The Effect of Noun Capitalization when Reading German and English

Dissertation zur Erlangung des akademischen Grades

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I. Einleitung

Das Promotionsprojekt, dessen Ergebnisse mit der vorliegenden Dissertation dargestellt werden, hatte als Ziel, die Fragestellung zu beantworten, ob die strukturelle wortinitiale Substantivgroßschreibung, wie sie sich neben dem Deutschen sonst nur noch im Luxemburgischen finden lässt, über eine Funktion verfügt, die dem Leser einen Vorteil bringt. Die übergeordnete Hypothese war, dass ein Vorteil dadurch erreicht wird, dass durch die parafoveale Wahrnehmung der Majuskel bereits eine syntaktische Kategorie, nämlich der Kern einer Nominalgruppe, aktiviert wird. Durch diese Wahrnehmung aus dem Augenwinkel sollte das nachfolgende Substantiv schon vorverarbeitet werden können. Im Ergebnis sollte eine Erleichterung der Satzverarbeitung bewirkt werden, was sich letztlich in insgesamt schnelleren Lesezeiten zeigen sollte.

Die dazu bereits vorliegende Forschung aus den 1980er- und frühen 1990er-Jahren (u.a. Bock, Augst, und Wegner 1985; Bock, Hagenschneider, und Schweer 1989; Bock 1989), machte einen positiven Effekt der Substantivgroßschreibung aus. Diese Forschung stellte zweifellos Pionierarbeit dar. Da die Ergebnisse der Studien auf dem Vergleich von Gesamtlesezeiten unterschiedlicher Schreibungsvarianten basieren, entschieden wir uns, uns der o.g. Forschungsfrage mittels Eye-tracking-Studien anzunähern, welche beispielsweise in einer Studie von Gfroerer und Kollegen (1989), die an die weiter oben referenzierten Studien von Bock et al. angelehnt war, gemacht wurde. Die, seit den Studien von Gfroerer et al. (1989) immer weiter ausdifferenzierte, Eye-tracking-Technik, lässt es zu, mehr als nur reine Lesezeiten zu vergleichen, und erlaubt es, beispielsweise Einzelfixationsdauern zu untersuchen.

Um sich der Beantwortung der Forschungsfrage anzunähern, war es nötig, ein Untersuchungsdesign zu schaffen, das im Falle eines Vergleichs von Sätzen mit wortinitialer Substantivgroßschreibung und solchen, bei denen diese normwidrig fehlt, unterschiedliche Fixationszeiten nicht auf den Gewöhnungsfaktor, das heißt die Gewohnheit der korrekten Orthographie, zurückgeführt werden sollten, denn es ist erwartbar, dass Sätze mit orthographisch falsch geschriebenen Bestandteilen langsamer als korrekt geschriebene Sätze verarbeitet werden. Aus dieser unterschiedlichen Verarbeitungszeit wiederum ließe sich die Funktion der Substantivgroßschreibung jedoch nicht ableiten.

In einem ersten Experiment (nachfolgend **Studie 1**) entschieden wir uns deshalb für ein Design, das mittels semantischem Priming und der Erstellung sogenannter Holzwegsätze die Funktionsweise der Substantivgroßschreibung für den Leser hervorbringen sollte.

Um die Fragestellung ganzheitlich und zufriedenstellend beantworten können, ist die Untersuchung, ob ein Sprachtransfer dieser zwar dem Grunde nach simplen orthographischen Regel stattfinden kann, die aber für die hinter dieser Regel stehende Markierung der Satzstruktur nicht unentscheidend ist, notwendig. Dementsprechend replizierten wir in einem zweiten Schritt das Design der ersten Studie, indem wir englischsprachige Items kreierten (nachfolgend **Studie 2**). Neben der Untersuchungssprache Englisch, die keine systematische Substantivgroßschreibung kennt, trugen wir der Untersuchung des Sprachtransfers durch die Variation der Versuchspersonengruppen Rechnung. Insgesamt nahmen drei Versuchspersonengruppen an dieser zweiten größeren Studie teil: 1) Englische L1-Sprecher gänzlich ohne Deutschkenntnisse, 2) englische L1-Sprecher, die regelmäßig deutsche Texte lesen, 3) deutsche L1-Sprecher mit exzellenten Englischkenntnissen. Durch diese Auswahl wollten wir eine weitgehende Ganzheitlichkeit erreichen: Die Gruppe ohne Deutschkenntnisse sollte als Referenzgruppe dienen, da dort auf Grund der fehlenden Systematik im Englischen keine oder nur eine geringe vorteilhafte Nutzung der Majuskel im Leseprozess zu erwarten war. Anders sah es bei den englischen L1-Sprechern mit regelmäßiger Leserezeption der deutschen Sprache aus, bei denen es zu überprüfen galt, ob der vermutete Vorteil der Substantivgroßschreibung auf die eigene Erstsprache übertragbar ist, was zu einer schnelleren bzw. veränderten Verarbeitung gegenüber den englischen L1-Sprechern ohne Deutschkenntnisse führen sollte. Die gleiche Annahme wie bei den englischen Versuchspersonen mit Deutschkenntnissen galt für die deutschen L1-Sprecher mit exzellenten Englischkenntnissen, jedoch sollte auf Grund der Zweitsprachrezeption insgesamt eine langsamere Verarbeitung stattfinden. Die englischen L1-Sprecher galten also als Referenzgruppe, wohingegen die beiden anderen Gruppen jeweils dazu dienen sollten, ob ein Sprachtransfer der Substantivgroßschreibung und ihres vermuteten Vorteils stattfindet. Der Transfer konnte dadurch doppelt überprüft werden: Einerseits der Transfer von einer Zweit- oder Drittsprache auf die Erstsprache (englische Versuchspersonen) und anderseits von der Erstsprache auf die Zweitsprache (deutsche Versuchspersonen).

Da wir *ex post* in den Studien 1 und 2 den Einfluss der Substantivfrequenz auf die Verarbeitung von Adjektiv und Substantiv in Abhängigkeit der Substantivschreibung analysierten und

Hinweise auf ein (parafoveales) Zusammenspiel von Substantivfrequenz und Substantivschreibung fanden, untersuchten wir in einer dritten Experimentreihe (nachfolgend **Studie 3**) den Einfluss der Substantivfrequenz auf eine potentielle Vorverarbeitung. Die Idee war, dass sich der Vorteil der Substantivgroßschreibung nur unter bestimmten Bedingungen entfalten kann, nämlich dann, wenn das Substantiv großgeschrieben und hochfrequent ist. In diesem Falle, also einem großgeschriebenen hochfrequenten Substantiv, sollten die Lesezeiten auf dem Wort *vor* dem Substantiv, höher sein – verglichen beispielsweise mit einem niedrigfrequenten und/oder kleingeschriebenen nachfolgenden Substantiv. Die Hypothese war, dass eine Vorverarbeitung auf dem vorigen Wort nur dann möglich ist, wenn die Majuskel die Kategorie Substantiv „aktiviert" und die hohe Frequenz eine Vorverarbeitung auf dem Wort vor dem Substantiv ermöglicht. Im Falle des Fehlens der Majuskel wäre die Substantivkategorie nicht aktiviert worden, im Falle einer niedrigen Frequenz wäre eine Vorverarbeitung unökonomisch gewesen bzw. die Verarbeitungskapazitäten hätten nicht ausgereicht. Der Effekt, auf dem diese Hypothese fußte, ist bezogen auf die Frequenz ein sogenannter lexikalischer Parafovea-auf-Fovea-Effekt (für einen Überblick: Schotter, Angele, und Rayner 2012). Dieser hochumstrittene Effekt zeigt sich eigentlich darin, dass die Lesezeiten auf einem Wort vor einem Zielwort dann kürzer sind, wenn die Frequenz des Zielworts hoch ist im Vergleich zu einem niedrigfrequenten Zielwort. Wir haben diesen Effekt im Zusammenspiel mit der Majuskel dahingehend hypothetisch umgedeutet, dass eine parafoveale, d.h. das, was man, vereinfacht gesagt, aus dem Augenwinkel wahrnimmt, Vorverarbeitung eben überhaupt nur messbar bei einem hochfrequenten Wort mit Majuskel stattfindet. Diese Vorverarbeitung sollte dann eben zusätzlich zu der eigentlich stattfindenden fovealen (= Bereich der größten Sehschärfe) Verarbeitung, d.h. das Wort, das gerade fixiert wird, addiert werden. Die eigentliche Verarbeitung des nachfolgenden Substantivs sollte dann deutlich niedriger ausfallen, so dass in der Summe ein Verarbeitungsvorteil entsteht, sprich, die Kosten der Vorverarbeitung auf dem vorangegangenen Wort sollten mehr als aufgewogen werden.

Um dieses Zusammenspiel von Frequenz und Majuskel nachzuweisen, bedienten wir uns des *boundary paradigm* (Rayner 1975), das es ermöglicht, den Bildschirm bzw. hier Sätze während des Lesens nach Überschreiten nach einer unsichtbaren Grenze zu verändern – dies geschieht im Regelfall unbemerkt für den Leser. Mittels dieser Technik konnten wir ein Untersuchungsdesign erzeugen, das beispielsweise eine parafoveale Majuskelpräsentation,

aber eine foveale Minuskelpräsentation ermöglichte. Dies war auch umgekehrt möglich, so dass man das Substantiv aus dem Augenwinkel kleingeschrieben, aber im Falle der direkten fovealen Fixierung großgeschrieben verarbeitete. Darüber hinaus präsentierten wir die Sätze auch ohne Veränderung der Substantive, variierten jedoch die Schreibung, indem die Substantive entweder durchgängig groß- oder kleingeschrieben wurden.
Neben der Untersuchung deutschsprachiger Versuchspersonen, die diese Versuchsanordnung im Deutschen durchliefen, gingen wir auch hier der Frage nach einem potentiellen Sprachtransfer nach. Wiederum entschieden wir uns für das Englische, auch um die Vergleichbarkeit mit den vorigen Experimenten herzustellen. Dabei wählten wir erneut englische L1-Sprecher ohne Deutschkenntnisse sowie deutsche L1-Sprecher mit überdurchschnittlichen Englischkenntnissen.

Diese Dissertation ist inhaltlich wie folgt aufgebaut:
In Kapitel II stelle ich überblicksartig die diachrone und synchrone Entwicklung der Groß- und Kleinschreibung allgemein sowie ihrer Didaktik dar, bevor ich den Forschungsstand bezogen auf vorliegende empirische Arbeiten, die der Frage nach einer Funktion der Groß- und Kleinschreibung für den Leser nachgehen, vorstelle, diskutiere und in den Kontext von oben beschriebener **Studie 1** anhand vorläufiger deskriptiver Daten einbette. Die der Studie zugrunde liegende Methode des Eye-Tracking-Verfahrens sowie dessen gängige Parameter werden zunächst erläutert. Abschließend werden die Resultate in einen didaktischen Kontext eingefügt.
In Kapitel III-V werden nacheinander die Ergebnisse der **Studien 1-3** mittels inferenzstatistischer Verfahren analysiert, diskutiert und in den Kontext der Forschung eingebettet, bevor ich in Kapitel VI ein Abschlussfazit ziehe.

Anmerkung zum formalen Aufbau:
Da die Inhalte der Kapitel II und III bereits publiziert sind, wurde der Text jeweils in der Fassung der Publikation eingefügt (minimale Abweichungen sind möglich), dementsprechend unterscheiden sich die Zitationsstile sowie die Sprachen der Texte. Darüber hinaus wurden die Abbildungs- und Tabellennummern kapitelweise vergeben. Aus diesem Grund verfügt jedes Kapitel über ein eigenes Literatur-, Tabellen- und Abbildungsverzeichnis.

II. Die Groß- und Kleinschreibung (beim Lesen) – kognitive Prozesse und didaktische Implikationen

II.1 Vorbemerkung und Errata

Dieser Abschnitt basiert auf: Pauly, Dennis Nikolas & Nottbusch, Guido (2016). Die Groß- und Kleinschreibung (beim Lesen) – kognitive Prozesse und didaktische Implikationen. In: System, Norm und Gebrauch - drei Seiten derselben Medaille? Orthographische Kompetenz und Performanz im Spannungsfeld zwischen System, Norm und Empirie, Edition: Thema Sprache - Wissenschaft für den Unterricht, Publisher: Schneider-Verlag Hohengehren, Editors: Birgit Mesch, Christina Noack, pp.122-145.

In Kapitel II.7 „Gegenwärtige Tendenzen“ passt der Beispielsatz nicht zur Kasusbezeichnung, entweder man lässt die Präposition *an* weg, ggf. ersetzt durch die Präposition ob, ggf. nur mit freuen *Er [er]freut sich [ob] der Dicke der Wand* (= Dicke der Wand, explizites Derivat, Gen. Sg.) oder man konstruiert den Satz leicht um *Er ist ein Fan der Dicke der Wand* (= Dicke der Wand, explizites Derivat, Gen. Sg.) – an der Argumentation ändert es nichts.

Seit dem 29. Juni 2017 ist das große ß Bestandteil der amtlichen deutschen Rechtschreibung – als der Text verfasst wurde, war dem noch nicht so.

II.2 Abstract

Der folgende Artikel thematisiert überblicksartig die diachrone und synchrone Entwicklung der Groß- und Kleinschreibung allgemein sowie ihrer Didaktik. Weiterhin werden vorliegende empirische Arbeiten, die der Frage nach einer Funktion der Groß- und Kleinschreibung für den/die Leser/in nachgehen, vorgestellt, diskutiert und in den Kontext einer eigenen Blickbewegungsstudie (Eye-Tracking) eingebettet. Die der Studie zugrunde liegende Methode des Eye-Tracking-Verfahrens sowie dessen gängige Parameter werden zunächst erläutert. Das Design der Studie – leises Lesen manipulierter Einzelsätze –, welches der Kritik an bisherigen Forschungsstudien Rechnung trägt, wird ebenso wie deren Ergebnisse vorgestellt. Die Ergebnisse zeigen im Gegensatz zu bisherigen älteren Forschungsarbeiten, die allesamt eine Funktion für den/die Leser/in ausgemacht haben, nur Tendenzen, die auf einen Nutzen zwar hindeuten, ein signifikanter Nachweis jedoch konnte nicht erbracht werden. Abschließend werden die Resultate in einen didaktischen Kontext eingefügt.

II.3 Einleitung

„*Bildungsvergleich. Rechtschreibtest für Grundschüler*“ (Schmoll 2015b); „*Mangelnde Bildung. Rechtschreibung lehren!*“ (Schmoll 2015a); „*Orthographie in Schulen. Schraibm nach gehöa.*“ (Rasche 2015). Diese exemplarische Nennung von drei Artikeln, die alle im März 2015 in der Frankfurter Allgemeinen (Sonntags-)Zeitung erschienen, könnte beliebig auf andere Medien ausgedehnt werden. Plakativ formuliert könnte man die Rechtschreibung als des Deutschen liebste und als bedrohtest wahrgenommene Norm definieren. Einen nicht unerheblichen Teil dieser Norm macht die Groß- und Kleinschreibung (im Folgenden kurz: GKS) aus, deretwegen bereits erbitterte Debatten ausgefochten wurden.

Es ist bemerkenswert, dass bereits 1955 folgender Satz formuliert wurde:

Was der Satzbau verkorkst, macht die Großschreibung, wenigstens zum Teil, auch in diesem Fall gut: sie gliedert fürs Auge, fängt und lenkt den Blick, sie gibt in vielen Fällen sogar grammatische Hinweise. (Hotzenköcherle 1955: 42)

Diese in sich auf den ersten Blick logische und nachvollziehbare Aussage wäre im Falle ihres Zutreffens eine eindeutige Legitimation für die Existenz der satzinternen GKS. Eine überzeugende empirische Überprüfung steht jedoch aus (s. u.). Der nachfolgende Beitrag soll helfen, die Frage, ob die GKS dem/der Leser/in einen Nutzen bringt, zu beantworten. Neben einigen Vorbemerkungen soll zunächst ein diachroner und synchroner Überblick zur GKS gegeben werden mit anschließender Betrachtung des Forschungsstandes empirischer Studien. In einem gesonderten Abschnitt werden wir überblicksartig eine von uns durchgeführte Eye-Tracking-Studie vorstellen und deren Ergebnisse diskutieren. Die Didaktik und sich aus der Studie ergebende didaktische Implikationen werden dabei stets im Blick behalten.

II.4 Vorbemerkungen

„Für geschriebene Sprache herrscht allgemein stärkeres Normbewußtsein als für gesprochene Sprache“ (Lewandowski 1990: 1039) – eine Erkenntnis, die sich für das Deutsche sehr eindeutig an der Existenz einer verbindlichen Orthographie nachweisen lässt, untermauert durch deren hohen gesellschaftlichen Stellenwert. Im Falle der GKS ist diese Norm nicht nur in der gesprochenen Sprache nicht existent, sondern darüber hinaus in der geschriebenen Sprache weitestgehend funktionslos für den/die Schreiber/in. Der/die Schreiber/in wird – ganz im Gegenteil – vor kognitive Herausforderungen gestellt, was sich darin zeigt, dass der Bereich der GKS in verschiedenen Studien für Schüler/innen ab der vierten Klasse als der fehlerträchtigste der deutschen Orthographie identifiziert wurde (vgl. Moser 1958; Menzel 1985; Zimmermann/ Heckel 1986; Zabel 1992; Kluge 1995; Röber-Siekmeyer 1999; Günther/Nünke 2005; Granzow-Emden 2002; Siekmann/Thomé 2012). Jeder vierte Rechtschreibfehler stammt in der 3. und 4. Klasse aus dem Bereich der GKS (vgl. Menzel 1985; Siekmann/Thomé 2012) und betrifft nach Menzel (1985) auch den Kernbereich.[1] Einen Hinweis auf die Komplexität der Thematik gibt bereits das Amtliche Regelwerk, in dem die

[1] Ergänzend sei angemerkt, dass den Erhebungen unterschiedliche Normierungen zugrunde lagen: vor der Rechtschreibreform 1996 sowie zwischen dieser bis zur gegenwärtig gültigen Rechtschreibung 2006. Die Veränderungen im Bereich der Groß- und Kleinschreibungen waren jedoch nicht struktureller Natur und sind dem Peripheriebereich zuzuschreiben, siehe auch unten.

GKS-Regeln neben denen für die Interpunktion den mit Abstand größten Raum einnehmen. Das vielfach vorgebrachte Argument, dass die GKS Ambiguitäten auflöse, wurde durch Korpusuntersuchungen (Augst 1980; ähnlich auch bezüglich Ambiguität: Mentrup 1979a) widerlegt. Augst zeigte, dass Satzambiguitäten in weniger als einem Prozent der Fälle überhaupt existieren und sich vollständig durch den Kontext auflösen. Sätze wie „ich habe in moskau liebe genossen“ wirken zumeist konstruiert.[2, 3]

Es gilt also zu überprüfen, ob es aus psycholinguistischer Sicht Gründe dafür gibt, warum das Deutsche, das neben dem eng verwandten Luxemburgischen die letzte verbliebene Sprache ist, die Substantive mit einer Majuskel auszeichnet (im Dänischen wurde dies im Zuge einer Rechtschreibreform im Jahre 1948 abgeschafft). Falls nicht, wären aus rationaler Sicht nur noch die Ästhetik des Schriftbildes, Traditionalismus sowie die Kosten einer Umstellung die einzig verbleibenden Gründe für den Erhalt der satzinternen Großschreibung.[4]

II.5 Historischer Abriss

Der nachfolgende Abschnitt soll überblicksartig darstellen, wie sich die Groß- und Kleinschreibung als orthographischer Regelbereich im Deutschen in der heutigen Norm etablieren konnte. Vorweg sei gesagt, dass es sich dabei nicht um eine von Grammatikern explizit entwickelte Norm handelt. Während in der Antike Majuskelschriften vorherrschten, kamen zwischen dem 7. und 9. Jahrhundert Minuskelschriften auf. Für das Deutsche am bedeutsamsten war die „karolingische Minuskel“.[5] Im Zuge dessen können sich Großbuchstaben als auszeichnende Elemente – mit Ausnahme des <ß>, das nur als Kleinbuchstabe existiert – in zwei parallel angelegten Schriftzeicheninventaren überhaupt erst etablieren. Die (satzinitiale) Großschreibung ist bereits im Althochdeutschen sichtbar und ab

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[2] Dem häufig verwendeten Argument der Befürworter einer Kleinschreibung, dass andere Sprachen ebenfalls ohne die Großschreibung auskämen und keinen Nachteil hätten, entgegnet Hotzenköcherle (1955: 44), dass das Französische im Gegensatz zum Deutschen eine postdeterminierende Sprache sei, sodass das Substantiv immer an erster Stelle stehe, was nachvollziehbar erscheint. Etwas weniger nachvollziehbar ist die Zurückweisung der Vergleichbarkeit mit dem Englischen, weil dies sehr starr dem Subjekt-Objekt-Prinzip folge (vgl. ebd.). Das mag sein, aber gerade im Englischen, wo beispielsweise Komposita in den seltensten Fällen mit einem Bindestrich verbunden werden, sondern durch ein Spatium getrennt sind, und der Wortstatus somit nicht eindeutig erkennbar ist, sollte das doch eher zu Verwirrungen und Problemen führen
(vgl. „university staff member“ vs. „Universitätsmitarbeiter“;
„Bertolt Brecht complete edition“ vs. „Bertolt-Brecht-Gesamtausgabe“).

[3] Davon unbenommen sind die Ergebnisse von Funke/Sieger (2009), nach denen Schüler/innen in unterschiedlich starkem Ausmaß auf konstruierte Ambiguitäten reagieren.

[4] Die von Hotzenköcherle (1955: 47) aufgestellte These, dass auf Grund der zentralen Bedeutung der Satzklammer die Syntax des Deutschen bei einer durchgängigen Kleinschreibung in Gefahr wäre, erscheint gewagt und nicht hinreichend belegt.

[5] Nach Licht (2012) ist die karolingische Minuskel wahrscheinlich älter als angenommen und somit bereits vor der Zeit Karls des Großen entwickelt worden. Nerius (2007) verwendet den Plural „karolingische Minuskeln“, ebenfalls verwendet wird „karlingische Minuskel“.

dem 15. Jahrhundert für Text-, Strophen- und Versanfang Usus, ab dem 16. Jahrhundert für den Beginn eines Ganzsatzes. Dass sie hinsichtlich einer besseren Gliederung und Lesbarkeit syntaktisch bzw. textuell motiviert ist, erscheint (abgesehen von untergeordneten ästhetischen Aspekten) unstrittig. Nerius (2007: 196f.) sieht für die Herausbildung der wortinitialen Großschreibung drei sich kreuzende Grundsätze, die er als semantisch bzw. pragmatisch bestimmt ansieht; jedoch handelt es sich maßgeblich um Wörter substantivischer Teilklassen:

1. Wortklassenindifferenter Hervorhebungsgrundsatz: Dieser bezieht sich vollkommen unabhängig von der Wortart auf Wörter, die inhaltlich bedeutsam sind.
2. Markierung von Propria (Eigennamen) und proprialer Teilklassen: Dies bezieht sich u. a. auf Personennamen und geographische Namen; später wird dies auf Sachnamen ausgeweitet.
3. Kennzeichnung der Respektbekundung, Ehrerbietung und Höflichkeit: Nomina sacra (z. B. Gott), Titel, Standes- und Amtsbezeichnungen.

Die Großschreibung wird – wie andere Bereiche der Orthographie auch – maßgeblich von den Druckern bestimmt und beeinflusst. Im 16. Jahrhundert weitet sich die Tendenz zur Großschreibung stark aus, bis es dann im 17. Jahrhundert zu einer vermehrten Abstrakta-Großschreibung und einer somit letztlich grammatisch motivierten Auszeichnung der Wortart „Substantiv“ kommt, da nach 1650 die Zahl der Markierungen von Nicht-Substantiven deutlich abnimmt. Dabei gab es im deutschen Sprachraum regionale Unterschiede, jedoch hatte sich bis zum Ende des 17. Jahrhunderts die Substantivgroßschreibung weitgehend durchgesetzt. Dies ist im Grunde genommen die „Norm, wie sie im Grundsatz bis heute in der deutschen Orthographie Gültigkeit besitzt“ (Nerius 2007: 197). Interessant erscheint das Verhalten der Grammatiker dieser Zeit. Während die satz- und textinitiale Großschreibung von den Autoren des 16. und 17. Jahrhunderts beschrieben wurde, verhält es sich mit der wortinitialen Großschreibung anders. Diese wird in den Grammatiken größtenteils außer Acht gelassen, und wenn überhaupt bemerkt, dann lediglich beschrieben (so z. B. Johann Becherer im 16. Jhdt.), so dass von einem Mitwirken oder Einfluss der Grammatiker auf die Entstehung der Norm nicht ausgegangen werden kann. Nerius (2007: 200) äußert sich dazu wie folgt:

Sicher ist nur, dass diese Entwicklung nicht ursächlich auf den Einfluss der Grammatiker zurückgeht oder gar eine Erfindung der Grammatiker darstellt. Sie haben vielmehr fast immer nur auf den vorgefundenen Schreibgebrauch reagiert, mitunter und vor allem in der Anfangsphase sogar mit beträchtlicher Verspätung gegenüber dem tatsächlichen Gebrauch [...].

Nerius (2007: 199) hält es jedoch für möglich, dass sie durch ihre Beschreibungen den generellen Gebrauch gefördert haben. Erst *nach* der Etablierung der Norm Ende des 17. Jahrhunderts fanden sich Stimmen, die über den Gebrauch hinausgingen: Die Zahl der Grammatiken, in denen eine Beschreibung der Großschreibung fehlte, nahm ab, und durch das Verfassen von Lehr- und Regelwerken durch führende Sprachgelehrte wie Freyer (1722), Gottsched (1748) und Adelung (u. a. 1781/1788) wurde die Norm letztlich gefestigt. Die beiden letztgenannten hatten mit ihren Werken dann auch Einfluss auf die Didaktik, worauf weiter unten eingegangen wird.

