested immediately after stimulus presentation should also increase the strength of the memory-related WFE (see Fawcett et al., 2013). In addition to these questions probing participants' memory, the questionnaire included a few rating items about the threat and unusualness of the critical object (see Experiment 3 in Körner et al., 2023, for details).

#### **3.4.1.4 Data Analysis**

The data were analyzed using SR Research Data Viewer, Python, and R (see Appendix 1 for software details). Eye movements were analyzed only for the sequence during which the perpetrator was visible. For each participant, only the data from the eye with the lower average error during the eye-tracker validation were analyzed (cf. Hooge et al., 2019). The empirically determined quality of the eye-tracking data was high, with a high accuracy (average validation error:  $M = 0.32^\circ$ ,  $SD = 0.07$ ), high precision (root-mean-square sample-to-sample deviation:  $M = 0.0191^\circ$ ,  $SD = 0.0032$ ), and low data loss (missing samples:  $M = 1.70\%$ ,  $SD = 3.36$ ).

#### **3.4.1.5 Dynamic Regions of Interest**

To analyze the allocation of attention and gaze, dynamic regions of interest (ROIs) were defined around the perpetrator, the victim, and the critical object (see Figure 3.2). Additional ROIs were created for the heads of the perpetrator and the victim to allow for a more fine-



**Figure 3.2** Examples of the stimulus material with superimposed regions of interest. Left panel: sample frame from the knife condition. Right panels: close-ups on the different critical objects, i.e., the knife, water bottle, and plunger. Transparent overlays mark the regions of interest for the perpetrator (blue), the critical object (red), and the victim (orange). The blue and the orange ellipses mark the borders of the region of interest for the head of the perpetrator and the victim, respectively. Faces were pixelated for privacy protection; note that this was not the case in the experimental stimuli.

grained analysis. For our main analyses, viewing times on the people were determined by adding the viewing times on their head and their body. To account for inaccuracies in the eye-tracking hardware, a margin of approximately  $0.5^\circ$  was added to each ROI (see Orquin et al., 2016).

All ROIs were generated automatically. Specifically, image-segmentation machine-learning algorithms were used to detect in each video frame the image regions belonging to the critical object or to one of the depicted people. The ROIs for the critical objects were created using the unsupervised semantic-segmentation framework *STEGO* (Hamilton et al., 2022) with a *DINO* backbone (Caron et al., 2021) and a refinement using a fully-connected conditional random field (Krähenbühl & Koltun, 2011). The ROIs for the perpetrator and the victim were created using the neural-network module *PointRend* (Kirillov et al., 2020) with a *ResNet-101* backbone (He et al., 2016). To create the ROIs for the heads of the perpetrator and the victim, ellipses were fitted to the top regions of the ROIs covering the entire body. This method was chosen because common face-detection algorithms failed to reliably detect the victim's face.

Generating the ROIs automatically yielded ROIs that closely matched the actual targets. This close fit was especially important for the critical objects. As illustrated in Figure 3.2, the individual critical objects, and consequently their corresponding ROIs, differed in size to some extent. Specifically, the ROI was largest for the plunger and smallest for the knife. Larger objects are generally more likely to be fixated than smaller ones (e.g., Nuthmann et al., 2020). In the context of the WFE, the assumed attentional effects of the critical objects are based on the different meanings of the objects and therefore should persist across various visual characteristics. This independence of the WFE from visual characteristics is supported to some extent by studies reporting similar memory effects for weapons of an unusual type or appearance compared to more conventional weapons (McRae et al., 2014; Pickel et al., 2006). To test whether the different ROI sizes affected the results, we also analyzed the data for critical-object ROIs which were equalized in their average size (see Appendix 2). However, using size-adjusted ROIs did not substantially alter the results, suggesting that the size differences were not pivotal to our findings.

Some of the ROIs overlapped. Specifically, the critical object ROI overlapped with the perpetrator ROI. There was virtually no overlap between the ROI for the critical object and the victim ROI, and the perpetrator ROI also did not overlap with the victim ROI. Naturally, the head ROIs for each person overlapped with their body ROIs. Due to these overlaps, gaze samples could fall into more than one ROI. In these cases, gaze samples were still assigned to a single ROI only. Specifically, gaze samples were assigned primarily to the critical object, and then to the person ROIs. Within each person ROI, the head ROI was given priority over the body ROI.

#### **3.4.1.6 Memory Score**

Subject responses were scored by a rater who was unaware of the underlying hypotheses. Each response was coded as either correct or incorrect, depending on whether it matched descriptions in an answer key. For the open-ended questions, each new piece of information provided by a given subject was counted as one detail. For example, if a subject reported that the perpetrator had worn a black belt, this would be counted as one correct detail (the perpetrator did wear a belt) and one incorrect detail (the belt was brown, not black). A subset of 90 subject responses was evaluated by a second, independent rater (cf. Pickel & Sneyd, 2018). Inter-rater reliability was high for both correct ( $r = .98$ ) and incorrect ( $r = .93$ ) details. For the analyses, only data from the rater who scored all subject responses were used. We used the proportion of correct

responses (i.e., the number of correct details divided by the total number of details, correct and incorrect) as a metric for memory performance (see Kocab & Sporer, 2016).

### 3.4.1.7 Details on Statistical Analyses

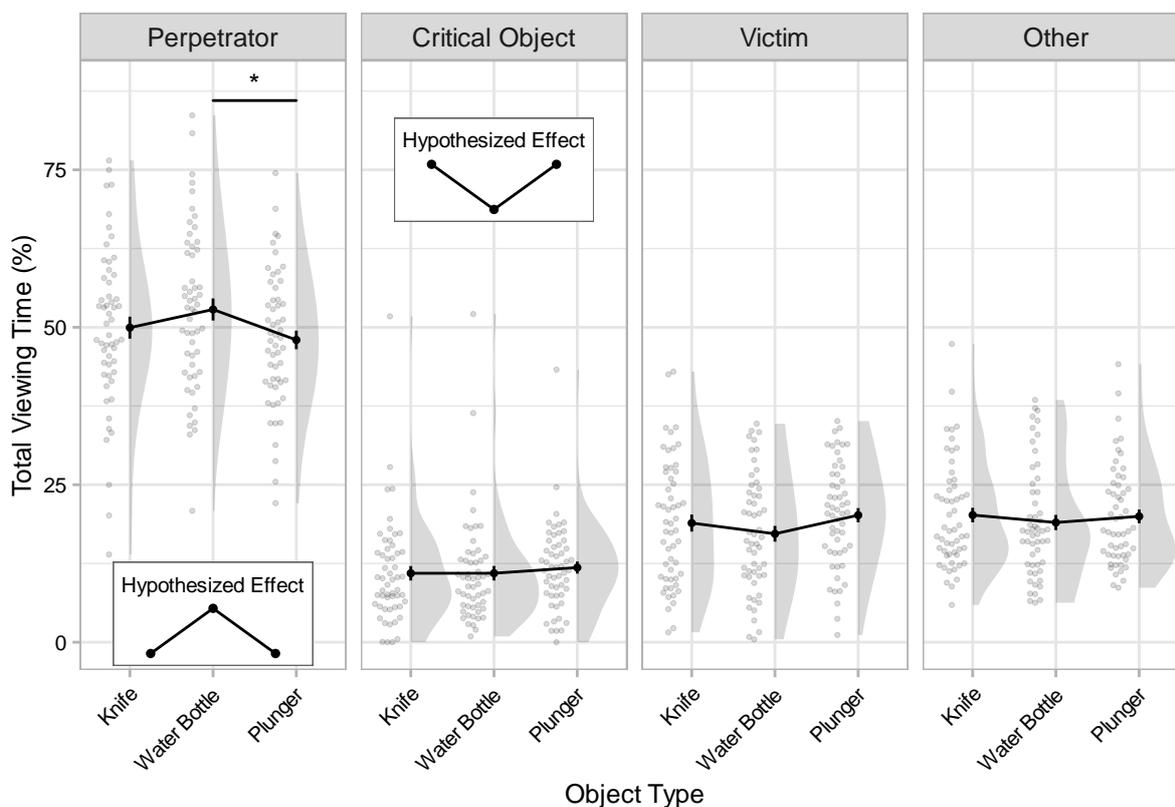
To account for potential smooth-pursuit eye movements, ROI matching was based on individual gaze samples as opposed to average fixation locations (see Körner et al., 2023, for details). Gaze samples classified as belonging to saccades were excluded from the analyses. Planned contrasts were used to compare the experimental groups. We complement results from null-hypothesis significance testing with Bayes factors (Jeffreys, 1935). While null-hypothesis significance testing provides researchers with a clear criterion on whether or not to accept the alternative hypothesis, Bayes factors also offer insights into how congruent the data are with the null hypothesis. Specifically, the Bayes factor  $BF_{01}$  is defined as the ratio of the probability for the observed data to have arisen under the null hypothesis to the probability for them to have arisen under the alternative hypothesis. If the null hypothesis and the alternative hypothesis explain the data equally well,  $BF_{01}$  is 1. In contrast, a value of  $BF_{01} = 5$  would indicate that it is 5 times more likely for the data to have arisen under the null hypothesis than under the alternative hypothesis. Thus, the larger the value of  $BF_{01}$ , the greater the support for the null hypothesis. Conversely, values below 1 indicate evidence in favor of the alternative hypothesis. We present the results using classifications proposed in the literature (Wagenmakers, Love, et al., 2018; Wagenmakers, Marsman, et al., 2018). Default priors (Morey et al., 2011; Rouder et al., 2009) were used.

## 3.4.2 Results

### 3.4.2.1 Total Viewing Time (General)

The total viewing time (TVT) is the summed duration of all gaze samples classified as fixations that landed within a given ROI. TVT was standardized as the percentage of the duration of the video segment during which the perpetrator was visible. Figure 3.3 and Table 3.1 show the relative TVT for the perpetrator, the critical object, the victim, and any area outside of these ROIs. Table 3.2 shows the results of the planned contrasts.

In all three experimental conditions, participants on average dedicated approximately half of their viewing time to the perpetrator. Contrary to predictions by current theories of the WFE, yet consistent with results by Körner et al. (2023), TVT on the perpetrator did not differ significantly between the knife and the water-bottle condition. In contrast, the presence of the



**Figure 3.3** Total viewing times in Experiment 1. Relative total viewing times are shown as a function of object type for the different regions of interest (see panel titles). The black dots represent the means. Each of the smaller, gray dots represents data from an individual participant. The larger gray areas show the distribution of the data. The insets present the expected pattern of results for the perpetrator and the critical object, respectively. Note that the connecting lines between the discrete levels of object type are included only to facilitate comparisons between experimental conditions. Error bars are  $\pm 1 SE$ .  $*p < .05$ .

Region of Interest	Knife	Water Bottle	Plunger
Perpetrator	49.94 (12.82)	52.83 (12.88)	48.00 (10.83)
Head	36.29 (14.06)	43.12 (13.52)	40.65 (12.57)
Body	13.65 (8.90)	9.71 (6.46)	7.35 (5.16)
Critical Object	10.95 (8.42)	10.95 (8.47)	11.85 (7.01)
Victim	18.92 (9.98)	17.21 (9.23)	20.17 (8.29)
Head	7.57 (6.25)	9.19 (7.25)	8.44 (6.40)
Body	11.35 (8.24)	8.02 (6.11)	11.73 (7.78)
Other	20.19 (8.53)	19.01 (8.88)	19.98 (7.97)

**Table 3.1** Means and standard deviations for the total viewing times (%) in Experiment 1. Standard deviations are presented in parentheses.  $N = 162$  ( $n = 54$  for each condition).

Region of Interest	Tails	<i>t</i>	<i>p</i>	<i>d</i>	<i>BF</i> <sub>01</sub>	Evidence for <i>H</i> <sub>1</sub>
Perpetrator						
Knife vs. Water Bottle	One	1.17	.123	0.22	1.55	–
Plunger vs. Water Bottle	One	2.11	.019	0.41	0.35	+
Knife vs. Plunger	Two	0.85	.395	0.16	3.54	--
Critical Object						
Knife vs. Water Bottle	One	< 0.01	.501	< 0.01	4.92	--
Plunger vs. Water Bottle	One	0.60	.274	0.12	2.91	–
Knife vs. Plunger	Two	0.61	.544	0.12	4.16	--
Victim						
Knife vs. Water Bottle	Two	0.92	.358	0.18	3.35	--
Plunger vs. Water Bottle	Two	1.75	.083	0.34	1.25	○
Knife vs. Plunger	Two	0.71	.480	0.14	3.92	--
Other						
Knife vs. Water Bottle	Two	0.71	.482	0.14	3.93	--
Plunger vs. Water Bottle	Two	0.60	.550	0.12	4.18	--
Knife vs. Plunger	Two	0.13	.895	0.03	4.87	--

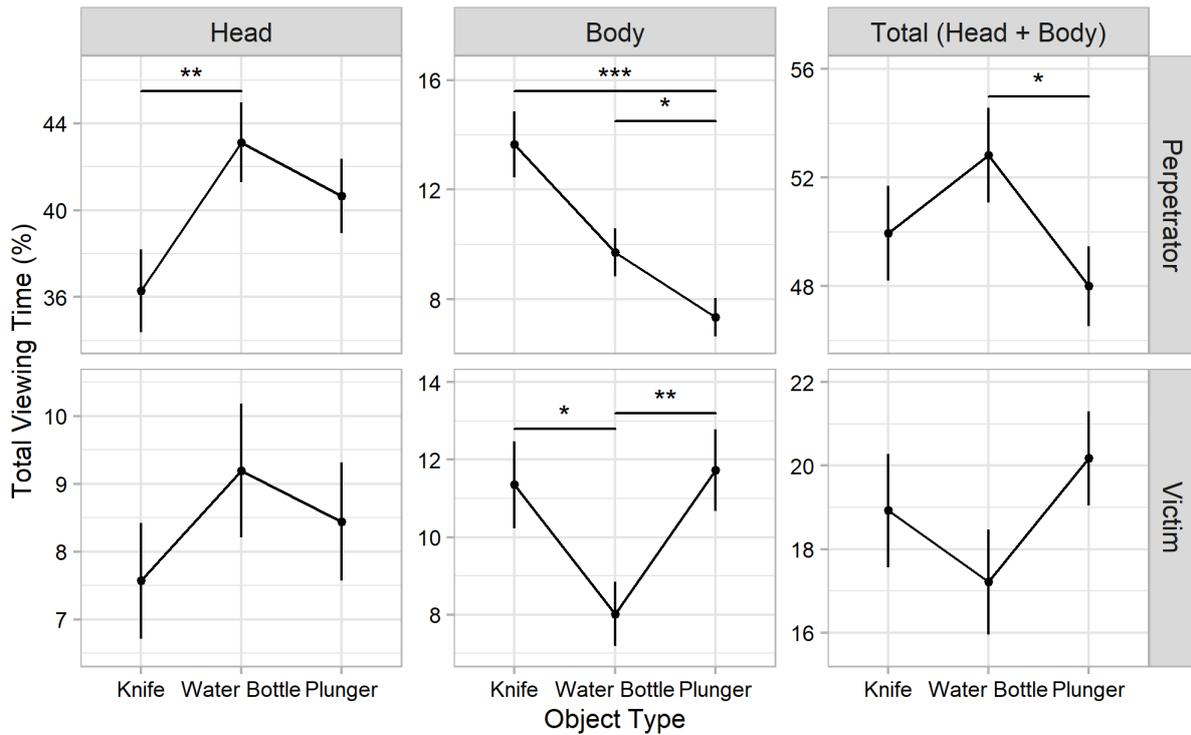
**Table 3.2** Results of the planned contrasts for the total viewing times in Experiment 1. All *ts* are absolute values. *df* = 106 for all tests. Classifications for the evidence in favor of the alternative hypothesis *H*<sub>1</sub> based on the Bayes Factor *BF*<sub>01</sub>: -- = moderate evidence against *H*<sub>1</sub>; – = weak evidence against *H*<sub>1</sub>; ○ = inconclusive evidence; + = weak evidence in favor of *H*<sub>1</sub>.

plunger significantly reduced TVT on the perpetrator compared with the water-bottle condition. TVTs on the perpetrator did not differ significantly between the knife and the plunger condition.

On average, the various critical objects received only 11%–12% of the overall viewing time. Neither the knife nor the plunger attracted significantly more gaze than the water bottle. TVTs on the knife and the plunger also did not differ significantly. Similarly, there were no significant differences between any of the experimental conditions in TVTs on the victim or on regions outside of the predefined ROIs.

### 3.4.2.2 Total Viewing Time (Heads versus Bodies)

A closer inspection of the viewing time on the depicted people revealed that object type affected TVT differently for the heads of the depicted people than for their bodies (see Figure 3.4 and Tables 3.1 and 3.3). For the perpetrator, most fixations were directed toward her head in all object conditions, with her body receiving substantially shorter TVTs. In the knife condition, TVT on the perpetrator's head was reduced compared with the water-bottle condition.



**Figure 3.4** Total viewing times in Experiment 1 by body region. Mean relative total viewing times are shown as a function of object type for the different body regions (columns) of the perpetrator and the victim (rows). Note that the scales of the y-axes differ for the various regions of interest. Also note that the connecting lines between the discrete levels of object type are included only to facilitate comparisons between experimental conditions. Error bars are  $\pm 1 SE$ . \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

Interestingly, this decrease in TVT on the head was offset by an increase in TVT on the body. Note that because current theories predict TVT on the perpetrator to be lower in the presence of a weapon compared to a neutral object, the clear increase in TVT on the perpetrator's body in the knife condition was not significant in the respective one-tailed test.

In the plunger condition, TVTs on the perpetrator's body were significantly lower than in both the water-bottle and the knife condition. TVTs on the perpetrator's head did not significantly differ between the plunger condition and the other two object conditions. For the victim, TVTs on the body were significantly elevated in the knife and plunger conditions compared with the water-bottle condition. TVTs on the victim's head were unaffected by object type.