Maas (2011: 21ff.) vertritt die These, dass ausschlaggebend für die Entwicklung der GKS das Lateinische war, das den im Lateinischen und der Sprachanalyse ausgebildeten Druckern (ebd.: 24) als Matrix für die aufkommende deutsche Schriftsprache diente. Er interpretiert dabei die Großschreibung als „Strukturkopie aus dem Lateinischen: der graphischen Repräsentation der Kohäsion einer komplexen nominalen Gruppe durch die Auszeichnung ihres Kerns“ (ebd.: 21). Er sieht diese Praxis als „Grammatikalisierung“ (ebd.: 22) an, die bis zur zweiten Hälfte des 16. Jahrhunderts fest verankert ist. Während Maas die GKS bereits in ihrer Geburtsstunde als syntaktisch geprägt ansieht, argumentiert kontrastierend dazu Nerius – der die wortinitiale Großschreibung auch synchron noch als lexikalisch definiert – zusammen mit Bergmann, dass bei der Herausbildung der GKS eine Dominanz semantischer und pragmatischer Faktoren vorherrschend waren (vgl. Bergmann/Nerius 1998: 971). Ähnlich äußert sich auch Bredel (2006: 153), indem sie schreibt, dass die Großschreibung in ihren Anfängen weit davon entfernt sei, syntaktische Eigenschaften sprachlicher Ausdrücke zu kennzeichnen und die Pragmatik ebenfalls als zentral ansieht. Dass auch adjektivische Ableitungen substantivischer Bezeichnungen großgeschrieben wurden, erscheint als gewichtiges Gegenargument zur syntaktischen Deutung (vgl. Nerius 2007: 197).

Die Herausbildung der Norm erscheint ebenso umstritten oder zumindest so polarisierend zu sein, wie die Norm selbst. In jedem Falle ist die Auseinandersetzung mit der historischen Entwicklung der GKS vor dem Hintergrund ihrer Evaluation hinsichtlich einer Nutzbarkeit aus gegenwärtiger Sicht relevant, da der Entstehungsprozess, wenn er systematisch erfolgt wäre, eher auf einen grammatischen Nutzen hindeuten würde. Auch wenn völlig ungrammatische

Aspekte wie z. B. Ehrerbietungen sozialer und religiöser Art nur einen kleinen Teil der Großschreibungen ausmachten, bleibt zu konstatieren, dass diese bei der Genese zumindest mitwirkten.

II.6 Didaktik historisch

Die didaktische Entwicklung der Vermittlung der GKS zum wortartbezogenen Ansatz hat Maas (2011: 31ff.) überzeugend nachgezeichnet. Er sieht den entscheidenden Wendepunkt in der Reformation: Im präreformatorischen Bildungssystem verfügte die Kirche noch weitestgehend über das Bildungsmonopol. Der Kanon für Schreibanfänger/innen sah Latein als Ausbildungssprache für die Schrift vor, was klassischen Grammatikunterricht einschloss. Mit der Reformation fiel dieses Monopol und die Volksschule wurde gegründet. Es kam in manchen Vorgängerstaaten des späteren Deutschen Reiches zur Einführung der Schulpflicht und der Gründung der Volksschule, welche sich rasch ausbreitete (vgl. Noack 2015: 32). Deren vorrangiges Bestreben war die Erziehung zum Christenmenschen, sodass Fertigkeiten wie Lesen und Schreiben mit dem Ziel, den klerischen Nachwuchs auszubilden, nicht länger im Vordergrund standen. Der Reformator Philipp Melanchthon schrieb eine pädagogische Grammatik (1526) und beschreibt darin Regeln, die er fachlich zwar für falsch, allerdings für kindgerecht hielt. Dazu gehören beispielsweise die Begriffe „Tu-“ und „Dingwörter“, womit bereits im 16. Jahrhundert die syntaktische Analyse erschwert war. Umgesetzt wurden diese grammatischen Vorgaben beispielsweise von Comenius in dem Fibelvorläufer *Orbis sensualium pictus* (1658), in welchem „Dingwörter“ sowohl für das Deutsche als auch das Lateinische (!) mit Majuskeln versehen wurden.

Die in der grammatischen Theorie vorliegende Auffassung vom obersten Rang der Substantive unter den Wortarten wurde mit der Bezeichnung „Hauptwort“ durch Gottsched in der *Grundlegung einer Deutschen Sprachkunst* (1748) zum grammatischen Terminus für das Substantiv (vgl. Nerius 2007: 200). Dieser Grundsatz wurde von Adelung dann in dem Werk *Vollständige Anweisung zur Deutschen Orthographie* (1788) auch für die Schule festgelegt, nämlich als Forderung „die Wörter nach dem Maße ihrer Wichtigkeit auch für das Auge auszuzeichnen“ und so „die großen Anfangsbuchstaben für Wörter von dem ersten Range" zu verwenden (Adelung 1788: 338, zitiert nach Maas 2011: 33). Es spricht somit einiges dafür, dass die Saatkörner für den wortartbezogenen Ansatz für das Substantiv sowohl didaktisch als auch sprachwissenschaftlich früh ausgesät wurden. Diese These wird nicht nur durch den

nachfolgenden Ausspruch des Lehrers Schubert aus dem Jahre 1817 untermauert, sondern bringt das bis heute gültige Dilemma anschaulich zum Ausdruck:

> Jetzt mache ich mittels des artikels der, die, das dem Kinde begreiflich, was hauptwoerter sind und diktiere nun: das gruene, rothe, blaue, gelbe Band, Tuch oder sonst etwas ... ich sehe nach, und das Kind hat geschrieben: Gruene, Rothe, Blaue, Gelbe Band, ich streiche die großen Buchstaben weg und ermahne es, aufzumerken und die Regel zu gebrauchen. Ist das kind nicht feig und sclavisch unterdrueckt, so antwortet es unbefangen: ja ich kann sagen, und es steht ja auch da: das Gruene...? Wie viel zeit und muehe geht nun wieder verloren, ehe ich das kind klug genug mache, einzusehen und zu unterscheiden, ob das wort fuer sich und statt eines hauptwortes steht, oder zu einem hauptwort gehoert, oder, wenn es auch nicht dabei steht, beziehung darauf hat? Bin ich nun auch so weit, so schreibt nun das kind alle augenblicke wenigstens die infinitivos groß als Lesen, Schreiben, Fallen u.s.w. und beruft sich allemal darauf, dass es ja: das vorsetzen koenne. Ich muss ihm gerechtigkeit widerfahren lassen, indem ein solcher infinitivos wirklich oft als hauptwort gebraucht wird; will ich ihm aber begreiflich machen, wo dies der fall, und wo er es nicht ist, so wird das kind am ende darueber so verwirrt, dass es gar nicht weiß, wie es schreiben soll, und dass es jahre lang noethig hat, um sich heraus zu finden. (Schubert 1817, zitiert nach Mentrup 1979b: 54)

Dass den Rechtschreibregeln bis heute ein Wörterverzeichnis angehängt wird („doppelte Kodifikation“, Kohrt 1987/1990), kann auch vor dem oben beschriebenen Hintergrund wie eine Kapitulation in dem Sinne anmuten, dass rein durch das Regelwerk eine zweifelsfreie Schreibung nicht möglich sei. Der Grundsatz, dass im Zweifelsfalle kleinzuschreiben sei – mit anschließendem Verweis auf das Wörterverzeichnis – findet sich nicht mehr im aktuellen Regelwerk, allerdings haben sich sowohl die Kodifikation der GKS als auch die Probleme mit dieser seit der letzten Reform nicht grundlegend verändert, sodass man die Entfernung dieses Passus’ auch als schlicht selbstbewusstere Darstellung des Regelwerks interpretieren kann.[6] Die Interpretation, dass ein Wörterverzeichnis eine „umfassende grammatische Analyse“ (Röber 2011: 204) behindere, erscheint somit nicht völlig abwegig.

II.7 Gegenwärtige Tendenzen

Im Zuge der 1996 in Kraft getretenen und 2006 modifizierten Reform der deutschen Rechtschreibung fand eine Ausweitung zugunsten der Großschreibung statt. Diese betraf jedoch den Peripherie- statt den Kernbereich, sodass eine über Jahrzehnte von einigen Vertretern immer wieder geforderte gemäßigte Kleinschreibung (Großschreibung am Satzanfang sowie von Eigennamen, vgl. Mentrup 1979a/1979b), die mit der Schreibung im

[6] Der Satz *In Zweifelsfällen siehe das Wörterverzeichnis* findet sich auch im aktuellen Amtlichen Regelwerk (Rat für deutsche Rechtschreibung 2011: 16/41) noch an zwei Stellen, wobei einschränkend gesagt werden muss, dass einmal auf Fremdwörter Bezug genommen wird. Seit der Rechtschreibreform 1996 hat insgesamt eine stärkere Kodifikation stattgefunden, da bis dato Zweifelsfälle per Beschluss der Kultusministerkonferenz in die Hände der DUDEN-Redaktion gelegt wurden (sog. „DUDEN-Monopol“).

Englischen[7] vergleichbar ist, nicht umgesetzt wurde. Die folgenden Angaben geben einen Überblick mit exemplarischen Änderungen (vgl. Nerius 2007: 214f.):

- bestimmte Substantive in präpositionalen oder verbalen Fügungen in getrennter Stellung (z. B. *in Bezug auf*, *von Seiten*, *auf Grund* [*aufgrund* ebenfalls zulässig]); jedoch teilweise Rücknahme 2006: *leidtun* statt *Leid tun*),
- Bezeichnungen für Tageszeiten nach den Adverbien *gestern*, *heute*, *morgen* usw. (z. B. *gestern Abend*, *heute Mittag*),
- substantivische Bestandteile im Inneren mehrteiliger substantivischer Fügungen aus anderen Sprachen (z. B. *Nouvelle Cuisine*), sofern kein Zitatwortgebrauch vorliegt,
- viele formal substantivierte Adjektive/Partizipien in festen Wendungen (z. B. *im Allgemeinen*, *aufs Neue*), jedoch nicht konsequent, da teilweise nur Kleinschreibung zulässig ist: *die einen*, *die anderen*.

Umgekehrt gab es auch eine leichte Ausweitung der Kleinschreibung – am folgenreichsten ist sicherlich, dass das Anredepronomen *du* lediglich in Briefen o.ä. großgeschrieben werden darf.

Diese Reform erfuhr jedoch auch Kritik – u. a. nachzulesen in Eisenberg (2013) oder Fuhrhop (2009). Kernpunkt der Kritik ist, dass die Ausweitung der Großschreibung nicht begründbar ist, wenn man annimmt, dass die Großschreibung distinktiv für Substantive bzw. Nicht-Substantive ist. Nachfolgend sollen zwei Fälle exemplarisch diskutiert werden:

1. Fuhrhop argumentiert nachvollziehbarerweise, dass im Falle von *heute Abend* dieses weder attribut- noch genus- noch pluralfähig[8] sei. Man könnte jedoch die Wortgruppe *heute Abend* als elliptische, in den allgemeinen Sprachgebrauch übergegangene, Variante[9] von *heute am Abend* ansehen. In den Sätzen: *Ich gehe heute Abend zum Dortmund-Spiel* sowie *Ich gehe heute am Abend zum Dortmund-Spiel* ist aus grammatischer Sicht *heute Abend* bzw. *heute am Abend* jeweils Temporaladverbial (Letzteres mit Attribut). Ein Bedeutungsunterschied ist unseres Erachtens nicht erkennbar. Weiterhin wäre zusätzlich adjektivische

[7] Paradoxerweise könnte eine analoge Großschreibungsregel wie im Englischen – die Auszeichnung von Sprachen und Nationalitäten mit einer Majuskel – eine potentielle Fehlerquelle des Deutschen ausmerzen. Die Unterscheidung zwischen Adjektiv und Substantiv im Falle von Sprachen ist nicht immer ganz eindeutig für unsichere Schreiber/innen, wie der nachfolgende Abschnitt anschaulich zeigt: „Angela Merkel spricht Russisch, Wladimir Putin spricht Deutsch, sodass die beiden bei ihrem Treffen im Kreml abwechselnd deutsch und russisch miteinander sprachen. Da Putins Begleiter jedoch kein Wort Deutsch verstanden, unterhielt man sich meistens auf Russisch." Der Abschnitt ist Schmachthagen (2012) entnommen.

[8] S. folgende Beispiele: *heute schöner Abend; *der heute Abend – *heute der Abend; *heute Abende (Fuhrhop 2009: 44).

[9] Zur Klärung des Konzepts der Variation, insbesondere der graphematischen, vgl. Berg (in diesem Band)

Attribuierbarkeit gegeben: *heute am späten Abend*. Als weitere Begründung für die Großschreibung von *Abend* bieten wir *Ich gehe am heutigen Abend zum Dortmund-Spiel*[10] an. Auch in dieser Konstruktion ist weder eine strukturelle grammatische – bezogen auf die Satzglieder – noch eine semantische Veränderung erkennbar. In beiden Begründungen kann zumindest Kasus- und Genusfähigkeit sowie Attribuierbarkeit deutlich gemacht werden. Aber nicht alle Substantive verfügen über die prototypischen Eigenschaften von Kasus, Numerus und Genus sowie Attribuierbarkeit. Dies wird an folgendem Beispiel sichtbar: Die mehr und mehr in der Standardsprache – und nicht mehr nur in Dialekten wie dem Rheinischen – zu findende Verlaufsform *am/beim + substantivierter Infinitiv*: *Ich bin beim Essen*[11] ist (wie im nachfolgenden Beispiel auch mehrfach) attribuierbar: *Ich bin beim abendlichen Essen des Brotes.* Hier erscheint die Verschmelzung *beim* auflösbar: *Ich bin bei dem abendlichen Essen des Brotes*, d. h. Genus- und Kasusfähigkeit liegen vor (jedoch keine Pluralfähigkeit).

2. Genau an der Nicht-Auflösbarkeit der Verschmelzung setzt eine weitere Kritik an: Eisenberg (2013: 332) argumentiert, dass z. B. bei *im Folgenden*[12] die Verschmelzung nicht mehr aufgelöst werden könne, sondern *in dem folgenden (Abschnitt)* gerade ein Substantiv verlange. Die verwendete Kasusmarkierung ist adjektivisch. Diese adjektivische Kasusmarkierung ist nicht notwendigerweise ein Argument gegen Großschreibung, da substantivierte Adjektive ihre Kasusmarkierungen behalten und bereits vor der Reform großgeschrieben wurden:

   - *Er ist der Freund der Dicken*. (= dicke Person, Substantivierung, Gen. Sg.) vs.
   - *Er erfreut sich an der Dicke der Wand*. (= Dicke der Wand, explizites Derivat, Gen. Sg.)[13]

[10] Diesem Beispiel liegt eine Wortartkonversion von heute (Adverb) zu heutig (Adjektiv) zugrunde.
[11] Da in diesem Beispiel der Vorgang beschrieben wird, handelt es sich nicht um das lexikalisierte Substantiv „Essen".
[12] Gleiches gilt für im Allgemeinen, im Wesentlichen, um ein Beträchtliches, zum Besten, im Entferntesten, im Einzelnen, im Ganzen.
[13] Modifiziertes Beispiel aus Nerius (2007: 208); ähnlich verhält es sich mit den adjektivischen Komparationsstufen: Sie war die Schönste des Abends (vgl. ebd.).

Didaktisch bedeutet dies im Falle von *heute Abend*, dass die Großschreibung mit den gängigen syntaktischen Proben nicht für einen/eine Rechtschreiblerner/in begründbar sein wird. Möglicherweise ist die Gefahr der Fehlschreibung dennoch gering, da die Substantivierung von *Abend* lexikalisiert sein kann, weil *Abend* isoliert über alle prototypischen Substantiveigenschaften verfügt, zum Kernbereich der Substantive zählt und hochfrequent ist. Auch wenn wir uns hier für eine Ausweitung des syntaktischen Ansatzes aussprechen, der Zweifelsfälle wie die Verlaufsform als expandierbarem Kern einer Nominalgruppe auflösen kann, sollte unseres Erachtens nach den vorliegenden Ausführungen nicht gänzlich auf den lexikalischen Ansatz verzichtet werden (s. auch Abschnitt 9 zur „Anfass-“ und „Sehprobe“).

Ob man die Schreibung der substantivierten Adjektive im Falle fester Wendungen als Teil eines „Reformunfall[s]“ (Eisenberg 2013: 333) ansieht oder nicht, soll hier offengelassen werden; sie widersprechen zumindest nicht jedweder Logik.

II.8 Forschungsstand

Der Forschungsstand bezüglich des Lesens in Abhängigkeit von der Groß- und Kleinschreibung (für einen ausführlicheren Überblick s. Nottbusch und Jonischkait 2011) besteht im Wesentlichen aus Arbeiten von Michael Bock und Kollegen. Diese Arbeiten werden nachfolgend dargestellt, da sie in engem Zusammenhang mit dem von uns durchgeführten Eye-Tracking-Experiment stehen. Hauptbestandteil der Forschungen war der Vergleich der Lesezeiten von Texten, die den Versuchspersonen in unterschiedlichen Schreibungen präsentiert wurden. Die verwendeten Varianten sind in Tabelle 1 dargestellt.

Tabelle 1: Schreibvarianten in den Experimenten von Bock et al.

Schreibvariante[14]	**Beispiel**
normgerechte GKS	Warum die Fledermäuse am Tag schlafen.
gemäßigte Kleinschreibung	Warum die fledermäuse am tag schlafen.
durchgängige Großschreibung	Warum Die Fledermäuse Am Tag Schlafen.
Zufallsvariation	warum die fledermäuse Am tag Schlafen.
Umkehr der normgerechten GKS	warum Die fledermäuse Am tag Schlafen.

[14] S. Fn. 9.

Im ersten Experiment (Bock/Augst/Wegner 1985) wurden 80 Studierenden jeweils 20 Texte vorgelegt. Ihre Aufgabe war es, vier Texte (ca. 125 Wörter: Substantivanteil 30%) nacheinander in einer der oben beschriebenen Varianten zu lesen, bevor anschließend die nächste Variante präsentiert wurde. Wesentliche Analysemerkmale neben der Lesezeit waren die Zahl inhaltlicher Lesefehler sowie das Auffinden eingebauter Textfehler (Variation von null bis fünf pro Text). Als Hauptergebnis lässt sich festhalten, dass die benötigte Lesezeit umso länger ausfiel, je ungewohnter die Schreibung war, d. h. je mehr sie von der Norm abwich. Daraus ergibt sich folgende Reihenfolge[15]: normgerechte GKS (33,12 Sekunden mittlere Lesezeit) < gemäßigte Kleinschreibung (34,62 s) < durchgängige Großschreibung (36,84 s) = Zufallsvariation (37,17 s) < Umkehr der normgerechten GKS (39,44 s). Bezüglich der Fehleridentifikation zeigte sich kein Effekt der Schreibungen. Dieses Ergebnis überrascht nicht und lässt keine Rückschlüsse auf einen tatsächlichen Vorteil der GKS zu, da nur bestätigt wurde, dass sich das Lesetempo verringert, je mehr eine Schreibvariation von der korrekten Orthographie bzw. der gewohnten Schreibweise abweicht. Im Fazit wird dies jedoch als Interpretation für die Funktion der deutschen GKS-Norm interpretiert.

In den Untersuchungen von Bock (1989) wurden u. a. die Größenverhältnisse von Majuskel und Minuskel variiert, d. h. der typographische Großbuchstabe als solcher wurde verwendet, aber beispielsweise kleiner dargestellt als der Kleinbuchstabe. Diese Verfremdungen wurden dann in den o. g. fünf Schreibvarianten präsentiert. Unseres Erachtens scheinen diese Ergebnisse hinsichtlich der Funktion der GKS für den/die Leser/in nur schwer interpretierbar und lassen letztlich nur Schlüsse darüber zu, wie Leser/innen auf ungewohnte Buchstabengrößen reagieren. Weiterhin wurde in zwei Untersuchungen wiederum mittels der fünf Schreibvariationen überprüft, welchen Einfluss die GKS auf das laute im Vergleich zum leisen Lesen hat. Als Ergebnis lässt sich konstatieren, dass eine normwidrige Schreibung beim leisen Lesen einen weit stärker verzögernden Einfluss als beim lauten Lesen hat. In einer Replikation von Bock et al. (1985) mit Schülern/innen (Dritt-, Siebt- und Zehntklässler/innen) konnten für die Gruppe der Drittklässler/innen kaum Unterschiede in den Schreibvarianten gefunden werden, wohingegen die Ergebnisse der anderen beiden Gruppen sehr vergleichbar mit denen der Studierenden waren. Erklärbar ist dies durch den noch nicht automatisierten Leseprozess der Drittklässler/innen, wohingegen bei älteren Kindern und Erwachsenen das

[15] „<“ bedeutet, dass ein signifikanter Unterschied vorliegt; „=“ bedeutet, dass es keine statistisch bedeutsame Abweichung gibt.

leise Lesen sehr viel schneller abläuft als das laute Lesen. Daher haben die Leser/innen beim lauten Lesen mehr Zeit, die ungewohnten Schreibungen zu kompensieren.

Der in den Untersuchungen von Bock und Kollegen (1989) – verkürzt auch in Bock (1989) – gewählte Ansatz erscheint vielversprechend: Jeweils 100 Versuchspersonen (deutsche Studierende der Anglistik und niederländische Studierende des Faches Deutsch als Zweitsprache) lasen 20 deutsche Originaltexte (Fabeln, durchschnittlich 247 Wörter), davon jeweils zehn auf Deutsch sowie zehn auf Niederländisch (niederländische Versuchspersonen) bzw. zehn auf Englisch (deutsche Muttersprachler). Präsentiert wurden die Texte in den bekannten Schreibvarianten (vgl. Tabelle 2).

Die Ergebnisse der deutschen Probanden/innen beim Lesen deutscher Texte aus Bock et al. (1985) konnten repliziert werden. Beim Lesen englischer Texte zeigte sich kein signifikanter Unterschied zwischen (der im Englischen regulären) gemäßigten Kleinschreibung und der (dort irregulären) GKS nach deutscher Norm. Bock erklärt dies durch zwei gegenläufige Prozesse, die er als Indiz für den Nutzen der GKS interpretiert: 1. Die Abweichung von der regulären Wortform vs. 2. die Erleichterung des Lesens durch die syntaktischen Hinweise der GKS. Die naheliegende Interpretation ist somit, dass ein Transfer der GKS auf eine fremde Sprache stattfinden kann. Dementsprechend könne ausgeschlossen werden, dass sie an eine lexikalische Kategorie gebunden sei, insofern nicht englische, sondern deutsche Muttersprachler/innen englische Texte gelesen haben.

Die Ergebnisse der niederländischen Versuchspersonen beim Lesen deutscher Texte entsprechen denen der deutschen Versuchspersonen. Im Falle der muttersprachlichen Texte war die Reihenfolge: normgerechte gemäßigte Kleinschreibung < GKS (der Norm im Deutschen entsprechend) < durchgängige Großschreibung = Zufallsvariation < Umkehr der GKS. Die Störung durch die GKS war weniger stark ausgeprägt als die restlichen normwidrigen Schreibungen. Es lässt sich somit konstatieren: Je stärker die Abweichung von der jeweils gültigen Rechtschreibnorm, desto geringer die Lesegeschwindigkeit.

Gfroerer et al. (1989) replizierten das gerade beschriebene Experiment unter Einsatz des Eye-Tracking-Verfahrens. (Dabei zeichnet eine Kamera die Blickbewegungen auf, sodass registriert wird, wann, wo und wie lange eine Versuchsperson ein Wort fixiert hat und wohin sie anschließend geschaut hat). Überblicksartig sind die nachfolgenden Termini in Abbildung 1 und Tabelle 2 erläutert. Fixation bedeutet, dass das Auge kurzzeitig an einem bestimmten Ort verweilt, währenddessen finden kognitive Verarbeitungsvorgänge statt. Eine

durchschnittliche Fixation dauert 200-250 ms. Die Dauer ist beispielsweise abhängig von der Wortlänge und -frequenz: Je länger ein Wort ist (Anzahl der Buchstaben), desto größer ist die Wahrscheinlichkeit, dass es (mehrfach) fixiert wird. Bezogen auf die Wortfrequenz verhält es sich ähnlich: Je weniger frequent ein Wort ist, desto länger ist die erwartbare Fixationsdauer. Weitere Maße sind die Blicksprünge: Vorwärtsgerichtete Blicksprünge werden Sakkaden genannt, rückwärtsgerichtete Regressionen. Während einer Sakkade kann keine Information aufgenommen werden. Gemessen werden können die Distanzen der Sakkaden beispielsweise anhand von Buchstabenweiten. Regressionen (Blicksprünge entgegen der Leserichtung) können unterteilt werden in solche, die innerhalb eines Wortes stattfinden und solche, die von einem späteren Wort zu einem bereits gelesenen oder übersprungenen Wort zurückgehen. Durch die genaue Positionsbestimmung bietet Eye-Tracking den Vorteil, dass ein sehr grobes Maß wie die reine Lesezeit eines Satzes wesentlich feiner in Einzelfixationen unterteilt werden kann, so dass Unterschiede wortweise interpretiert werden können. Insgesamt sind komplexere Versuchsanordnungen möglich. Zum einen dadurch, dass wort- oder buchstabenweise Manipulationen sinnvoll interpretiert werden können, zum anderen, dass beispielsweise auch Sätze während des Lesens nach Überschreitung einer unsichtbaren Grenze verändert und die Auswirkungen dieser Veränderung untersucht werden können.

Im von Gfroerer et al. (1989) durchgeführten Experiment lasen 15 niederländische Versuchspersonen die gleichen Texte (Niederländisch und Deutsch) in den fünf Schreibvarianten (50 Texte insgesamt, zehn Texte pro Schreibvariante) wie in Bock et al. (1989). Es wurden Lesezeiten, Fixationszeiten (Durchschnittszeiten für den gesamten Text), Sakkadenlänge (gemessen in Buchstaben) sowie Regressionen (Anzahl pro Wort) als Maße verwendet. Als Ergebnis berichten die Autoren, dass die niederländischen Texte von den muttersprachlichen Lesern/innen in allen Schreibvarianten schneller als die deutschen Texte gelesen wurden. Dabei waren die Verhältnisse der Lesezeiten für die fünf unterschiedlichen Varianten in beiden Sprachen gleich (Reihenfolge: Groß- und Kleinschreibung, gemäßigte Kleinschreibung, durchgängige Großschreibung, Zufallsvariation, Umkehr der Groß- und Kleinschreibung). Hochinteressant jedoch ist die Tatsache, dass im Unterschied zu Bock et al. (1989) die niederländischen Leser/innen die niederländischen *und* die deutschen Texte schneller lasen, wenn sie gemäß deutscher GKS präsentiert wurden. Daraus schlussfolgern die Autoren ebenso wie Bock (1989), dass die deutschen GKS-Regeln auf andere Schreibsysteme übertragbar sind und die deutsche GKS-Norm über eine Funktion verfügt, die unabhängig von

der Wortform ist. Die Ergebnisse sind erstaunlich, allerdings aus unterschiedlichen Gründen mit Vorsicht zu interpretieren: Zum einen betonen die Autoren selbst, dass es sich um eine Pilotstudie handelte, weiterhin weisen sie auf die „komplexe Technik“ hin, die zu einer hohen Ausfallrate der schon geringen Versuchspersonenzahl führte – nur 15 statt 22 waren auswertbar. Die Überschriften und Textenden wurden auf Grund „unkontrollierte[r] abweichende[r] Muster“ (ebd.: 124) ausgespart. Die Lesesituation wich sehr stark von einer natürlichen ab (Zahnarztstuhl mit Stirngurt, Monitor vor den Augen) und die Dauer der Kalibrierung (15 Minuten) ist verglichen mit heutigen Geräten recht hoch. All dies wirkt sich natürlich auf die Probanden/innen aller Gruppen aus, beeinträchtigt jedoch die Untersuchungsergebnisse. Dennoch haben die Autoren Pionierarbeit in der Analyse der Eye-Tracking-Daten geleistet. Die heutigen technologischen Möglichkeiten erlauben eine höhere Präzision sowie einen höheren Automatisierungsgrad durch die Kalibrierung. Nichtsdestotrotz sind die Befunde bemerkenswert.

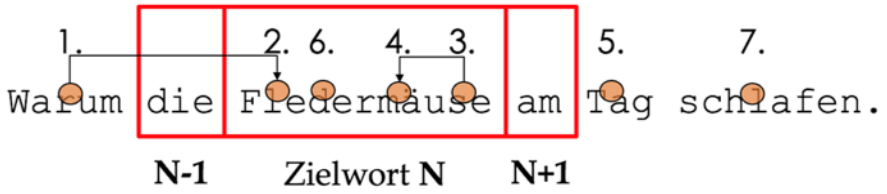

Abbildung 1 Fiktives Lesebeispiel mit eingezeichneten Fixationen

Tabelle 2: Definition verschiedener Eye-Tracking-Termini und -Messwerte

Terminus	***Beschreibung***	***Beispiel Abbildung 1***
Fixation	Kreis steht für eine Fixation, durchschnittliche Fixationsdauer 200-250 ms, 6-8 Buchstaben in der Fovea[16] (Bereich des schärfsten Sehens)	*1.*
Sakkade	Vorwärtsgerichtete Blicksprünge (Dauer ca. 30-60 ms; Weite: 7-9 Buchstaben; absolute Blindheit	*Abstand zwischen 1. und 2.*
Regression	Rückwärtsgerichtete Sakkade: • Regression innerhalb eines Wortes • Regression, nachdem Wort bereits verlassen (Refixation) oder übersprungen wurde	*Rücksprung von 3. zu 4.* *Rücksprung von 5. zu 6.*
First Fixation Duration (FFD)	Erste Fixation auf einem Wort	*Zielwort N: 2.*
Gaze Duration (GAZE)	Summe der Fixationsdauern des ersten Durchgangs (vor dem Verlassen dieses Wortes) auf dem Zielwort	*Zielwort N: 2.+3.+4.*
Total Fixation Duration (TOTAL)	Summe aller Fixationen auf dem Zielwort (inkl. Regressionen, die von späteren Zielworten ausgehen)	*Zielwort N: 2.+3.+4.+6.*

II.9 Experiment

Neben den bereits in Abschnitt 6 erläuterten Termini erscheinen zum besseren Verständnis der nachfolgend beschriebenen Studie einige weitere einleitende Bemerkungen zu den Vorgängen beim Lesen sinnvoll: Der Bereich der höchsten Sehschärfe wird *Fovea* genannt, deren Ausdehnung beträgt – abhängig von der Schriftgröße – ca. 6 bis 8 Buchstaben. Die Fovea ist vom parafovealen Bereich umgeben, aus dem ca. 15 bis 20 Buchstaben wahrgenommen werden können, in dem jedoch die Sehschärfe vermindert ist. Dabei ist die Wahrnehmung eines/r geübten Lesers/in asymmetrisch – bei Lesern/innen eines rechtsläufigen alphabetischen Schriftsystems ist diese in Schreibrichtung verschoben, d. h. nach links sind nur 3 bis 4 Buchstaben sichtbar, nach rechts aber 14 bis 15 Buchstaben; eine Majuskel ist noch weiter entfernt wahrnehmbar. Durch parafoveale Wahrnehmung ist eine Vorverarbeitung des nächsten Wortes oder sogar mehrerer Wörter möglich, was zu einer kürzeren Fixationsdauer auf diesem Wort/diesen Wörtern führt (erstmals beschrieben in Rayner 1975).

[16] Zur Erläuterung s. Abschnitt 7.

In dem von uns durchgeführten Experiment[17] schlossen wir uns der Ausgangsfragestellung von Bock und Kollegen (1985) an: Verfügt die GKS über eine nachweisbare Funktion für den/die Leser/in? Bei der Herangehensweise an das experimentelle Design stand zu Beginn die Frage, wie eine solche Funktion nachgewiesen werden könne, ohne dass die erwartbar längeren Lesezeiten für normwidrige Texte nur auf die jeweils bezüglich der Norm ungewohnte Variation zurückzuführen sei. Somit war die Schaffung eines Satzkontextes nötig, der Unterschiede in den Fixationszeiten auf die GKS zurückführt. Methodisch entschieden wir uns für das sinnentnehmende Lesen von einzeiligen Einzelsätzen, die einmal in regulärer Schreibung und einmal in gemäßigter Kleinschreibung[18] präsentiert wurden. Sätze sind nicht nur syntaktisch einfacher zu kontrollieren als ganze Texte mit Zeilensprüngen, sondern auch einfacher zu interpretieren. Die Sätze wurden systematisch so manipuliert, dass unseres Erachtens Unterschiede beim Lesen durch das Vorhandensein bzw. Fehlen der GKS erklärt werden können. Die Ausgangshypothesen lauteten:

- Die GKS verfügt über eine Funktion, die durch das systematische Erkennen von Kernen von Nominalphrasen die Verarbeitung des Satzes für den/die Leser/in erleichtert.
- Der/die Leser/in erkennt bereits parafoveal („aus dem Augenwinkel“) die Majuskel und kann das nachfolgende Wort systematisch vorverarbeiten, da auch eine syntaktische Kategorie aktiviert wird.

Die Überlegung war die, dass der oben beschriebene Satzkontext, der Fixationszeitunterschiede auf das Vorhandensein bzw. Fehlen der wortinitialen Majuskelschreibung zurückzuführen erlaubt, nur über die Ermöglichung eines semantischen Primings und die Erstellung von Holzwegsätzen erreicht werden konnte. Priming bedeutet, dass ein Reiz in der Verarbeitung dadurch beeinflusst wird, dass ein vorangeganger Reiz implizite Gedächtnisinhalte bereits aktiviert hat, bevor der neue Reiz auftritt. Im Falle von semantischem Priming heißt dies konkret, dass die Verarbeitung eines Wortes durch ein vorangegangenes Wort dann beeinflusst wird, wenn eine semantische Beziehung besteht. So

[17] Das hier beschriebene Experiment kann im Rahmen dieser Arbeit nur grob umrissen werden. Eine tiefergehende Analyse findet sich in Pauly/Nottbusch/Kliegl (i. Vorb.).

[18] Bei der Erstellung der Sätze wurde darauf geachtet, dass keine Eigennamen oder Ausnahmen, die im Falle der gemäßigten Kleinschreibung großgeschrieben werden müssten, vorkamen, so dass letztlich nur der Satzanfang kapitalisiert war.

findet beispielsweise eine schnellere Verarbeitung des Wortes *Haar* statt, wenn zuvor das Wort *Friseur* gelesen wurde.[19]

Bei Holzwegsätzen ist die Wahl einer falschen Lesart auf Grund von Ambiguitäten wahrscheinlich. Angesichts des Kontextes bemerkt der/die Leser/in seinen/ihren Irrtum und es erfolgt eine Korrektur (Reanalyse): *Bei meinem Haus am Stausee müssen die Staubecken gesäubert werden, am besten mit einem Staubtuch*.

Tabelle 3: Items des Experiments: EXP bzw. KON stehen für Experimental-/Kontrollbedingung. GKS/geKS für Groß- und Kleinschreibung/gemäßigte Kleinschreibung; PrG=Präpositionalgruppe

Bedingung	Modus					N-1	N Adjektiv (immer)	N+1 Nomen (immer)			
		Präpositionalgruppe			Verb	Nominalgruppe			PrG		
EXP	GKS	In	der	Gymnastikhalle	liegen	die	matten	Sportler	auf	dem	Boden.
EXP	geKS	In	der	gymnastikhalle	liegen	die	matten	sportler	auf	dem	boden.
KON	GKS	In	der	Gymnastikhalle	liegen	die	steten	Sportler	auf	dem	Boden.
KON	geKS	In	der	gymnastikhalle	liegen	die	steten	sportler	auf	dem	boden.

In Tabelle 3 findet sich beispielhaft ein Satz in allen präsentierten Varianten. Insgesamt wurden je 40 konstruierte Experimental- und Kontrollsätze (im Folgenden: EXP bzw. KON) mit einheitlicher syntaktischer Struktur (1. Nominalgruppe; 2. Verb (einteiliges Prädikat); 3. Nominalgruppe/Präpositionalgruppe mit Adjektivattribut; 4. Nominalgruppe/Präpositionalgruppe ohne Attribut) erstellt. Die Kontrollsätze wurden an einer mit Adjektiv besetzten Stelle (N) verändert, insofern dort das Adjektiv jeweils durch ein gleich langes anderes Adjektiv ersetzt wurde, bei dem höchst unwahrscheinlich war, dass es im Falle der Kleinschreibung der Sätze als Substantiv interpretiert werden konnte (im Falle des aufgeführten Beispiels wurde *matten* durch *steten* ersetzt). Weiterhin orientierte sich die Frequenz des Ersatzadjektivs am Mittelwert der Frequenz[20] des zu ersetzenden Adjektivs

[19] Das zugrunde liegende Modell wurde beschrieben in Collins/Loftus (1975).
[20] Die Frequenz basierte auf „DLEXDB“ (Korpus: DWDS (Digitales Wörterbuch der Deutschen Sprache)). Tiefgehende Informationen zu DLEXDB als Frequenzdatenbank finden sich in Heister et al. (2010).

sowie der potentiellen Lesart Substantiv.[21] Zur Distraktion lasen die Versuchspersonen 120 Fillersätze.[22]

Jede Versuchsperson las pseudo-randomisiert insgesamt 160 Sätze (20 EXP, 20 KON, 120 Filler), welche je hälftig gemäß regulärer Schreibung und gemäßigter Kleinschreibung präsentiert wurden. Neben der Aufforderung, diese sinnentnehmend zu lesen, wurden in zufälliger Reihenfolge im Anschluss an die Sätze in automatisierter Form Multiple-Choice-Fragen gestellt. Im Anschluss an das Experiment wurde neben anderen Parametern in einem Fragebogen per Selbsteinschätzung (4er-Matrix: „nie“ bis „sehr häufig“) abgefragt, wie hoch die persönliche Exposition mit Texten sei, die die Groß- und Kleinschreibung missachten, wie sehr den/die Probanden/in das störe sowie wie häufig (auf einer vierstufigen Skala von „nie“ bis „immer“) diese/r selbst die GKS in der Schreibproduktion missachte. Es sei vorweggenommen, dass diese Selbsteinschätzung keinerlei statistisch relevante Auswirkung auf die Ergebnisse bei der Verarbeitung der Sätze hatte. Die Erwartung war wie folgt:

- EXP in normgerechter Schreibung: Da der Satz der Normschreibung folgt, sollte er nicht als ambiger Satz fehlinterpretiert werden können. Nimmt man das Beispiel aus Tabelle 3, so ist *matten* in diesem Satzkontext nicht ambig, da vorher und nachher im Satz regulär geschriebene Substantive auftreten. Dementsprechend sollte eine Verarbeitung ohne Irritation erfolgen. Gemäß unserer Ausgangshypothese erwarteten wir, dass auf Grund der parafoveal sichtbaren Majuskel eine Vorverarbeitung auf N (*matten*) stattfinden kann und somit kürzere Fixationszeiten auf N+1 (*Sportler*) beobachtbar sind.
- EXP in normwidriger Schreibung: Neben generell höheren Fixationsdauern auf Grund der normwidrigen Schreibung sollte sich in dieser Bedingung ein Holzwegeffekt einstellen. Dies würde bedeuten, dass der/die Leser/in angesichts des semantischen Kontextes und dessen Kleinschreibung (*gymnastikhalle*) die Lesart „Substantiv“ bei *matten* annimmt. Das könnte zu einem deutlich werdenden Unterschied auf N+1 (*Sportler*) in der Gaze Duration (GAZE), d. h. im ersten Lesedurchgang ohne Regressionen, führen, da die inhaltliche Irritation der Satzkonstruktion auf N+1 offenkundig werden müsste. Weiterhin wäre wahrscheinlich, dass höhere

[21] Beispiel: Frequenz matten (Adjektiv): 284; Frequenz Matten (Substantiv): 224; Mittelwert beider Frequenzen: 254; Frequenz Ersetzungswort steten: 239.

[22] Diese stammten aus dem „Potsdam Sentence Corpus v. 1.0“, welches eine syntaktische Vielfalt aufweist. Einzelheiten dazu in Kliegl et al. (2004).

Fixationsdauern auf N in der Gesamtfixationszeit (TOTAL, d. h. inklusive Regressionen) auftreten, die sich signifikant von den Experimentalsätzen gemäß regulärer GKS unterscheiden müssten.

- KON in normgerechter Schreibung: Erwartung wie EXP in normgerechter Schreibung.
- KON in normwidriger Schreibung: In dieser Bedingung sollte es auf Grund der Fehlschreibung des Substantivs verglichen mit KON gemäß regulärer GKS zu längeren Fixationsdauern kommen, weiterhin zu kürzeren auf dem Adjektiv (N), da keine Vorverarbeitung stattfinden kann.

II.10 Ergebnisse

Die Kontrollsätze weisen sowohl auf N (dem Adjektiv) als auch auf N+1 (dem Substantiv) jeweils absolut höhere Fixationszeiten auf als das in den Experimentalsätzen der Fall ist. Wir vermuten, dass die Kontrollsätze zum Teil konstruiert und unnatürlich wirken. Dies kam dadurch zustande, dass sie den letzten Schritt bei der Erstellung des Untersuchungsmaterials darstellen mussten und die Ersetzung des Adjektivs den oben beschriebenen unvermeidlichen Kontrollen unterlag.

II.10.1 Deskriptive Betrachtung

II.10.1.1 *EXP und KON: Fixationszeiten ohne Regressionen, normgerechte- und normwidrige Schreibungen*

Betrachtet man die Daten rein deskriptiv, ergibt sich folgendes Bild: Die Fixationszeiten (ohne Regressionen) zeigen sowohl in den Experimental- als auch in den Kontrollsätzen in der regulären Schreibung (GKS) eine geringere Fixationsdauer des Substantivs (*Sportler*) im Vergleich mit dem Adjektiv (*matten*/*steten*). Dies lässt von der Tendenz her zunächst darauf schließen, dass das Substantiv bereits während der Fixation auf dem Adjektiv parafoveal vorverarbeitet werden kann. Im Falle der normwidrigen Kleinschreibung ergibt sich für beide Bedingungen (EXP geKS bzw. KON geKS) das gegenteilige Bild: Die Fixationsdauern auf dem Adjektiv sind kürzer als die auf dem Substantiv. Vergleicht man die Großschreibung mit der Kleinschreibung für beide Bedingungen (EXP und KON), so sind die Unterschiede für das Adjektiv in den beiden Schreibungen gering, jedoch zeigt die reguläre Schreibung (GKS) höhere Fixationszeiten. Für das Substantiv sind die Unterschiede jedoch beträchtlich, was nicht überraschend ist, da dieses in der Bedingung „Kleinschreibung“ orthographisch falsch geschrieben ist. Dementsprechend wird die normwidrige Schreibung deutlich länger fixiert.

II.10.1.2 *EXP und KON: alle Fixationszeiten, normgerechte Schreibung*

Betrachtet man alle Fixationen (inklusive der Regressionen/Rücksprünge), bleibt die Tendenz wie bei der regulären, normgerechten Schreibung ohne Regressionen bestehen: Das Adjektiv wird länger fixiert als das folgende Substantiv, die Unterschiede zwischen Adjektiv- und Substantiv-Fixation werden jedoch verglichen mit den Fixationen ohne Regression größer. Das könnte dafür sprechen, dass das Substantiv auf Grund der Großschreibung weniger oft und/oder weniger lang refixiert wird.

II.10.1.3 *KON: alle Fixationszeiten, normwidrige Kleinschreibung*

Im Falle der Kleinschreibung nivelliert sich in der Kontrollbedingung der Unterschied von Adjektiv (*steten*) und Substantiv (*sportler*), was dadurch erklärbar ist, dass es lange und häufigere Regressionen zu dem Adjektiv gab, das möglicherweise im Satzkontext zu konstruiert wirkte.

II.10.1.4 *EXP: alle Fixationszeiten, normwidrige Kleinschreibung*

In den Experimentalsätzen (Kleinschreibung) ergibt sich von der Tendenz her weiterhin das gleiche Bild wie bei den Fixationszeiten ohne Regressionen, jedoch werden die Unterschiede von N (*matten*) zu N+1 (*sportler*) geringer, d.h. das Adjektiv wird länger refixiert als das Substantiv. Dies entspricht zwar grundsätzlich der Hypothese, dass sich ein Garden-Path-Effekt einstellen kann und dieser durch Refixation des Adjektivs behoben werden sollte. Allerdings sollte dieser viel stärker hervortreten, so dass die Schlussfolgerung der bisherigen Analyse diejenige ist, dass die Groß- und Kleinschreibung zwar vermutlich einen Effekt hat, dieser jedoch schwach ausgeprägt ist.

II.10.2 Statistische Auswertungen

Die Auswertung der Daten mittels gemischter linearer Modelle ergab ein ebenso nicht ganz eindeutiges Bild, das von der Tendenz her die oben genannten deskriptiven Daten stützt, jedoch statistische Bedeutsamkeit an den entscheidenden Stellen vermissen lässt. Die inferenzstatistischen Analysen werden in Kürze detailliert veröffentlicht und können daher hier nicht abgedruckt werden (siehe Pauly/Nottbusch/Kliegl i.V.).

II.10.3 Zwischenfazit Ergebnisse

Als Zwischenfazit kann somit festgehalten werden: Folgt der substantivische Kern einer Nominalgruppe bei normgemäßer Schreibung auf ein Adjektivattribut, wird das Substantiv kürzer fixiert als das Attribut. Dies gilt sowohl für den ersten Lesedurchgang ohne Regressionen als auch, wenn sämtliche Fixationen betrachtet werden. Zusammengefasst zeigten die Ergebnisse dieser Studie eine Tendenz dahingehend, dass der/die Leser/in die Groß- und Kleinschreibung zur schnelleren Verarbeitung nutzen kann, jedoch waren diese Ergebnisse nicht statistisch bedeutsam.

II.10.4 Ergebnisse in Abhängigkeit der Frequenz

Dessen ungeachtet war ein Ergebnis bemerkenswert: Zur weiteren Analyse wurden die Substantive ex post am Median ihrer jeweiligen Frequenzen in hoch- bzw. niedrigfrequent eingeteilt. Betrachtet man die Fixationszeiten des ersten Lesedurchgangs ohne Regressionen jeweils auf Adjektiv und Substantiv in Abhängigkeit von der Frequenz des Substantivs, lässt sich folgendes ablesen: Lasen die Versuchspersonen die Sätze in Kleinschreibung, hatte die Frequenz des nachfolgenden normwidrig geschriebenen Substantivs keinerlei Einfluss auf die Fixationszeiten auf dem Adjektiv N – völlig unabhängig davon, ob die Experimental- oder die Kontrollbedingung betroffen war. Daraus lässt sich schließen, dass der/die Leser/in im Falle der normwidrigen Schreibung das nachfolgende Wort in diesem Fall eher nicht vorverarbeitet. Auf dem Substantiv selbst fanden sich dann typische Frequenzeffekte, d. h. höhere Fixationsdauern bei niedriger Frequenz sowie umgekehrt. Im Falle der regulären Schreibung verhielt es sich jedoch anders: In der Experimentalbedingung waren die Fixationsdauern auf dem Adjektiv höher, wenn das nachfolgende Substantiv eine hohe Frequenz hatte, als wenn es niedrigfrequent war. Dies ist ein Indiz für die Vorverarbeitung des Substantivs. Dafür spricht ebenso, dass die Fixationszeiten auf dem hochfrequenten Substantiv deutlich absanken. Daraus lässt sich ableiten, dass die Großschreibung zumindest im Falle eines hochfrequenten Substantivs zu einem Nutzen für den/die Leser/in führt. In jedem Falle scheint ein anderes Verarbeitungsmuster vorzuliegen. Über die Gründe lässt sich nur spekulieren – ein Nachfolgeexperiment soll überprüfen, ob diese Befunde bestätigt werden können. Was gezeigt werden konnte, ist, dass die „Großschreibung des substantivischen Kerns einer Nominalphrase“ mehr ist als der Unterschied zwischen Minuskel und Majuskel. Dass die lexikalische Bedeutung eines Wortes fest an dessen Wortform gebunden ist – darauf deuteten schon die Bock’schen Untersuchungen hin –, gilt als widerlegt (Neveling 2004: 29), wenngleich

ein Zusammenhang zwischen beiden besteht.[23] Dementsprechend müsste ein Wort auch dann vorverarbeitet werden, wenn es klein- statt großgeschrieben ist, da das lexikalische Wort in seiner Normgestalt nur minimal verändert und nach wie vor parafoveal sichtbar ist. Eine parafoveale Vorverarbeitung könnte demzufolge auch völlig unabhängig von einem Großbuchstaben erfolgen. Im Falle unserer Erhebung scheint der Großbuchstabe aber in jedem Falle die Verarbeitung zu beeinflussen, was dafür spricht, dass dieser eine grammatische Kategorie aktiviert. Global gesehen sollte daraus allerdings nicht abgeleitet werden, dass das Deutsche gegenüber anderen Sprachen in der Verarbeitung einen Vorteil böte, da diese Befunde mutmaßlich nur für deutsche Muttersprachler/innen gelten, die als Schriftsprache das Deutsche erlernt haben. Weiterhin erscheinen alternative optimierte Verarbeitungsstrategien in anderen Sprachen wahrscheinlich. Der Befund, den wir nach Auswertung dieses einen Experiments sowie nach Evaluation des Forschungsstands anbieten, wäre somit: Beim Lesen eines in Deutsch abgefassten Textes durch eine/n L1-Leser/in erfolgt eine für das deutsche GKS-System optimierte Verarbeitung.

Sprachverarbeitung tendiert mutmaßlich zur Ökonomisierung.[24] Die im Zuge veränderten Sprachnutzungsverhaltens individuell erhöhte Exposition mit normwidrig geschriebenen Texten zeigt zumindest in dieser Erhebung keine Effekte auf das Lesen. Weitere Erhebungen zur Stützung der Ergebnisse erscheinen vonnöten, allen voran solche, die die Verarbeitung der Substantivgroßschreibung beim Lesen einer Fremdsprache durch unterschiedliche Versuchspersonengruppen (fremdsprachliche Muttersprachler mit bzw. ohne Deutschkenntnisse/n sowie deutsche L1-Leser/innen mit den jeweiligen Fremdsprachenkenntnissen) untersuchen. Weiterhin erscheint die bereits angesprochene Überprüfung des Frequenzeffekts vielversprechend.

II.11 Didaktische Schlussfolgerungen

Unserer Untersuchung lag die These zugrunde, dass beim Lesen durch Auszeichnung von Substantiven durch Großbuchstaben implizit eine syntaktische Kategorie aktiviert wird – nämlich die des Kerns einer Nominalphrase. Auf Basis unserer bisherigen Studien können wir die Hypothese weder bestätigen noch ablehnen. Weitere Untersuchungen sind notwendig. Trotzdem gehen wir davon aus, dass diese Untersuchungen auch für didaktische

[23] Neveling (2004: 29) schreibt: „Zusammenfassend ist für die Wortform festzuhalten, dass Phoneme und Grapheme, Morpheme und möglicherweise auch Propositionen in einem vom Inhalt getrennten Formspeicher repräsentiert sind, wahrscheinlich gemeinsam mit einem System operativer Regeln."