### 3.4.2.3 Cumulative Time Course (General)

To more closely investigate participants' allocation of attention, we also analyzed the proportion of gaze samples falling into the various ROIs over time. Figure 3.5 shows the cumulative relative proportion of samples for the different ROIs as a function of time and object type. Here, individual gaze samples were grouped into bins of width  $\Delta t = 100$  ms. The interval  $T_k =$

Region of Interest	Tails	$t$	$p$	$d$	$BF_{01}$	Evidence for $H_1$
Perpetrator's Head						
Knife vs. Water Bottle	One	2.57	.006	0.50	0.13	++
Plunger vs. Water Bottle	One	0.98	.163	0.19	1.93	-
Knife vs. Plunger	Two	1.70	.093	0.33	1.36	o
Perpetrator's Body						
Knife vs. Water Bottle	One	2.63	.995	0.51	16.77	---
Plunger vs. Water Bottle	One	2.10	.019	0.40	0.36	+
Knife vs. Plunger	Two	4.50	< .001	0.87	< 0.01	+++++
Victim's Head						
Knife vs. Water Bottle	Two	1.25	.216	0.24	2.46	-
Plunger vs. Water Bottle	Two	0.57	.569	0.11	4.24	--
Knife vs. Plunger	Two	0.72	.476	0.14	3.90	--
Victim's Body						
Knife vs. Water Bottle	Two	2.39	.019	0.46	0.40	+
Plunger vs. Water Bottle	Two	2.76	.007	0.53	0.18	++
Knife vs. Plunger	Two	0.25	.806	0.05	4.78	--

**Table 3.3** Results of the planned contrasts for total viewing times by body region in Experiment 1. All  $t$ s are absolute values.  $df = 106$  for all tests. Classifications for the evidence in favor of the alternative hypothesis  $H_1$  based on the Bayes Factor  $BF_{01}$ : --- = strong evidence against  $H_1$ ; -- = moderate evidence against  $H_1$ ; - = weak evidence against  $H_1$ ; o = inconclusive evidence; + = weak evidence in favor of  $H_1$ ; ++ = moderate evidence in favor of  $H_1$ ; ++++ = extreme evidence in favor of  $H_1$ .

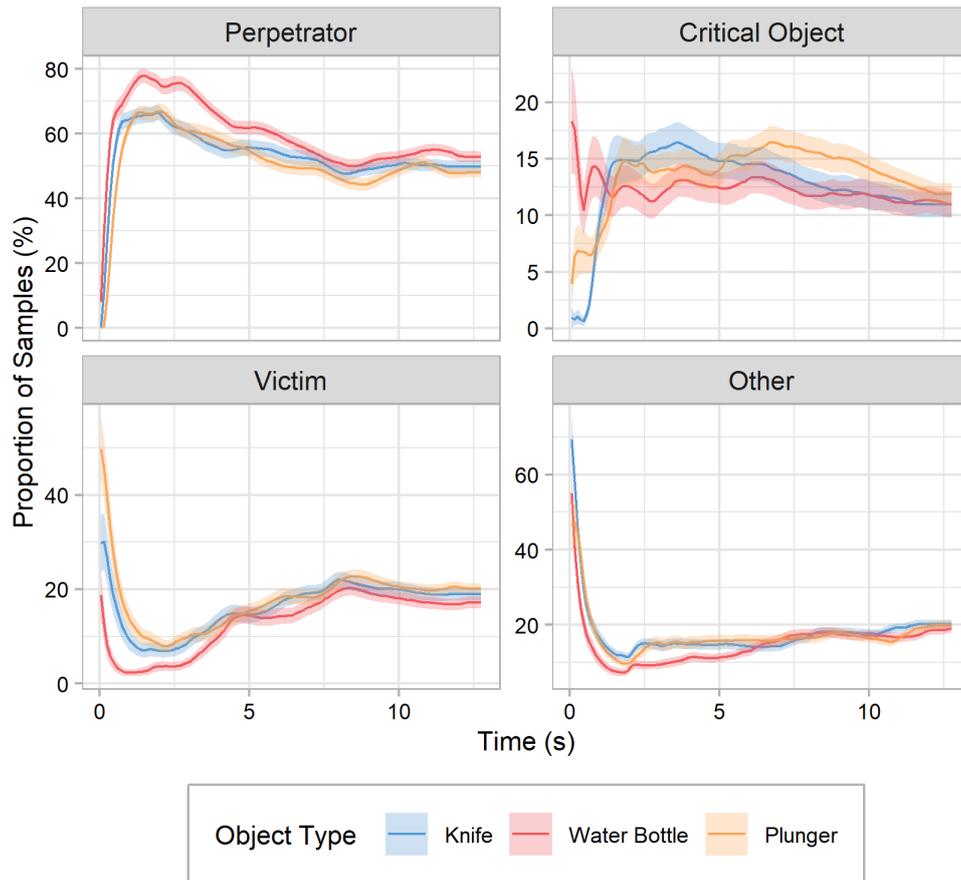
$\{t|0 < t \leq k\Delta t\}$  accumulates the time up to the  $k$ th bin. The discrete cumulative time course  $DCTC_r$  for a given ROI  $r$  within the time interval  $(k-1, k]\Delta t$  then is

$$DCTC_r(k) = \frac{\sum_{t \in T_k} S_{t,r}}{\sum_{t \in T_k} S_t},$$

where  $S_t$  are gaze samples at time  $t$ , and  $S_{t,r}$  are gaze samples that fell within the ROI  $r$  at time  $t$ . Finally, the cumulative time course  $CTC_r$  for a given ROI  $r$  is

$$CTC_r(t) = DCTC_r\left(\left\lceil \frac{t}{\Delta t} \right\rceil\right) 100.$$

Thus, each value along the  $x$ -axis marks the TVT for a given object condition and ROI up to that point in time. For example, the values at the 5-s mark show the TVT as reported above when only eye movements within the first 5 s after the perpetrator entered are considered. The values at the right end of Figure 3.5 show the TVT for the entire duration that the perpetrator was visible and are therefore identical to the TVTs displayed in Figure 3.3. Because each value



**Figure 3.5** Cumulative time-course analysis for the gaze data in Experiment 1. The mean cumulative proportions of samples that landed within the different regions of interest (see panel titles) are shown as a function of time and object type. Individual gaze samples are grouped into 100-ms time bins. For each experimental condition, values at a given point in time add up to 100% across regions of interest. Note that the scales of the y-axes differ for the various regions of interest. Error ribbons are  $\pm 1 SE$ .

of the cumulative time course corresponds to the TVT up to that point in time, this analysis offers insights into the effects that may have been observed for shorter exposure durations.

At the beginning of the scene, participants generally shifted their gaze toward the perpetrator. This is likely due to the fact that the victim and the rest of the scene were already present beforehand, whereas the perpetrator and the critical object she held were new and moving elements. Although this shift toward the perpetrator could be observed across all experimental conditions, it was less pronounced for the knife and plunger conditions compared with the water-bottle condition. For the knife and plunger conditions, most gaze samples were also allocated to the perpetrator as she entered, but a higher proportion of gaze samples remained on the victim and on regions outside of the defined ROIs compared with the water-bottle condition. The knife and the plunger themselves did not attract more gaze during this initial period

than the water bottle. In fact, when considering only the very first second after the perpetrator had entered, both the knife and the plunger were looked at less than the water bottle.

In general, the differences between the experimental conditions diminished over time. Thus, object type affected attention allocation primarily at the beginning of the critical sequence, but these initial effects did not persist throughout the remainder of the sequence. As described above, when considering the total time during which the perpetrator was visible, the only significant effect remaining was a reduction in TVT on the perpetrator for the plunger condition compared with the water-bottle condition.

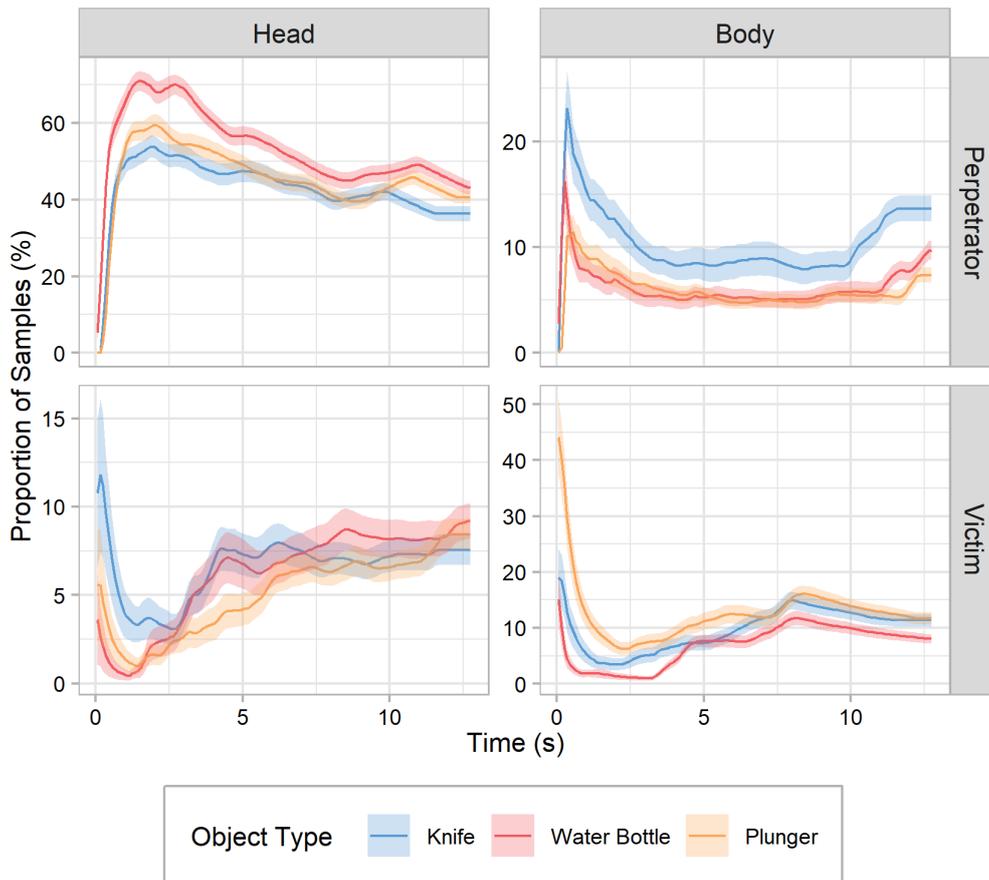
#### **3.4.2.4 Cumulative Time Course (Heads versus Bodies)**

As with the TVT, we also examined the cumulative time course separately for the head and body ROIs of the perpetrator and the victim, respectively (see Figure 3.6). For the perpetrator, the initial difference between the water-bottle condition on the one hand and the knife and plunger conditions on the other hand stems from a difference in viewing time on the perpetrator's head rather than her body. Viewing time on the perpetrator's body was elevated in the knife condition, and this difference to the other two object conditions remained nearly constant throughout the duration of the scene. For the victim, participants initially spent less time looking at both the victim's head and his body in the water-bottle condition compared with both the knife and the plunger condition. While the decrease in viewing time on the victim's head in the water-bottle condition was quickly compensated for, the difference in viewing time on the victim's body persisted throughout the duration of the entire scene.

#### **3.4.2.5 Non-Cumulative Time Course**

Finally, to more closely investigate the attentional allocation during the initial sequence of the scene, we also examined the non-cumulative time course for the first 6 s after the perpetrator entered for the ROIs of the perpetrator and the critical object (see Figure 3.7). Here, individual gaze samples were again grouped into 100-ms time bins, but, in contrast to the cumulative analysis, each bin contains the data for that 100-ms interval only and not for all data up to that point in time.

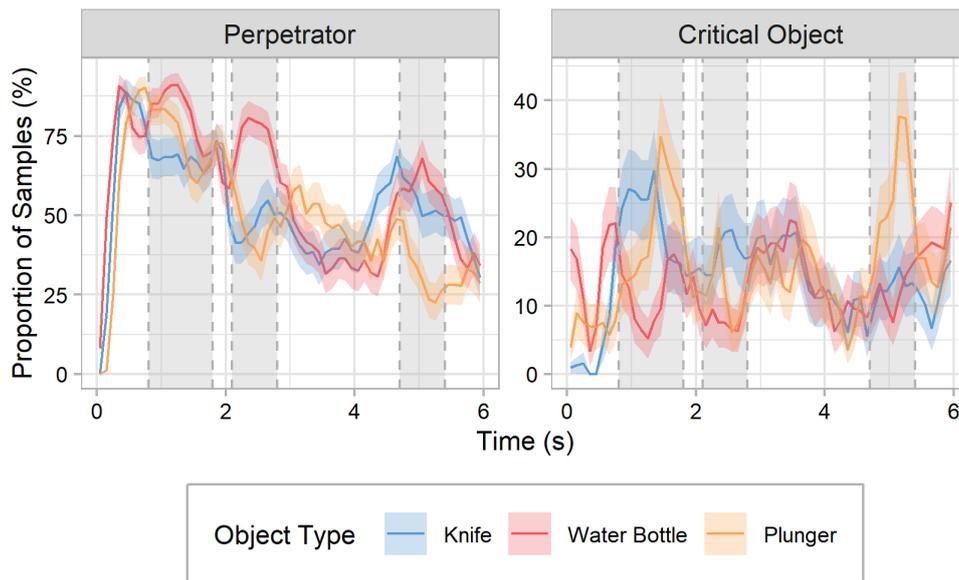
The non-cumulative analysis reveals that, while the knife and the plunger were looked at later than the water bottle, there were also time periods during which the knife and the plunger were focused on more than the water bottle (see the highlighted periods in Figure 3.7). Specifically, there were peaks around the 1.5- and 2.5-s marks where both the knife and the plunger received roughly twice as much viewing time as the water bottle. Interestingly, these spikes in viewing time on the knife and the plunger each coincided with a decrease in time spent looking



**Figure 3.6** Cumulative time-course analysis by body region for the gaze data in Experiment 1. The mean cumulative proportions of samples that landed within the regions of interest for the head and the body (columns) of the perpetrator and the victim (rows) are shown as a function of time and object type. Individual gaze samples are grouped into 100-ms time bins. For each experimental condition, values at a given point in time add up to 100% across regions of interest (including the ones not presented in this figure). Note that the scales of the y-axes differ for the various regions of interest. Error ribbons are  $\pm 1 SE$ .

at the perpetrator. For the plunger, there was an additional third spike, which again paralleled a dip in viewing time for the perpetrator. These time periods each reflect moments in the videos in which the perpetrator is actively addressing the victim, urging him to hand over the money (see Figure 3.1).

Thus, the non-cumulative analysis demonstrates that there were short periods of time near the beginning of the scene for which the predicted attentional shift away from the perpetrator and toward the knife and plunger, respectively, could be observed. Our data suggest that the predicted attentional shift is more prominent in time periods which are (a) near the beginning of the scene and during which (b) the perpetrator assumes a more active role. However, as the cumulative analysis has shown, even in this initial sequence the knife and the plunger were overall not looked at for substantially longer than the water bottle. Instead, the spikes observed

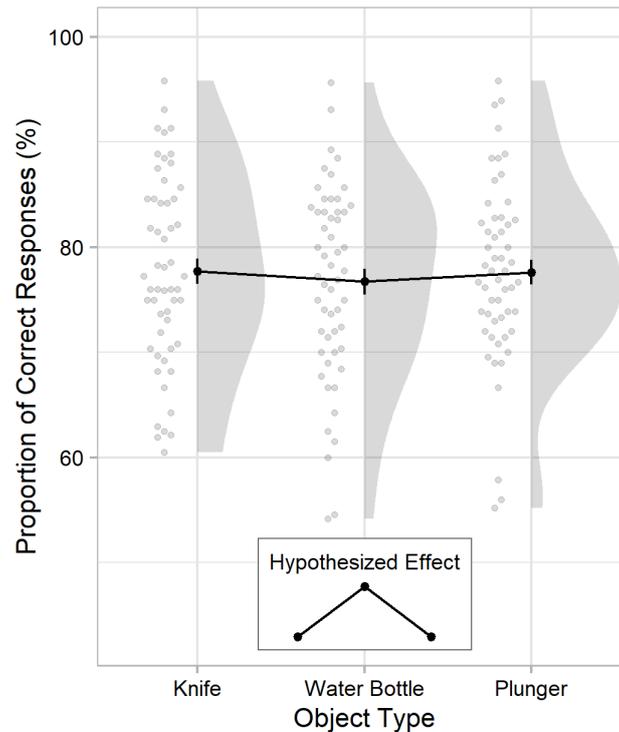


**Figure 3.7** Non-cumulative time-course analysis for the gaze data in Experiment 1. The proportions of samples that landed within the regions of interest for the perpetrator and the critical object are shown as a function of time and object type. During the time periods highlighted by a gray background, either both the knife and the plunger (the first two intervals) or only the plunger (the third interval) received longer viewing times than the water bottle. These shifts toward the critical object each coincided with reduced viewing times on the perpetrator. Data are shown only for the first 6 s after the perpetrator entered. Individual gaze samples are grouped into 100-ms time bins. For each experimental condition, values at a given point in time add up to 100% across regions of interest (including the ones not presented in this figure). Note that the scales of the y-axes differ for the two regions of interest. Error ribbons are  $\pm 1 SE$ .

in the non-cumulative analysis only compensated for previous instances where the water bottle received a larger proportion of gaze samples compared with the knife and the plunger.

### 3.4.2.6 Memory Accuracy

Figure 3.8 and Table 3.4 show the effects of object type on memory accuracy. Memory performance was highly similar in all three experimental conditions. Contrary to expectations derived from previous WFE results, memory accuracy was not reduced by the presence of a knife ( $M = 77.71\%$ ,  $SD = 8.97$ ) compared to the water bottle ( $M = 76.71\%$ ,  $SD = 9.17$ ). Similarly, there was no decrease in memory performance in the plunger condition ( $M = 77.60\%$ ,  $SD = 8.57$ ) compared to the water-bottle condition. Thus, there was no classic WFE, and, contrary to predictions by the unusual-item hypothesis, the unusual object also did not impair memory for the perpetrator's appearance. There was no significant difference in memory performance between the knife and the plunger condition either.



**Figure 3.8** Memory accuracy in Experiment 1. Proportions of correct responses are shown as a function of object type. The black dots represent the means. Each of the smaller, gray dots represents data from an individual participant. The larger gray areas show the distribution of the data. The inset presents the expected pattern of results. Note that the connecting lines between the discrete levels of object type are included only to facilitate comparisons between experimental conditions. Error bars are  $\pm 1 SE$ .

### 3.4.3 Discussion

Weapons and non-threatening unusual objects have long been theorized to have similar effects on attention and memory (E. F. Loftus et al., 1987). Previous research on the WFE in general and on the unusual-item hypothesis in particular has focused heavily on investigating memory effects, whereas attentional aspects have not been studied as extensively. Here, for the first

Comparison	Tails	$t$	$p$	$d$	$BF_{01}$	Evidence for $H_1$
Knife vs. Water Bottle	One	0.57	.716	0.11	7.19	--
Plunger vs. Water Bottle	One	0.52	.698	0.10	6.97	--
Knife vs. Plunger	Two	0.06	.949	0.01	4.90	--

**Table 3.4** Results of the planned contrasts for the memory accuracy in Experiment 1. All  $t$ s are absolute values.  $df = 106$  for all tests. Classifications for the evidence in favor of the alternative hypothesis  $H_1$  based on the Bayes Factor  $BF_{01}$ : -- = moderate evidence against  $H_1$ .

time, we compared the attentional effects of a weapon and a non-threatening unusual object to those of a neutral control object using eye tracking and dynamic stimuli.