[24] Exemplarisch zur schriftlichen Sprachverarbeitung: Nottbusch (2008: 146).

Schlussfolgerungen gewinnbringend sind. Die hier vorgestellte Annahme impliziert didaktisch, dass der Erwerb der GKS unter rezeptiven und zugleich syntaktischen Gesichtspunkten erfolgen sollte. Unterrichtsbeispiele dazu finden sich u. a. in Röber-Siekmeyer (1999), Günther und Nünke (2005), Noack (2006/2011) oder Müller (2010). Die Artikelprobe ist zwar eine grammatische (Genusfähigkeit), allerdings führt sie regelmäßig zu Problemen, wenn sie in verkürzter Form angewendet wird. Normwidrig großgeschriebene Wörter (z. B. *das Blaue Haus*) kommen dementsprechend häufig vor. Das erscheint im Kontrast zur ebenfalls gescholtenen Anfassprobe („Groß schreibt man, was man anfassen kann") bzw. zu deren modifizierter Form, der Sehprobe („Groß schreibt man, was man sehen kann"), nachteilig. Diese dem Wortartenkonzept zugehörige semantische Überprüfung des Substantivstatus kann zwar fälschliche Kleinschreibungen produzieren,[25] allerdings nur in ausgewiesenen Fällen fälschliche Großschreibungen,[26] sodass es sich hierbei im Wesentlichen „nur" um eine defizitäre Probe handelt, die als Herangehensweise an das Konzept der Großschreibung nicht per se zurückzuweisen ist. Insgesamt kann die genuin syntaktische Attributprobe linguistisch gesehen (vgl. auch Müller 2016) und in ihrer didaktischen Umsetzung in der Form von Treppengedichten (Röber-Siekmeyer 1999) als die vielversprechendste angesehen werden. Selbst für die nicht prototypische Großschreibung im Falle der Verlaufsform (s. Abschnitt 5) kann die Attribuierbarkeit als Nachweis dienen und zu Schülereinsichten auch in unteren Klassenstufen führen, wenn sie denn systematisch vermittelt wird. In der Konsequenz wäre eine syntaktische Definition des Substantivs als attribuierbarem Kern einer Nominalphrase didaktisch angemessen, was dann auch nicht völlig vom traditionellen Wortartenkonzept abweichen würde, sofern man dies mit prototypischen Substantiven des Kernwortschatzes einführt.

Dass die syntaktische Vermittlung nicht nur ein theoretisches Plädoyer von Sprachdidaktikern ist, sondern empirisch nachweislich nutzbringend ist, konnte in der Interventionsstudie von Gaebert (2012) gezeigt werden. In dieser Erhebung ist ein selbstentwickeltes syntaktisches Umlernkonzept, das sich u. a. an Röber-Siekmeyer (1999) orientiert, an einer 5. bzw. später 6. Jahrgangsstufe (29 Schüler, nochmals unterteilt in

[25] Dies gilt erst recht, wenn man kindliche Logik nicht außer Acht lässt: „Ich schreibe Hund klein! Ich fasse doch keinen Hund an!" (Spitta 1990: 2).

[26] Gegen die Anfassprobe könnte man einwenden, dass Kinder weich in weiches Fell großschreiben, da dies etwas mit Anfassen zu tun hat. Dies träfe allerdings nur auf einen kleinen Kreis von Attributen zu, die semantisch etwas mit Anfassbarkeit zu tun haben; das erscheint deshalb vernachlässigbar. Sollte dieser Fall eintreten, müsste man dem Schüler erklären, dass es nur um konkret Anfassbares geht. Gleiches gilt im Falle der Sehprobe beispielsweise für Farben.

rechtschreibschwache (13) und -starke Probanden/innen (16)) über zwei Halbjahre hin erprobt und mit einer Kontrollgruppe (24 Schüler) verglichen worden. Grob zusammengefasst kann konstatiert werden, dass sich alle Gruppen in ihren Rechtschreibleistungen verbesserten, die Kontrollgruppe jedoch weniger deutlich, was als Indiz für den Mehrwert des syntaxbezogenen Ansatzes gewertet werden kann. Die Interpretation der Ergebnisse lässt sich bezogen auf alle Großschreibungen jedoch nicht generalisieren, wenn die Auswertungen hinsichtlich Abstrakta-Großschreibung oder Substantivierungen detaillierter werden. Diesbezüglich sind weitere Studien vonnöten.

Möglicherweise könnte die konsequente didaktische Umsetzung einer syntaktisch motivierten Großschreibung zu einem potentiell höheren ex- und impliziten grammatischen Verständnis führen, als dies bislang mit dem starren Festhalten am traditionellen lexikalischen Wortansatz der Fall ist, so dass die Großschreibung stärker von Lesern/innen genutzt werden kann. Der Erwerb der GKS könnte damit nicht nur zur Rechtschreibkompetenz des/der Schreibers/innen, sondern auch zur Rezeptionskompetenz des/der Lesers/innen beitragen

III. The Influence of the German Capitalization Rules on Reading

III.1 Vorbemerkung

Dieser Abschnitt basiert auf:

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III.2 Abstract

German orthography systematically marks all nouns (even other nominalized word classes) by capitalizing their first letter. It is often claimed that readers benefit from the uppercase-letter syntactic and semantic information, which makes the processing of sentences easier (e.g Bock et al. 1985, 1989). In order to test this hypothesis, we asked 54 German readers to read single sentences systematically manipulated by a target word (N).

In the experimental condition (EXP), we used semantic priming (in the following example: *sick* → *cold*) in order to build up a strong expectation of a noun, which was actually an attribute for the following noun (N+1) (translated to English e.g. "*The sick writer had a cold* (N) *nose* (N+1) …"). The sentences in the control condition were built analogously, but word N was purposefully altered (keeping word length and frequency constant) to make its interpretation as a noun extremely unlikely (e.g. "*The sick writer had a blue* (N) *nose* (N+1) …"). In both conditions, the sentences were presented either following German standard orthography (Cap) or in lowercase spelling (NoCap). The capitalized nouns in the EXP/Cap condition should then prevent garden-path parsing, as capital letters can be recognized parafoveally. However, in the EXP/NoCap condition, we expected a garden-path effect on word N+1 affecting first-pass fixations and the number of regressions, as the reader realizes that word N is instead an adjective. As the control condition does not include a garden-path, we expected to find (small) effects of the violation of the orthographic rule in the CON/NoCap condition, but no garden-path effect.

As a global result, it can be stated that reading sentences in which nouns are not marked by a majuscule slows a native German reader down significantly, but from an absolute point of view, the effect is small. Compared with other manipulations (e.g. transpositions or substitutions), a lowercase letter still represents the correct allograph in the correct position without affecting phonology. Furthermore, most German readers do have experience with other alphabetic writing systems that lack consistent noun capitalization, and in (private) digital communication lowercase nouns are quite common.

Although our garden-path sentences did not show the desired effect, we found an indication of grammatical pre-processing enabled by the majuscule in the regularly spelled sentences: In the case of high noun frequency, we post hoc located parafovea-on-fovea effects, i.e. longer fixation durations, on the attributive adjective (word N). These benefits of capitalization could only be detected under specific circumstances. In other cases, we conclude that longer reading durations are mainly the result of disturbance in readers' habituation when the expected capitalization is missing.

III.3 Introduction

To our knowledge, German is (besides Luxembourgish, which is in fact a German dialect) the only remaining language which systematically marks nouns by capitalized letters (majuscules), which also includes nominalizations of all word classes, while using the Latin alphabet. Not only are all noun classes capitalized, but also all kinds of nominalization, which includes all word classes. Besides punctuation rules, capitalization rules take up most of the space in the German standard orthography regulations called "Amtliches Regelwerk" (Rat für deutsche Rechtschreibung, 2018). Due to the fact that German capitalization rules are the most fault-prone area in German orthography from 4th grade on (Moser, 1958; Menzel, 1985; Zimmermann and Heckel, 1986; Zabel, 1992; Kluge, 1995; Röber-Siekmeyer, 1999; Granzow-Emden, 2002; Günther and Nünke, 2005; Röber, 2011), discussions are held at regular intervals regarding its necessity (e.g. Mentrup, 1979a, 1979b).

The most relevant arguments for keeping the capitalization rules should be either that they (1) clarify ambiguities or that (2) the reader benefits to the effect of faster text processing. If neither of those were true, the only arguments left would be historical or aesthetic.

Concerning (1), Augst (1980) argued by investigating a massive text corpus that there would be almost no sentence ambiguity and absolutely no context ambiguity when using a purely lowercase (minuscule) spelling. Augst's final conclusion that marking a noun by a majuscule is functionless for the writer and unnecessary for the reader's text comprehension leaves open the question whether there is any other benefit for the reader at all.

For this reason, an examination of the potential benefits becomes necessary. In the mid-1980s and early 1990s, several studies were conducted: Bock and colleagues (1985) ran different studies (for more detailed descriptions and discussion, see: Pauly and Nottbusch 2016; Nottbusch and Jonischkait 2011) concerning the question of the function of majuscule and minuscule for German readers. The hypothesis was that the majuscule gives a clear sign to the noun word class, which supports semantic analysis or may even make it obsolete, so that reading is supported. The methodology for validating the theory was a systematic manipulation of the beginning of words in all word classes. Subjects were supposed to read 20 short texts with five spelling varieties: 1) German capitalization rules, 2) English standard orthography, 3) all words beginning capitalized, 4) a random mixture of lower- and uppercase letters, and 5) inversion of the German capitalization rules. A total of 80 subjects read 20 texts (approximately 125 words, 30% nouns), four in sequence from one of the varieties described above. The only significant result was the difference in reading duration between the varieties.

The more the spelling varied from the regularities the slower the reading duration was, which led to the following ranking: German capitalization rules (33.1 seconds mean reading time, 229.6 words per minute (wpm)) < English standard orthography (34.6 s, 219.7 wpm) < All words capitalized (36.8 s, 206.4 wpm) = Random mixture (37.2 s, 204.6 wpm) < Inversion of capitalization rules (39.4 s, 192.8 wpm). The result is not astonishing and allows no conclusion regarding any benefit of the German capitalization rules, because it only confirms that reading speed decreases the more a spelling varies from the standard orthography. In Bock et al. (1989), 100 German students of English and 100 Dutch students of German took part. The participants read 20 German texts (fables, mean length: 247 words), 10 in German (all participants) and 10 in English (German participants) or 10 in Dutch (Dutch participants). The texts were presented in the five spelling varieties described above. The results of Bock et al. (1985) were replicated for the Germans reading German texts. However, when German students read English texts there was no significant difference between the texts following German standard orthography (which is irregular here) and the regular English standard orthography (212 wpm each). Bock concluded that this can be explained by two contrary effects on reading: The violation of the English orthography produces a cost, but the German capitalization rules lead to a benefit due to syntactic hints, which in sum leads to a zero difference. He further concluded that the German Capitalization System would be transferable to other languages. The Dutch participants read the German texts with the same ranking as the Germans did: The Dutch texts were read fastest when following the standard orthography (like in English, very fast: 361 wpm), the German capitalization rules ranked second (348 wpm), but led to less deceleration than the three other spellings (Bock et al., 1989, 48–49). In sum, for both groups it can be stated that the more spelling varies from the norm, the longer the reading time.

The first eye-tracking study so far which systematically examined the function of the German Capitalization System was conducted by Gfroerer et al. (1989), who replicated the experiment just reported: 15 Dutch participants read the same texts as in Bock et al. (1989) in Dutch and German in the five spelling modes (50 texts total, 10 per spelling mode). The authors found the Dutch texts to be read faster than the German texts in all spelling modes. However, one result is very interesting: Not only the German (182 wpm) but also the Dutch texts (311 wpm vs. 286 wpm when following standard orthography) were read fastest by the Dutch readers when they followed the German capitalization rules. Therefore, the authors concluded that

the German Capitalization System is transferable to other writing systems. The results are astonishing, but should be treated carefully, because it was a pilot study and because of technical problems the authors reported.

While these studies report interesting findings by making global conclusions regarding the function of one orthographic rule, we wanted to validate these results by using the eye-tracking technique, which has become even more precise over the years.

Our overall task was to find an answer to the question of whether the German Capitalization System serves a function for the reader, i.e. whether the additional syntactic information helps the reader parse the sentence. To clarify our hypothesis, we first describe here the chronological processing of foveal word identification: As a first step, visual information is obtained before the orthography (letter identity and word length), phonology (sounds), and morphology (units of meaning, grammatical gender, etc.) of the word can be analyzed. It may be noted that the orthographic analysis takes place at a very early stage of processing. Afterwards, the lexical representation (the abstract representation of the word form) is accessed. In the end, the semantic (word meaning) and syntactic (grammatical role) representations of the word are accessed and integrated into the meaning of the sentence (cf. Schotter et al., 2012, 7f.). Although the syntactic processing is one of the last steps in processing, it could be argued that in the case of German nouns it somehow occurs together with orthographic processing, due to the fact that a reader implicitly knows that a noun is systematically marked by a majuscule. A similar effect could also be assumed in a more parallel and interactive model, in which orthographic information triggers syntactic processes.
In the very beginning of word identification, at least parafoveally, a majuscule can be identified. Readers of a left-to-right alphabetic writing system obtain useful information from a region extending from 3-4 letters to the left of the fixation to about 14-15 character spaces to the right of the fixation, although information used for word identification is obtained from an even smaller region, 7-8 letters to the right of the fixation (Rayner and Castelhano, 2008). A majuscule, however, can be recognized even further away. After having identified and processed this capital letter, a competent speaker and reader of German should possess an implicit knowledge about the syntactical function a noun serves in a German sentence, which should speed up processing. If capitalization is omitted, not only is the orthography violated,

but the syntactical information is also missing. The capitalization of nouns makes parafovea-on-fovea effects (PoF) more likely, while these effects are controversial. There is a "great deal of evidence that PoF effects are driven by orthography, and not lexical status, syntactic role, or meaning" (Rayner and Schotter, 2014, 24). However, this could be different for noun capitalization in German, which is easy to identify parafoveally and which exclusively marks a word class.

Therefore, we chose a study design that should pinpoint the effect. The idea was to create an experimental context which ascribes differences in the measured parameters to the fact that nouns are being systematically marked, i.e. via the German Capitalization System, which makes it possible to eliminate the habit factor. That means that readers process sentences following the German standard orthography faster compared to those in which the orthography is violated not just because of habituation.

III.4 Experiment

In our study design, we systematically manipulated single sentences, which were presented in regular German spelling (Cap) and in lowercase spelling (like in English orthography; NoCap). Our hypotheses were the following:

- The German Capitalization System does serve a function for the reader, facilitating sentence processing through the systematic recognition of heads of noun phrases.
- The reader parafoveally recognizes the majuscule and is therefore able to systematically pre-process the following noun because a syntactic category becomes activated as well.

We created garden-path sentences containing ambiguous adjectives (word N) in the second noun phrase. By means of semantic priming, which was provoked by the first noun phrase (e.g. The sick writer had a cold (N) nose (N+1), cf. Table 1), the adjective was manipulated in order to be interpreted as a noun (experimental condition, EXP). Actually, this adjective was acting as an attribute for an upcoming noun (word N+1; cf. Table 1), so that reparsing of the sentence should become necessary on N+1. The garden-path effect and thus reparsing of the sentence read so far, however, should only become necessary in the NoCap condition because, if the sentences followed the standard orthography, the reader would not misinterpret an adjective as a noun because the nouns were capitalized and the adjective was not. Orthographic familiarity should not be a problem, i.e. the fact that capitalization or non-

capitalization is linked strongly to the word, because in German the so-called "morphematisches Prinzip" [morphemic principle] is very dominant in the orthography, which means that words which consist of the same morpheme are written identically or at least similarly. This principle was even strengthened in the last orthography reform (1996-2006). German readers are, since nominalization is very common in German, used to seeing the same morphemes capitalized and non-capitalized.

We also created control sentences (CON) in which word N was replaced by a non-ambiguous adjective that could not be misinterpreted as a noun. CON was also presented in both conditions (Cap and NoCap).

We expected the following effects (on N and N+1):

- EXP in Cap: Because of the capitalized nouns (N+1), processing should be possible without any confusion; parafoveal processing of the noun while fixating on the adjective should lead to shorter a fixation duration on the noun.
- EXP in NoCap: Again, due to violation of orthography, the fixation duration should be longer in general. Besides that, reparsing of the sentence due to the garden-path effect, which leads to a distinctly longer fixation duration on the noun in first-pass reading and regression to the adjective afterwards.
- CON in Cap: If possible, even less confusion; otherwise, see EXP in Cap.
- CON in NoCap: Again, due to orthography violation, the fixation duration on the noun should be longer compared to CON in Cap and shorter on the adjective due to a lack of parafoveal preprocessing.

III.5 Method

III.5.1 Material

A total of 40 experimental sentences (EXP) and 40 control sentences (CON) were constructed. CON was identical to EXP besides the manipulated position "N." To find matching ambiguous items for position "N," we searched through the CELEX Database (Baayen et al., 1995): We found 1032 examples including all flections; only 68 noun-adjective pairs were left after sighting of the examples, e.g. deletion of uncommon, incorrect or inflected word forms, derivations, etc. The inflected word forms in particular reduced the number to at least a third. We then created sentences which were independently evaluated by six language experts from

our department regarding the garden-path trap and their naturality, and finally chose 40 items (see Appendix).

The sentences had a length of 7 to 10 words (M: 8.6, SD: 0.74); word length within the sentences varied from 2 to 16 letters (M: 5.7, SD: 3.05). The sentences were 44 to 74 characters long (including spaces and final period; M: 57.6, SD: 6.56). All sentences followed a very similar syntactical structure which consisted of four units: Position one was either occupied by a Nominal Phrase (NP) or an Adpositional Phrase (AP), which always contained a noun. The following position was occupied by the verb. The third and fourth units again were composed of either a NP or an AP. The EXP sentences were systematically manipulated following the concept of semantic and partially syntactic priming (cf. Table 1): The first AP/NP and the verb were supposed to create a semantic context that evoked a certain reading of the following (second) AP/NP, depending on the orthography of the sentence. The second AP/NP consisted of three words: "N-1," which was either the determiner of the noun (indefinite or definite article) or a preposition. Position two ("N") always represented an attribute of the following noun ("N+1"). The noun N+1 had a word length from 3 to 13 letters (M: 7.38, SD: 2.60); syllables ranged from 1 to 4 (M: 2.33, SD: 0.88). Word N in EXP was semantically related to the first noun phrase and the sentence could syntactically and semantically end after N (i.e. the adjective would serve as a noun). The frequency of interpreting N in EXP either as an adjective (849, log10: 2.93; SD: 1240, log10: 3.1) or a noun (1020, log10: 3.0; SD: 1486, log 10: 3.2) was comparable. As mentioned above, the semantic context should lead the reader into a garden-path trap when capitalization is missing in the whole sentence, which should make parsing as a noun more likely. EXP and CON were presented in two different spellings: 1) The German standard orthography including the capitalization rules and 2) following the English standard orthography with a majuscule (only) at the beginning of the sentence – proper names and other exceptions were avoided.

As mentioned before, the only difference between EXP and CON was position "N," which had a length of 5 to 11 letters (M: 7.58, SD: 2.11). The number of syllables in N differed slightly between EXP (Range: 2 to 5, M: 2.73, SD: 0.89) and CON (Range: 2 to 4, M: 2.9, SD: 0.77). The adjectives (i.e. N) for EXP and the corresponding CON were identical in word length and their frequency was matched as far as it was possible to construct a CON sentence which made syntactic and semantic sense. The frequency of N was determined by the two possible readings of EXP: N could be identified as either a noun or an adjective, depending on the

spelling presented. Therefore, we decided to use the calculated mean of the two frequencies (adjective and noun) in EXP (M: 934, log10: 2.97; SD: 1034, log10: 3.01) when matching the frequency of N in CON (M: 922, log10: 2.96; SD: 1057, log10: 3.02). N+1 had a mean frequency of 7861 (log10: 3.90; SD: 12103, log10: 4.08). Word frequencies (i.e., frequencies of complete word forms) were based on "DLEXDB" (Corpus: DWDS [Digital Dictionary of the German Language]) with over 100 million running words (Heister et al., 2011).

The filler sentences were 6 to 10 words in length (M: 8.1, SD: 1.21); word length varied from 2 to 20 letters (M: 5.48, SD: 2.68); the sentences were 43 to 69 characters long (including spaces and final period; M: 52.5, SD: 6.06). Their syntactic structure differed from the EXP and CON sentences. The filler sentences were mainly extracted from the Potsdam Sentence Corpus (PSC) v. 1.0, which was "constructed with the goal of representing a large variety of grammatical structures" (Kliegl et al., 2004, 267; White et al., 2008, 1271). By using a large range of syntactic constructions, we wanted to make sure that it was not very likely for the participants to see through the syntactic scheme of EXP and CON (each participant read three times more filler sentences than experimental/control ones, see below). As in the EXP and CON sentences, partial minor modifications were made, e.g. avoiding proper names within the sentence, so that no capitalization was necessary.

*Table 1: Example sentence of EXP and CON in all conditions (differences between the modes are printed in bold letters). In EXP/NoCap, the nouns are not capitalized; hence, the adjective in position N ("matten" / "tired") can be misinterpreted as a noun ("Matten" / "mat"). This is not the case for "steten" / "steady." Analogous examples in English would be: "The sick writer had a **cold** nose throughout the winter" vs. "The sick writer had a **blue** nose throughout the winter."*

Sentence Mode	Spelling					N-1	N Adjective	N+1 Noun				Garden-path
		Adpositional Phrase			Verb	Noun Phrase			Adpositional Phrase			
EXP	Cap	In	der	**G**ymnastikhalle	liegen	die	**matten**	**S**portler	auf	de m	**B**oden.	**No**
	NoCap			**g**ymnastikhalle			**matten**	**s**portler			**b**oden.	**Yes**
CON	Cap			**G**ymnastikhalle			**steten**	**S**portler			**B**oden.	**No**
	NoCap			**g**ymnastikhalle			**steten**	**s**portler			**b**oden.	**No**

III.5.2 Participants

Fifty-four participants, mostly undergraduate students and a small number of academic staff members from Potsdam University (37 female, 17 male) with normal or corrected-to-normal vision, took part in the experiment. All participants were totally fluent in German; fifty-two of them were native speakers, the non-natives without any accent. The age span ranged from 19 to 46 years; the mean age was 25.8 (SD: 6.01).

The sessions lasted for about 30 min, after which the participants filled out an anonymous questionnaire asking for personal data and questions concerning spoken languages and possible problems with German. 93 percent of our participants had learned at least one foreign (alphabetic) language, i.e. were familiar with at least one non-capitalized script; 87 % of the participants were familiar with English, which they had practiced for a mean duration of 13.5 years (SD: 5.4). In addition, they had to answer questions regarding their exposure to (in reading) and production of text violating German capitalization rules, e.g. in digital form. In addition to that, they were asked to evaluate how disturbed they feel by spelling violations (especially non-capitalized nouns) during reading.

III.5.3 Apparatus

Eye movements of the subjects were recorded monocularly in a darkened laboratory with an SR EyeLink 1000 system (500 Hz); the experiment was programmed with Experiment Builder software by SR Research. Sentences occupied only one line on the screen and were presented one at a time in the 1/3 vertical position from the top of the screen of a 22-in. TFT Monitor (1680 × 1050 resolution; frame rate 120 Hz). Subjects were seated 60 cm in front of the monitor with their head positioned on a chin rest; participants' dominant eye was tracked. Texts were displayed using 26 pt. bold font Courier New.

III.5.4 Procedure

Before the beginning of the main experiment, there was a pretest consisting of three sentences, so that the participants had a chance to ask questions to clarify ambiguity if necessary. Each subject read 160 sentences in the main experiment: all 120 filler sentences, 20 EXP (10 capitalized, 10 not capitalized) and the remaining counterpart of 20 control sentences, again 10 Cap and 10 NoCap. The order was pseudo-randomized, i.e. all 40 experimental sentences (see Appendix) were presented in all four conditions resulting in each sentence per condition being read by 14 participants.

Subjects' measurements were calibrated with a standard nine-point grid. After the validation of calibration accuracy, a drift correction point appeared on the center of the screen. When the dot was fixated, the fixation point re-appeared on the left side of the monitor. If the eye tracker identified a fixation on the fixation spot within 2000 ms for at least 50 ms, the fixation point disappeared and a sentence was presented such that the center of the first letter in the

sentence appeared to the right of the fixation-point position. If there was no identification, the calibrating procedure was repeated.

Subjects were instructed to read the sentences for comprehension and to signal the completion of a trial by fixating on a dot in the lower right corner which either automatically led to the next sentence or to a dual choice task regarding the content of the sentence they had read before. The reason for the question was to ensure that the participants read all the sentences attentively, supported by the fact that the questions appeared in a random order. The answer options were of similar but different structures (e.g. different word classes; example question: “How was the game? A) Spectacular B) Boring”). The answer was given by a left (answer A) or right (answer B) mouse-click, which was supported by an image below the question to avoid confusion. Questions were already asked in the pretest mentioned before. A total of 40 questions were asked per subject (i.e. in 25% of the trials), and subjects correctly answered 99.2% of questions with a maximum of two wrong answers per participant.