Weapon presence did not reduce viewing time on the perpetrator, and participants spent no more time looking at the weapon than at the neutral object. These findings are at odds with the attention-shift explanation inherent to current theories of the WFE. The results are, however, consistent with our previous findings regarding the attentional effects of weapon presence in dynamic scenes (Körner et al., 2023).

Similarly, the unusual object did not attract significantly more gaze than the other two objects. However, the perpetrator was looked at for a shorter duration when she carried an unusual object than when she held a neutral object. This reduction in viewing time on the perpetrator is partially consistent with the unusual-item hypothesis, although this hypothesis would predict a similar effect for the weapon, which was also unusual in the given (spatial) context. Viewing times on the victim and on regions outside of the predefined ROIs were not significantly affected by object type.

Thus, overall, attention allocation was similar across the various object conditions. However, a closer inspection revealed that object type did affect attention allocation on a more fine-grained level. For one, there was an interesting dissociation between viewing times on the perpetrator's face and her body. Specifically, in the presence of a weapon, attention shifted from the perpetrator's face towards her body. Thus, while weapon presence had no effect on *how long* observers looked at the perpetrator, it did affect *how* they looked at her.

Secondly, the effects of object type varied over time. Within the first few seconds after the perpetrator had entered, viewing time on the perpetrator was reduced for both the weapon condition and the unusual-object condition compared with the neutral-object condition. This initial reduction in viewing time on the perpetrator was driven exclusively by a decrease in viewing time on her face, with viewing time on the perpetrator's body not being reduced for either the weapon condition or the unusual-object condition. In fact, viewing time on the perpetrator's body was elevated rather than decreased throughout the duration of the scene for the weapon condition, but not the unusual-object condition.

Finding a decrease in attention paid to the perpetrator for both a weapon and a non-threatening unusual object is in line with predictions by the unusual-item hypothesis. Contrary to these predictions, however, the weapon and the unusual object themselves were not looked at for longer than the neutral object during this initial time period either. Instead, viewing times were increased for the victim and for other aspects of the scene besides the critical object and the depicted people. This shift toward the victim could indicate that observers wanted to assess

how the victim would react to these unusual objects. As the videos progressed, these initial differences in attentional allocation did not persist, resulting in such effects being largely negligible in the overall viewing times (at least for the coarser ROIs covering the individuals as a whole).

The observed reduction in viewing time on the face of the person holding the weapon is also consistent with results by Biggs et al. (2013). In contrast, Körner et al. (2023) found no effect of weapon presence on viewing time on the perpetrator's face. One possible explanation for this apparent inconsistency is a difference in exposure duration. In Körner et al. (2023), the perpetrator and the critical object were in view for a total of 32 s, whereas Biggs et al. (2013) presented isolated images for 5 s each, and the exposure duration in the current study was 12 s. A strong influence of exposure duration is further supported by the results of the time-course analyses. The differences in viewing time on the perpetrator's face between the object conditions were most prominent during the first few seconds of the scene, with viewing times converging over time. In line with predictions by current theories, these initial attentional shifts away from the perpetrator were accompanied by a temporary focus on the weapon and the unusual object, respectively, although there were other time periods during which the neutral object received the most attention.

These results suggest that an initial decrease in attention paid to the perpetrator's face may be reflected in overall viewing times for short exposure durations only. The idea that an attentional shift away from the perpetrator's face is more prominent for shorter exposure durations is also consistent with memory results by Erickson et al. (2022), who found that weapon presence impaired participants' ability to construct recognizable facial composites for an encoding duration of 10 s, but not for 30 s. Our results suggest that the differences in viewing time on the body of the perpetrator are less time-course dependent. The increase in viewing time on the perpetrator's body due to the presence of a weapon remained approximately constant throughout the duration of the scene, indicating that this attentional shift may be a more stable and long-lasting phenomenon.

There were no effects of object type on memory performance: Participants recalled the appearance of the perpetrator as accurately when she was holding a weapon or an unusual object as when she was holding a non-threatening context-congruent object. This absence of a memory impairment is at odds with much of the previous research on the WFE (see Fawcett et al., 2013; Kocab & Sporer, 2016). Not finding a WFE is, however, consistent with the results of our previous study (Körner et al., 2023). Several other recent studies similarly failed to replicate

the WFE, at least under certain conditions, and even found reversed effects, with weapon presence enhancing memory performance rather than impairing it (Harvey et al., 2020; Harvey & Sekulla, 2021; Mansour et al., 2019; Nyman et al., 2020).

### **3.5 Experiment 2**

To further investigate the inconsistencies between our memory results and previous research, Experiment 2 focused on the memory effects of weapons and unusual objects compared to a neutral object. We presented the same stimuli as in Experiment 1, but online and without eye tracking. We also investigated whether and how presenting stimuli with a soundtrack compared to no soundtrack modulates the memory-related WFE.

In the eye-tracking experiments of our previous study (Körner et al., 2023), we chose not to present the English soundtrack to our German participants. We argued that omitting the soundtrack should not matter since the WFE had previously been found both for presentations with sound (e.g., Carlson et al., 2017; Cutler et al., 1987; Pickel & Sneyd, 2018) and for presentations without sound (e.g., Carlson et al., 2016; Mitchell et al., 1998; Pickel, 1998, 1999). In an additional online experiment, where the soundtrack was included, we successfully replicated the memory results of the eye-tracking experiments (Körner et al., 2023).

Although consistent results indicate similar effects for presentations with and without sound, a systematic investigation of the impact of including versus omitting the soundtrack is still pending. While some studies have compared stimuli with and without soundtrack either between experiments (Kramer et al., 1990) or between subject groups (Beehr et al., 2004), these manipulations of sound were confounded with differences in other potentially relevant aspects of the stimuli, such as the presence versus absence of an assault or a shooting.

Based on current theories of the WFE, one could argue that the presentation of sound may modulate the effect. For one, omitting the soundtrack could enhance the WFE by increasing the ambiguity of the depicted situation. To increase ambiguity in this way, Pickel (1998) presented her stimuli without sound and deliberately avoided incorporating details into the material that would have conclusively established the depicted action as a robbery (e.g., the victim did not raise her hands in the air or react with fear). Our own videos similarly included no visual details that clearly identified the situation as a robbery. However, the words spoken by the perpetrator indicated that she was robbing the victim. If omitting the soundtrack leads observers to interpret the situation as a robbery in the weapon condition only, this would involve comparing an armed robbery on the one hand to interactions which are not interpreted as a

crime and which do not involve a weapon on the other hand. Such a difference in interpretation could increase the classic WFE, although the potential effects are less clear for the non-threatening unusual object.

Conversely, one could reasonably contend that the WFE should be weaker, rather than stronger, when stimuli are presented without sound. For example, including the soundtrack could enhance participants' immersion in the depicted situation, thereby increasing the impact of the weapon (cf. Beehr et al., 2004; Kramer et al., 1990). Finally, it is also possible that including a soundtrack does not, in fact, modulate the WFE.

### **3.5.1 Methods**

#### **3.5.1.1 Design, Participants, Stimuli, and Questionnaire**

The experiment had a 3 (object type: knife, water bottle, and plunger)  $\times$  2 (audio: with and without audio) between-subjects design. The sample consisted of  $N = 228$  participants (166 women, 61 men, and 1 non-binary person). Subjects' age ranged from 18 to 72 years of age ( $M = 27.2$  years,  $SD = 11.2$ ). The stimuli and questionnaire were the same as in Experiment 1.

#### **3.5.1.2 Procedure**

The procedure was identical to that of Experiment 1, with the exception that Experiment 2 was conducted online and without the use of eye tracking. Participants were informed beforehand whether the video would have sound or not. In the conditions with audio, subjects were instructed to enable the sound on their device. The video could not be paused or replayed.

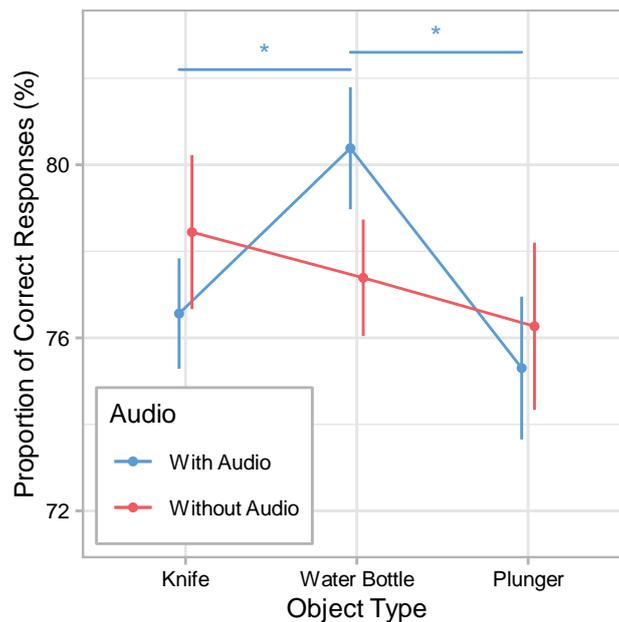
#### **3.5.1.3 Data Analysis**

As in Experiment 1, a subset of 90 participant responses were evaluated by a second rater. Inter-rater reliability was again high for both correct ( $r = .98$ ) and incorrect ( $r = .90$ ) details. Planned contrasts were used to compare the different object-type conditions within each audio condition.

### **3.5.2 Results**

#### **3.5.2.1 Memory Accuracy**

Figure 3.9 and Tables 3.5 and 3.6 show the effects of object type and audio on the proportion of correct responses. For the conditions with audio, memory performance was best in the water-bottle condition. Memory for the perpetrator's appearance was significantly worse when she



**Figure 3.9** Memory accuracy in Experiment 2. Mean proportions of correct responses are shown as a function of object type and audio condition. Error bars are  $\pm 1 SE$ .  $*p < .05$ .

carried a knife compared with a water bottle. Thus, there was a classic WFE. In line with predictions by the unusual-item hypothesis, memory accuracy was also significantly worse in the plunger condition than in the water-bottle condition. Memory performance did not differ significantly between the knife condition and the plunger condition. For the conditions without audio, memory performance was more similar for the various object types, with no significant differences between any of the object conditions. Thus, in contrast both to predictions by the unusual-item hypothesis and to the results in the conditions with sound, there was no memory impairment due to the presence of either a weapon or an unusual object when the stimuli were presented without sound.

### 3.5.2.2 Ratings

Since the memory effects differed depending on the audio condition, we examined participants' ratings of threat and unusualness (see Table 3.7). If the difference in memory effects between

Condition	With Audio		Without Audio	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Knife	76.56	7.87	78.44	10.97
Water Bottle	80.38	8.69	77.39	8.30
Plunger	75.30	10.17	76.27	11.91

**Table 3.5** Memory accuracy (%) in Experiment 2.  $N = 228$  ( $n = 38$  for each condition).

Audio	Tails	$t$	$p$	$d$	$BF_{01}$	Evidence for $H_1$
With Audio						
Knife vs. Water Bottle	One	2.01	.024	0.46	0.39	+
Plunger vs. Water Bottle	One	2.34	.011	0.54	0.21	++
Knife vs. Plunger	Two	0.60	.548	0.14	3.60	--
Without Audio						
Knife vs. Water Bottle	One	0.47	.681	0.11	5.78	--
Plunger vs. Water Bottle	One	0.48	.318	0.11	2.85	-
Knife vs. Plunger	Two	0.83	.410	0.19	3.13	--

**Table 3.6** Results of the planned contrasts for the memory accuracy in Experiment 2. All  $t$ s are absolute values.  $df = 74$  for all tests. Classifications for the evidence in favor of the alternative hypothesis  $H_1$  based on the Bayes Factor  $BF_{01}$ : -- = moderate evidence against  $H_1$ ; - = weak evidence against  $H_1$ ; + = weak evidence in favor of  $H_1$ ; ++ = moderate evidence in favor of  $H_1$ .

the audio conditions is due to a difference in perceived threat or unusualness, this should be reflected in these ratings. However, the pattern of results for the rating variables was the same for both audio conditions.

As expected, the knife was rated to be more threatening than both the water bottle and the plunger (all  $ps < .001$ , one-tailed tests). Similarly, self-reported arousal was significantly higher in the knife condition than in the other two object conditions (all  $ps < .035$ , one-tailed tests). Nevertheless, self-reported arousal, which was rated on a scale from 0 to 5, was still quite low in the knife conditions both with audio ( $M = 1.74$ ,  $SD = 1.27$ ) and without audio ( $M = 1.42$ ,  $SD = 1.20$ ). Ratings for threat and self-reported arousal did not differ significantly between the plunger and the water-bottle conditions (all  $ps > .11$ , two-tailed tests).

In line with our expectations, the general unusualness of the water bottle was rated lower compared with both the knife and the plunger (all  $ps < .007$ , one-tailed tests). The plunger was rated to be more unusual in general than the knife (all  $ps < .010$ , two-tailed tests). For the situational unusualness (i.e., the unusualness in the context of the video), a different pattern emerged. Here, the knife was judged to be the least unusual in the given situation (all  $ps < .001$ , two-tailed tests). The plunger was deemed more situationally unusual than the water bottle (all  $ps < .019$ , two-tailed tests).

Measure	With Audio			Without Audio		
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
Threat						
Knife	38	7.47	2.52	37	7.05	2.32
Water Bottle	35	1.14	1.88	33	1.76	2.54
Plunger	36	0.97	1.70	36	1.39	1.92
Self-reported arousal						
Knife	38	1.74	1.27	38	1.42	1.20
Water Bottle	38	1.13	0.99	38	0.74	0.69
Plunger	38	0.95	1.16	38	1.00	0.74
General unusualness						
Knife	37	4.05	3.39	36	3.67	2.80
Water Bottle	35	1.97	3.56	32	1.25	2.45
Plunger	37	6.22	3.60	36	6.03	3.33
Situational unusualness						
Knife	38	3.82	3.33	35	3.94	3.28
Water Bottle	35	8.71	2.61	32	8.78	1.90
Plunger	35	9.80	0.53	36	9.69	0.67

**Table 3.7** Ratings of threat and unusualness in Experiment 2. Threat as well as general and situational unusualness were rated on a scale from 0 to 10. Self-reported arousal was rated on a scale from 0 to 5.

### 3.5.3 Discussion

In this online experiment, we investigated the memory effects of a weapon and a non-threatening unusual object compared to a neutral control object using the same stimuli as in Experiment 1. Moreover, we examined the effects of presenting stimuli either with or without sound. The effects of object type differed depending on whether the stimuli were presented with or without sound. When the videos included a soundtrack, memory was poorer in the presence of either a weapon or an unusual object compared with the neutral object. Thus, the results for the conditions with sound matched predictions by the unusual-item hypothesis as an explanation for the WFE. In contrast, object type had no significant effects on memory when the videos were presented without sound.

The fact that we found a WFE with sound, but no effects without sound is surprising. Previous research has shown that the WFE can occur both when stimuli are presented with sound (e.g., Carlson et al., 2017; Cutler et al., 1987) and when they are presented without sound (e.g.,

Carlson et al., 2016; Pickel, 1998). In our previous study (Körner et al., 2023), we found no memory-related WFE, and this result was consistent across experiments with and without sound. Importantly, the eye-tracking results of the current Experiment 1 are consistent with the findings of our previous study, demonstrating that these previous eye-tracking results are not limited to presentations without sound. Finally, finding a WFE in the conditions with sound of Experiment 2 is at odds with the memory results of Experiment 1. In Experiment 1, the same videos were also presented with sound, but no memory effects were observed for either the weapon or the unusual object.

It is unclear why the presence of sound seems to have modulated the WFE in our Experiment 2. Self-reported arousal was low in all conditions, although slightly higher in the presence of a weapon than for the other two objects, regardless of sound condition. This generally low level of self-reported arousal contradicts the assumption that including the soundtrack meaningfully increased participants' emotional involvement in the videos. Moreover, the unusual object also impaired memory relative to the neutral-object condition, even though self-reported arousal was similar in both conditions.

Differing interpretations of the scene depending on the sound condition are also unlikely to explain our findings. Firstly, if participants in the non-weapon conditions interpreted the scene as a crime only when the videos were presented with sound, the WFE would be expected to be *weaker* in the conditions with sound, not stronger (see the reasoning above). Secondly, situational-unusualness ratings, which should depend on the interpretation of the scene, were highly consistent between the conditions with and without sound. However, it should be noted that the questionnaire about the woman's appearance, which subjects completed prior to the ratings, unambiguously referred to the situation as a robbery and the woman as the perpetrator, which may have retroactively influenced participants' interpretation of the scene.

### **3.6 General Discussion**

Previous research has found that weapons and non-threatening unusual objects can impair memory to a similar extent (e.g., Mitchell et al., 1998; Pickel, 1998). The unusual-item hypothesis attributes this memory effect to an attentional shift from the perpetrator toward the objects themselves. The primary aim of the current study was to directly test this assumption by comparing the attentional effects of weapons and non-threatening unusual objects under naturalistic viewing conditions. In our main Experiment 1, we tracked participants' eye movements while

they watched a video of a staged robbery. Depending on the experimental condition, the perpetrator held either a weapon, an unusual object, or a neutral control object. Our results show that the allocation of attention between the weapon and the unusual object was more similar than between either object and the neutral object. However, the attentional effects of a weapon also differed substantially from those of a non-threatening unusual object in some respects.

The similarities between the weapon and the non-threatening unusual object were most prominent during the first few seconds of the scene. Results from the cumulative time-course analyses in Experiment 1 show that the perpetrator initially drew most attention when she held a neutral object, and viewing times on the actual weapon and the unusual object were initially lower than for the neutral object. For both the weapon and the unusual object, attention seemed to linger longer on the victim and on other aspects of the scene. In particular, viewing times on the victim's body were increased compared with the neutral-object condition. This shift toward the victim's body remained present throughout the duration of the entire scene, whereas many of the other initial differences did not persist even for the comparatively short exposure duration of 12 s used in the current study (see the discussion of Experiment 1 for details).

In contrast, the weapon and the non-threatening unusual object had different effects on overall viewing times on the perpetrator. In the weapon condition, the initially reduced viewing time on the perpetrator relative to the neutral-object condition was only temporary, whereas this reduction persisted until the end of the scene in the unusual-object condition. Moreover, observers focused on different aspects of the perpetrator depending on the type of unusual object. For the non-threatening unusual object, the reduced viewing time on the perpetrator relative to the neutral-object condition was primarily due to a reduced viewing time on her body. In contrast, the presence of a weapon led to an increase, rather than a reduction, in viewing time on the perpetrator's body, but here observers paid less attention to her face.

The observed similarities between the weapon and the non-threatening unusual object support the idea that unusualness is a key feature influencing the effects weapons have on attention, whereas the clear differences in results indicate that other factors besides unusualness are also at play. The most natural explanation seems to be that the threat posed by weapons likewise affects observers' allocation of attention (cf. Easterbrook, 1959; E. F. Loftus et al., 1987). However, it is important to consider that, despite the differences highlighted above, the overall distribution of viewing times was very similar across all three object conditions. This similarity suggests that attentional allocation was primarily driven by the interaction of the depicted people rather than by the specific object held by the perpetrator.

Results from the current study are consistent with our previous findings (Körner et al., 2023) on the attentional effects of weapons under naturalistic viewing conditions. Most notably, all critical objects on average received only 11%–12% of the overall viewing time. These comparatively short viewing times are inconsistent with the notion of an extensive attentional focus on weapons or unusual objects. In contrast, participants in all object conditions dedicated about half of their viewing time to the perpetrator. The fact that, in the presence of a weapon, observers shifted their attention toward the bodies of the depicted people can be interpreted as a heightened focus on the interaction of the people, which would also be consistent with the time-course results reported by Körner et al. (2023). Interestingly, the shift toward the body of the perpetrator was not observed in the unusual-object condition, which suggests that the threat posed by the weapon, rather than its unusualness, is responsible for this effect. An explanation for the focus on the perpetrator's body could be that observers were looking for signs that the perpetrator was about to use the knife, such as a movement of the arm.

Our eye-tracking results contrast some findings from the broader literature on context-incongruent objects (e.g., Henderson et al., 1999; G. R. Loftus & Mackworth, 1978). Specifically, neither the non-threatening unusual object nor the weapon, which was also incongruent to the given context, attracted more attention than a context-congruent control. This effect was also absent at the beginning of the scene. The context-incongruent objects were not looked at earlier than the congruent object either. If anything, there was an inverse effect, with the congruent object being looked at earlier than the incongruent objects (see Figures 3.5 and 3.7).

This apparent inconsistency with previous findings is probably due to a number of methodological differences. Firstly, we used video stimuli, and the critical objects themselves as well as the depicted people and the objects they touched were moving. Secondly, the fact that our stimuli included people deviates from the common practice of using images without individuals in studies on object–scene (in)congruencies. Finally, in contrast to studies using static images, our stimulus material did not feature a defined scene onset. Instead, eye movements were analyzed for the duration for which the perpetrator and the critical object were visible. At the time the perpetrator entered the room, the observer had already processed the victim and the rest of the scene. Clearly, future research is needed to determine how these methodological aspects influence the attentional effects of context-incongruent objects.

A second aim of the current study was to compare the *memory* effects of weapons and non-threatening unusual objects. The unusual-item hypothesis proposes that, as a consequence of an assumed attentional shift from the perpetrator toward unusual objects, encoding is impaired for details of the perpetrator's appearance. We found mixed results in regard to this memory-

related WFE. In Experiment 1, the different critical objects did not affect memory performance. This seems generally consistent with our eye-tracking results, where we found similar viewing times for the perpetrator across all object conditions. Although the presence of a non-threatening unusual object was associated with a reduced overall viewing time on the perpetrator, this did not translate into a memory impairment. In Experiment 2, however, we did observe a memory impairment for both the weapon and the unusual-object condition relative to the neutral-object condition when the videos were presented with sound, but found no effects of object type when the videos were presented without sound. Since we used the same videos in both experiments and included the soundtrack in Experiment 1, the memory findings of our two experiments are contradictory.

The only difference in experimental design between Experiment 1 and the conditions with sound in Experiment 2 was that Experiment 2 was an online study, whereas Experiment 1 included eye tracking and was conducted in the laboratory. The WFE has been investigated in various experimental settings, including online studies (e.g., Carlson et al., 2017; Erickson et al., 2014), group sessions (e.g., Kramer et al., 1990; Pickel, 2009), individual laboratory sessions (e.g., Harvey & Sekulla, 2021; Mansour et al., 2019), and live-simulation studies (e.g., Maass & Köhnken, 1989). How these different settings may affect the WFE has not been studied extensively, although Pickel and Sneyd (2018) found no significant differences between data obtained online versus in group laboratory sessions.

Another potentially relevant difference between our Experiments 1 and 2 is the sample composition. Within online studies, it is easier to recruit a more diverse sample, whereas laboratory research often relies more heavily on student participants. This difference is reflected in the sample compositions of the laboratory Experiment 1 and the online Experiment 2. For example, the average age was higher and the age range wider in Experiment 2 than in Experiment 1. Future research is needed to assess whether and to what extent the experimental setting as well as different sample characteristics modulate the WFE.

Alternatively, it may also be the case that the inconsistency in results is simply due to chance. Considering the data from all conditions in both experiments, it seems more likely that, in the conditions with sound of Experiment 2, memory was incidentally elevated in the neutral-object condition, rather than being impaired in the presence of the weapon or the unusual object. Average memory accuracy was above 80% in this specific condition, whereas it ranged from 75% to 78% in all other conditions. The idea that the slightly higher memory performance in this condition may be a statistical fluke is supported to some extent by the fact that, for the comparison between the weapon and the neutral object, the corresponding Bayes factor was

below the conventional threshold for the evidence to be considered more than anecdotal. For the unusual object, however, the Bayes factor indicated moderate evidence in favor of a true difference from the neutral object. Still, compared with this evidence in favor of a memory-related WFE obtained in the conditions with sound of Experiment 2, the results of Experiment 1 provided stronger evidence *against* a memory impairment caused by either a weapon or an unusual object.

It should be noted that because we failed to find a memory-related WFE in Experiment 1, it is unclear to what extent the eye-tracking results from this experiment generalize to a sample that does show the classic WFE. However, there is reason to think that the inconsistency between our data and previous studies providing evidence in favor of the attention-shift hypothesis is more likely to be due to the type of stimulus material used than to sample characteristics. When using slide shows in our previous study (Körner et al., 2023), we were able to replicate the eye-tracking results of the classic study by E. F. Loftus et al. (1987), even though we did not find a memory effect in that experiment either. Moreover, viewing behavior for dynamic scenes has been shown to be strongly influenced by bottom-up factors such as motion (e.g., Hutson et al., 2022; Itti, 2005; Loschky et al., 2015), which implies that viewing behavior is similar across observers. Thus, samples that do show a memory-related WFE may still fail to exhibit an attentional shift from the perpetrator to the weapon for dynamic scenes. Note, however, that we found significant differences in gaze behavior between our experimental conditions, suggesting that the tyranny of film was incomplete for our more naturalistic dynamic scenes (cf. Dorr et al., 2010; Levin et al., 2021). In any case, until evidence for the attentional shift predicted by current theories is provided for more naturalistic viewing conditions, the attention-shift explanation for the WFE should be considered tentative.

In the current study, we used stimulus material deliberately created to elicit a maximum memory effect based on known moderator variables of the WFE. For example, a knife was used as the weapon, the perpetrator was portrayed by a woman, and exposure duration and retention interval were within the ranges found to produce the strongest effects (see Fawcett et al., 2013; Kocab & Sporer, 2016). Therefore, the fact that we failed to find a memory effect both in Experiment 1 and in the no-sound conditions of Experiment 2 is striking. Even the memory effect we did observe in the conditions with sound of Experiment 2 was substantially smaller than what would be expected under these rather extreme circumstances.

In our previous study (Körner et al., 2023), we discussed cultural differences as a possible reason for not finding a memory-related WFE. Specifically, we argued that a difference in “gun culture” between the U.S. and Europe could be responsible for the fact that we failed to find a

WFE despite using material for which large memory effects had been demonstrated in a U.S. study (Pickel & Sneyd, 2018). However, cultural differences are unlikely to justify the absence of a WFE in Experiment 1 and the no-sound conditions of Experiment 2. Firstly, a knife was used as the weapon, for which cultural differences between the U.S. and Europe are presumably less pronounced than for firearms. Secondly, one would not necessarily expect the effects of non-threatening unusual objects to be modulated by cultural differences, provided the objects in question are in fact unusual in the given culture. In light of the present results, it is therefore unlikely that our repeated failures to replicate the memory-related WFE are due to cultural specificities.

### **3.6.1 Conclusion**

Our results show that gaze behavior was similar for a weapon and a non-threatening unusual object, supporting the idea that the unusualness of weapons in many contexts is a key factor influencing their effects on the allocation of attention. However, there were also differences between the effects of the weapon and the unusual object, which indicates that other features of weapons, such as their threatening nature, are also important. Contrary to predictions by current theories, neither the weapon nor the non-threatening unusual object drew attention away from the perpetrator for an extended period of time. While both objects reduced the time spent looking at the perpetrator's face initially, these effects were short-lived and had little impact on the overall viewing times. The present results corroborate our previous findings (Körner et al., 2023) suggesting that the attentional effects of weapons are more complex than the previously assumed shift away from the perpetrator toward the weapon. One interesting finding was that, in the presence of a weapon, observers shifted their attention from the perpetrator's face to the body, possibly to assess whether the perpetrator was about to use the weapon.

### 3.7 References

- Ahlmann-Eltze, C., & Patil, I. (2021). ggsignif: R package for displaying significance brackets for 'ggplot2'. *PsyArxiv*. Advance online publication. <https://doi.org/10.31234/osf.io/7awm6>
- Aphalo, P. J. (2024). *ggpp: Grammar extensions to 'ggplot2'* (Version 0.5.8-1) [Computer software]. <https://CRAN.R-project.org/package=ggpp>
- Beehr, T. A., Ivanitskaya, L., Glaser, K., Erofeev, D., & Canali, K. (2004). Working in a violent environment: The accuracy of police officers' reports about shooting incidents. *Journal of Occupational and Organizational Psychology*, *77*(2), 217–235. <https://doi.org/10.1348/096317904774202153>
- Beyer, L. (2018). *pydensecrf* (Version 1.0rc3) [Computer software]. <https://pypi.org/project/pydensecrf>
- Biggs, A. T., Brockmole, J. R., & Witt, J. K. (2013). Armed and attentive: Holding a weapon can bias attentional priorities in scene viewing. *Attention, Perception, & Psychophysics*, *75*(8), 1715–1724. <https://doi.org/10.3758/s13414-013-0538-6>
- Bradski, G. (2000). The OpenCV library. *Dr. Dobb's Journal of Software Tools*, *25*(11), 120–125
- Brainard, D. H. (1997). The Psychophysics Toolbox. *Spatial Vision*, *10*(4), 433–436. <https://doi.org/10.1163/156856897x00357>
- Carlson, C. A., Dias, J. L., Weatherford, D. R., & Carlson, M. A. (2017). An investigation of the weapon focus effect and the confidence–accuracy relationship for eyewitness identification. *Journal of Applied Research in Memory and Cognition*, *6*(1), 82–92. <https://doi.org/10.1016/j.jarmac.2016.04.001>
- Carlson, C. A., Pleasant, W. E., Weatherford, D. R., Carlson, M. A., & Bednarz, J. E. (2016). The weapon focus effect: Testing an extension of the unusualness hypothesis. *Applied Psychology in Criminal Justice*, *12*(2), 87–100.
- Caron, M., Touvron, H., Misra, I., Jegou, H., Mairal, J., Bojanowski, P., & Joulin, A. (2021). Emerging properties in self-supervised Vision Transformers. *IEEE/CVF International Conference on Computer Vision (ICCV)*, 9650–9660. <https://doi.org/10.1109/iccv48922.2021.00951>
- Clark, J. A. (2023). *pillow* (Version 9.5.0) [Computer software]. <https://pypi.org/project/Pillow>

- Coco, M. I., Nuthmann, A., & Dimigen, O. (2020). Fixation-related brain potentials during semantic integration of object-scene information. *Journal of Cognitive Neuroscience*, *32*(4), 571–589. [https://doi.org/10.1162/jocn\\_a\\_01504](https://doi.org/10.1162/jocn_a_01504)
- Cornelissen, F. W., Peters, E. M., & Palmer, J. (2002). The EyeLink Toolbox: Eye tracking with MATLAB and the Psychophysics Toolbox. *Behavior Research Methods, Instruments, & Computers*, *34*(4), 613–617. <https://doi.org/10.3758/bf03195489>
- Cutler, B. L., Penrod, S. D., & Martens, T. K. (1987). The reliability of eyewitness identification: The role of system and estimator variables. *Law and Human Behavior*, *11*(3), 233–258. <https://doi.org/10.1007/BF01044644>
- 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. <https://doi.org/10.1007/s10979-004-0565-x>
- Dorr, M., Martinetz, T., Gegenfurtner, K. R., & Barth, E. (2010). Variability of eye movements when viewing dynamic natural scenes. *Journal of Vision*, *10*(10), Article 28. <https://doi.org/10.1167/10.10.28>
- Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review*, *66*(3), 183–201. <https://doi.org/10.1037/h0047707>
- Erickson, W. B., Brown, C., Portch, E., Lampinen, J. M., Marsh, J. E., Fodarella, C., Petkovic, A., Coultas, C., Newby, A., Date, L., Hancock, P. J. B., & Frowd, C. D. (2022). The impact of weapons and unusual objects on the construction of facial composites. *Psychology, Crime & Law*. Advance online publication. <https://doi.org/10.1080/1068316X.2022.2079643>
- Erickson, W. B., Lampinen, J. M., & Leding, J. K. (2014). The weapon focus effect in target-present and target-absent line-ups: The roles of threat, novelty, and timing. *Applied Cognitive Psychology*, *28*(3), 349–359. <https://doi.org/10.1002/acp.3005>
- Fawcett, J. M., Russell, E. J., Peace, K. A., & Christie, J. (2013). Of guns and geese: A meta-analytic review of the ‘weapon focus’ literature. *Psychology, Crime & Law*, *19*(1), 35–66. <https://doi.org/10.1080/1068316X.2011.599325>
- Flowe, H. D., Hope, L., & Hillstrom, A. P. (2013). Oculomotor examination of the weapon focus effect: Does a gun automatically engage visual attention? *PloS ONE*, *8*(12), Article e81011. <https://doi.org/10.1371/journal.pone.0081011>
- Fu, Q. (2023). *pyhelpers* (Version 1.4.6) [Computer software]. <https://pypi.org/project/pyhelpers>

- Google. (2023). *tensorboard* (Version 2.11.2) [Computer software]. <https://pypi.org/project/tensorboard>
- Hamilton, M., Zhang, Z., Hariharan, B., Snavely, N., & Freeman, W. T. (2022). Unsupervised semantic segmentation by distilling feature correspondences. *International Conference on Learning Representations (ICLR)*, 1–26. <https://doi.org/10.48550/arXiv.2203.08414>
- Harris, C. R., Millman, K. J., van der Walt, S. J., Gommers, R., Virtanen, P., Cournapeau, D., Wieser, E., Taylor, J., Berg, S., Smith, N. J., Kern, R., Picus, M., Hoyer, S., van Kerkwijk, M. H., Brett, M., Haldane, A., Fernández del Río, J., Wiebe, M., Peterson, P., . . . Oliphant, T. E. (2020). Array programming with NumPy. *Nature*, *585*(7825), 357–362. <https://doi.org/10.1038/s41586-020-2649-2>
- Harvey, A. J., & Sekulla, A. (2021). Evidence of alcohol induced weapon focus in eyewitness memory. *Applied Cognitive Psychology*, *35*(5), 1263–1272. <https://doi.org/10.1002/acp.3858>
- Harvey, A. J., Shrimpton, B., Azzopardi, Z., O'Grady, K., Hicks, E., Hirst, E., & Atkinson-Cox, K. (2020). The influence of alcohol and weapon presence on eyewitness memory and confidence. *Applied Cognitive Psychology*, *34*(2), 489–503. <https://doi.org/10.1002/acp.3636>
- He, K., Zhang, X., Ren, S., & Sun, J. (2016). Deep residual learning for image recognition. *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 770–778. <https://doi.org/10.1109/cvpr.2016.90>
- Henderson, J. M., Weeks, P. A., & Hollingworth, A. (1999). The effects of semantic consistency on eye movements during complex scene viewing. *Journal of Experimental Psychology: Human Perception and Performance*, *25*(1), 210–228. <https://doi.org/10.1037/0096-1523.25.1.210>
- Hooge, I. T. C., Holleman, G. A., Haukes, N. C., & Hessels, R. S. (2019). Gaze tracking accuracy in humans: One eye is sometimes better than two. *Behavior Research Methods*, *51*(6), 2712–2721. <https://doi.org/10.3758/s13428-018-1135-3>
- Hope, L., & Wright, D. (2007). Beyond unusual? Examining the role of attention in the weapon focus effect. *Applied Cognitive Psychology*, *21*(7), 951–961. <https://doi.org/10.1002/acp.1307>
- Hugh-Jones, D. (2023). *huxtable: Easily create and style tables for LaTeX, HTML and other formats* (Version 5.5.6) [Computer software]. <https://CRAN.R-project.org/package=huxtable>

- Hunter, J. D. (2007). Matplotlib: A 2D graphics environment. *Computing in Science & Engineering*, 9(3), 90–95. <https://doi.org/10.1109/MCSE.2007.55>
- Hutson, J. P., Chandran, P., Magliano, J. P., Smith, T. J., & Loschky, L. C. (2022). Narrative comprehension guides eye movements in the absence of motion. *Cognitive Science*, 46(5), Article e13131. <https://doi.org/10.1111/cogs.13131>
- Hutson, J. P., Smith, T. J., Magliano, J. P., & Loschky, L. C. (2017). What is the role of the film viewer? The effects of narrative comprehension and viewing task on gaze control in film. *Cognitive Research: Principles and Implications*, 2(1), Article 46. <https://doi.org/10.1186/s41235-017-0080-5>
- Itti, L. (2005). Quantifying the contribution of low-level saliency to human eye movements in dynamic scenes. *Visual Cognition*, 12(6), 1093–1123. <https://doi.org/10.1080/13506280444000661>
- Jeffreys, H. (1935). Some tests of significance, treated by the theory of probability. *Mathematical Proceedings of the Cambridge Philosophical Society*, 31(2), 203–222. <https://doi.org/10.1017/s030500410001330x>
- Johnson, P. (2024). *devEMF: EMF graphics output device* (Version 4.4-2) [Computer software]. <https://CRAN.R-project.org/package=devEMF>
- Kassambara, A. (2023). *ggpubr: 'ggplot2' based publication ready plots* (Version 0.6.0) [Computer software]. <https://CRAN.R-project.org/package=ggpubr>
- Kay, M. (2024). ggdist: Visualizations of distributions and uncertainty in the grammar of graphics. *IEEE Transactions on Visualization and Computer Graphics (TVCG)*, 30(1), 414–424. <https://doi.org/10.1109/TVCG.2023.3327195>
- Kim, K., Park, K. K., & Lee, J.-H. (2014). The influence of arousal and expectation on eyewitness memory in a virtual environment. *Cyberpsychology, Behavior, and Social Networking*, 17(11), 709–713. <https://doi.org/10.1089/cyber.2013.0638>
- Kirillov, A., Wu, Y., He, K., & Girshick, R. (2020). PointRend: Image segmentation as rendering. *IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, 9796–9805. <https://doi.org/10.1109/cvpr42600.2020.00982>
- Kleiner, M., Brainard, D., & Pelli, D. (2007). What's new in Psychtoolbox-3? *Perception*, 36, 14. <https://doi.org/10.1177/03010066070360S101>
- Kocab, K., & Sporer, S. L. (2016). The weapon focus effect for person identifications and descriptions: A meta-analysis. In M. K. Miller & B. H. Bornstein (Eds.), *Advances in psychology and law* (Vol. 1, pp. 71–117). Springer. [https://doi.org/10.1007/978-3-319-29406-3\\_3](https://doi.org/10.1007/978-3-319-29406-3_3)