III.5.5 Data Analysis

Fixations were automatically determined by the EyeLink Data Viewer by SR Research. Outliers within the eye movement data were omitted in two steps: First, all potentially mislocated fixations (50 ms or less) were deleted. Second, fixations exceeding 2.5 SD of the mean for each eye movement measure were deleted for each participant. The following measures were calculated:

- First fixation duration (the first of multiple fixations or the only fixation on a target),
- Gaze duration (summation of the duration across all fixations of the first run within the current area of interest),
- Total fixation duration (all fixations on the target, including regressions),
- Regression duration (Total minus Gaze),
- Reading speed (the start time of the first fixation within a sentence until the end of the last fixation, divided by the number of words, minimum duration of 1200 milliseconds).

This left 97.3 % of the data remaining. Apart from that, the number of fixations in Gaze and Total, the number of regressions, is part of our analysis. Linear-mixed models (lme) were used to analyze the eye movement data for each dependent measure in the R environment with the lme4 package version 1.1-13 (Bates et al., 2015b).

The independent measures were as follows:

- Mode of spelling ("SPELLING"), which means whether the nouns have been capitalized (Cap) or not (NoCap);
- Mode of the sentence ("SENTENCEMODE"), which means the two conditions EXP (garden-path, ambiguous in NoCap) and CON (non-ambiguous);
- Position/location of fixation ("POSITION"), which means either Adjective ("N") or Noun ("N+1");
- Word length ("LENGTH"), which means word length in letters - measures were centered;
- Frequency ("FREQUENCY"), which means the absolute token frequency of adjective N and noun N+1 - measures were logarithmized and centered;
- Frequency of noun ("FREQNOUN"; only for one model), which means frequency of the noun N+1, divided into two equal-sized groups "high" (Min: 2589, log10: 3.41; Max: 48779, log10: 4.69; M: 14938, log10: 4.17, SD: 13863, log10: 4.14) and "low" (Min: 1, log10: 0; Max: 2381, log10: 3.38; M: 785, log10: 2.89; SD: 771, log10: 2.89).

Spelling, sentencemode, position and the noun frequency (FREQNOUN) were transformed into effect contrasts. Participants and items were treated as crossed random effects, and all fixation duration measures were log transformed. By including word length and frequency as a main effect, we ensured that the found effects would be ascribed to our experimental variations and not to linguistic determinants of the words themselves. The criterion for significance was a *t*-value of two. Statistical models were selected following the pattern of parsimonious mixed models (Bates et al., 2015a). We selected the models by using the RePsychLing package which provides the function "rePCA" (random-effects Principal Components Analysis), which makes it possible to check models fitted with lmer for rank deficiency. Using the rePCA function, it is possible to determine parsimonious random effect structures because the "maximal model in many analyses of data from Psychology and Linguistics experiments, is almost always shown by this analysis to be degenerate" (Bates et al., 2015a, 3). A detailed description of model selection by using RePsychLing can be found in Bates et al. (2015a, 3).

III.6 Results

III.6.1 Global reading speed EXP and CON

Mean reading speed was 183.8 words per minute (wpm) in the capitalized condition and 171.1 wpm in the non-capitalized condition, i.e. reading sentences which conform to German orthography is faster than reading sentences without capitalization of nouns. This difference was highly significant (t value: -6.54). The sentence mode had a highly significant influence as well (t value: -4.60); it becomes obvious that the experimental sentences (EXP) were read significantly faster (181.4 wpm) than the control sentences (CON: 173.4 wpm). Including the interaction of spelling and sentence mode (n.s.), the effect of spelling/capitalization is very similar in both modes; reading speed for EXP is 189.5 wpm (Cap) vs. 173.7 wpm (NoCap), and for CON 178.3 wpm (Cap) vs. 168.6 wpm (NoCap).

III.6.2 Global reading speed filler sentences

Comparing the results of the experimental and control sentences with the 120 filler sentences, which consist of simpler syntactic structures, it becomes obvious that they were generally read faster: 210.2 wpm in the capitalized and 200.7 wpm in the non-capitalized condition; this effect was significant (t value: -7.5).

III.6.3 Gaze and Total fixation duration (Adjective and Noun)

Table 2 summarizes the model data for the main effects and interactions of Gaze and the Total fixation duration. The fixation times for the words N (Adjective) and N+1 (Noun) in Gaze duration (first pass fixations, left panel) show a significant main effect for the mode of spelling (noun capitalized M: 278.5, SD: 90.5 vs. not capitalized M: 288.3, SD: 92.4), as well as for the mode of the sentence (EXP M: 276.8, SD: 88.1 vs. CON M: 290.1, SD: 95.4), i.e. comparable to the global reading speed, the words in focus (N, N+1) were fixated on for less time when capitalization was present (as expected) in both experimental settings. Apart from that, a main effect for word length is detectable. Although there is no main effect for the location of fixation (i.e. adjective vs. noun), the interaction with capitalization is striking (t value: -7.08, cf. Figure 1): In regularly capitalized sentences, the adjective is fixated on for longer than the following noun, but if capitalization is missing the noun receives longer fixations; apart from that, adjectives show generally longer Gaze duration when capitalization is present.

Table 2: Gaze and Total, model data for the independent variables of the Fixation Duration, values appearing bold are significant.

	GAZE			TOTAL		
	Estimate	Std. Error	t value	Estimate	Std. Error	t value
(Intercept)	5.596	0.021	266.26	5.74	0.028	201.89
SPELLING	-0.034	0.01	**-3.29**	-0.045	0.012	**-3.86**
SENTENCEMODE	-0.044	0.014	**-3.14**	-0.081	0.019	**-4.26**
POSITION	0.032	0.026	1.19	-0.003	0.026	-0.10
LENGTH	0.155	0.013	**12.22**	0.147	0.014	**10.30**
FREQUENCY	-0.01	0.013	-0.76	-0.029	0.015	-1.96
SPELLING:SENTENCEMODE	-0.007	0.021	-0.34	-0.005	0.023	-0.20
SPELLING:POSITION	-0.147	0.021	**-7.08**	-0.174	0.023	**-7.54**
SENTENCEMODE:POSITION	0.03	0.021	1.42	0.055	0.023	**2.36**
SPELLING:SENTENCEMODE:POSITION	-0.004	0.042	-0.09	-0.047	0.046	-1.02

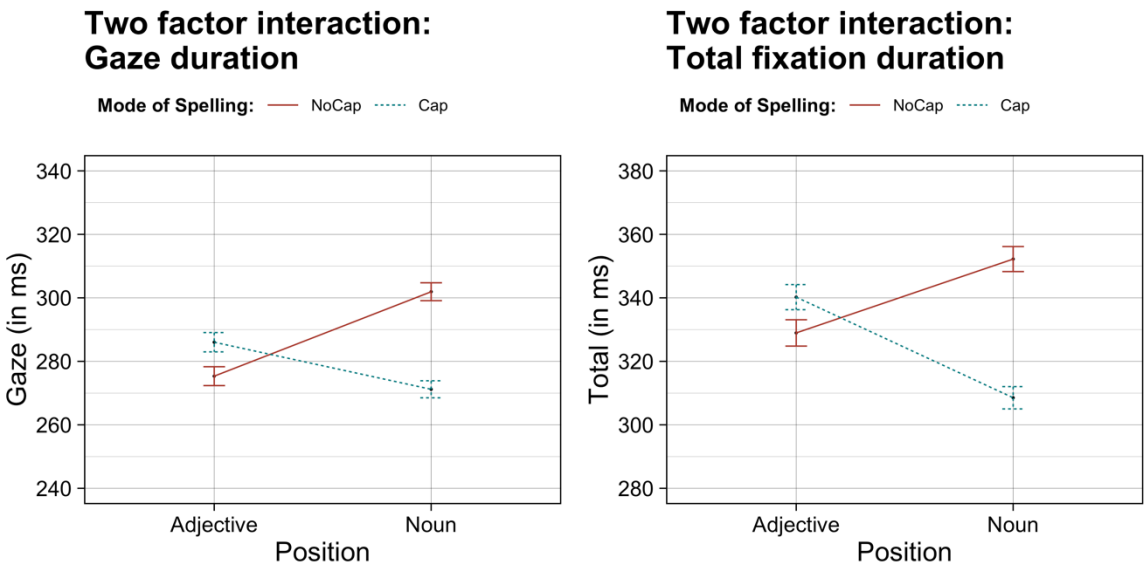

*Figure 1: Estimated values of the **two factor interactions of SPELLING (Cap vs. NoCap) and POSITION (Adjective vs. Noun)** (cf. Table 2) in Gaze duration (to the left) and in the Total fixation duration (to the right); error bars represent the standard errors. The blue (dotted) lines represent sentences that follow German standard orthography; the red (solid) lines represent sentences in which the nouns are not capitalized.*

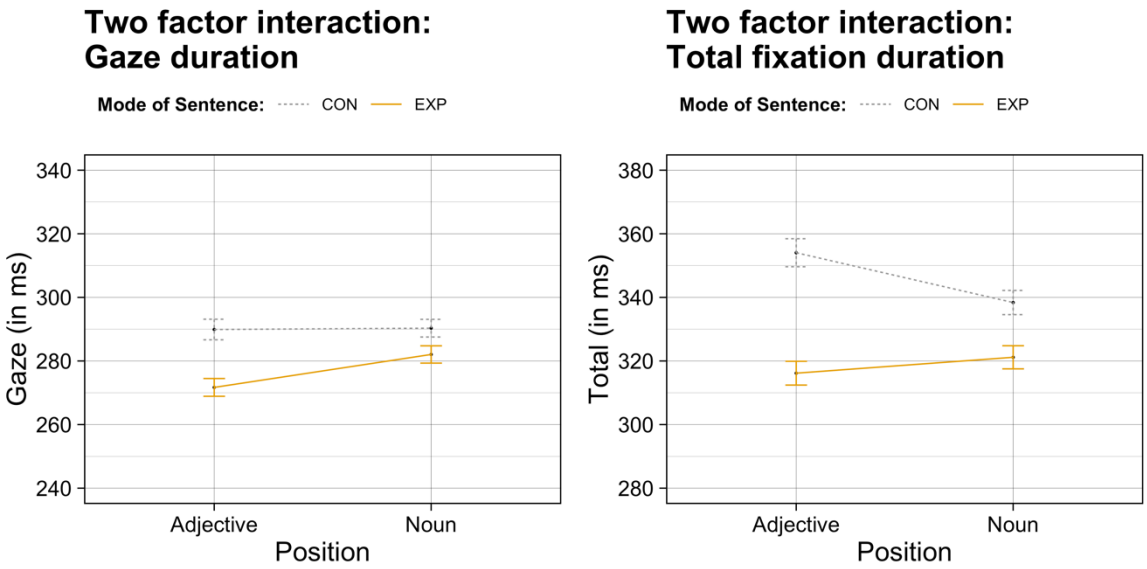

*Figure 2: Estimated values of the **two factor interactions of SENTENCEMODE (EXP vs. CON) and POSITION (Adjective vs. Noun)** (cf. Table 2) in Gaze duration (to the left, n.s.) and in the Total fixation duration (to the right); error bars represent the standard errors. The garden-path sentences (EXP) are represented by yellow (solid) lines and the control sentences (CON) are represented by grey (dotted) lines.*

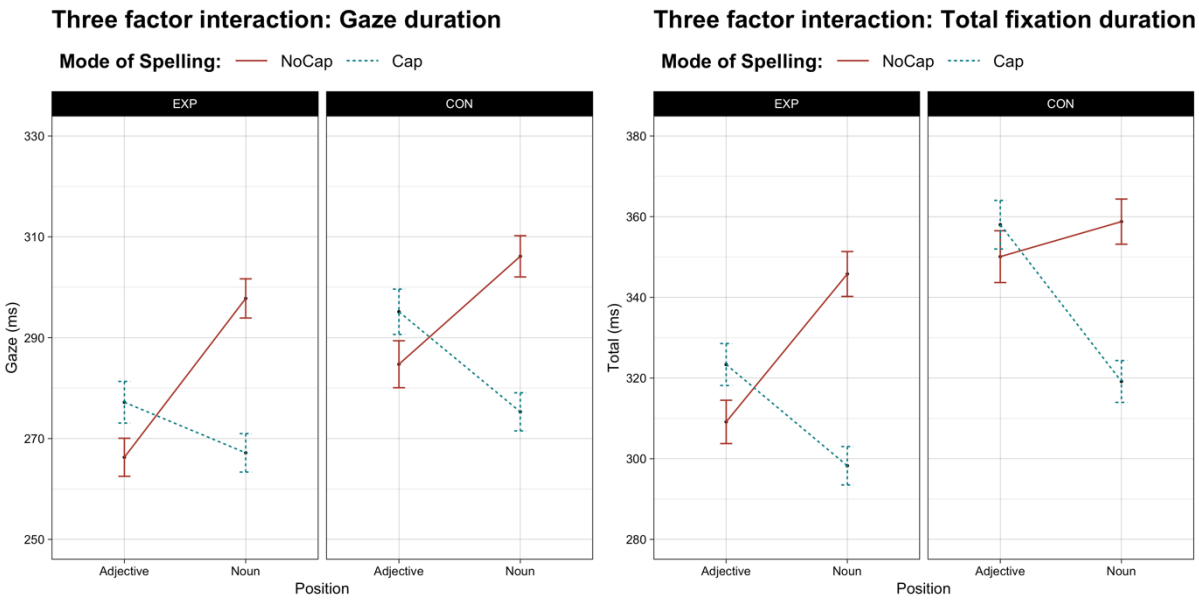

*Figure 3: Estimated values of the **three-way interactions of SPELLING (Cap vs. NoCap), SENTENCEMODE (EXP vs. CON) and POSITION (Adjective vs. Noun)** (cf. Table 2) in Gaze duration (to the left) and in the Total fixation duration (to the right); error bars represent the standard errors. The garden-path sentences (EXP) are shown to the left and the control sentences (CON) are represented to the right. The blue (dotted) lines represent sentences that follow German standard orthography; the red (solid) lines represent sentences in which the nouns are not capitalized.*

An interaction between the mode of the sentence and the location of fixation (cf. Table 2, Figure 2) did not reach significance, nor did, contrary to our hypothesis, the three-way interaction of all independent measures (cf. Figure 3), i.e. the sentence mode did not modulate the reading behavior for any kind of adjective or noun. Due to the complexity of our experimental design, we decided to show these plots to support the reader's understanding. Generally, the settings EXP and CON differed to such an extent that the control sentences were read more slowly. We will discuss this issue below.

The fixation times for the word N (Adjective) and N+1 (Noun) in the Total fixation duration (all fixations for each word including regressions) again show a significant main effect for the spelling mode (noun capitalized M: 324.0, SD: 118.3 vs. not capitalized M: 340.4, SD: 130.2) as well as for the sentence mode (EXP M: 318.7, SD: 118.2 vs. CON M: 346.1, SD: 130.6), i.e. we found shorter fixation durations on N/N+1 when capitalization was present in both experimental settings. Once more, the word length effect is significant. The interaction with capitalization is again striking (t value: -7.54, cf. Figure 1): In regularly capitalized sentences, the adjective is fixated on for longer than the following noun, but if capitalization is missing the noun receives longer fixations; however, this difference is not significant.

The only difference compared to Gaze is the significant interaction of the sentence mode (cf. Table 2, Figure 2) and the fixation location in such a way that the control sentences receive

longer regressions on the adjective when the noun is not capitalized compared to the experimental sentences, i.e. the reader seems to clarify the meaning of this specific adjective. A possible explanation for this will be discussed below. Again, the three-way interaction of all independent measures did not reach significance.

III.6.4 Gaze and Total fixation rate (Adjective and Noun) and inter-word regressions

Regarding the *number of fixations* (cf. Table 3) in the first run on adjectives and nouns (i.e. Gaze), there is no main effect for the spelling mode (capitalization vs. missing capitalization of the noun), which means that in contrast to the significantly longer fixation durations reported above when capitalization is missing, the mean number of fixations does not differ significantly. In contrast to that, there is a very small effect for Total, in which significantly more fixations in NoCap are made compared to Cap (Cap: M: 1.616, SD: 0.634; NoCap: M: 1.659, SD: 0.683). Word length and frequency as main effects are detectable in Gaze and Total. The latter is exclusive for the number of fixations and does not occur in case of mean fixation durations.

Regarding the sentence mode, there is another main effect which only occurs in Total (cf. Table 3), i.e. significantly more fixations are made in CON compared to EXP. An explanation for that will be discussed below and is connected with the longer regressions on the adjective mentioned above (CON M: 1.674, SD 0.667; EXP M: 1.600, SD 0.651). Hand in hand with the mean fixation durations, there is also a significant – although weaker – interaction between the spelling mode and fixation position (cf. Figure 4) in Gaze and Total. Please note that the characteristic between Gaze and Total is slightly different: When capitalization is present, adjectives are fixated on more often compared to nouns, but this is only significant in Total. Instead, in cases where the capitalization is absent, it is vice versa: Adjectives are fixated on less often compared to nouns, but the difference between them is only significant in Gaze. The explanation for that is that adjectives receive more regressions compared to nouns (see also Table 4). Apart from that, there is no significant difference between the two spelling modes. In sum, the number of fixations is less affected than the fixation durations.

Table 3: Gaze and Total, model data for the independent variables of the mean number of fixations; values appearing bold are significant.

	GAZE			TOTAL		
	Estimate	Std. Error	t value	Estimate	Std. Error	t value
(Intercept)	1.378	0.023	58.91	1.637	0.050	32.58
SPELLING	-0.023	0.015	-1.52	-0.043	0.021	**-2.02**
SENTENCEMODE	-0.012	0.015	-0.78	-0.074	0.027	**-2.69**
POSITION	0.014	0.036	0.38	-0.041	0.038	-1.07
LENGTH	0.244	0.017	**14.78**	0.253	0.021	**12.33**
FREQUENCY	-0.039	0.018	**-2.14**	-0.062	0.022	**-2.76**
SPELLING:SENTENCEMODE	0.009	0.030	0.28	-0.006	0.042	-0.13
SPELLING:POSITION	-0.079	0.030	**-2.64**	-0.138	0.042	**-3.27**
SENTENCEMODE:POSITION	0.032	0.030	1.06	0.083	0.042	1.95
SPELLING:SENTENCEMODE:POSITION	0.091	0.060	1.51	0.032	0.084	0.38

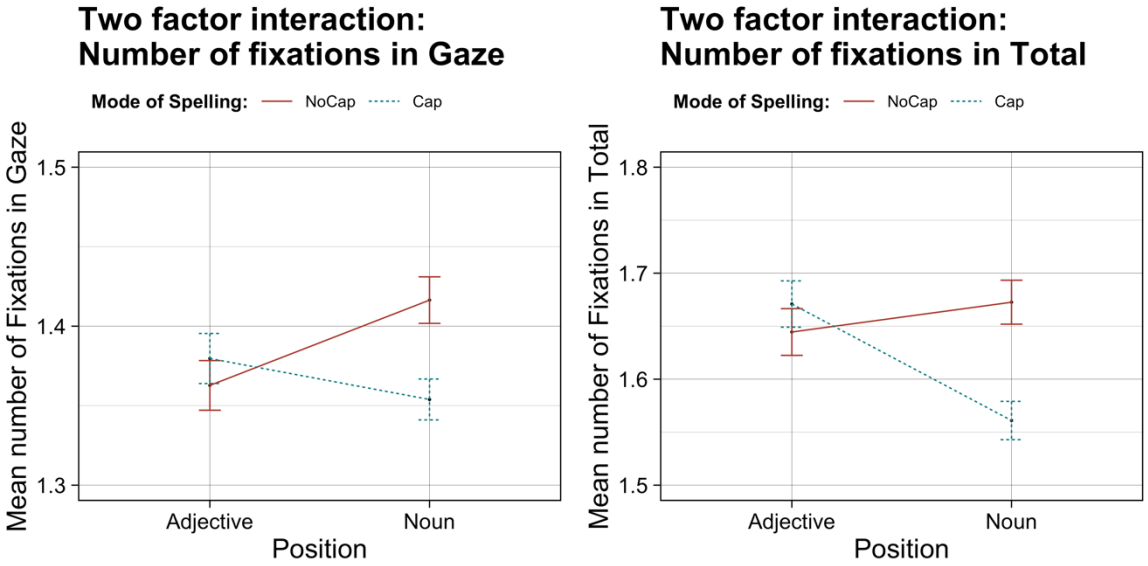

Figure 4: Significant two-factor interactions of SPELLING and POSITION regarding the mean number of fixations in Gaze (left) and in Total (right). The blue (dotted) lines represent sentences that follow German standard orthography; the red (solid) lines represent sentences in which the nouns are not capitalized.

Regarding the inter-word regression rate (cf. Table 4), i.e. the rate of receiving at least one regression from a word to the right, we found values between 6.7 % and 13.4 %. A clear tendency becomes apparent: The adjectives receive more regressions compared to the nouns, and regressions are more likely in the NoCap condition.

Table 4: Descriptive Statistics: Probability of receiving at least one regression from a higher Interest Area (word from the right); colors are shading from dark green (low value) to yellow (middle value) to red (high value)

	Cap	NoCap	Diffe-rence
all (Noun & Adj. in EXP & CON	9.53%	10.62%	1.09%
CON all	9.66%	10.94%	1.28%
EXP all	9.40%	10.31%	0.91%
all Adjective	11.92%	12.28%	0.36%
CON Adjective	11.85%	13.35%	1.50%
EXP Adjective	11.99%	11.24%	-0.75%
all Noun	7.10%	9.00%	1.90%
CON Noun	7.51%	8.62%	1.11%
EXP Noun	6.68%	9.39%	2.71%

III.6.5 Fixation duration depending on the frequency of the noun

The following analysis of noun frequency effects was integrated *post-hoc*, and the division of the nouns into high- and low-frequency items cuts the sample size per condition by half. Therefore, we present these results with considerable caution. Relating the Gaze duration (cf. Table 5) of the adjective and the noun to the frequency of the noun (FREQNOUN, low vs. high frequency), there are once again notable effects caused by SPELLING (Cap vs. NoCap), i.e. shorter fixation durations on N/N+1 in cases where the spelling of the noun is correct, and caused by the SENTENCEMODE (EXP vs. CON), i.e. shorter fixation durations in the EXP condition. Furthermore, a notable effect caused by word length is demonstrable (LENGTH). Moreover, interaction for SPELLING:POSITION (Cap vs. NoCap : Adjective vs. Noun) is highly significant. The three-way (SENTENCEMODE:POSITION:FREQNOUN) and four-way interactions (SPELLING:SENTENCEMODE:POSITION:FREQNOUN) are significant as well, notwithstanding the small sample size.

Among the capitalized conditions of the control sentences, the duration of the Gaze on the nouns is not affected by the frequency of the nouns but rather the adjectives (cf. Figure 5, upper-left and upper-right graph, gray line grey dotted line; see “Problems with Garden-Path and Control Sentences” below and discussion). The Gaze durations on the adjective in the correctly spelled EXP non-garden-path sentences, however, show a highly interesting finding: If the following noun is of low frequency, the Gaze durations on the adjective are significantly shorter compared to a high-frequency noun with a difference of more than 21 ms. Over the course of the exercise, the processing time of the noun is influenced. Apart from that, the ratios of adjective and noun mean durations in EXP depend on the frequency (cf. Figure 5

upper-left and upper-right graphs, yellow solid line): While in the context of a low-frequency noun the adjective is fixated on shorter compared to the noun, this is vice versa when the noun frequency is high.

The Gaze durations on the noun – in cases where it is correctly spelled – follow a typical pattern of frequency effects, which are well known (e.g. Broadbent, 1967; Becker, 1979): The mean fixation durations are significantly higher when the frequency is low compared to a higher frequency. In our experiment, this effect is only clearly visible in the capitalized EXP condition. When comparing capitalized with non-capitalized nouns, the durations are significantly shorter for the former. The mode of the sentence has no significant influence on the noun as long as it is not capitalized or, if it is capitalized, is low frequency. However, in the case of a capitalized high-frequency noun (cf. Figure 5, upper-right graph), there is a significant difference in the mean duration in EXP compared to CON. The slopes of the EXP line on the noun and adjective (cf. Figure 5, upper-right graph, solid yellow line) is the steepest of all lines. We interpret this as a sign of parafoveal preprocessing in cases where the noun is spelled correctly and of high frequency.

Table 5: Gaze duration depending on the Frequency of the Noun, model data for the independent variables of the Fixation Duration; values appearing bold are significant.

	Estimate	Std. Error	t value
(Intercept)	5.477	0.023	240.56
SPELLING	-0.034	0.01	**-3.29**
SENTENCEMODE	-0.044	0.014	**-3.16**
POSITION	0.024	0.025	0.96
FREQNOUN	-0.027	0.024	-1.13
LENGTH	0.204	0.015	**13.89**
SPELLING:SENTENCEMODE	-0.008	0.021	-0.39
SPELLING:POSITION	-0.148	0.021	**-7.16**
SENTENCEMODE:POSITION	0.028	0.021	1.34
SPELLING:FREQNOUN	-0.001	0.021	-0.04
SENTENCEMODE:FREQNOUN	0.025	0.028	0.90
POSITION:FREQNOUN	-0.034	0.044	-0.78
SPELLING:SENTENCEMODE:POSITION	-0.004	0.041	-0.10
SPELLING:SENTENCEMODE:FREQNOUN	0.018	0.042	0.42
SPELLING:POSITION:FREQNOUN	-0.065	0.042	-1.55
SENTENCEMODE:POSITION:FREQNOUN	-0.114	0.042	**-2.71**
SPELLING:SENTENCEMODE:POSITION:FREQNOUN	-0.222	0.084	**-2.66**

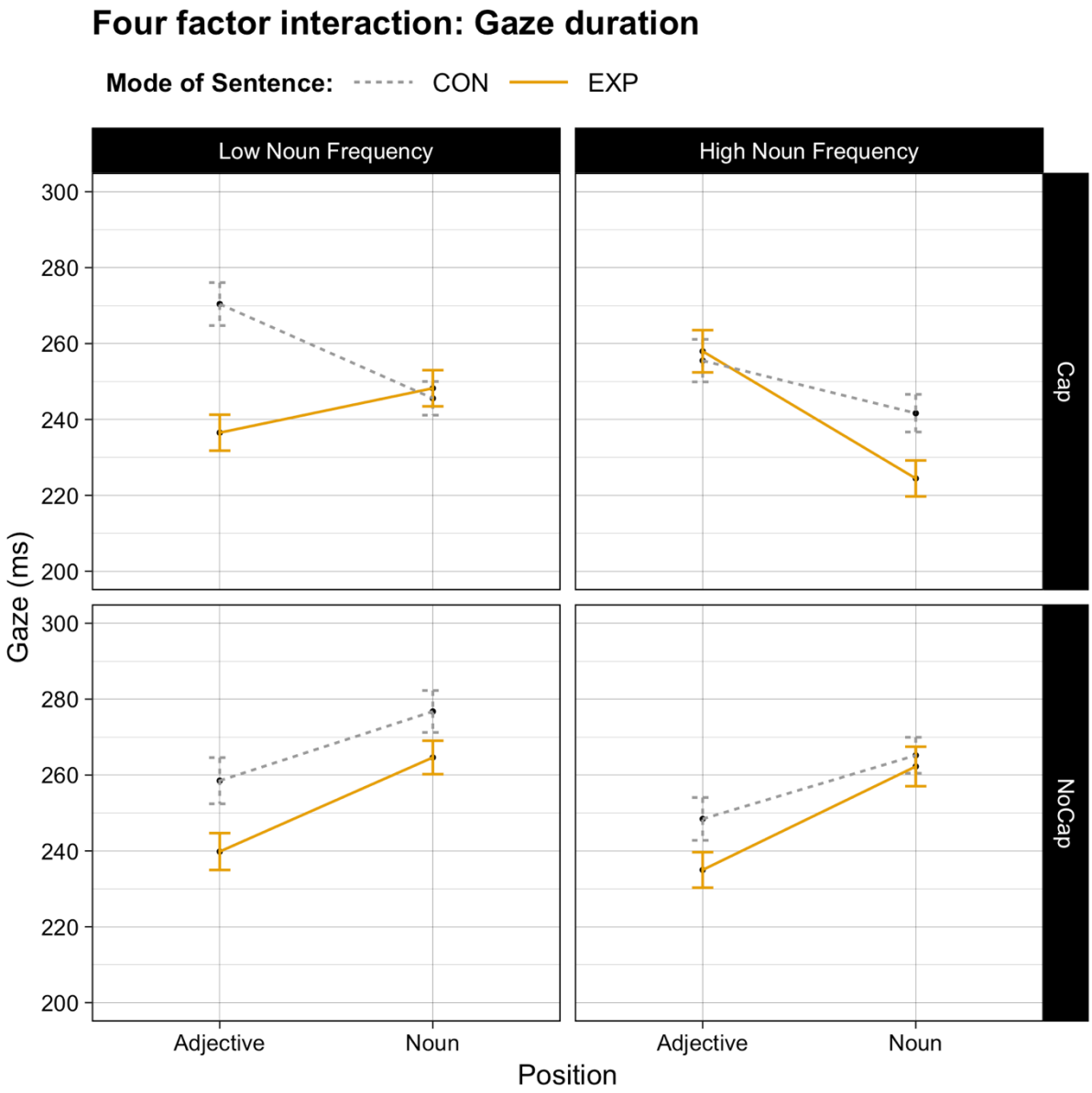

*Figure 5: Gaze duration on Adjective and Noun depending on the noun frequency. Estimated values of the **four-way interactions of SPELLING (Cap vs. NoCap), SENTENCEMODE (EXP vs. CON), POSITION (Adjective vs. Noun) and FREQNOUN**, i.e. the influence of the noun frequency on the fixation durations on the adjective and the noun themselves, divided into two groups: Adjective vs. Noun in Gaze duration (to the left); error bars represent the standard errors. Within both panels, "Low Noun Frequency" is shown to the left, "High Noun Frequency" to the right. Sentences following German standard orthography (Cap) are shown in the upper part of the graph, while the lower part represents sentences, in which the standard orthography is violated, i.e. noun with lowercase letter (NoCap). "Low" and "high" show the fixation duration depending on the level of noun frequency. The garden-path sentences (EXP) are represented by solid yellow lines and the control sentences (CON) are represented by dotted grey lines.*

III.7 Problems with Garden-Path and Control Sentences

The results reported so far do not support the hypothesis of garden-path parsing by the participants in the EXP/NoCap condition. A clear demonstration of this outcome is provided by the fact that the interaction of spelling mode, sentence mode and position has no significant effect on either Gaze or Total fixation duration, i.e. the mode of sentence (EXP vs. CON) does not influence the processing in a statistically significant way. Therefore, we provide a post hoc analytic explanation: As described above, the garden-path type was always

semantic, i.e. the first noun phrase initiated a semantic field that was supposed to lead the reader onto the garden path, i.e. parsing the adjective in the second NP as a noun. However, it is possible to divide the sentences (see Appendix) into two subtypes that differ according to the semantic relation between the adjective and the following noun:

- Subtype I: The adjective and the noun are semantically similar or tautological. The full sentence would remain intact if the noun were omitted: "jugendliche Kinder" (*juvenile children*), "kriminellen Dieb" (*criminal thief*), "neugeborene Baby" (*newborn baby*); 24 sentences (60 %) belong to this category;
- Subtype II: The adjective is semantically dissimilar: "Der Kapitän kommandiert die flotte [engl. *brisk*] Mannschaft…" (*The captain commands the fleet crew…*), "In der Gymnastikhalle liegen die matten Sportler… (*In the gym hall lie the [exercise] mats* [garden-path parsing] / *faint* [actual meaning] *sportsmen*…"); 16 sentences (40 %) belong to this category.

Concerning sentences of Subtype I, the garden-path word is semantically in a similar field as the following noun. If capitalization is missing in the sentence *"Die mutter hält das neugeborene baby im arm"* (English: The mother holds the *newborn* baby in her arm"), "newborn" is likely to be interpreted as a noun, but a complete reparsing of the sentence will not be necessary when continuing reading, because a newborn baby is in fact a "newborn" and a "baby" – it is tautological. The adjectives in sentences of Subtype I have different shades of meaning (Juhasz and Pollatsek, 2011, 883). The only thing that fundamentally changes is the word class. After having analyzed the data, we came to the conclusion that, especially in these cases, the garden-path effect is unable to fully unfold, because a complete reparsing is not necessary.

Unfortunately, the number of items of Subtype II is too small to report inferential statistics here. Nevertheless, we report some tendencies that will be of interest in future studies. The two subtypes differ substantially concerning Gaze and Total in both conditions (EXP / CON), showing longer fixations on the noun than on the adjective in Gaze except for CON/Cap. However, there should be no differences between Subtypes I and II in CON. This may be largely due to non-balanced frequencies between the subtypes. It is interesting, though, that there are more regressions towards the adjective in EXP / Subtype II, even in the capitalized condition.

Regardless, not all items of Subtype II lead to a reparsing of the sentence as clearly as the example sentences above indicate. One reason for that can be found in the German language: The garden-path words were all adjectives which acted as an adjunct of a following noun. Compared to English, in which attributive adjectives do not have flectional endings (e.g. "blue": *the blue nose*; *the blue noses),* adjectives as adjuncts in German always consist of the adjective stem and a flectional ending ("*blau*": *die blau**e** Nase*; *die blau**en** Nasen)*. The flectional ending itself cannot be predicted easily. On the one hand, it depends on the case, number and gender of the following noun to which the adjective adapts itself (case-number-gender-congruency). On the other hand, the flection type is defined by the determiner before the adjective, which leads to three different types of flection: the so-called strong flection, the weak flection, and the mixed flection (Eisenberg, 2013). Since nouns in German also belong to the inflectable word classes, which consist of flectional endings that are added to the stem even though the flection type of nouns and adjectives differ (Eisenberg, 2013), this proves to be another indicator for a hard-to-predict flectional ending.
In sum, it seems as though semantic processing is stronger than a minor orthographic spelling deviation, both foveally (garden-path parsing on the adjective in the NoCap condition) and parafoveally (garden-path parsing on the adjective in the Cap condition). In other words, the ambiguity of the adjective in EXP is not dissolved by the parafoveal perception of the majuscule.

Additionally, the control sentences generally showed consistently longer fixation durations without delivering other results regarding the direction of the effects. We think that this is primarily explainable by the complexity of the experimental design: As described above, when designing the experimental sentences many properties had to be taken into account in addition to the semantic requirements of ambiguity. Also as mentioned above, only 68 potential EXP items remained after CELEX sighting, from which we constructed 40 sentences. The CON items were created at the very end: They had to be of the same length, matching semantically and matching a specific frequency corridor, and it had to be impossible to misinterpret them as a noun of any kind. All of the CONs are proper German sentences in theory, but at least some of them must have appeared a little peculiar to the participants. This is also an explanation for the significant interaction of the mode of the sentence (EXP vs. CON)

and the position (Adjective vs. Noun) in the Total fixation duration, because the adjectives in CON are regressed longer, we assume, due to their oddity.

III.8 Discussion

In In the present study, it was our goal to find out whether the German capitalization rules for nouns present a benefit to the reader. A benefit could result from the fact that it is possible to perceive the majuscule parafoveally, which could lead to grammatical preprocessing due to the syntactic function of a noun as the core of a nominal phrase.

Reaching disambiguation through capitalization in garden-path sentences and thus singularizing an effect of the German noun capitalization did not work out, mainly due to language constraints and the design-specific reasons outlined above. This conclusion is supported by the non-significant interaction of SENTENCEMODE:POSITION in Gaze duration (cf. Table 2, Figure 2 to the left); i.e. the fact that processing in the Gaze duration is not affected by the sentence modes (garden-path or control sentence) regarding a capitalized or a non-capitalized noun. The significance of this interaction in Total (cf. Table 2, Figure 2 to the right) stems from longer and more regressions in the control sentence condition on the adjective when the upcoming noun is not capitalized. We explain that based on the peculiarity of the adjectives in the CON sentences due to the reasons mentioned above.

As a global result, it can be stated that reading sentences in which nouns are not marked by a majuscule slows down a native German reader significantly, but from an absolute point of view, the effect is small. These results coincide with several previous findings (e.g. Bock et al., 1985), but differ from a result by Hohenstein and Kliegl (2013, 2556), in which the global reading speed was higher compared to our study and reading speed was almost identical for both conditions: 208 words per minute in the capitalized condition vs. 207 words per minute in the non-capitalized condition (184 vs. 171 words in our study, but more comparable regarding our filler sentences: 210 vs. 200).

Furthermore, it can be noted that the mean fixation duration on a non-capitalized noun in Gaze is always significantly higher compared to a capitalized noun (by 30 ms on average). The effect is stable and independent of the sentence mode (EXP vs. CON) in our experiment. The result is expected, but, compared to other deviations from the standard orthography, its

impact is less strong: In an experiment by Rayner and Kaiser (1975), where internal or ending letters were substituted by visually similar letters (*pncblem*/*problnc* for *problem*), reading time doubled; when initial letters (*qroblem*) were substituted, reading time became even 2.5 times longer than normal. Our results are more in line with those from an experiment by White et al. (2008), in which letters (among other conditions) were transposed in the beginning of the word (e.g., *rpoblem* for *problem*). The mean difference in Gaze between a correct and a transposed word was 45 ms (White et al., 2008, 1271). The authors state that a transposition in the beginning of a word is most critical for foveal and parafoveal processing (White et al., 2008, 1274).

The difference between a capitalized and a non-capitalized noun for the Total fixation duration increases to about 43 ms (plus 13 ms) in our experiment. Compared to the experiment of White et al. (2008), this is a moderate increase; they report a difference of 120 ms (Correct: M: 336, SD: 169 vs. Transposed: M: 456, SD: 390), which means an absolute increase of 75 ms. While the experiment of White et. al (2008) did not examine capitalization, it is therefore worth noting that capitalization differs from substitution or transposition of letters because the underlying allograph remains constant; the letter is just substituted by its own lower- or uppercase form and the phonological level is not affected. Therefore, capitalization can be conceived as a lesser violation of orthography resulting in less strong effects on the number and duration of fixations. In addition, our participants are used to seeing non-capitalized nouns in English and other alphabetic writing systems (see participants section) and, finally, in modern communication channels the concept of non-capitalized nouns in German is quite familiar.

Concerning the advantages capitalization may have for the reader, this study provides indications that there is a (small) benefit under specific circumstances. As reported above, we also found a significant interaction between SPELLING and POSITION in Gaze and Total, which is a stable effect and independent of SENTENCEMODE (cf. Table 2, Figure 1). This includes a significant difference for the adjective, resulting in longer fixation durations throughout the capitalization condition; the actual number of fixations on the adjective does not differ significantly (cf. Figure 4). The difference in the mean duration is about 10 ms in Gaze and in the Total duration. These results can be compared with those by Hohenstein and Kliegl (Hohenstein, 2013, 112; cf. Hohenstein and Kliegl, 2013, 2557; 2014). They conducted several

boundary paradigm experiments regarding the benefits of semantic preview and also included the influence of noun capitalization as a factor in one experiment. They examined whether a related or unrelated semantic preview of the target word and the target itself (always a noun) is modulated by capitalization, i.e. whether or not the noun is capitalized (example: “Beim Ausgraben waren *K/knochen* zum Vorschein gekommen” [During the excavation, bones appeared.]; related preview: *S/schädel* [skulls] unrelated: *S/stiefel* [boots]; target and preview word in italics). Fixation durations were longer for the pretarget word when the following noun was capitalized, independently of the preview mode (Capitalization related/unrelated preview (in ms): M: 260/270, SD: 101/119; Lowercase: M: 241/237, SD: 114/97 (Hohenstein and Kliegl, 2014, 175)). This is similar to our finding, with the difference that in their case the pretarget word could represent all word classes (but nouns), while in our study it was consistently an adjective.

It can be seen that “fixation durations in sentences presented completely in lowercase are less modulated by properties of the fixated and surrounding text” (Hohenstein and Kliegl, 2013, 2557). Below we refer to this phenomenon when discussing the influence of the frequencies of an upcoming noun. The authors reanalyzed this experiment in the form of an eye-movement corpus analysis (Hohenstein and Kliegl, 2013), in which astonishingly no main effect of capitalization was demonstrable, which is in line with the same global reading speed in both conditions. The authors explained that by referring to the proficiency of reading text without capitalization due to internet-based communication by the participants (young adults). In the present study, we did not find any systematic effects regarding the self-assessment of the participants concerning the disturbance intensity of non-capitalized nouns and/or their own violation of noun capitalization, although our participants were mainly young adults as well. The authors also report a significant interaction between word class and capitalization. They divided the word class into two groups, nouns and non-nouns, and examined the Gaze duration on the current word as a function of capitalization and word class of the previous, the current, and the next word. Significance of this interaction was found for the current and the next word. This means that in the capitalized condition a currently fixated noun is fixated on less compared to a non-noun; for the next word this effect is reversed.
Similar to our findings, the reading time for the current word increases when the next word is a noun and decreases when the current word is a noun, provided the orthography is correct.

Hohenstein and Kliegl (2013) argue that the word before a noun is highly associated with the noun and that therefore both words are processed before the noun is actually fixated upon (word group hypothesis). The evidentiary status of the word group(ing) hypothesis – processing two words as one whole – (e.g. Radach 1996; Kliegl 2007; Drieghe et al. 2008), though, is unclear. Radach (1996) found this kind of processing for two-word groups (in German), in which the first one was short and the second one a five- to seven-letter noun. Drieghe et al. (2008) were able to replicate the effect in English; they showed that it was restricted to cases in which the first word was an article, but processing was different for highly frequent three- or five-letter non-articles as a first word. Based on the fact that the word before the noun was not controlled and that there is only evidence for three-letter words so far, we are unsure about the conclusion, but we agree that their and our findings are providing evidence for parafoveal processing in reading.

In another boundary paradigm experiment, Tiffin-Richards and Schroeder (2015) examined the preview effect of nouns in German. They compared regularly presented nouns with those presented without a majuscule before crossing an invisible boundary. The preview effect was not significant, but the 10 ms difference in Gaze duration is comparable with our findings reported above: There seems to be a slight parafoveal preprocessing of about 10 ms of the word before a capitalized noun which leads to a lower processing duration of the noun itself.
Parafovea-on-fovea effects (PoF) of word frequency are highly controversial (for an overview: Hyönä, 2011; Drieghe, 2011). While in some corpus studies (Pynte et al., 2005; Pynte and Kennedy, 2006) and reading-like tasks (e.g. Kennedy, 1998, 2000) the effect was reported, in experimentally manipulated settings the effect was rarely found (e.g. Carpenter and Just 1983; Henderson and Ferreira, 1993; Angele, Slattery, Yang, Kliegl, & Rayner, 2008); Hyönä & Bertram (2004) found an effect in one out of five of their reported experiments.
In our study, the processing of an adjective-noun word group with or without a capitalized letter also seems to interact with the frequency of the noun (cf. Table 5, Figure 5). In the capitalized EXP condition, the mean difference in Gaze duration between a high-frequency noun (224 ms) and a low-frequency noun (248 ms) is noteworthy. For the adjective, a reverse effect can be observed: An adjective followed by a high-frequency noun is fixated on 21.5 ms longer compared to an adjective followed by a low-frequency noun. Quite the opposite can

be observed for the adjective in the NoCap condition; the mean fixation durations are almost identical (difference < 5ms) and thus independent of the frequency of the upcoming noun. Interestingly, the mean fixation durations on adjectives are quite similar to the durations on the following nouns in NoCap (independent of the noun frequency) and in Cap / low-frequency nouns. Only in case of capitalized high-frequency nouns are the adjectives fixated on longer than the following noun. Besides that, no frequency effects are detectable on the noun itself when the orthographic regular capitalization is missing – a low-frequency noun is fixated on only 2.4 ms longer compared to a high-frequency one. The observations reported above are similar (but shifted) for the non-capitalized control sentences.

This leads us to the following conclusions on frequency effects, which should be observed with considerable caution due to sample-size and post hoc analyses:

1. Orthographic violation in the form of missing noun capitalization levels frequency effects on the noun itself.
2. Parafoveal preprocessing of a noun does not occur when the following noun is not capitalized – independent of the frequency of the upcoming noun.
3. Parafoveal preprocessing of a capitalized noun does not occur when the following noun has a low frequency.

However, there is reason to assume that parafoveal preprocessing occurs, but only under optimal circumstances (cf. Table 6): The frequency of the upcoming noun needs to be high and the current word (adjective) must not be peculiar (like in some of our CON sentences). Even then, the advantage is rather small or even nonexistent: When the mean durations for adjective and noun are added together, fixation durations in the Cap condition are only 2.3 ms shorter with a high-frequency noun. The preprocessing of the following noun while fixating on the adjective seems to cost almost as much as the benefits it provides while processing the noun itself. An explanation for this could be that these effects are only present in the results of the experimental sentences and that noun frequencies in this post hoc analyses were not controlled in advance.

Table 6: Mean Gaze durations (in ms) on the word group (Adjective + Noun) in both spelling modes split by Noun frequency in the EXP condition

	low	**high**
Cap	484.7	482.4
NoCap	504.5	497.3

Together with the findings of Hohenstein and Kliegl (2013, 2014) and Tiffin-Richards and Schroeder (2015), our findings indicate that the capitalization of German nouns supports parafoveal preprocessing and, in cases where the capitalization is missing, there is some cost to the inhibition of proper preprocessing. However, it is unclear whether this is due to the violation of the familiar orthographic system or whether in some contexts (e.g. high frequency of the upcoming noun) the parafoveal preview of the majuscule is prevented to enable another approach to (faster) processing. In favor of the latter are results by Rayner and Schotter (2014), who did not find evidence of semantic preview benefit to readers of English for semantically related previews when following the English standard orthography, but they did find evidence for semantic preview benefit when the target/preview words were capitalized.

German capitalization of nouns supports parafoveal preprocessing, but the question whether this leads to an actual overall processing benefit is still not satisfyingly answered. Besides a replication of our study to put the results on a more solid footing with more stimulus materials and participants (cf. Brysbaert and Stevens, 2018; Brysbaert, 2019), further research could envisage two paths to a better understanding of these effects. One path should include language comparison: Are German native speakers able to transfer the application of German orthographic rules regarding noun capitalization to another writing system, e.g. English? Flectional endings for adjectives regarding case, number and gender do not exist in English, which means that one problem of our study would be eliminated. The second path we would like to follow is a boundary paradigm experiment in which the interaction of the frequency and spelling of a noun on the preceding word is examined to clarify whether the preprocessing does actually lead to a processing benefit or whether it is just a different form of processing.

IV. The effect of noun capitalization on reading of English for English and German participants

IV.1 Vorbemerkung

Dieser Abschnitt basiert auf:

Pauly, Dennis Nikolas & Nottbusch, Guido (under review). The effect of noun capitalization on reading of English for English and German participants.

IV.2 Abstract

German orthography systematically marks nouns by capitalization. Our theory is that the reader benefits from the uppercase letter receiving the syntactic information, which eases sentence processing. We designed an experiment, previously conducted in German (Pauly and Nottbusch, 2020), in which the function of German capitalization rules should become obvious in readers' eye movements. We found effects indicating that noun capitalization influences the reading process, although the benefit for the reader seems to be rather small. Since further experiments (Bock et al., 1989; Gfroerer et al., 1989; Rayner and Schotter, 2014) showed contradictory results regarding the possibility of transferring the assumed benefit of noun marking to another language, we created a design analogous to our German experiment for English. The participants' task was to read single sentences, half of which followed German standard orthography (Cap; irregular in English orthography) and half lowercase spelling (NoCAP; regular in English orthography). The sentences were systematically manipulated on a target word (N) in order to build up a strong expectation of a noun (using semantic priming), which was finally counteracted (experimental condition; EXP) – N was an attribute for the following noun (N+1) instead. In an additional control condition (CON), in which it was crucial that the interpretation of a noun was extremely unlikely, N was replaced by a word of the same length and similar frequency.

Example: The sick w/Writer had a cold (EXP; N) / blue (CON; N) N/nose (N+1) throughout the winter.

To obtain a more detailed picture, we examined three different participant groups: English natives without knowledge of German (Participant Group E, n = 48), English natives who regularly read German (Participant Group E+G, n = 49) and Germans with excellent English skills (Participant Group G+E, n = 47).

Overall, noun capitalization influenced the reading process of the three participant groups differently.

- Participant group E was clearly influenced by noun capitalization, but it is doubtful whether there was any benefit.
- Participant group E+G was the least disturbed by noun capitalization; under specific circumstances, there were indications of a benefit from noun capitalization.
- Participant group G+E showed signs of a mild transfer of noun capitalization processing to the foreign language.

Significant effects on N/N+1 were detectable in Gaze and Total fixation durations and the number of fixations. As a global result, it can be stated that differences in the noun itself were mostly non-significant but mostly affected the preceding adjective.

IV.3 Introduction

Since *systematic* noun marking with a capital letter (majuscule) is exclusive to the German and Luxembourgish writing systems, we wanted to find out whether and how this noun marking influences the reading process. The global hypothesis is – at least for German natives reading German – that nouns that act as heads of noun phrases from a grammatical point of view are recognized parafoveally due to the majuscule, which would lead to early preprocessing. This preprocessing can be concerned with either the grammatical category "head of noun phrase" or semantically regarding the meaning of the content-carrying noun, or both. For the writer, noun marking is functionless and, beyond that, does not clarify ambiguities in German except for very rare or constructed cases (cf. Augst, 1980). If it were to do so, ambiguities in all other writing systems except for German and Luxembourgish should occur with significant frequency. Since this is not the case, a benefit for the reader would be an important argument for legitimizing this orthographic specificity. The available studies in German were conducted in the mid-1980s and early 1990s: Bock, Augst & Wegner (1985) ran various studies concerning the function of noun capitalization for German readers. Through systematic manipulation of the beginning of nouns [1) German capitalization rules, 2) English standard orthography, 3) all words begin capitalized, 4) random mixture of lower and uppercase letters, 5) inversion of the German capitalization rules], the reading durations for 80 participants reading 20 texts (125 words each) in the five spelling varieties were compared. Their results can be summarized as follows: the greater the difference from regular spelling, the slower the reading duration (for more details, see: Pauly & Nottbusch, 2016; Nottbusch & Jonischkait, 2011). This result was replicated in the studies of Bock et al. (1989). Since these results perhaps only demonstrate that a deviation from the familiar orthography slows down the reading process, further experiments are needed to find a possible underlying cause.

We therefore designed an experiment (Pauly and Nottbusch, 2020) to track the effect: sentences were systematically manipulated on a target word (N) in order to build up a strong expectation of a noun (using semantic priming), which was finally counteracted (experimental condition; EXP) – N was an attribute for the following noun (N+1) instead. In the control condition (CON), N was replaced by a word of the same length and similar frequency, but the replacement words were chosen to ensure that the interpretation of N as a noun was extremely unlikely (e.g. EXP: *Der Kapitän kommandiert die **flotte** (N) Mannschaft (N+1) mit aller Strenge.* [The captain commands the quick crew with severity.]), CON: *Der Kapitän kommandiert die **übrige** (N) Mannschaft (N+1) mit aller Strenge.* [The captain commands the

remaining crew with severity.]). For half of the sentences, N+1 was presented in regular uppercase spelling (Cap), the other half in irregular lowercase spelling (NoCap). The main hypotheses were that noun marking serves a function for the reader in facilitating processing through the recognition of heads of noun phrases. It was assumed that the reader parafoveally recognizes the majuscule and is therefore able to systematically preprocess the following noun. We found significant effects for both the adjective (N) and the noun (N+1) in Gaze and Total fixation durations to such an extent that nouns were fixated on more often and longer when they were not capitalized. Under specific circumstances (e.g. high-noun frequency), parafovea on fovea effects (PoF) were detectable on the preceding attributive adjective, which led to longer fixation durations on the adjective, making possible shorter fixations on the noun. Overall, noun capitalization influenced the reading process and seemed to benefit the reader, although the effect was rather small. Hence, compared to the conclusions of the studies by Bock et al., we have reservations about interpreting a beneficial effect size of noun capitalization for the reader.