- Körner, H. M., Faul, F., & Nuthmann, A. (2023). Revisiting the role of attention in the "weapon focus effect": Do weapons draw gaze away from the perpetrator under naturalistic viewing conditions? *Attention, Perception, & Psychophysics*, *85*(6), 1868–1887. <https://doi.org/10.3758/s13414-022-02643-8>
- Krähenbühl, P., & Koltun, V. (2011). Efficient inference in fully connected CRFs with Gaussian edge potentials. *Conference on Neural Information Processing Systems (NIPS)*, 109–117. <https://doi.org/10.48550/arXiv.1210.5644>
- Kramer, T. H., Buckhout, R., & Eugenio, P. (1990). Weapon focus, arousal, and eyewitness memory: Attention must be paid. *Law and Human Behavior*, *14*(2), 167–184. <https://doi.org/10.1007/BF01062971>
- Levin, D. T., Salas, J. A., Wright, A. M., Seiffert, A. E., Carter, K. E., & Little, J. W. (2021). The incomplete tyranny of dynamic stimuli: Gaze similarity predicts response similarity in screen-captured instructional videos. *Cognitive Science*, *45*(6), Article e12984. <https://doi.org/10.1111/cogs.12984>
- Lightning AI. (2023). *pytorch-lightning* (Version 1.9.5) [Computer software]. <https://pypi.org/project/pytorch-lightning>
- Loftus, E. F., Loftus, G. R., & Messo, J. (1987). Some facts about "weapon focus". *Law and Human Behavior*, *11*(1), 55–62. <https://doi.org/10.1007/bf01044839>
- Loftus, G. R., & Mackworth, N. H. (1978). Cognitive determinants of fixation location during picture viewing. *Journal of Experimental Psychology: Human Perception and Performance*, *4*(4). <https://doi.org/10.1037/0096-1523.4.4.565>
- Loschky, L. C., Larson, A. M., Magliano, J. P., & Smith, T. J. (2015). What would Jaws do? The tyranny of film and the relationship between gaze and higher-level narrative film comprehension. *PloS ONE*, *10*(11), Article e0142474. <https://doi.org/10.1371/journal.pone.0142474>
- Maass, A., & Köhnken, G. (1989). Eyewitness identification: Simulating the "weapon effect". *Law and Human Behavior*, *13*(4), 397–408. <https://doi.org/10.1007/BF01056411>
- Mansour, J. K., Hamilton, C. M., & Gibson, M. T. (2019). Understanding the weapon focus effect: The role of threat, unusualness, exposure duration, and scene complexity. *Applied Cognitive Psychology*, *33*(6), 991–1007. <https://doi.org/10.1002/acp.3515>
- McKinney, W. (2010). Data structures for statistical computing in Python. *Proceedings of the 9th Python in Science Conference (SciPy)*, 56–61. <https://doi.org/10.25080/Majora-92bf1922-00a>

- McRae, K., Sharps, M. J., Power, J., & Newton, A. (2014). Eyewitness memory for typical and atypical weapons in cognitive context. *Journal of Investigative Psychology and Offender Profiling*, *11*(2), 179–189. <https://doi.org/10.1002/jip.1410>
- Microsoft. (2023). *azureml-core* (Version 1.54.0.post1) [Computer software]. <https://pypi.org/project/azureml-core>
- 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. <https://doi.org/10.1111/j.2044-8333.1998.tb00367.x>
- Morey, R. D., & Rouder, J. N. (2023). *BayesFactor: Computation of Bayes factors for common designs* (Version 0.9.12-4.7) [Computer software]. <https://CRAN.R-project.org/package=BayesFactor>
- Morey, R. D., Rouder, J. N., Pratte, M. S., & Speckman, P. L. (2011). Using MCMC chain outputs to efficiently estimate Bayes factors. *Journal of Mathematical Psychology*, *55*(5), 368–378. <https://doi.org/10.1016/j.jmp.2011.06.004>
- Nuthmann, A., Schütz, I., & Einhäuser, W. (2020). Saliency-based object prioritization during active viewing of naturalistic scenes in young and older adults. *Scientific Reports*, *10*(1), Article 22057. <https://doi.org/10.1038/s41598-020-78203-7>
- Nyman, T. J., Antfolk, J., Lampinen, J. M., Korkman, J., & Santtila, P. (2020). Eyewitness identifications after witnessing threatening and non-threatening scenes in 360-degree virtual reality (or 2D) from first and third person perspectives. *PloS ONE*, *15*(9), Article e0238292. <https://doi.org/10.1371/journal.pone.0238292>
- Olafenwa, A. (2021). *PixelLib* (Version 0.7.1) [Computer software]. <https://pypi.org/project/pixellib>
- Orquin, J. L., Ashby, N. J. S., & Clarke, A. D. F. (2016). Areas of interest as a signal detection problem in behavioral eye-tracking research. *Journal of Behavioral Decision Making*, *29*(2-3), 103–115. <https://doi.org/10.1002/bdm.1867>
- Paszke, A., Gross, S., Massa, F., Lerer, A., Bradbury, J., Chanan, G., Killeen, T., Lin, Z., Gimpelshein, N., Antiga, L., Desmaison, A., Kopf, A., Yang, E., DeVito, Z., Raison, M., Tejani, A., Chilamkurthy, S., Steiner, B., Fang, L., . . . Chintala, S. (2019). PyTorch: An imperative style, high-performance deep learning library. *Proceedings of the 33rd Conference on Neural Information Processing Systems (NeurIPS)*, 7994–8005. <https://doi.org/10.48550/arXiv.1912.01703>

- Pelli, D. G. (1997). The VideoToolbox software for visual psychophysics: Transforming numbers into movies. *Spatial Vision*, 10(4), 437–442. <https://doi.org/10.1163/156856897x00366>
- Pickel, K. L. (1998). Unusualness and threat as possible causes of "weapon focus". *Memory*, 6(3), 277–295. <https://doi.org/10.1080/741942361>
- Pickel, K. L. (1999). The influence of context on the "weapon focus" effect. *Law and Human Behavior*, 23(3), 299–311. <https://doi.org/10.1023/A:1022356431375>
- Pickel, K. L. (2009). The weapon focus effect on memory for female versus male perpetrators. *Memory*, 17(6), 664–678. <https://doi.org/10.1080/09658210903029412>
- Pickel, K. L. (2015). Eyewitness memory. In J. M. Fawcett, E. F. Risko, & A. Kingstone (Eds.), *The handbook of attention* (pp. 485–502). MIT Press. <https://doi.org/10.7551/mitpress/10033.003.0024>
- Pickel, K. L., Ross, S. J., & Truelove, R. S. (2006). Do weapons automatically capture attention? *Applied Cognitive Psychology*, 20(7), 871–893. <https://doi.org/10.1002/acp.1235>
- Pickel, K. L., & Sneyd, D. E. (2018). The weapon focus effect is weaker with Black versus White male perpetrators. *Memory*, 26(1), 29–41. <https://doi.org/10.1080/09658211.2017.1317814>
- Rouder, J. N., Speckman, P. L., Sun, D., Morey, R. D., & Iverson, G. (2009). Bayesian *t* tests for accepting and rejecting the null hypothesis. *Psychonomic Bulletin & Review*, 16(2), 225–237. <https://doi.org/10.3758/PBR.16.2.225>
- Techtonik, A. (2015). *wget* (Version 3.2) [Computer software]. <https://pypi.org/project/wget>
- Torchiano, M. (2020). *effsize: Efficient effect size computation* (Version 0.8.1) [Computer software]. <https://CRAN.R-project.org/package=effsize>
- TorchVision maintainers and contributors. (2022). *torchvision* (Version 0.14.1) [Computer software]. <https://pypi.org/project/torchvision>
- tqdm developers. (2023). *tqdm* (Version 4.66.1) [Computer software]. <https://pypi.org/project/tqdm>
- Underwood, G., Templeman, E., Lamming, L., & Foulsham, T. (2008). Is attention necessary for object identification? Evidence from eye movements during the inspection of real-world scenes. *Consciousness and Cognition*, 17(1), 159–170. <https://doi.org/10.1016/j.concog.2006.11.008>
- van den Brand, T. (2023). *ggh4x: Hacks for 'ggplot2'* (Version 0.2.8) [Computer software]. <https://CRAN.R-project.org/package=ggh4x>

- van der Walt, S., Schönberger, J. L., Nunez-Iglesias, J., Boulogne, F., Warner, J. D., Yager, N., Gouillart, E., & Yu, T. (2014). scikit-image: Image processing in Python. *PeerJ*, 2, Article e453. <https://doi.org/10.7717/peerj.453>
- Virtanen, P., Gommers, R., Oliphant, T. E., Haberland, M., Reddy, T., Cournapeau, D., Burovski, E., Peterson, P., Weckesser, W., Bright, J., van der Walt, S. J., Brett, M., Wilson, J., Millman, K. J., Mayorov, N., Nelson, A. R. J., Jones, E., Kern, R., Larson, E., . . . van Mulbregt, P. (2020). SciPy 1.0: Fundamental algorithms for scientific computing in Python. *Nature Methods*, 17(3), 261–272. <https://doi.org/10.1038/s41592-019-0686-2>
- Võ, M. L.-H., & Henderson, J. M. (2009). Does gravity matter? Effects of semantic and syntactic inconsistencies on the allocation of attention during scene perception. *Journal of Vision*, 9(3), Article 24. <https://doi.org/10.1167/9.3.24>
- Wagenmakers, E.-J., Love, J., Marsman, M., Jamil, T., Ly, A., Verhagen, J., Selker, R., Gronau, Q. F., Dropmann, D., Boutin, B., Meerhoff, F., Knight, P., Raj, A., van Kesteren, E.-J., van Doorn, J., Šmíra, M., Epskamp, S., Etz, A., Matzke, D., . . . Morey, R. D. (2018). Bayesian inference for psychology. Part II: Example applications with JASP. *Psychonomic Bulletin & Review*, 25(1), 58–76. <https://doi.org/10.3758/s13423-017-1323-7>
- Wagenmakers, E.-J., Marsman, M., Jamil, T., Ly, A., Verhagen, J., Love, J., Selker, R., Gronau, Q. F., Šmíra, M., Epskamp, S., Matzke, D., Rouder, J. N., & Morey, R. D. (2018). Bayesian inference for psychology. Part I: Theoretical advantages and practical ramifications. *Psychonomic Bulletin & Review*, 25(1), 35–57. <https://doi.org/10.3758/s13423-017-1343-3>
- Waskom, M. (2021). seaborn: Statistical data visualization. *Journal of Open Source Software*, 6(60), Article 3021. <https://doi.org/10.21105/joss.03021>
- Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis* (2nd ed.). Springer. <https://doi.org/10.1007/978-3-319-24277-4>
- Wickham, H., Vaughan, D., & Girlich, M. (2023). *tidyr: Tidy messy data* (Version 1.3.1) [Computer software]. <https://CRAN.R-project.org/package=tidyr>
- Wu, C.-C., Wick, F. A., & Pomplun, M. (2014). Guidance of visual attention by semantic information in real-world scenes. *Frontiers in Psychology*, 5, Article 54. <https://doi.org/10.3389/fpsyg.2014.00054>
- Xie, Y. (2015). *Dynamic documents with R and knitr* (2nd). Chapman and Hall/CRC. <https://doi.org/10.1201/9781315382487>

Yadan, O. (2022). *omegaconf* (Version 2.3.0) [Computer software]. <https://pypi.org/project/omegaconf>

Yadan, O. (2022). *hydra-core* (Version 1.3.2) [Computer software]. <https://pypi.org/project/hydra-core>

### 3.8 Appendix 1 – Software Details

The eye-tracking experiment was implemented in MATLAB (Version R2019b) using the Psychophysics Toolbox extension (Brainard, 1997; Kleiner et al., 2007; Pelli, 1997), which incorporates the EyeLink Toolbox (Cornelissen et al., 2002). The online experiment was implemented in LimeSurvey (Version 2.23.3). All ROIs were generated in Python (Version 3.7.9) using the libraries *azureml-core* (Version 1.54.post1; Microsoft, 2023), *hydra-core* (Version 1.3.2; Yadan, 2023), *matplotlib* (Version 3.5.3; Hunter, 2007), *numpy* (Version 1.21.6; Harris et al., 2020), *omegaconf* (Version 2.3.0; Yadan, 2022), *opencv-python* (Version 4.8.1.78; Bradski, 2000), *pandas* (Version 1.3.5; McKinney, 2010), *pillow* (Version 9.5.0; Clark, 2023), *pixellib* (Version 0.7.1; Olafenwa, 2021), *pydensecrf* (Version 1.0rc3; Beyer, 2018), *pyhelpers* (Version 1.4.6; Fu, 2023), *pytorch-lightning* (Version 1.9.5; Lightning AI, 2023), *scikit-image* (Version 0.19.3; van der Walt et al., 2014), *scipy* (Version 1.7.3; Virtanen et al., 2020), *seaborn* (Version 0.12.2; Waskom, 2021), *tensorboard* (Version 2.11.2; Google, 2023), *torch* (Version 1.13.1; Paszke et al., 2019), *torchvision* (Version 0.14.1; TorchVision maintainers and contributors, 2022), *tqdm* (Version 4.66.1; tqdm developers, 2023), and *wget* (Version 3.2; Tecthonik, 2015).

SR Research Data Viewer (Version 4.3.210) was used to process the raw eye-movement data. Both eye-movement data and behavioral data were then analyzed in R (Version 4.4.1) using the packages *BayesFactor* (Version 0.9.12-4.7; Morey & Rouder, 2023), *devEMF* (Version 4.4-2; Johnson, 2024), *effsize* (Version 0.8.1; Torchiano, 2020), *ggdist* (Version 3.3.2; Kay, 2023), *gg4x* (Version 0.2.8; van den Brand, 2023), *ggplot2* (Version 3.5.1; Wickham, 2016), *ggpp* (Version 0.5.8-1; Aphalo, 2024), *ggpubr* (Version 0.6.0; Kassambara, 2023), *ggsignif* (Version 0.6.4; Ahlmann-Eltze & Patil, 2021), *huxtable* (Version 5.5.6; Hugh-Jones, 2023), *knitr* (Version 1.48; Xie, 2015), and *tidyr* (Version 1.3.1; Wickham et al., 2023).

### 3.9 Appendix 2 – Control Analysis

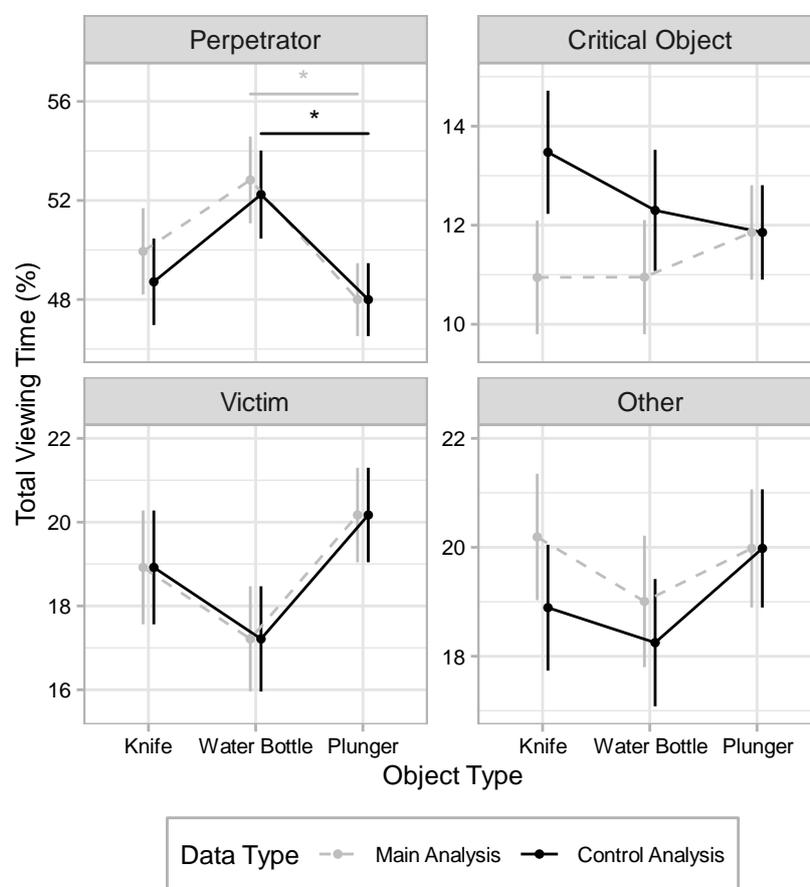
Current theories of the WFE predict an attentional shift away from the perpetrator and toward the weapon. In our main analysis, we failed to find this predicted effect on viewing times both for the perpetrator and for the critical object. However, the ROI sizes for the critical objects used for this main analysis differed to some extent, which may have influenced the results. The goal of this control analysis is to check whether our failure to find the predicted attentional WFE could be attributed to this difference in ROI size.

For the main analysis, the ROI was smallest for the knife and largest for the plunger. Larger objects are generally more likely to be fixated than smaller objects (e.g., Nuthmann et al., 2020). Thus, the predictions of current theories on the one hand and size-based considerations on the other hand are contradictory, with current theories predicting viewing times on the knife to be longest and size-based considerations predicting viewing times on the knife to be shortest. It is therefore important to investigate the influences that object ROI size has on the viewing times of Experiment 1. To maximize the chances of detecting a corresponding effect in the control analysis, we chose to equalize the average ROI sizes of all critical objects.