Bock et al. (1989) also conducted experiments in which they examined whether their findings were transferable to other writing systems. They also took into account that the results might have relied on the participant group (German natives reading a foreign language vs. learners of German reading their native language): 100 German students of English and 100 Dutch students of German as a second language took part in the study. The participants read 20 German texts (fables, M: 247 words), 10 in German (both groups) and 10 in English (German participants) or 10 in Dutch (Dutch participants). The texts were presented in the five spelling varieties described above. For both German and Dutch students reading Germen texts, the results of Bock et al. (1985) were replicated. However, when German students read English texts there was no significant difference between the texts following German standard orthography (which is irregular here) and the regular English standard orthography. Bock and colleagues concluded that this could be explained by two contradictory effects on reading: the violation of the English orthography produces a cost, but the German capitalization rules produce a benefit due to syntactic hints, which in sum leads to a zero difference. They further concluded that the German Capitalization System is transferable to other languages. The Dutch texts read by Dutch participants were read the fastest when following the standard orthography (like in English); the German capitalization rules ranked second, but "interfered" less than the three other spellings (Bock et al., 1989, 48–49). In sum, for both groups it can be

stated that the more the spelling varies, the longer the reading time, with one minor exception: the Dutch participants read the inversed spelling slower than the capitalization of all words.

The first eye-tracking study so far that systematically examined the function of the German Capitalization System was conducted by Gfroerer, Günther, & Bock (1989), who replicated the experiment just described: 15 Dutch participants read the same texts as in Bock et al. (1989) in Dutch and German in the five spelling modes (50 texts total, 10 per spelling mode). The authors found that the Dutch texts were read faster than the German texts in all spelling modes. One result is very interesting, though: not only the German but also the Dutch texts were read the fastest when they followed the German capitalization rules. Therefore, the authors concluded that the German Capitalization System is transferable to other writing systems. The results are astonishing, but should be treated carefully due to the pilot character of the study and also because of technical problems the authors reported.

Readers of a right-sided alphabetic writing system obtain useful information from a region extending 3-4 letters to the left of fixation to about 14-15 character spaces to the right of the fixation, but information used for word identification is obtained from a smaller region: 7-8 letters to the right of fixation (Rayner and Castelhano, 2008). A majuscule, however, can probably be recognized even farther away. Since initial letters are most influential on word recognition (Johnson et al., 2007), the capitalization of words should make parafovea on fovea effects (PoF) more likely.

In a more recent study, Rayner and Schotter (2014) examined the effect of initial letter capitalization on semantic preview benefit in English using the boundary paradigm (Rayner, 1975). Semantic preview benefit is controversial in general (especially for alphabetic writing systems; for an overview, see Rayner & Schotter 2014, pp. 1617), but for English in particular. Rayner et al. (1986, replication: 2014) did not find any preview benefit in the case of a semantically related word (*wine* as a preview for *beer*) presented parafoveally, while for an orthographically related preview (*been*) a benefit was observable. In German, however, semantic preview benefit was found in a study by Hohenstein and Kliegl (2014), in which all target words were nouns. Although the effect in German was independent of noun capitalization, the effect was stronger when capitalization was present. It is not astonishing that the effect is stronger for orthographically correct spellings, but it is still remarkable that it is also present when orthography is violated, i.e. even misspelled nouns can be preprocessed

semantically. This would lead to the conclusion that semantic processing is rather robust towards minor orthographic violations, specifically an allograph, which does not influence the phonology and only marginally influences the shape of the morpheme.

For English specifically, there are indications that uppercase letters can be used beneficially parafoveally and foveally in cases where the rest of the sentence is predominantly lowercase (Slattery et al., 2011): in a boundary-paradigm experiment (which actually focused on phonological processing), abbreviations (acronyms with normal grapheme-phoneme correspondence (GPC) like *NASA* and initialisms (no GPC) like *NCAA*) were presented in regularly spelled sentences and all capitalized letters; the preview type varied (identical to abbreviation: NASA or NCAA, orthographically legal: *NUSO* or *NOBA* or illegal: *NRSB* or *NRBA*). The results have shown that if majuscules are outstanding, they influence processing parafoveally and foveally. This can clearly be seen in the longer fixation durations in the all-capitalized sentences (abbreviations themselves spelled correctly) and the significant interaction of sentence case manipulation and identity preview for the fixation prior to boundary crossing (i.e. parafoveally), which suggests that previews are processed differently when they are typographically distinct from the rest of the sentence. But, of course, the abbreviations consisted of a series of majuscule letters, which draws even more attention compared to a single capital letter at the beginning of a word. These presuppositions lead back to the experiment by Rayner and Schotter (2014), in which they investigated the research questions 1) whether general preview benefit is increased by a capital letter and, more specifically, 2) whether this could cause a significant semantic preview benefit in English. First of all, the authors made sure that the capitalized target word would not violate English orthography, which meant that the items could be presented as capitalized (*Ballet* of Paris) or lowercase ([…] *ballet* that was…), i.e. a change from a common to a proper noun was possible. On the one hand, this restricted the number and type of items, while on the other hand the authors wanted to prevent the participants from employing a divergent processing strategy. To test the semantic preview benefit, either semantically related preview benefits were shown parafoveally (e.g. *dancer* for *ballet*) or unrelated ones (*needle*), or no manipulation was carried out, i.e. an identical preview was shown. Depending on the sentence, the preview was either capitalized or not. The 60 items also contained 20 representing a small group of words for which capitalization is distinct regarding their meaning (*china* cups vs. *China* as a country). For this group, the semantic preview differed depending on whether or not the word was

capitalized (*plate* for china; *Japan* for *China*); but no difference was found for the unrelated items. The results show no significant preview benefit for any fixation duration measures, when the preview is not capitalized. However, the authors report that the capital letter drew more attention from the reader, which led to significantly shorter fixations in the early time measures, but not for the total fixation duration (more on this later).

While these studies report interesting findings and make global conclusions regarding the function of a language-specific orthographic rule, the work at hand reports an attempt to validate these results and examine language transfer (inspired by Bock and colleagues) in a replication of our experiment with English items and participant groups with varying degrees of knowledge of German and English orthography.

IV.4 Experiment

IV.4.1 Hypotheses

In our study design, we systematically manipulated single English sentences in which the nouns were presented both in lowercase spelling (English standard orthography; NoCap) and with initial uppercase letters (like German standard orthography (Cap). As in Pauly and Nottbusch (2020), we created garden-path sentences containing ambiguous adjectives (word N). By means of semantic priming, the adjective was manipulated to be interpreted as a noun (experimental condition, EXP). In fact, however, this adjective was acting as an attribute for an upcoming noun (word N+1; cf. Table 1), so that reparsing of the sentence would become necessary on N+1. The garden-path effect and thus reparsing of the sentence read so far, however, was probably less likely in the Cap condition (depending on the type of participant group: see below) because if the noun were capitalized, the reader would not misinterpret the adjective (N) because s/he would parafoveally recognize the majuscule, which is attributed a noun even for English readers. But, it cannot be excluded that garden-path parsing also occurs in the Cap condition, since the majuscule is not a systematic sign of noun marking for English natives. Nevertheless, the effects should be more powerful in the NoCap condition. Apart from that, the reader of the sentences had already seen at least one capitalized noun presented in the sentence, because N+1 was always the second noun of the sentence. We also created control sentences (CON) in which word N was replaced by a non-ambiguous adjective that could not be misinterpreted as a noun. CON was also presented in both conditions (Cap and NoCap).

In order to measure different grades of transfer between writing systems, we set up three groups of participants with varying degrees of knowledge of German and English orthography. All participants read English sentences. The first group were English natives without any knowledge of German and a transfer across writing systems was not possible for this group. However, the participant's reading processes might not be 'disturbed' too much by capitalized nouns, as proper nouns and names are capitalized in English as well (other words/nouns can also be capitalized as an author's stylistic device). In addition, capitalization is, more or less, a method to highlight an important content word within a sentence. Therefore, capitalization might as well facilitate sentence processing without any transfer. The second group consists of English natives who regularly read German (for selection criteria, see below). This group corresponds to the Dutch readers in Bock et al. (1989) and a possible transfer would be directed from the foreign language, which they as at least bilinguals regularly read, to the first language. The notion of capitalization should be very common to these readers. The third group consisted of German natives with excellent English skills (for selection criteria, see below). Here, the direction of the possible transfer would be from L1 to L2.
Our hypotheses (along the four sentence types) were:

EXP in NoCap: The garden-path effect should make a reparsing of the sentence more likely for readers of all three groups. We expect distinctly longer fixation durations on the noun in first-pass reading and regressions (towards the adjective) afterwards.
EXP in Cap: The capitalized nouns should attenuate the necessity to reparse in all groups. The garden-path effect will decrease along with increasing familiarity with the German writing system (transfer). Through parafoveal recognition of the majuscule while fixating on the adjective, the reader is able to systematically preprocess the following noun. Hence, garden-path parsing can be avoided. On the other hand, the reading process could be inhibited by the violation of an orthographic rule, again gradually between the three groups: for the German natives, the capitalized nouns are part of their automated reading process in their native language. This is, to a lesser extent, also the case for English readers with knowledge of German.
In sum, the within-group differences between Cap and NoCap for the garden-path sentences (EXP) will be the smallest for English natives without knowledge of German and the largest for German natives.

CON in NoCap: As these sentences are not garden-path sentences and no orthographic rule is violated, this should represent the "normal" reading process with the shortest fixation durations on adjectives and nouns within all three groups.

CON in Cap: Due to the violation of an orthographic rule, we expect (slightly) longer fixation durations on the noun for the English natives without knowledge of German. As substantiated above, this could be less the case for the English readers with knowledge of German and the German readers, due to familiarity. In addition, both groups might be able to transfer the facilitative effect to their own or the second language, respectively. The irritation caused by orthographic violation and advantages through preprocessing could neutralize each other, which could lead to identical fixation durations as in CON NoCap.

Hypotheses regarding position:

Adjective: In Cap, we expect longer fixation durations due to potential preprocessing compared to a NoCap adjective; this effect should be strongest for the group of English natives who regularly read German.

Noun: In Cap, we expect shorter fixation durations due to potential preprocessing on the adjective compared to a NoCap noun; again, this effect depends on the participant group and should occur especially for the English natives who regularly read German. Especially for the English natives without any knowledge of German, an irritation might also be plausible.

In other words, we expected four different effects on the reading performance of our participants:

1. In the experimental condition (EXP), a negative/inhibitive effect via **garden-path** parsing was expected.

2. For the sentences with capitalized nouns (EXP Cap, CON Cap), we assumed a positive/facilitative effect for the two groups familiar with the German writing system through **transfer**.

3. **Highlighting** of nouns through capitalization might have a positive/facilitative effect irrespective of transfer.

4. The **violation** of an orthographic rule could have a negative/inhibitive effect. Comparing between the Cap vs. NoCap conditions in each sentence group (EXP and CON) should therefore help to judge whether the positive effects of transfer and/or highlighting outweigh the negative effects of rule violation or vice versa.

IV.5 Method

IV.5.1 Material

A total of 40 experimental sentences (EXP) and 40 control sentences (CON) were constructed: two sentences (EXP and CON) had to be eliminated due to orthographic mistakes and one control sentence was eliminated because of a grammatical error. This left 38 experimental and 37 control sentences. CON was identical to EXP besides the manipulated position "N". They were 8 to 11 words in length (M: 9.0, SD: 0.6); word length varied within the sentences from 1 to 13 letters (M: 5.1, SD: 2.6). The sentences were 45 to 61 characters long (including spaces and final period; M: 52.5, SD: 4.5). All sentences followed a very similar syntactic structure that consisted of four units: position one was occupied with either a Nominal Phrase (NP) or an Adpositional Phrase (AP), which always contained a noun. The following position was occupied by the verb. Units three and four again were composed of either an NP or an AP. The EXP sentences were systematically manipulated following the concept of semantic and partially syntactic priming (cf. Table 1): the first AP/NP and the verb were supposed to create a semantic context that evoked a certain reading of the subsequent (second) AP/NP. The critical AP/NP after the verb consisted of three words: "N-1" was either the determiner of the noun (indefinite or definite article) or a preposition. Word two ("N") always represented an attribute of the following noun ("N+1"). The noun N+1 had a word length from 4 to 14 letters (M: 8.1, SD: 2.3). The adjective N in EXP was semantically related to the first noun phrase and the sentence could end syntactically and semantically after N (if N was parsed as a noun). EXP and CON were presented in two different spellings: 1) following the English standard orthography with a majuscule only at the beginning of the sentence – proper names and other exceptions like month names were avoided; and 2) the German standard orthography in which nouns are systematically marked by a majuscule.

EXP and CON mainly differed in position "N", which was identical in word length (34 sentence pairs or deviated by one letter (4 sentence pairs). N had a length of 4 to 11 letters (EXP: M: 6.2, SD: 2.0; CON: M: 6.2, SD: 2.0; both identical due to rounding). In some sentences, it was necessary to insert the article "an" instead of "a" or vice versa ahead of word "N" (EXP: "an orange carrot" vs. CON: "a sliced carrot"). The frequency was matched as far as it was possible to construct a CON sentence, which made sense syntactically and semantically. The matched frequency of N in CON was determined by the two possible readings of EXP: depending on the spelling EXP was presented in, the likelihood of identifying N as either a noun (German

standard orthography) or an adjective (English standard orthography) varied. Therefore, we decided to orient ourselves to the calculated mean of the two frequencies (adjective and noun) in EXP (M: 592, SD: 596) when matching the frequency of "N" in CON (M: 804, SD: 1404). N+1 had a mean frequency of 1672 (SD: 4301). Word frequencies (i.e., frequencies of complete word forms) were based on "CELEX2" (Baayen et al., 1995).

By using a large range of syntactic constructions, we wanted to make sure that it was not very likely for the participants to see through the syntactic scheme of EXP and CON. We therefore created filler sentences; each participant read almost three times more filler sentences than experimental ones: see below. The filler sentences were 6 to 13 words in length (M: 9.01, SD: 1.29), word length varied from 1 to 15 letters (M: 4.71, SD: 2.36) and the sentences were 42 to 66 letters long (including spaces and final dot; M: 50.42, SD: 5.40). Their syntactic structure differed from the EXP and CON sentences. The filler sentences were mainly translations of sentences from the Potsdam Sentence Corpus (PSC) v. 1.0, which was "constructed with the goal to represent a large variety of grammatical structures" (Kliegl et al., 2004, 267). As in the EXP and CON sentences, partial minor modifications were made, e.g. avoiding proper names within the sentence, so that no necessity to capitalize them occurred.

Table 1: Example sentence of EXP and CON in all conditions.

Sentence Mode	Spelling					N-1	N Adjective	N+1 Noun				Garden-path?
		Noun Phrase			Verb	Noun Phrase			Adpositional Phrase			
EXP	Cap	The	sick	**W**riter	had	a	**cold**	**N**ose	throughout	the	**W**inter.	Maybe
	NoCap			**w**riter			**cold**	**n**ose			**w**inter.	Yes
CON	Cap			**W**riter			**blue**	**N**ose			**W**inter.	No
	NoCap			**w**riter			**blue**	**n**ose			**w**inter.	No

IV.5.2 Participants

IV.5.2.1 *Participant Group E: English natives*

Forty-eight participants, mostly undergraduate students and a few staff members from Nottingham Trent University (33 female, 15 male) with normal or corrected-to-normal vision took part in the experiment. All participants were fluent in English; 46 of them were native speakers. The age span ranged from 18 to 44 years; the mean age was 22.81 (SD: 4.75). Undergraduate participants received credit for their study; some received a voucher for an

online marketplace. A requirement for participation was that they had no or at least very little knowledge of German. This group will henceforth be abbreviated as "E".

The sessions lasted for about 30 min, after which they filled out a questionnaire asking for the typical personal data and questions concerning spoken languages and problems with their mother tongue and knowledge of German.

IV.5.2.2 *Participant Group E+G: English natives who regularly read German*

Forty-nine participants, a mixture of undergraduate and graduate students from Potsdam University and certain citizens not related to Potsdam University (32 female, 17 male) with normal or corrected-to-normal vision took part in the experiment. The mother tongue of all participants was English, 12 grew up bilingually, 7 of those acquired German parallel to English and three of them first learned to write in German. The age span ranged from 18 to 65 years; the mean age was 29.57 (SD: 10.19). Requirements for participation were that they were English native speakers and regularly read texts following German standard orthography. Their German skills in terms of spoken German were heterogeneous. Participants received cash for their participation. This group will henceforth be abbreviated as "E+G".

The sessions lasted for about 30 minutes, after which they anonymously filled out a questionnaire in which – besides the typical personal data and questions concerning spoken languages and problems with the mother tongue – they had to answer questions regarding their exposure to reading German texts following capitalization rules.

IV.5.2.3 *Participant Group G+E: German natives with high proficiency in English*

Forty-seven participants (35 female, 12 male), mostly Master's or Bachelor's students majoring in English or studies that are taught in English, but some also had other proof of language proficiency in English (minimum TOEFL result of 100, IELTS result of 7 corresponding to at least level B2 of the Common European Framework of Reference for Languages (CEFR); longer stays abroad dating back no longer than two years, etc.). The participants had normal or corrected-to-normal vision; all subjects were German native speakers. The age span ranged from 20 to 38 years; the mean age was 25.83 (SD: 3.90).

The sessions lasted for about 30 minutes, after which they anonymously filled out a questionnaire in which – besides the typical personal data and questions concerning spoken languages, stays abroad in English-speaking countries and problems with the mother tongue

– they were asked whether they encountered problems with items they read. This group will henceforth be abbreviated as "G+E".

IV.5.3 Apparatus

Eye movements of the subjects were recorded monocularly in a darkened laboratory with an SR EyeLink 1000 system (500 Hz); the experiment was programmed with Experiment Builder software by SR Research. Sentences occupied only one line on the screen and were presented one at a time at the 1/3 vertical position from the top of the screen of a 17'' CRT Monitor (1024 × 768 resolution; frame rate 85 Hz) for group E and a 22'' TFT Monitor (1680 × 1050 resolution; frame rate 120 Hz) for groups E+G and G+E. Subjects were seated 55 cm (group E) to 60 cm (groups E+G and G+E) in front of the monitor with the head positioned on a chin rest. Texts were displayed using 18 pt. (group E) or 26 pt. (groups E+G and G+E) bold font Courier New.

IV.5.4 Procedure

Before the beginning of the main experiment, there was a pretest consisting of three sentences, so that the participants had the chance to ask questions to clarify any possible ambiguities. Each subject read 140 sentences in the main experiment: all 100 filler sentences, 20 EXP (10 capitalized, 10 not capitalized) and the remaining counterpart of 20 control sentences, again 10 CAP and 10 NoCap. The order was pseudo-randomized.

Participants' measurements were calibrated with a standard nine-point grid. After the validation of calibration accuracy, a drift correction point appeared in the centre of the screen. In case the dot was fixated, the fixation point re-appeared on the left side of the monitor. If the eye tracker identified a fixation on the fixation spot within 2000 ms for at least 50 ms, the fixation point disappeared and a sentence was presented such that the centre of the first letter in the sentence appeared to the right of the fixation-point position. If there was no identification, the calibrating procedure was repeated.

Subjects were instructed to read the sentences for comprehension and to signal the completion of a trial by fixating on a dot in the lower right corner which either automatically led to the next sentence or to a dual choice task regarding the content of the sentence they had read before. The reason for the question was to ensure that the participants read all the sentences with attention, supported by the fact that the questions appeared in a random order. The answer options were of similar but different structures (e.g. different word classes;

example question: “How was the game? A) Spectacular, B) Boring”). The answer was given by a left (answer A) or right (answer B) mouse-click, which was supported by an image below the question to avoid confusion. These questions were already asked in the pretest mentioned above. A total of 35 questions was asked per subject (i.e. in 25% of the trials), who correctly answered at least 98.27% per participant group with a maximum of four wrong answers (only one occurrence; also one occurrence for three wrong answers; others: maximum of two) per participant.

IV.5.5 Data Analysis

The EyeLink Data Viewer software by SR Research automatically determined fixations. Outliers within the eye movement data were omitted in two steps: first, all potentially mislocated fixations (50 ms or less) were deleted. Second, fixations exceeding 2.5 SD of the mean for each eye movement measure were deleted for each participant. The following measures were calculated:

First fixation duration (the first of multiple fixations or the only fixation on a target),

Gaze duration (summation of the duration across all fixations of the first run within the current area of interest),

Total fixation duration (all fixations on the target, including regressions),

Regression duration (Total minus Gaze)

Reading speed (the start time of the first fixation within a sentence until the end of the last fixation, divided by the number of words).

This left more than 98% of the data for each of the three participant groups. Apart from that, the number of fixations in Gaze and Total and the number of regressions are part of our analysis. Linear-mixed models (lme) were used to analyse the eye movement data for each dependent measure in the R environment with the lme4 package version 1.1-13 (Bates et al., 2015b).

The independent measures were:

- Mode of spelling (“SPELLING”), i.e. whether the nouns have been capitalized (Cap) or not (NoCap);
- Mode of the sentence (“SENTENCEMODE”), i.e. the two conditions EXP (garden-path, ambiguous) and CON (non-ambiguous);

- Position/location of fixation (“POSITION”), i.e. either Adjective (“N”) or Noun (“N+1”);
- Word length (“LENGTH”), i.e. word length in letters, measures were centred;
- Frequency (“FREQUENCY”), i.e. absolute token frequency of adjective N and noun N+1, measures were logarithmized and centred;
- Frequency of the noun (“FREQNOUN”; only for one model), i.e. frequency of the noun N+1, divided into two groups “high” (Min: 550, Max: 26215, M: 3283, SD: 5918) and “low” (Min: 0, Max: 543, M: 224, SD: 176).

SPELLING, SENTENCEMODE, POSITION and the noun frequency (FREQNOUN) were transformed into effect contrasts. Participants and items were treated as crossed random effects and all fixation duration measures were log transformed. By including word length and frequency as main effects, we ensured that the effects found could be ascribed to our experimental variations and not to linguistic determinants of the words themselves. The criterion for significance was a t-value of two. Statistical models were selected following the pattern of parsimonious mixed models (Bates et al., 2015a). We selected the models using the RePsychLing package, which provides the function “rePCA” (**r**andom-**e**ffects **P**rincipal **C**omponents **A**nalysis), which makes it possible to check models fitted with lmer for rank deficiency. Using the rePCA function, parsimonious random effect structures can be determined because the “maximal model in many analyses of data from Psychology and Linguistics experiments, is almost always shown by this analysis to be degenerate” (Bates, et al., 2015, p. 3). A detailed description of model selection using RePsychLing can be found in Bates et al. (2015a, 3).

IV.6 Results

IV.6.1 Global reading speed

IV.6.1.1 *Participant group E: English readers without any knowledge of German*

Mean reading speed was 209.1 words per minute (wpm) in the non-capitalized and 204.1 wpm in the capitalized condition; the difference was significant (t-value: 2.33), i.e. reading sentences conforming to English standard orthography was significantly faster than reading sentences with capitalized nouns. The sentence mode also had a significant influence (t-value: -2.45); it became obvious that the experimental sentences (EXP) at 210.5 wpm were read significantly faster than the control sentences (CON: 202.9 wpm). Including the interaction of

spelling and sentence mode (not significant, n.s.), reading speed for EXP was 211.3 (NoCap) and 209.7 (Cap) words per minute vs. 207.0 in the NoCap and 198.7 in the Cap condition for the control sentences, that is, in the experimental condition there was almost no difference in reading speed regarding the capitalization.

IV.6.1.2 *Participant group E+G: English readers with good knowledge of German*

Mean reading speed was 215.4 words per minute (wpm) in the non-capitalized and 212.2 wpm in the capitalized condition; the difference was not significant, i.e. reading sentences conforming to English standard orthography was not significantly faster than reading sentences with capitalized nouns. In contrast to that, the sentence mode had a significant influence (t-value: -2.90); it became obvious that the experimental sentences (EXP) at 219.2 wpm were read significantly faster than the control sentences (CON, 208.6 wpm). Including the interaction of spelling and sentence mode (n.s.), reading speed for EXP was 220.6 in the NoCap and 217.8 words per minute in the Cap condition vs. 210.3 (NoCap) and 206.8 (Cap) for the control sentences.

IV.6.1.3 *Participant group G+E: German readers with excellent English skills*

Mean reading speed was 177.6 words per minute (wpm) in the non-capitalized and 172.8 wpm in the capitalized condition; this difference was significant (t-value: 2.22), i.e. reading sentences conforming to English standard orthography was significantly faster than reading sentences with capitalized nouns, which is an astonishing finding, because the German readers are familiar with capitalized nouns. In contrast to that, the sentence mode did not have a significant influence; the experimental sentences (EXP) had a mean reading speed of 177.8 wpm compared to 172.7 for the control sentences (CON). Including the interaction of spelling and sentence mode (n.s.), reading speed for EXP was 181.2 in the NoCap and 174.4 words per minute in the Cap condition vs. 174.2 (NoCap) and 171.2 (Cap) for the control sentences.