The size of the critical-object ROI affects not only viewing times on the critical object itself, but also viewing times on the perpetrator, because (a) the ROIs for the critical object and the perpetrator overlap, and (b) the object ROI was given priority when assigning gaze samples to ROIs, meaning that larger object ROIs occlude more of the perpetrator ROI. Consequently, increasing the size of the object ROI generally leads to shorter viewing times for the perpetrator. To explore the extent to which the differing sizes of the critical-object ROIs affect the results, we evenly increased the size of the smaller ROIs in all directions for each frame up to the point where the average size across frames was approximately equal for the ROIs of the knife, water bottle, and plunger.

As mentioned above, this analysis method maximizes the chance to observe the predicted attentional shift away from the perpetrator and toward the weapon. Since the knife had the smallest ROI in the main analysis, its ROI size is inflated the most. This leads to more gaze samples being assigned to the knife and, consequently, to longer viewing times on the knife. Conversely, inflating the knife ROI covers up larger portions of the perpetrator ROI, thereby reducing viewing times on the perpetrator. Thus, the implemented adjustment in ROI size, if it has any effect at all, should generally result in viewing times that are more congruent with the predicted shift away from the perpetrator and toward the weapon.

The results of the control analysis are shown in Figure 3.10 and in Tables 3.8 and 3.9. The differences in results between the size-adjusted control analysis and the main analysis were small. The largest change was observed for the knife, for which the average TVT increased by approximately 2.5 percentage points compared with the main analysis. The overall pattern of results remained the same for all ROIs. As with the main analysis, the only significant difference between the various object conditions was a reduced viewing time on the perpetrator in the plunger condition compared with the water-bottle condition. Thus, contrary to the predictions of current theories, the presence of a knife again did not significantly reduce viewing time on the perpetrator, and the knife was not looked at for significantly longer than the water bottle.



**Figure 3.10** Total relative viewing times in Experiment 1 (control analysis versus main analysis). Mean total viewing times are shown as a function of object type and analysis method. Each panel presents the total viewing times for a different region of interest (see panel titles). Note that the scales of the y-axes differ for the various regions of interest. Also note that the connecting lines between the discrete levels of object type are included only to facilitate comparisons between experimental conditions. Error bars are  $\pm 1 SE$ .  $*p < .05$ .

The results of this control analysis demonstrate that the attentional WFE predicted by current theories is not observed for the present data even when the most sensitive analysis method for detecting such an effect is chosen. The overall similarity in results compared to the main analysis suggests that the differences in ROI size between the critical objects were not pivotal to our findings. Thus, the fact that we failed to find the attentional WFE cannot be explained by these differences in object ROI size.

Region of Interest	Knife	Water Bottle	Plunger
Perpetrator	48.71 (12.83)	52.24 (13.08)	48.00 (10.83)
Critical Object	13.47 (9.14)	12.30 (8.98)	11.85 (7.01)
Victim	18.92 (9.98)	17.21 (9.23)	20.17 (8.29)
Other	18.89 (8.49)	18.25 (8.59)	19.98 (7.97)

**Table 3.8** Means and standard deviations for the total viewing times (%) in Experiment 1 (control analysis). Standard deviations are presented in parentheses.  $N = 162$  ( $n = 54$  for each condition).

Region of Interest	Tails	$t$	$p$	$d$	$BF_{01}$	Evidence for $H_1$
Perpetrator						
Knife vs. Water Bottle	One	1.41	.080	0.27	1.11	○
Plunger vs. Water Bottle	One	1.84	.035	0.35	0.57	+
Knife vs. Plunger	Two	0.31	.754	0.06	4.69	--
Critical Object						
Knife vs. Water Bottle	One	0.67	.252	0.13	2.73	-
Plunger vs. Water Bottle	One	0.29	.613	0.06	6.01	--
Knife vs. Plunger	Two	1.03	.306	0.20	3.06	--
Victim						
Knife vs. Water Bottle	Two	0.92	.358	0.18	3.35	--
Plunger vs. Water Bottle	Two	1.75	.083	0.34	1.25	○
Knife vs. Plunger	Two	0.71	.480	0.14	3.92	--
Other						
Knife vs. Water Bottle	Two	0.39	.697	0.08	4.58	--
Plunger vs. Water Bottle	Two	1.09	.280	0.21	2.90	-
Knife vs. Plunger	Two	0.69	.494	0.13	3.97	--

**Table 3.9** Results of the planned contrasts for the total viewing times in Experiment 1 (control analysis). All  $t$ s are absolute values.  $df = 106$  for all tests. Classifications for the evidence in favor of the alternative hypothesis  $H_1$  based on the Bayes Factor  $BF_{01}$ : -- = moderate evidence against  $H_1$ ; - = weak evidence against  $H_1$ ; ○ = inconclusive evidence; + = weak evidence in favor of  $H_1$ .



## 4 SCHLUSSFOLGERUNG

Der WFE beschreibt das Phänomen, dass Beobachterinnen und Beobachter sich schlechter an das Aussehen einer Person erinnern können, wenn diese eine Waffe in der Hand hielt. Aktuelle Theorien gehen davon aus, dass Waffen die Aufmerksamkeit der Betrachtenden binden. In der Folge würde die Person, die die Waffe hält, weniger beachtet, wodurch ihr Aussehen schlechter im Gedächtnis enkodiert werden könne. Im Gegensatz zu den Erinnerungseffekten von Waffen wurde diese Aufmerksamkeitskomponente des WFE jedoch selten direkt untersucht. Die wenigen Studien, in denen der Einfluss von Waffen auf die Aufmerksamkeitsverteilung untersucht wurde, nutzten dabei ausschließlich statische Stimuli in Form von Dia-Shows (z. B. E. F. Loftus et al., 1987) oder einzelnen, unzusammenhängenden Bildern (z. B. Biggs et al., 2013).

Das Hauptziel der in der vorliegenden Arbeit enthaltenen Studien war es, die Aufmerksamkeitseffekte von Waffen unter naturalistischen Betrachtungsbedingungen zu untersuchen. Dazu wurden in zwei Studien die Blickbewegungen von Versuchspersonen aufgezeichnet, während sie Videos von inszenierten Raubüberfällen ansahen. Die Ergebnisse zur Aufmerksamkeitsverteilung sowie zur ebenfalls untersuchten Erinnerung an das Aussehen der Täterin bzw. des Täters widersprechen sowohl den Befunden der bisherigen Forschung als auch den Annahmen der aktuellen Theorien zum WFE.

### 4.1 Aufmerksamkeitsbefunde

Die Eye-Tracking-Ergebnisse sowohl aus Studie 1 als auch aus Studie 2 sprechen gegen die theoretische Vorstellung, dass Waffen die Aufmerksamkeit von Betrachtenden über einen längeren Zeitraum binden und dadurch die Zeit verkürzen, in der die Täterin oder der Täter angeschaut wird. In beiden Studien wurden die Waffen durchschnittlich nur für etwa 9–13 % der Zeit angeschaut, in der die Täterin bzw. der Täter und das Objekt sichtbar waren. Im Gegensatz dazu widmeten die Versuchspersonen der Täterin bzw. dem Täter den Großteil ihrer Aufmerksamkeit, durchschnittlich ca. 40–50 % der Zeit. Dabei hing weder die Betrachtungsdauer auf der Täterin bzw. dem Täter noch die Betrachtungsdauer auf dem Objekt selbst signifikant davon ab, ob das Objekt eine Waffe war oder nicht.

Neben diesem Widerspruch zu aktuellen Theorien weichen die für Video-Stimuli gefundenen Ergebnisse auch von bisherigen Befunden zu den Aufmerksamkeitseffekten von Waffen bei weniger natürlichen Stimuli ab. So wurde für Dia-Shows festgestellt, dass eine Waffe öfter

und länger angeschaut wird als ein neutrales Objekt (E. F. Loftus et al., 1987). Für unzusammenhängende Bilder konnte gezeigt werden, dass eine Aufmerksamkeitsverschiebung hin zur Waffe die Betrachtungsdauer auf dem Gesicht der Person reduzierte, die die Waffe in der Hand hielt (Biggs et al., 2013).

Um zu prüfen, ob sich diese Inkonsistenz durch die Verwendung von Videos statt solcher statischen Stimuli erklären lässt, wurde in Studie 1 ein Folgeexperiment durchgeführt. Dabei wurden die Videos zu Dia-Shows konvertiert, um die Methode von E. F. Loftus et al. (1987) nachzubilden. Für diese Dia-Shows konnten die Befunde von E. F. Loftus et al. (1987) repliziert werden: Die Waffe wurde länger angeschaut als das neutrale Objekt. Da die Dia-Shows auf demselben Material basierten wie die Videos aus dem Hauptexperiment von Studie 1, sprechen diese Ergebnisse dafür, dass die Art des Stimulusmaterials einen substantiellen Einfluss auf die Aufmerksamkeitseffekte von Waffen hat. Demnach lassen sich die für statische Stimuli gefundenen Effekte nicht uneingeschränkt auf natürlichere Betrachtungsbedingungen generalisieren (vgl. Dorr et al., 2010).

Anders als von Biggs et al. (2013) für unzusammenhängende Bilder berichtet, führte die in Studie 1 für Dia-Shows festgestellte verstärkte Fokussierung auf der Waffe nicht zu kürzeren Betrachtungsdauern auf dem Täter. Auch diese Inkonsistenz kann plausibel durch die unterschiedliche Art des Stimulusmaterials erklärt werden. Wenn mehrere Bilder mit wechselnden Personen und Objekten präsentiert werden, müssen Betrachtende bei jedem Bildwechsel eine neue Szene verarbeiten. Auch bei Dia-Shows gibt es Hinweise darauf, dass jedes neue Dia von Betrachtenden zumindest teilweise wie eine neue Szene verarbeitet wird. So berichteten Dorr et al. (2010), dass kurz nach der Darbietung eines neuen Dias jeweils ein *Center Bias* (d. h. ein Aufmerksamkeitsfokus auf der Bildmitte) zu beobachten war. Dieses Phänomen tritt verstärkt zu Beginn einer neuen Szene auf (Tatler, 2007).

Bei dynamischen Szenen in Videos gibt es, sofern nicht unterschiedliche Szenen durch Bildschnitte miteinander verknüpft werden, nur einen einmaligen Beginn der Szene; anschließend verändert sich die Szene kontinuierlich. Die Ergebnisse der Zeitverlaufsanalysen aus Studie 2 zeigen, dass die Unterschiede zwischen den verschiedenen Experimentalbedingungen zu Beginn der Szene besonders stark ausgeprägt waren. Wenn die Unterschiede zwischen Waffen und anderen Objekten vor allem zu Beginn einer Szene auftreten, werden die Effekte von Waffen bei Untersuchungen mit statischen Stimuli, bei denen regelmäßig neue Szenen einsetzen, möglicherweise überschätzt.

Außerdem wurden die einzelnen Bilder in der Studie von Biggs et al. (2013) nur für jeweils 5 Sekunden dargeboten. In Studie 2 wurde für eine Darbietungszeit von 12 Sekunden ebenfalls

eine Reduktion in der Betrachtungsdauer auf dem Gesicht der Täterin gefunden, wobei diese Reduktion durch eine erhöhte Betrachtungsdauer auf ihrem Körper kompensiert wurde. Allerdings war die Reduktion in der Betrachtungsdauer auf dem Gesicht vor allem zu Beginn der Szene zu beobachten. In Studie 1 konnte für eine Darbietungszeit von 32 Sekunden kein entsprechender Effekt festgestellt werden. Bei kurzen Darbietungszeiten macht die Anfangsphase einen größeren Teil der Gesamtdauer aus, sodass anfängliche Unterschiede hier stärker ins Gewicht fallen. Somit könnte auch die kurze Darbietungszeit in früheren Studien zur Aufmerksamkeitskomponente des WFE dazu beigetragen haben, dass die Aufmerksamkeitseffekte von Waffen bisher überschätzt wurden.

Die in früheren Studien berichteten Aufmerksamkeitsverschiebungen von dem Gesicht einer Person hin zu der Waffe in ihrer Hand scheinen somit zumindest teilweise methodische Artefakte zu sein, die der Verwendung von statischem Stimulusmaterial geschuldet sind. Es ist jedoch keineswegs so, dass Waffen unter natürlicheren Betrachtungsbedingungen gar keinen Einfluss auf die Aufmerksamkeitsverteilung hätten. Wie oben bereits beschrieben, wurde in Studie 2 eine Verschiebung der Aufmerksamkeit von dem Gesicht der Täterin hin zu ihrem Körper festgestellt, wenn sie eine Waffe in der Hand hielt. Die Ergebnisse der Zeitverlaufsanalysen legen dabei nahe, dass die erhöhte Betrachtungsdauer auf dem Körper ein langlebigerer Effekt ist als die insbesondere zu Beginn auftretende verringerte Betrachtungsdauer auf dem Gesicht.

Eine mögliche Erklärung für den verstärkten Fokus auf den Körper der Täterin könnte sein, dass Betrachtende einschätzen wollten, ob die Täterin die Waffe (ein Messer) einsetzen würde. Ein solches Vorhaben ließe sich potenziell etwa an einer Bewegung des Arms erkennen. Sowohl in Studie 1 als auch in Studie 2 führte die Anwesenheit einer Waffe außerdem zu einem stärkeren Aufmerksamkeitsfokus auf der Interaktion der gezeigten Personen. Die Aufmerksamkeitseffekte von Waffen sind demnach unter natürlichen Betrachtungsbedingungen komplexer als die bisher angenommene Aufmerksamkeitsverschiebung von der Täterin oder dem Täter hin zur Waffe. Außerdem treten viele Effekte insbesondere zu Beginn einer neuen Szene auf und sind vergleichsweise kurzlebig.

Die Ungewöhnlichkeitshypothese besagt, dass Waffen deshalb Aufmerksamkeit auf sich ziehen, weil sie in vielen Kontexten ungewöhnliche Objekte sind. Zum Test dieser Hypothese wurden in Studie 2 die Aufmerksamkeitseffekte einer Waffe mit denen eines nicht bedrohlichen ungewöhnlichen Objekts verglichen. Entgegen den Vorhersagen der Hypothese konnte auch bei dem nicht bedrohlichen ungewöhnlichen Objekt keine Aufmerksamkeitsverschiebung von der Zielperson hin zum Objekt selbst beobachtet werden.

Beim Vergleich der Aufmerksamkeitseffekte der Waffe und des ungewöhnlichen Objekts zeigten sich sowohl Gemeinsamkeiten als auch Unterschiede. Beispielsweise führten beide Objekte im Vergleich zu einem neutralen Objekt zu einer anfänglichen Reduktion der Betrachtungsdauer auf dem Gesicht der Täterin. Die Aufmerksamkeitsverschiebung hin zum Körper der Täterin trat jedoch nur in der Waffen-Bedingung auf. Die Gemeinsamkeiten in den Effekten sprechen dafür, dass die Ungewöhnlichkeit von Waffen ein entscheidender Faktor für deren Effekte auf die Aufmerksamkeitsverteilung ist. Gleichzeitig deuten die Unterschiede darauf hin, dass auch andere Faktoren eine Rolle spielen. Eine naheliegende Schlussfolgerung ist, dass auch die Bedrohlichkeit von Waffen einen Einfluss auf die Aufmerksamkeitsverteilung hat.

Ein gemeinsamer Einfluss von Bedrohlichkeit und Ungewöhnlichkeit ist auch mit einigen Ergebnissen zu den Erinnerungseffekten von Waffen vereinbar. So berichteten Kim et al. (2014), dass Bedrohlichkeit und Ungewöhnlichkeit unabhängig voneinander zu einer Verschlechterung der Erinnerungsgüte beitragen. Meta-Analysen ergaben, dass ungewöhnliche Objekte die Erinnerung ähnlich stark beeinträchtigen wie Waffen, wobei der WFE in bedrohlichen Situationen jedoch stärker ausgeprägt ist (Fawcett et al., 2013; Kocab & Sporer, 2016). Sowohl die Bedrohlichkeits- als auch die Ungewöhnlichkeitshypothese scheinen somit fruchtbare Ansätze zur Erklärung des WFE zu sein. Die hier vorgestellten Aufmerksamkeitsbefunde zeigen jedoch, dass die in beiden Hypothesen enthaltenen Vorstellungen über die Aufmerksamkeitseffekte von Waffen überarbeitet werden müssen.

## **4.2 Erinnerungsbefunde**

Sowohl in Studie 1 als auch in Studie 2 wurde überwiegend kein WFE gefunden, d.h. die Erinnerung der Versuchspersonen an das Aussehen der Täterin bzw. des Täters wurde durch die Anwesenheit einer Waffe nicht beeinträchtigt. Diese Befunde sind grundsätzlich konsistent mit den Aufmerksamkeitsbefunden, bei denen kaum Effekte des Objekttyps auf die Dauer der Betrachtung der Täterin bzw. des Täters gefunden wurden. Die Erinnerungsbefunde widersprechen jedoch einem Großteil der bisherigen Literatur zum WFE, in der der Effekt als gut etabliertes Phänomen gilt (z.B. Kocab & Sporer, 2016; Pickel, 2015).

Anders als die vorhergesagte Aufmerksamkeitsverschiebung wurde der erinnerungsbezogene WFE in der bisherigen Forschung nicht nur für statische, sondern auch für dynamische Stimuli nachgewiesen (z.B. Cutler et al., 1987; Pickel, 2009; Pickel & Sneyd, 2018). Die Inkonsistenz der Erinnerungsbefunde kann somit nicht durch die Verwendung von Videos in den vorliegenden Studien erklärt werden. Im Gegenteil orientierte sich die Methodik von Studie 1

stark an derjenigen einer US-amerikanischen Studie (Pickel & Sneyd, 2018), in der große Erinnerungseffekte nachgewiesen wurden. Insbesondere waren das Stimulusmaterial und der Fragebogen zum Erfassen der Erinnerungsgüte aus dieser Studie adaptiert. Statt methodischer Unterschiede scheinen somit Eigenschaften der Stichprobe für die inkonsistenten Befunde verantwortlich zu sein.

Die Tatsache, dass sich die Befunde zwischen den deutschen Stichproben in Studie 1 und der US-amerikanischen Stichprobe von Pickel und Sneyd (2018) trotz ähnlicher Methodik unterscheiden, lässt zunächst einen Einfluss kultureller Unterschiede vermuten. Im Vergleich zu Deutschland ist die Regulierung von Schusswaffen in den USA deutlich weniger restriktiv. Außerdem sind Schusswaffen in den USA weitaus verbreiteter und die Raten der Tötungsdelikte und Suizide mit Schusswaffen sind um ein Vielfaches höher als in Deutschland (Grinshteyn & Hemenway, 2016). Es ist denkbar, dass solche Unterschiede sowie Unterschiede in der allgemeinen kulturellen Verankerung von (Schuss-)Waffen sich darauf auswirken, welche Effekte Waffen auf die Aufmerksamkeit und das Gedächtnis haben.

Gegen diesen Erklärungsansatz spricht jedoch, dass auch in Studie 2 überwiegend kein WFE gefunden wurde. Bei dem hier als Waffe verwendeten Messer sind die kulturellen Unterschiede zwischen Deutschland und den USA mutmaßlich weniger ausgeprägt als bei Schusswaffen. Außerdem trat auch bei dem nicht bedrohlichen ungewöhnlichen Objekt kein Erinnerungseffekt auf. Hinsichtlich der Effekte von nicht bedrohlichen ungewöhnlichen Objekten ist ein Einfluss kultureller Unterschiede weniger plausibel, sofern die Objekte in der jeweiligen Kultur tatsächlich als ungewöhnlich gelten. Die Befunde aus Studie 2 legen daher nahe, dass nicht der kulturelle Hintergrund, sondern andere Eigenschaften der Stichprobensammensetzung für das wiederholte Ausbleiben des WFE verantwortlich sind.

Das Online-Experiment von Studie 2 ist das einzige Experiment aus den vorliegenden Studien, in dem teilweise ein WFE auftrat. Bei Darbietungen mit Ton war hier die Erinnerung an das Aussehen der Täterin schlechter, wenn sie eine Waffe oder ein nicht bedrohliches ungewöhnliches Objekt in der Hand hielt, als wenn sie ein neutrales Objekt in der Hand hielt. Diese Ergebnisse widersprechen den Befunden aus dem Laborexperiment derselben Studie, in dem mit der grundsätzlich gleichen Methodik kein WFE gefunden wurde. Eine mögliche Erklärung für diese Inkonsistenz ist, dass die Stichprobensammensetzung bei Online-Studien potenziell repräsentativer ist als bei Laborexperimenten, bei denen in der Regel auf studentische Versuchspersonen zurückgegriffen wird.

Allerdings trat in demselben Online-Experiment kein WFE auf, wenn die Videos ohne Ton dargeboten wurden, obwohl der WFE in der Vergangenheit durchaus auch bei Präsentationen

ohne Ton nachgewiesen wurde (z. B. Carlson, Pleasant et al., 2016; Kramer et al., 1990; Pickel, 1998, 1999). Dieser Unterschied zwischen den Bedingungen mit und ohne Ton lässt sich weniger plausibel durch Unterschiede in der Stichprobenszusammensetzung erklären.

Zudem gab es Hinweise darauf, dass der in der Bedingung mit Ton gefundene WFE ein falsch-positives Ergebnis sein könnte. Im Vergleich über alle Bedingungen in Studie 2 hinweg war die Erinnerungsgüte in den Bedingungen mit der Waffe und dem ungewöhnlichen Objekt nicht beeinträchtigt, sondern vielmehr in der neutralen Bedingung unerwartet hoch. Die berechneten Bayes-Faktoren deuten außerdem darauf hin, dass die Evidenz für einen echten Effekt im Online-Experiment insbesondere in der Waffen-Bedingung vergleichsweise schwach war. Allein auf Grundlage der Daten aus den vorliegenden Studien lässt sich nicht abschließend klären, welche Ursachen für die Inkonsistenz zwischen den beiden Experimenten in Studie 2 und, entscheidender, die Inkonsistenz zwischen dem wiederholten Ausbleiben des WFE in den vorliegenden Studien und bisherigen Befunden zum WFE verantwortlich sind.

### **4.3 Implikationen und Limitationen**

Die Befunde der vorliegenden Studien verdeutlichen, wie wichtig es ist, theoretische Annahmen umfassend empirisch zu prüfen. Obwohl eine angenommene Aufmerksamkeitsverschiebung ein zentrales Element gegenwärtiger Theorien zum WFE ist, wurden die Aufmerksamkeitseffekte von Waffen in der bisherigen Forschung selten untersucht. Stattdessen wurden Aufmerksamkeitseffekte häufig indirekt aus Erinnerungsunterschieden abgeleitet. Die wenigen Studien, in denen die Aufmerksamkeitskomponente des WFE direkt untersucht wurde, waren auf statische Stimuli und kurze Darbietungszeiten beschränkt. In den vorliegenden Studien wurden die Aufmerksamkeitseffekte von Waffen dagegen erstmals in dynamischen Szenen und über längere Darbietungszeiten hinweg untersucht.

Die Ergebnisse dieser Studien widersprechen sowohl den gegenwärtigen theoretischen Vorstellungen zum WFE als auch bisherigen Befunden unter weniger natürlichen Betrachtungsbedingungen. Es wurde kein umfassender Aufmerksamkeitsfokus auf der Waffe festgestellt und es konnten keine Belege für die vorhergesagte Aufmerksamkeitsverschiebung von der Täterin bzw. dem Täter hin zur Waffe gefunden werden. Stattdessen wurden komplexere Aufmerksamkeitseffekte beobachtet. Zukünftige Forschung sollte direkt und mit objektiven Messmethoden untersuchen, inwieweit sich die in den vorliegenden Studien gefundenen Ergebnisse auf verschiedene Beobachtungssituationen generalisieren lassen. Die Untersuchung der Aufmerksamkeitsverteilung sollte dabei, wie in den vorliegenden Studien, unter möglichst

natürlichen Betrachtungsbedingungen erfolgen. Die theoretischen Vorstellungen zum WFE müssen an die so gewonnenen Erkenntnisse angepasst werden.

In keinem der Eye-Tracking-Experimente der vorliegenden Arbeit wurde ein Effekt des Objekttyps auf die Erinnerung gefunden. Es ist daher unklar, inwieweit sich die gefundenen Ergebnisse zur Aufmerksamkeitsverteilung auf solche Stichproben generalisieren lassen, die einen erinnerungsbezogenen WFE zeigen. Es ist nicht auszuschließen, dass in diesem Fall tatsächlich die vorhergesagte Aufmerksamkeitsverschiebung von der Täterin oder dem Täter hin zur Waffe auftritt.

Die Ergebnisse der vorliegenden Studien liefern jedoch Indizien dafür, dass die Abweichung von bisherigen Aufmerksamkeitsbefunden eher auf die Verwendung von natürlicherem Stimulusmaterial zurückzuführen ist als auf Unterschiede in der Stichprobenszusammensetzung. So zeigen die Ergebnisse der Zeitverlaufsanalysen aus beiden vorliegenden Studien, dass die Aufmerksamkeitsverteilung jeweils stark von der Interaktion der gezeigten Personen getrieben war. Demnach scheint die Aufmerksamkeitsverteilung mehr von dem gezeigten Material abzuhängen und weniger von individuellen Eigenschaften der Betrachtenden.

Ein weiteres Indiz ergibt sich aus den Ergebnissen aus Studie 1. Hier konnten für Dia-Shows die Befunde von E. F. Loftus et al. (1987) repliziert werden, während sich für Videos ein anderes Ergebnismuster ergab. Außerdem wurden die Waffen, wie oben beschrieben, in beiden Eye-Tracking-Experimenten mit Videos durchschnittlich nur 10–12 % der Zeit angeschaut. Es scheint daher wenig plausibel, dass die Effekte bei einer anderen Stichprobe so stark von den hier gefundenen abweichen, dass die Annahme eines umfassenden Aufmerksamkeitsfokus auf der Waffe gestützt würde.

Bei Videos waren die Einflüsse des Objekttyps auf die Aufmerksamkeitsverteilung allgemein gering und die gefundenen Effekte oft kurzlebig. Damit widersprechen die Aufmerksamkeitsbefunde auch der Vorstellung, dass die Anwesenheit einer Waffe die Erinnerung an das Aussehen der Täterin oder des Täters deshalb beeinträchtigt, weil sich die Aufmerksamkeitsverteilung durch die Anwesenheit einer Waffe substantiell verändert. Sofern die Aufmerksamkeitsbefunde bei Stichproben, die einen erinnerungsbezogenen WFE zeigen, nicht grundlegend anders ausfallen, müssen andere Faktoren für die in bisherigen Studien gefundene Beeinträchtigung der Erinnerung verantwortlich sein.

Hinweise darauf, dass der WFE auf andere Faktoren als Unterschiede in der Aufmerksamkeitsverteilung zurückzuführen sein könnte, ergeben sich auch aus einigen anderen Studien zum WFE. So berichteten Erickson et al. (2014), dass die Erinnerung an das Aussehen einer Zielperson auch dann durch die Anwesenheit einer Waffe beeinträchtigt war, wenn Zielperson

und Waffe nacheinander auf separaten Dias dargeboten wurden. Weiterhin kann ein WFE auch dann auftreten, wenn die Waffe erst zu einem späteren Zeitpunkt sichtbar wird, sodass die Beobachtenden die Zielperson zunächst ohne Waffe enkodieren können (Carlson, Young et al., 2016; Kramer et al., 1990). In solchen Situationen konkurrieren Waffe und Zielperson weniger oder gar nicht um die Aufmerksamkeit der Beobachtenden. Daher lassen sich diese Befunde weniger plausibel durch eine Aufmerksamkeitsverschiebung von der Zielperson hin zur Waffe erklären.

Anhaltspunkte für mögliche alternative Erklärungsansätze könnten beispielsweise in der allgemeineren Literatur zum Einfluss von Stress auf das Erinnerungsvermögen gesucht werden. So wurde in einigen Studien festgestellt, dass hinsichtlich der Erinnerungsgüte ein Interaktionseffekt zwischen dem Inhalt des enkodierten Materials bzw. dem Erregungsniveau während der Enkodierung einerseits und dem Erregungsniveau während der Konsolidierung andererseits auftritt (Cahill, Gorski & Le, 2003; Echterhoff & Wolf, 2012). Da die Manipulation des Erregungsniveaus bei der Konsolidierung hier jeweils erst erfolgte, nachdem die Stimuluspräsentation abgeschlossen war, können diese Befunde nicht allein durch Aufmerksamkeitsprozesse erklärt werden.

Weiterhin berichteten Christianson, Loftus, Hoffman und Loftus (1991), dass sich Versuchspersonen an emotionale Bilder auch dann anders erinnerten als an neutrale, wenn sie nur eine einzige Fixation machen konnten oder wenn bei der Auswertung für die Anzahl der Fixationen auf dem zu erinnernden Objekt kontrolliert wurde. Auch diese Befunde können nicht allein durch Unterschiede in der Verteilung der (offenen) Aufmerksamkeit erklärt werden. Christianson et al. (1991) schlugen vor, dass emotionale Ereignisse im Vergleich zu neutralen Ereignissen nicht nur anders enkodiert werden, sondern auch bei der Gedächtniskonsolidierung ausführlicher elaboriert werden. Dabei scheint die Erinnerung zusätzlich vom Erregungsniveau während dieser Konsolidierungsphase beeinflusst zu werden (Cahill et al., 2003; Echterhoff & Wolf, 2012).

Der Einfluss von Stress auf die Erinnerungsgüte wurde in den vorliegenden Studien nicht direkt untersucht. Die Bedrohlichkeitshypothese zum WFE besagt, dass die Anwesenheit einer Waffe zu einem erhöhten Erregungsniveau führt, welches wiederum die Erinnerungsgüte beeinträchtigt. Im Kontext realer Straftaten ist plausibel, dass die Anwesenheit einer Waffe zu erhöhtem Stress bei Augenzeuginnen und Augenzeugen führt. Diese mutmaßlich hohe Angst ist auch durchaus begründet: Straftaten haben um ein Vielfaches häufiger tödliche Konsequenzen, wenn eine Waffe im Spiel ist (z. B. Cook, 1987; Weaver et al., 2004). Es ist jedoch unklar,

inwieweit die Anwesenheit einer Waffe auch bei Experimenten zu einem erhöhten Erregungsniveau führt, in denen Versuchspersonen Videos oder Dia-Shows inszenierter Straftaten in sicherer Umgebung auf einem Computerbildschirm betrachten.

Wie in den meisten Studien zum WFE wurde das physiologische Erregungsniveau der Versuchspersonen in den vorliegenden Studien nicht erfasst. Im Selbstbericht gaben die Versuchspersonen in allen Experimenten jedoch ein vergleichsweise niedriges Erregungsniveau an, wengleich dieses in den Bedingungen mit einer Waffe statistisch signifikant erhöht war. Dagegen zeigte sich in Studien zu Augenzeugenberichten, in denen nachweislich Stress induziert wurde, eine Beeinträchtigung der Erinnerungsleistung durch Stress (siehe Deffenbacher et al., 2004).

Aufgrund der geringen Vergleichbarkeit der Bedingungen in Laborexperimenten einerseits und bei realen Straftaten andererseits stellten einige Autorinnen und Autoren die ökologische Validität von Laborexperimenten zu Augenzeugenberichten infrage (z. B. Konečni & Ebbesen, 1986). In Feldstudien und Archivanalysen wurde untersucht, inwieweit sich Befunde aus Laborexperimenten auf Augenzeugenberichte bei realen Straftaten generalisieren lassen (z. B. Mecklenburg, 2006; Tollestrup, Turtle & Yuille, 1994; Valentine, Pickering & Darling, 2003). In diesen Studien wurde größtenteils kein signifikanter Einfluss der Anwesenheit einer Waffe auf die Erinnerungsgüte gefunden.

In einer Meta-Analyse wurde über verschiedene Studien zu realen Straftaten hinweg jedoch eine geringfügige, aber signifikante Verschlechterung der Erinnerungsleistung festgestellt (Fawcett et al., 2013). Den vergleichsweise kleinen WFE bei realen Straftaten führten Fawcett et al. (2013) darauf zurück, dass sowohl die Expositionsdauer (d. h. der Zeitraum, in dem die Täterin oder der Täter sichtbar war) als auch das Retentionsintervall (d. h. der Zeitraum zwischen dem Ereignis und dem Abruf der Erinnerung) bei den untersuchten realen Straftaten deutlich länger waren als in den meisten Laborexperimenten.

Diese Meta-Analyse liefert zumindest einen Hinweis darauf, dass die Befunde aus Laborexperimenten auf reale Straftaten übertragbar sind. Dennoch ist nicht auszuschließen, dass die Auswirkungen von Waffen auf die Aufmerksamkeitsverteilung und die Erinnerungsgüte im Kontext realer Straftaten andere sind als im Labor, etwa aufgrund des mutmaßlich extrem hohen Erregungsniveaus. In den vorliegenden Studien wurden die Aufmerksamkeitseffekte von Waffen bereits unter natürlicheren Bedingungen untersucht als in früheren Arbeiten. Zukünftige Laborstudien könnten jedoch insbesondere die Aufmerksamkeitskomponente des WFE unter Bedingungen untersuchen, die den Umständen bei realen Straftaten noch näher kommen.

Dazu könnten zum einen realitätsnähere Situationen untersucht werden, etwa indem die Blickbewegungen aufgezeichnet werden, während realistische Stimuli über Virtual-Reality-Brillen dargeboten werden oder während die Versuchspersonen in reale Interaktionen involviert sind. Zum anderen könnten vor oder während der Stimulusdarbietung etablierte Verfahren zur Stressinduktion wie der *Cold Pressor Test* (siehe Lovallo, 1975), der *Trier Social Stress Test* (Kirschbaum et al., 1993) oder der *Maastricht Acute Stress Test* (Smeets et al., 2012) eingesetzt werden, um auch im Labor ein erhöhtes Erregungsniveau auszulösen (vgl. Marr, Quaedflieg, Otgaar, Hope & Sauerland, 2021; Sauerland et al., 2016). Natürlich wird es aus ethischen Gründen jedoch nie möglich sein, die Auswirkungen des extremen Stressniveaus, das bei realen Gewaltstraftaten mutmaßlich auftritt, experimentell zu untersuchen.

Es ist wichtig zu beachten, dass die eingeschränkte Generalisierbarkeit aufgrund des niedrigen Erregungsniveaus nicht nur die vorliegenden Studien betrifft, sondern die Forschung zum WFE insgesamt. Auch die bisherigen Studien zum WFE waren überwiegend Labor- oder Onlinestudien, in denen Versuchspersonen Videos oder Dia-Shows inszenierter Verbrechen gezeigt wurden. In den Studien, in denen das selbstberichtete Erregungsniveau erhoben wurde, war dieses ebenfalls niedrig bis moderat (siehe Kocab & Sporer, 2016). Zudem orientierte sich die Methode von Studie 1 eng an dem Vorgehen einer publizierten Studie, in der ein großer Erinnerungseffekt nachgewiesen wurde, und das Material in Studie 2 war so konzipiert, dass ein möglichst starker WFE auftreten sollte. Das niedrige Erregungsniveau in den vorliegenden Studien kann somit die Abweichung der Ergebnisse von früheren Befunden nicht erklären. Es gibt zudem bisher keine empirische Evidenz dafür, dass bei realen Straftaten die von aktuellen Theorien angenommene Aufmerksamkeitsverschiebung von der Täterin oder dem Täter hin zur Waffe auftritt.

#### **4.4 Fazit**

Die Befunde der vorliegenden Studien zeigen, dass die Aufmerksamkeitseffekte von Waffen unter natürlichen Betrachtungsbedingungen sowohl von bisherigen Forschungsergebnissen unter weniger natürlichen Bedingungen als auch von den Vorhersagen der aktuellen Theorien zum WFE abweichen. Insgesamt wurden die Waffen von den Betrachtenden deutlich kürzer beachtet als die handelnden Personen. Die Waffen standen somit nicht im Fokus der Aufmerksamkeit. Es wurde zudem keine Evidenz für die bisher angenommene Aufmerksamkeitsverschiebung von der Täterin oder dem Täter hin zur Waffe gefunden. Stattdessen hatte die

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Anwesenheit einer Waffe komplexere Effekte auf die Aufmerksamkeitsverteilung. Diese Effekte traten insbesondere zu Beginn der Szenen auf und betrafen unter anderem, wie stark auf den Körper der Zielperson im Vergleich zu ihrem Gesicht geachtet wurde.

Der Vergleich mit den Effekten eines nicht bedrohlichen ungewöhnlichen Objekts legt nahe, dass die Ungewöhnlichkeit von Waffen einen wesentlichen Anteil daran hat, welche Auswirkungen Waffen auf die Aufmerksamkeitsverteilung haben. Andere Eigenschaften von Waffen, wie die von ihnen ausgehende Bedrohlichkeit, scheinen jedoch ebenfalls eine Rolle zu spielen. Das überwiegende Ausbleiben einer Beeinträchtigung der Erinnerungsgüte durch die Anwesenheit einer Waffe lässt darauf schließen, dass der WFE kein universelles Phänomen ist, sondern von Charakteristika der Betrachtenden und der Beobachtungssituation abhängt.



## LITERATURVERZEICHNIS

- Biggs, A. T., Brockmole, J. R. & Witt, J. K. (2013). Armed and attentive: Holding a weapon can bias attentional priorities in scene viewing. *Attention, Perception, & Psychophysics*, 75, 1715–1724. <https://doi.org/10.3758/s13414-013-0538-6>
- Brunyé, T. T. & Mahoney, C. R. (2019). Exercise-induced physiological arousal biases attention toward threatening scene details. *Psychological Reports*, 122, 79–95. <https://doi.org/10.1177/0033294117750629>
- Buswell, G. T. (1935). *How people look at pictures. A study of the psychology of perception in art*. Chicago, IL: University of Chicago Press.
- Cahill, L., Gorski, L. & Le, K. (2003). Enhanced human memory consolidation with post-learning stress: Interaction with the degree of arousal at encoding. *Learning & Memory*, 10, 270–274. <https://doi.org/10.1101/lm.62403>
- Carlson, C. A., Pleasant, W. E., Weatherford, D. R., Carlson, M. A. & Bednarz, J. E. (2016). The weapon focus effect: Testing an extension of the unusualness hypothesis. *Applied Psychology in Criminal Justice*, 12, 87–100.
- Carlson, C. A., Young, D. F., Weatherford, D. R., Carlson, M. A., Bednarz, J. E. & Jones, A. R. (2016). The influence of perpetrator exposure time and weapon presence/timing on eyewitness confidence and accuracy. *Applied Cognitive Psychology*, 30, 898–910. <https://doi.org/10.1002/acp.3275>
- Carrasco, M. (2011). Visual attention: The past 25 years. *Vision Research*, 51, 1484–1525. <https://doi.org/10.1016/j.visres.2011.04.012>
- Christianson, S.-Å., Loftus, E. F., Hoffman, H. & Loftus, G. R. (1991). Eye fixations and memory for emotional events. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 17, 693–701. <https://doi.org/10.1037/0278-7393.17.4.693>
- Coco, M. I., Nuthmann, A. & Dimigen, O. (2020). Fixation-related brain potentials during semantic integration of object-scene information. *Journal of Cognitive Neuroscience*, 32, 571–589. [https://doi.org/10.1162/jocn\\_a\\_01504](https://doi.org/10.1162/jocn_a_01504)
- Cook, P. J. (1987). Robbery violence. *Journal of Criminal Law and Criminology*, 78, 357–376. <https://doi.org/10.2307/1143453>
- Cutler, B. L., Penrod, S. D. & Martens, T. K. (1987). The reliability of eyewitness identification: The role of system and estimator variables. *Law and Human Behavior*, 11, 233–258. <https://doi.org/10.1007/BF01044644>

- Deffenbacher, K. A. (1994). Effects of arousal on everyday memory. *Human Performance*, 7, 141–161. [https://doi.org/10.1207/s15327043hup0702\\_3](https://doi.org/10.1207/s15327043hup0702_3)
- 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, 687–706. <https://doi.org/10.1007/s10979-004-0565-x>
- Dorr, M., Martinetz, T., Gegenfurtner, K. R. & Barth, E. (2010). Variability of eye movements when viewing dynamic natural scenes. *Journal of Vision*, 10(10), Artikel 28. <https://doi.org/10.1167/10.10.28>
- Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review*, 66, 183–201. <https://doi.org/10.1037/h0047707>
- Echterhoff, G. & Wolf, O. T. (2012). The stressed eyewitness: The interaction of thematic arousal and post-event stress in memory for central and peripheral event information. *Frontiers in Integrative Neuroscience*, 6, Artikel 57. <https://doi.org/10.3389/fnint.2012.00057>
- Erickson, W. B., Lampinen, J. M. & Leding, J. K. (2014). The weapon focus effect in target-present and target-absent line-ups: The roles of threat, novelty, and timing. *Applied Cognitive Psychology*, 28, 349–359. <https://doi.org/10.1002/acp.3005>
- Fawcett, J. M., Russell, E. J., Peace, K. A. & Christie, J. (2013). Of guns and geese: A meta-analytic review of the ‘weapon focus’ literature. *Psychology, Crime & Law*, 19, 35–66. <https://doi.org/10.1080/1068316X.2011.599325>
- Fitzgerald, R. J. & Price, H. L. (2015). Eyewitness identification across the life span: A meta-analysis of age differences. *Psychological Bulletin*, 141, 1228–1265. <https://doi.org/10.1037/bul0000013>
- Flowe, H. D., Hope, L. & Hillstrom, A. P. (2013). Oculomotor examination of the weapon focus effect: Does a gun automatically engage visual attention? *PloS ONE*, 8(12), Artikel e81011. <https://doi.org/10.1371/journal.pone.0081011>
- Foulsham, T. & Kingstone, A. (2013). Where have eye been? Observers can recognise their own fixations. *Perception*, 42, 1085–1089. <https://doi.org/10.1068/p7562>
- Friedrichsen, G. (2000, 21. Mai). „Ich denk mal, er war‘ s“. *Spiegel*. Verfügbar unter: <https://spiegel.de/politik/ich-denk-mal-er-wars-a-893c72b2-0002-0001-0000-000016466537>
- Grinshteyn, E. & Hemenway, D. (2016). Violent death rates: The US compared with other high-income OECD countries, 2010. *American Journal of Medicine*, 129, 266–273. <https://doi.org/10.1016/j.amjmed.2015.10.025>

- Gross, S. R., O'Brien, B., Hu, C. & Kennedy, E. H. (2014). Rate of false conviction of criminal defendants who are sentenced to death. *Proceedings of the National Academy of Sciences of the United States of America*, *111*, 7230–7235. <https://doi.org/10.1073/pnas.1306417111>
- Harada, Y., Hakoda, Y., Kuroki, D. & Mitsudo, H. (2015). The presence of a weapon shrinks the functional field of view. *Applied Cognitive Psychology*, *29*, 592–599. <https://doi.org/10.1002/acp.3143>
- Henderson, J. M., Weeks, P. A. & Hollingworth, A. (1999). The effects of semantic consistency on eye movements during complex scene viewing. *Journal of Experimental Psychology: Human Perception and Performance*, *25*, 210–228. <https://doi.org/10.1037/0096-1523.25.1.210>
- Herlitz, A. & Lovén, J. (2013). Sex differences and the own-gender bias in face recognition: A meta-analytic review. *Visual Cognition*, *21*, 1306–1336. <https://doi.org/10.1080/13506285.2013.823140>
- Hope, L. & Wright, D. (2007). Beyond unusual? Examining the role of attention in the weapon focus effect. *Applied Cognitive Psychology*, *21*, 951–961. <https://doi.org/10.1002/acp.1307>
- Huff, C. R., Rattner, A. & Sagarin, E. (1986). Guilty until proved innocent: Wrongful conviction and public policy. *Crime & Delinquency*, *32*, 518–544. <https://doi.org/10.1177/0011128786032004007>
- Innocence Project*. (n. d.). Verfügbar unter: <https://innocenceproject.org/>
- Itti, L. (2005). Quantifying the contribution of low-level saliency to human eye movements in dynamic scenes. *Visual Cognition*, *12*, 1093–1123. <https://doi.org/10.1080/13506280444000661>
- Johnson, C. L. (1975). *The effects of arousal on the cognitive processing of information in an eyewitness setting* (Unveröffentlichte Masterarbeit). Oklahoma State University, Stillwater, OK.
- Johnson, C. L. (1977). *The effects of arousal, sex of witness and scheduling of interrogation on eyewitness testimony* (Unveröffentlichte Dissertation). Oklahoma State University, Stillwater, OK.
- Kim, K., Park, K. K. & Lee, J.-H. (2014). The influence of arousal and expectation on eyewitness memory in a virtual environment. *Cyberpsychology, Behavior, and Social Networking*, *17*, 709–713. <https://doi.org/10.1089/cyber.2013.0638>

- Kirschbaum, C., Pirke, K.-M. & Hellhammer, D. H. (1993). The ‘Trier Social Stress Test’ – A tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, 28, 76–81. <https://doi.org/10.1159/000119004>
- Kocab, K. & Sporer, S. L. (2016). The weapon focus effect for person identifications and descriptions: A meta-analysis. In M. K. Miller & B. H. Bornstein (Eds.), *Advances in psychology and law* (vol. 1, S. 71–117). Cham: Springer. [https://doi.org/10.1007/978-3-319-29406-3\\_3](https://doi.org/10.1007/978-3-319-29406-3_3)
- Konečni, V. J. & Ebbesen, E. B. (1986). Courtroom testimony by psychologists on eyewitness identification issues: Critical notes and reflections. *Law and Human Behavior*, 10, 117–126. <https://doi.org/10.1007/BF01044563>
- Kovera, M. B. & Evelo, A. J. (2017). The case for double-blind lineup administration. *Psychology, Public Policy, and Law*, 23, 421–437. <https://doi.org/10.1037/law0000139>
- Kramer, T. H., Buckhout, R. & Eugenio, P. (1990). Weapon focus, arousal, and eyewitness memory: Attention must be paid. *Law and Human Behavior*, 14, 167–184. <https://doi.org/10.1007/BF01062971>
- Loeffler, C. E., Hyatt, J. & Ridgeway, G. (2019). Measuring self-reported wrongful convictions among prisoners. *Journal of Quantitative Criminology*, 35, 259–286. <https://doi.org/10.1007/s10940-018-9381-1>
- Loftus, E. F. (1979). *Eyewitness testimony*. Cambridge, MA: Harvard University Press.
- Loftus, E. F., Loftus, G. R. & Messo, J. (1987). Some facts about “weapon focus”. *Law and Human Behavior*, 11, 55–62. <https://doi.org/10.1007/bf01044839>
- Loftus, G. R. & Mackworth, N. H. (1978). Cognitive determinants of fixation location during picture viewing. *Journal of Experimental Psychology: Human Perception and Performance*, 4. <https://doi.org/10.1037/0096-1523.4.4.565>
- Lovullo, W. (1975). The cold pressor test and autonomic function: A review and integration. *Psychophysiology*, 12, 268–282. <https://doi.org/10.1111/j.1469-8986.1975.tb01289.x>
- Maass, A. & Köhnken, G. (1989). Eyewitness identification: Simulating the “weapon effect”. *Law and Human Behavior*, 13, 397–408. <https://doi.org/10.1007/BF01056411>
- Mansour, J. K., Hamilton, C. M. & Gibson, M. T. (2019). Understanding the weapon focus effect: The role of threat, unusualness, exposure duration, and scene complexity. *Applied Cognitive Psychology*, 33, 991–1007. <https://doi.org/10.1002/acp.3515>
- Marr, C., Quaedflieg, C. W. E. M., Otgaar, H., Hope, L. & Sauerland, M. (2021). Facing stress: No effect of acute stress at encoding or retrieval on face recognition memory. *Acta Psychologica*, 219, Artikel 103376. <https://doi.org/10.1016/j.actpsy.2021.103376>

- Marr, C., Sauerland, M., Otgaar, H., Quaedflieg, C. W. E. M. & Hope, L. (2021). The effects of acute stress on eyewitness memory: An integrative review for eyewitness researchers. *Memory*, 29, 1091–1100. <https://doi.org/10.1080/09658211.2021.1955935>
- Mecklenburg, S. H. (2006). *Report to the legislature of the State of Illinois: The Illinois Pilot Program on sequential double-blind identification procedures*. Springfield, IL: Illinois State Police.
- 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, 3–35. <https://doi.org/10.1037/1076-8971.7.1.3>
- Mitchell, K. J., Livosky, M. & Mather, M. (1998). The weapon focus effect revisited: The role of novelty. *Legal and Criminological Psychology*, 3, 287–303. <https://doi.org/10.1111/j.2044-8333.1998.tb00367.x>
- Peters, D. P. (1988). Eyewitness memory and arousal in a natural setting. In M. M. Gruneberg, P. E. Morris & R. N. Sykes (Hrsg.), *Practical aspects of memory: Current research and issues. Vol. 1: Memory in everyday life* (S. 89–94). Chichester: Wiley.
- Pickel, K. L. (1998). Unusualness and threat as possible causes of “weapon focus”. *Memory*, 6, 277–295. <https://doi.org/10.1080/741942361>
- Pickel, K. L. (1999). The influence of context on the “weapon focus” effect. *Law and Human Behavior*, 23, 299–311. <https://doi.org/10.1023/A:1022356431375>
- Pickel, K. L. (2009). The weapon focus effect on memory for female versus male perpetrators. *Memory*, 17, 664–678. <https://doi.org/10.1080/09658210903029412>
- Pickel, K. L. (2015). Eyewitness memory. In J. M. Fawcett, E. F. Risko & A. Kingstone (Hrsg.), *The handbook of attention* (S. 485–502). Cambridge, MA: MIT Press. <https://doi.org/10.7551/mitpress/10033.003.0024>
- Pickel, K. L. & Sneyd, D. E. (2018). The weapon focus effect is weaker with Black versus White male perpetrators. *Memory*, 26, 29–41. <https://doi.org/10.1080/09658211.2017.1317814>
- Rhodes, M. G. & Anastasi, J. S. (2012). The own-age bias in face recognition: A meta-analytic and theoretical review. *Psychological Bulletin*, 138, 146–174. <https://doi.org/10.1037/a0025750>
- Rolfs, M., Jonikaitis, D., Deubel, H. & Cavanagh, P. (2011). Predictive remapping of attention across eye movements. *Nature Neuroscience*, 14, 252–256. <https://doi.org/10.1038/nn.2711>

- Sauerland, M., Raymaekers, L. H. C., Otgaar, H., Memon, A., Waltjen, T. T., Nivo, M. et al. (2016). Stress, stress-induced cortisol responses, and eyewitness identification performance. *Behavioral Sciences & the Law*, *34*, 580–594. <https://doi.org/10.1002/bsl.2249>
- Scrivner, C., Choe, K. W., Henry, J., Lyu, M., Maestripieri, D. & Berman, M. G. (2019). Violence reduces attention to faces and draws attention to points of contact. *Scientific Reports*, *9*, Artikel 17779. <https://doi.org/10.1038/s41598-019-54327-3>
- Shaw, J. I. & Skolnick, P. (1994). Sex differences, weapon focus, and eyewitness reliability. *Journal of Social Psychology*, *134*, 413–420. <https://doi.org/10.1080/00224545.1994.9712191>
- Smeets, T., Cornelisse, S., Quaedflieg, C. W. E. M., Meyer, T., Jelicic, M. & Merckelbach, H. (2012). Introducing the Maastricht Acute Stress Test (MAST): A quick and non-invasive approach to elicit robust autonomic and glucocorticoid stress responses. *Psychoneuroendocrinology*, *37*, 1998–2008. <https://doi.org/10.1016/j.psyneuen.2012.04.012>
- Sporer, S. L., Sauerland, M. & Kocab, K. (2014). Personenidentifizierung. In T. Bliesener, F. Lösel & G. Köhnken (Hrsg.), *Lehrbuch Rechtspsychologie* (S. 156–182). Bern: Huber.
- Stebly, N. M. (1992). A meta-analytic review of the weapon focus effect. *Law and Human Behavior*, *16*, 413–424. <https://doi.org/10.1007/bf02352267>
- Stennett, R. G. (1957). The relationship of performance level to level of arousal. *Journal of Experimental Psychology*, *54*, 54–61. <https://doi.org/10.1037/h0043340>
- Tatler, B. W. (2007). The central fixation bias in scene viewing: Selecting an optimal viewing position independently of motor biases and image feature distributions. *Journal of Vision*, *7*(14), Artikel 4. <https://doi.org/10.1167/7.14.4>
- Tollestrup, P. A., Turtle, J. W. & Yuille, J. C. (1994). Actual victims and witnesses to robbery and fraud: An archival analysis. In D. F. Ross, J. D. Read & M. P. Toglia (Eds.), *Adult eyewitness testimony. Current trends and developments* (S. 144–160). Cambridge: Cambridge University Press. <https://doi.org/10.1017/CBO9780511759192.008>
- Tooley, V., Brigham, J. C., Maass, A. & Bothwell, R. K. (1987). Facial recognition: Weapon effect and attentional focus. *Journal of Applied Social Psychology*, *17*, 845–859. <https://doi.org/10.1111/j.1559-1816.1987.tb00294.x>
- Valentine, T., Pickering, A. & Darling, S. (2003). Characteristics of eyewitness identification that predict the outcome of real lineups. *Applied Cognitive Psychology*, *17*, 969–993. <https://doi.org/10.1002/acp.939>

- Võ, M. L.-H., Aizenman, A. M. & Wolfe, J. M. (2016). You think you know where you looked? You better look again. *Journal of Experimental Psychology: Human Perception and Performance*, *42*, 1477–1481. <https://doi.org/10.1037/xhp0000264>
- Võ, M. L.-H. & Henderson, J. M. (2009). Does gravity matter? Effects of semantic and syntactic inconsistencies on the allocation of attention during scene perception. *Journal of Vision*, *9*(3), Artikel 24. <https://doi.org/10.1167/9.3.24>
- Vogel, S. & Schwabe, L. (2016). Stress in the zoo: Tracking the impact of stress on memory formation over time. *Psychoneuroendocrinology*, *71*, 64–72. <https://doi.org/10.1016/j.psyneuen.2016.04.027>
- Weaver, G. S., Wittekind, J. E. C., Huff-Corzine, L., Corzine, J., Petee, T. A. & Jarvis, J. P. (2004). Violent encounters. A criminal event analysis of lethal and nonlethal outcomes. *Journal of Contemporary Criminal Justice*, *20*, 348–368. <https://doi.org/10.1177/1043986204269381>
- Wells, G. L. (1978). Applied eyewitness-testimony research: System variables and estimator variables. *Journal of Personality and Social Psychology*, *36*, 1546–1557. <https://doi.org/10.1037/0022-3514.36.12.1546>
- Wells, G. L., Leippe, M. R. & Ostrom, T. M. (1979). Guidelines for empirically assessing the fairness of a lineup. *Law and Human Behavior*, *3*, 285–293. <https://doi.org/10.1007/BF01039807>
- West, E. & Meterko, V. (2016). Innocence Project: DNA exonerations, 1989-2014: Review of data and findings from the first 25 years. *Albany Law Review*, *79*, 717–795.
- Williams, C. C. & Castelhana, M. S. (2019). The changing landscape: High-level influences on eye movement guidance in scenes. *Vision*, *3*(3), Artikel 33. <https://doi.org/10.3390/vision3030033>
- Wu, C.-C., Wick, F. A. & Pomplun, M. (2014). Guidance of visual attention by semantic information in real-world scenes. *Frontiers in Psychology*, *5*, Artikel 54. <https://doi.org/10.3389/fpsyg.2014.00054>
- Yerkes, R. M. & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology*, *18*, 459–482. <https://doi.org/10.1002/cne.920180503>