IV.6.1.4 *Global reading speed – Comparison between groups*

Comparing the main effect of the three groups, there is no significant difference between the two groups of native English speakers. The German native speakers read significantly more slowly compared to the two other groups (E vs. G+E, t-value: 3.89; E+G vs. G+E, t-value: 4.79). Contrary to our expectations, the garden-path sentences were read faster than the control sentences in all three groups (not significant for G+E; for a discussion of this outcome, see below). All groups read sentences without capitalization faster than sentences with capitalized

nouns (not significant for E+G). However, the difference between No-Cap and Cap was smaller for the garden-path sentences than for the control sentences for group E, but for the German readers the reverse was true.

IV.6.2 Participant group E: Gaze, Total fixation duration, number of fixations and inter-word regression rate

IV.6.2.1 *Participant group E: Gaze and Total fixation duration (Adjective and Noun)*

Table 2 summarizes the model data of main effects and interactions for Gaze and Total fixation durations.

Regarding the three systematically controlled main effects (spelling, sentence mode and position), there is a distinct difference between Gaze duration and Total fixation duration. While in Gaze only the mode of the sentence (EXP vs. CON) appears as a significant main effect, all main effects are significant in Total:

- **Spelling:** The Gaze durations are surprisingly almost identical, which is not like the Totals (all fixations for each word including regressions) and the global reading speed, where differences between the spelling modes are significant, i.e. the Totals on N/N+1 when capitalization was (regularly) absent were shorter in both experimental settings:
    - Gaze (in ms): NoCap: M: 260.7 SD: 91.9 vs. Cap M: 260.3, SD: 89.1,
    - Total (in ms): NoCap M: 311.7, SD: 127.8 vs. Cap: M: 324.1, SD: 129.1.
- **Sentence mode:** The experimental sentences were fixated on significantly longer in Gaze and Total than the control sentences, which is in line with the global reading speed:
    - Gaze (in ms): EXP: M: 255.7, SD: 89.5 vs. CON: M: 265.4, SD: 91.4,
    - Total (in ms): EXP M: 306.1, SD: 125.0 vs. CON M: 330.0 SD: 131.0.
- **Position:** The significance regarding the main effect of position to the extent that the adjective is fixated on longer compared to the noun is exclusive to Total, but is already indicated in Gaze:
    - Gaze (in ms): Adjective: M: 266.0, SD: 95.9 vs. Noun: M: 255.1, SD: 85.1,
    - Total (in ms): Adjective: M: 333.2, SD: 135.8 vs. Noun: M: 303.2, SD: 121.6.

Finally, a main effect for word length is provable for both Gaze and Total.

Regarding the two-factor interactions, two out of three interactions are significant in Gaze and Total:

- **Spelling * Position** (cf. Figure 1, Gaze to the left, Totals to the right):
    - For Gaze in non-capitalized sentences, the adjective is fixated on as long as the following noun (cf. Figure 1, to the left, red solid line), but if capitalization is present, the Gaze durations for the adjective are significantly longer compared to the noun (more than 20 ms); as mentioned above, in sum the Gaze durations for NoCap and Cap are almost identical. The difference of about 10 ms between a non-capitalized and a capitalized noun in Gaze is significant.
    - Concerning the Totals, adjectives received longer regressions than the noun, independently of the mode of spelling. This led to a change of characteristics for NoCap: in non-capitalized sentences, the adjective is now also fixated on longer than the noun, but the effect is from an absolute point of view still much smaller in NoCap (18 ms vs. 42 ms). Comparing the capitalized noun with the irregular capitalized one, the fixation durations are now identical, which is due to longer regressions on Cap nouns.
- **Sentence mode * Position** (cf. Figure 2, Gaze to the left, Totals to the right):
    - Regarding Gaze, the adjectives in CON are fixated on distinctly longer than those in EXP. On the noun, there is almost no difference between EXP and CON, but the underlying processes seem to be different: while the adjective in EXP is fixated on as long as the noun, in CON the adjective is fixated on longer compared to the noun.
    - In the Totals this interaction is even more pronounced (t-value 4.81): the adjectives in the control sentences receive longer regressions compared to the experimental sentences, i.e. the reader seems to clarify the meaning of this specific adjective. A possible explanation for this will be discussed below.

Table 2: EXP 1: Gaze and Total, model data of the independent variables of the fixation duration and number of fixations

	Fixation Duration					
	GAZE			TOTAL		
	Estimate	Std. Error	t-value	Estimate	Std. Error	t-value
(Intercept)	5.507	0.023	236.091	5.685	0.027	207.676
SPELLING	-0.001	0.012	-0.09	0.041	0.014	3.00
SENTENCEMODE	-0.038	0.015	-2.61	-0.077	0.026	-2.92
POSITION	-0.032	0.026	-1.23	-0.088	0.028	-3.20
WORDFREQUENCY	-0.010	0.010	-1.00	-0.004	0.012	-0.30
WORDLENGTH	0.073	0.011	6.80	0.094	0.013	7.28
SPELLING:SENTENCEMODE	0.006	0.024	0.24	-0.030	0.028	-1.09
SPELLING:POSITION	-0.066	0.024	-2.81	-0.071	0.028	-2.57
SENTENCEMODE:POSITION	0.092	0.024	3.84	0.134	0.028	4.81
SPELLING:SENTENCEMODE:POSITION	0.081	0.047	1.73	0.055	0.055	0.99
	Number of Fixations					
	GAZE			TOTAL		
	Estimate	Std. Error	t-value	Estimate	Std. Error	t-value
(Intercept)	1.223	0.02	60.438	1.53	0.035	43.351
SPELLING	0.018	0.015	1.17	0.097	0.027	3.60
SENTENCEMODE	-0.043	0.015	-2.81	-0.128	0.039	-3.28
POSITION	-0.054	0.019	-2.89	-0.148	0.025	-5.97
WORDFREQUENCY	-0.012	0.008	-1.44	-0.009	0.014	-0.61
WORDLENGTH	0.088	0.009	10.40	0.146	0.015	9.43
SPELLING:SENTENCEMODE	-0.006	0.030	-0.21	-0.064	0.047	-1.36
SPELLING:POSITION	-0.080	0.030	-2.65	-0.082	0.047	-1.75
SENTENCEMODE:POSITION	0.054	0.030	1.79	0.159	0.047	3.35
SPELLING:SENTENCEMODE:POSITION	0.038	0.060	0.63	0.026	0.094	0.28

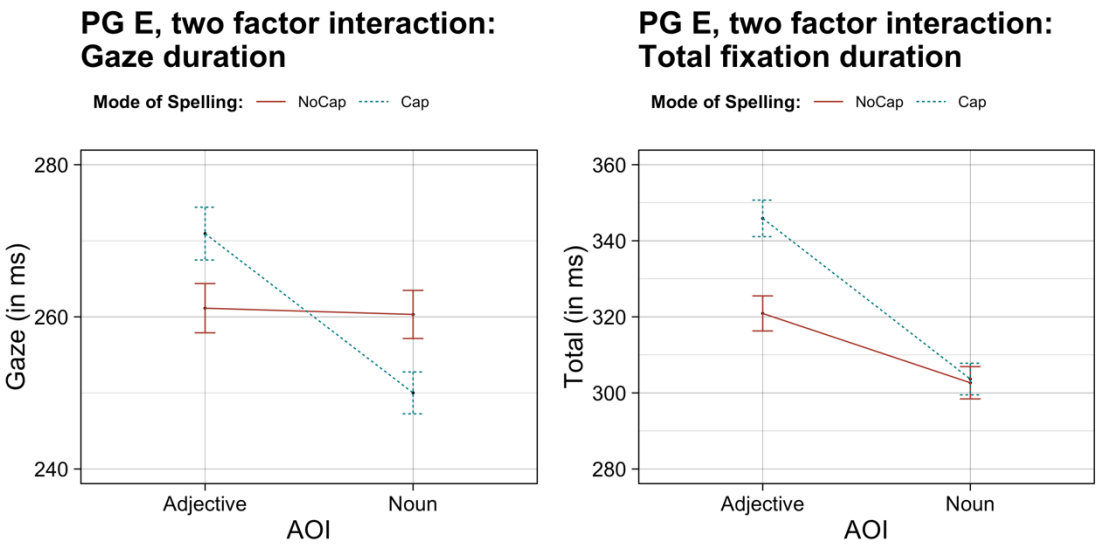

*Figure 1: Estimated values of the **two-factor interactions of SPELLING (Cap vs. NoCap) and POSITION (Adjective vs. Noun)** (cf. Table 2) in Gaze duration (to the left) and in the Total fixation duration (to the right); error bars represent the standard errors. The blue dotted lines represent sentences that follow German standard orthography; the red solid line represents sentences in which the nouns are not capitalized. AOI stands for Area of Interest (= Position).*

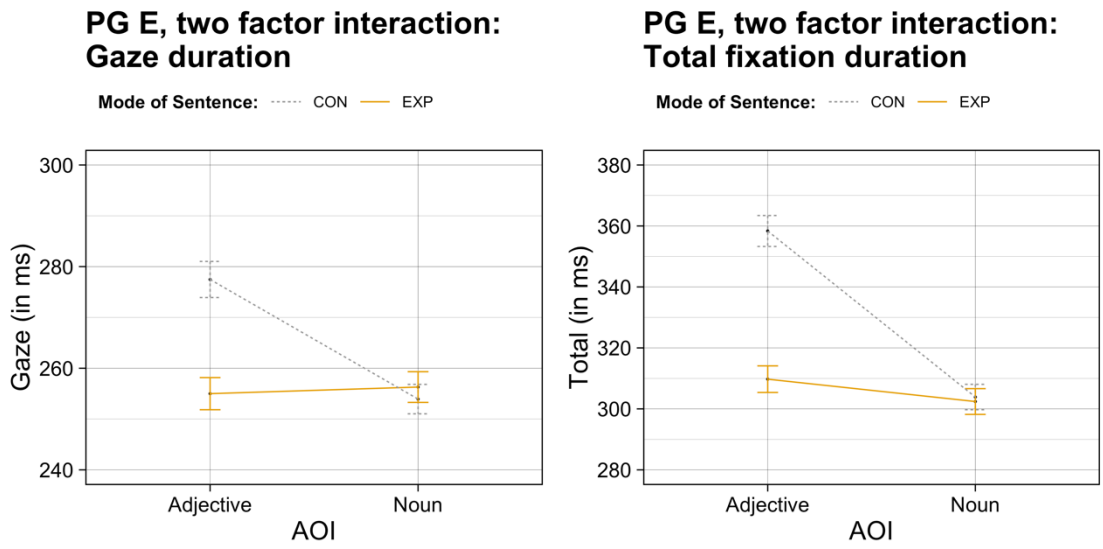

*Figure 2: Estimated values of the **two-factor interactions of SENTENCEMODE (EXP vs. CON) and POSITION (Adjective vs. Noun)** (cf. Table 2) in Gaze duration (to the left) and in the Total fixation duration (to the right); error bars represent the standard errors. The garden-path sentences (EXP) are represented by yellow solid lines and the control sentences (CON) are represented by grey dotted lines. AOI stands for Area of Interest (= Position).*

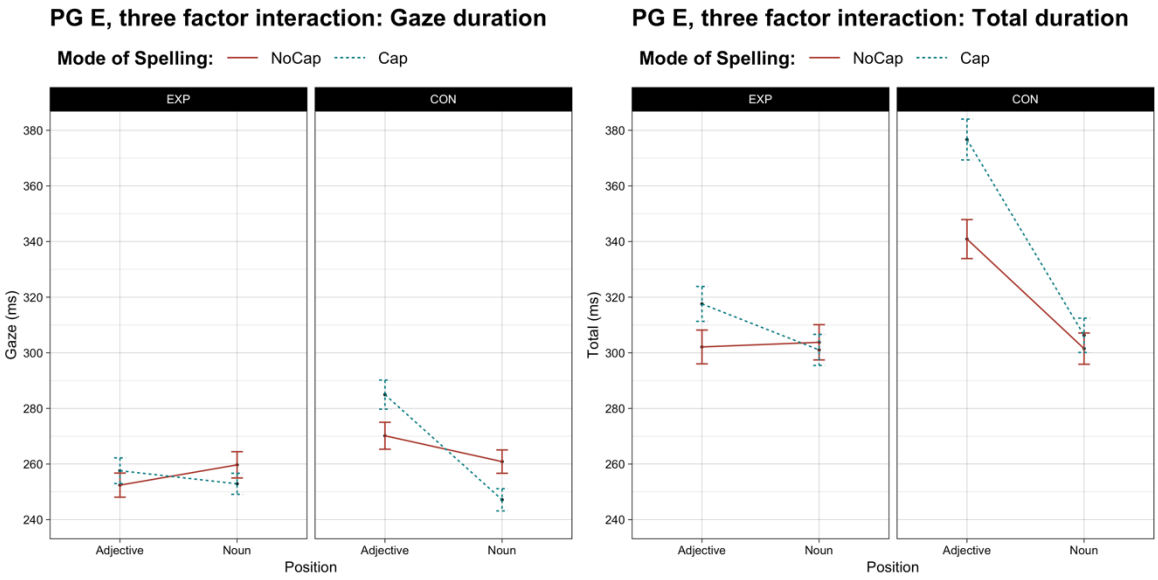

*Figure 3: Estimated values of the **three-way interactions of SPELLING (Cap vs. NoCap), SENTENCEMODE (EXP vs. CON) and POSITION (Adjective vs. Noun)** (cf. Table 2) in Gaze duration (to the left) and in the Total fixation duration (to the right); error bars represent the standard errors. The garden-path sentences (EXP) are shown to the left and the control sentences (CON) are represented to the right. The blue dotted lines represent sentences that follow German standard orthography, the red solid line represents sentences in which the nouns are not capitalized.*

The three-way interaction (cf. Figure 3) of all independent measures did – contrary to our hypothesis – not reach significance, i.e. the mode of the sentence did not modulate the reading behaviour of any kind on an adjective or noun. Due to the complexity of our experimental design and to (at least implied) differences in processing, we decided to show these plots to support the reader's understanding.

Considering the three-way interaction separately, a slightly varied picture compared to the two-way interactions emerges, which hints at differences concerning the underlying processes in EXP and CON and the two spelling modes:

While the adjective is fixated on for a shorter time than the subsequent noun in cases where the latter is not capitalized in EXP, the reverse is true in CON.

When calculating contrasts, only the differences in CON between a Cap/NoCap adjective and a Cap/NoCap noun are significant. In the case of a capitalized noun, the adjective is fixated on longer than the noun, but only significantly longer in CON. Especially the latter results are in line with the two-factor interactions above.

Although the lines of the three-way interaction (cf. Figure 3, to the left, left panel) in Gaze EXP hint, due to crossing lines, at differences in processing depending on the spelling, the differences are too weak (all values lie within 10 ms) to prove any garden-path parsing in this part of the figure; it can only be assumed when comparing the results with those of the control sentences.

IV.6.2.2 *Participant group E: Number of fixations (Adjective and Noun)*

We also had a look at the number of fixations, which can get divided into the first-pass fixations (equivalent to Gaze duration) and all fixations (equivalent to Total fixation duration). The number of fixations slightly varies regarding the effects compared to the fixation durations. In the following, we only present remarkable results (cf. Table 2):

- **Main effects:** In contrast to Gaze duration, the main effect of position is significant to the extent of more fixations on the adjective in the first run (Adjective: M: 1.249, SD: 0.441; Noun: M: 1.196, SD: 0.415).
- **Two-factor interactions:**
    - Spelling * position: This interaction is, like in Gaze, also significant regarding the first-pass number of fixations, but not for the summation of all fixations:
        - First-pass fixations: The character is different compared to Gaze duration, since the number of fixations differs significantly for the adjectives to the extent of more fixations in the Cap condition. Regarding the nouns, no difference is detectable.
        - All fixations: The characteristic is identical with first-pass fixations, but the interaction is not significant.
    - Sentence mode * Position: In contrast to Gaze duration, the two-factor interaction of position and sentence mode is not significant (t-value: 1.79) regarding the number of first-pass fixations.

IV.6.2.3 *Participant group E: Inter-word regression rate (Adjective and Noun)*

The inter-word regression rate (cf. Table 3) shows the percentage of cases with regressions from a word to the right. These range between 10.59% and 18.18%. Adjectives receive more regressions compared to nouns. Regressions are more likely in the Cap condition. Substantial differences between Cap and NoCap and these are more likely in EXP.

Table 3: Descriptive Statistics: Probability of receiving regressions from higher interest areas (word from the right), colours are shaded from dark green (low value) via yellow (middle value) to red (high value).

	NoCap	Cap	Difference
all (Noun & Adj. in EXP & CON	12.86%	14.76%	1.91%
CON all	14.56%	15.07%	0.50%
EXP all	11.20%	14.47%	3.27%
all Adjective	14.17%	17.29%	3.12%
CON Adjective	16.59%	18.18%	1.60%
EXP Adjective	11.82%	16.43%	4.61%
all Noun	11.56%	12.26%	0.70%
CON Noun	12.56%	12.02%	-0.54%
EXP Noun	10.59%	12.50%	1.91%

IV.6.3 Participant group E+G: Gaze, Total fixation duration, number of fixations and inter-word regression rate

IV.6.3.1 *Participant group E+G: Gaze and Total fixation duration (Adjective and Noun)*

Table 4 summarizes the model data of the main effects and interactions of Gaze and Total fixation durations.

Regarding the three systematically controlled main effects (spelling, sentence mode and position), two out of three main effects are significant in the Gaze and Total fixation durations:

- **Spelling:** The fixation times for adjectives and nouns are almost identical in Gaze and Total fixation durations; no effect is provable:
    - Gaze (in ms): NoCap: M: 249.3 SD: 81.5 vs. Cap: M: 252.2, SD: 83.3,
    - Total (in ms): NoCap: M: 293.5, SD: 114.1 vs. Cap: M: 299.0, SD: 116.5.
- **Sentence mode:** The mode of the sentence is significant in Gaze and Total to the extent of longer durations in the CON condition, which is in line with the global reading speed:
    - Gaze (in ms): EXP: M: 245.7, SD: 80.1 vs. CON: M: 255.9, SD: 84.8,

- Total (in ms): EXP M: 285.3, SD: 112.2 vs. CON M: 307.7 SD: 118.4.

- **Position:** Adjectives are fixated on significantly longer in Gaze and Total than nouns:
  - Gaze (in ms): Adjective: M: 257.4, SD: 86.0 vs. Noun: M: 244.3, SD: 78.9,
  - Total (in ms): Adjective M: 308.8, SD: 123.0 vs. Noun 284.2, SD: 107.9.

While the effect of the sentence mode is relatively stronger in Gaze, the effect of the position is more pronounced in Total.

Finally, a main effect for word length is provable for Gaze and Total.

Table 4: EXP 2: Gaze and Total, model data of the independent variables of the fixation duration and number of fixations

	Fixation Duration					
	GAZE			TOTAL		
	Estimate	Std. Error	t-value	Estimate	Std. Error	t-value
(Intercept)	5.474	0.023	242.517	5.622	0.029	194.264
SPELLING	0.009	0.011	0.85	0.017	0.013	1.30
SENTENCEMODE	-0.040	0.011	-3.59	-0.078	0.025	-3.15
POSITION	-0.048	0.024	-2.01	-0.076	0.024	-3.16
WORDFREQUENCY	-0.003	0.008	-0.45	0.019	0.011	1.79
WORDLENGTH	0.075	0.008	9.41	0.095	0.012	7.70
SPELLING:SENTENCEMODE	0.027	0.022	1.22	0.010	0.026	0.36
SPELLING:POSITION	-0.043	0.022	-1.97	-0.058	0.026	-2.24
SENTENCEMODE:POSITION	0.095	0.022	4.26	0.088	0.026	3.35
SPELLING:SENTENCEMODE:POSITION	-0.043	0.044	-0.98	0.024	0.052	0.46
	Number of Fixations					
	GAZE			TOTAL		
	Estimate	Std. Error	t-value	Estimate	Std. Error	t-value
(Intercept)	1.198	0.021	56.535	1.456	0.042	34.638
SPELLING	0.001	0.014	0.05	0.022	0.021	1.02
SENTENCEMODE	-0.018	0.014	-1.34	-0.089	0.041	-2.18
POSITION	-0.065	0.023	-2.86	-0.117	0.022	-5.26
WORDFREQUENCY	-0.008	0.009	-0.99	0.008	0.014	0.57
WORDLENGTH	0.109	0.009	11.73	0.157	0.015	10.32
SPELLING:SENTENCEMODE	0.05	0.027	1.82	0.022	0.042	0.53
SPELLING:POSITION	-0.007	0.027	-0.25	-0.016	0.042	-0.39
SENTENCEMODE:POSITION	0.026	0.028	0.95	0.041	0.043	0.97
SPELLING:SENTENCEMODE:POSITION	-0.032	0.055	-0.59	0.089	0.084	1.05

Regarding the two-factor interactions, only one out of three interactions are significant in Gaze *and* Total (Sentence mode * Position), while Spelling * Position is only significant in Total. In Gaze, this interaction slightly misses the significance level of 2:

- **Spelling * Position** (cf. Figure 4, Gaze to the left, Totals to the right):
  - In Gaze and Total, the adjective is, from an absolute point of view, fixated on longer compared to the noun in Cap and NoCap. However, in the Cap condition the difference between adjective and noun is significant. The adjective in Cap is fixated on significantly longer compared to that in NoCap. For the noun, there is no difference between a regular lowercase and an

irregular uppercase presentation. In both spelling modes there are longer fixation durations on the adjective compared to the noun, but only in Cap does this difference become significant.

  - Exclusively for Total, however, the whole interaction between spelling and position (cf. Figure 4, to the right) is significant.

- **Sentence mode * Position** (cf. Figure 5, Gaze to the left, Totals to the right):
  - In Gaze and Total, the adjectives in CON are fixated on distinctly longer than those in EXP. For the noun, there is no difference between EXP and CON, but processing seems to be different: while the adjective in EXP is fixated on as long as the noun, in CON the adjective is fixated on significantly longer than the noun.

Both interactions were also significant for participant group E.

Regarding the three-factor interaction (cf. Figure 6) of spelling, sentence mode and position in Gaze and Total, there are no differences between the fixation durations on the noun.
The only deviation of Gaze and Total is the no longer significant difference between a Cap and a NoCap adjective in EXP, i.e. in the Total fixation duration for EXP there are no longer any significant differences identifiable regarding the position and capitalization. Significant differences in CON between adjective and noun are identifiable in Gaze and Total, i.e. longer fixation durations on the adjective.

IV.6.3.2 *Participant group E+G: Number of fixations (Adjective and Noun)*

Remarkable results regarding the number of fixations (cf. Table 4):

- **Main effects:**
  - First-pass fixations: There is no main effect for the mode of the sentence (EXP vs. CON), while the effects of position and strong word length are more pronounced but with the same characteristic compared to the Gaze duration.
  - All fixations: Comparing the total number of fixations with the mean fixation duration, the main effects are identical, i.e. there is – in contrast to the first-pass fixations – an effect for the mode of the sentence. The effect position to the extent of more fixations on the adjective is due to more regressions than in the first run.

- **Two-factor interactions:** Astonishingly, no two-factor interaction has reached significance, neither in the first run nor regarding all fixations.

For this participant group, the position (adjective vs. noun) seems to be the decisive factor for the number of fixations (first run and total number of fixations).

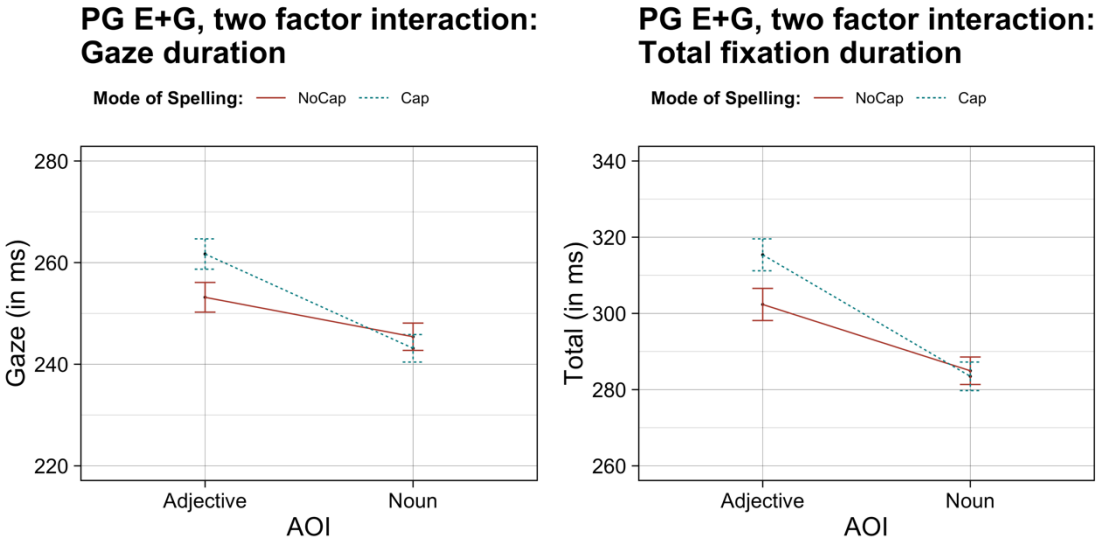

*Figure 4: Estimated values of the **two-factor interactions of SPELLING (Cap vs. NoCap) and POSITION (Adjective vs. Noun)** (cf. Table 4) in Gaze duration (to the left) and Total fixation duration (to the right); error bars represent the standard errors. The blue dotted lines represent sentences that follow German standard orthography; the red solid line represents sentences in which the nouns are not capitalized. AOI stands for Area of Interest (= Position).*

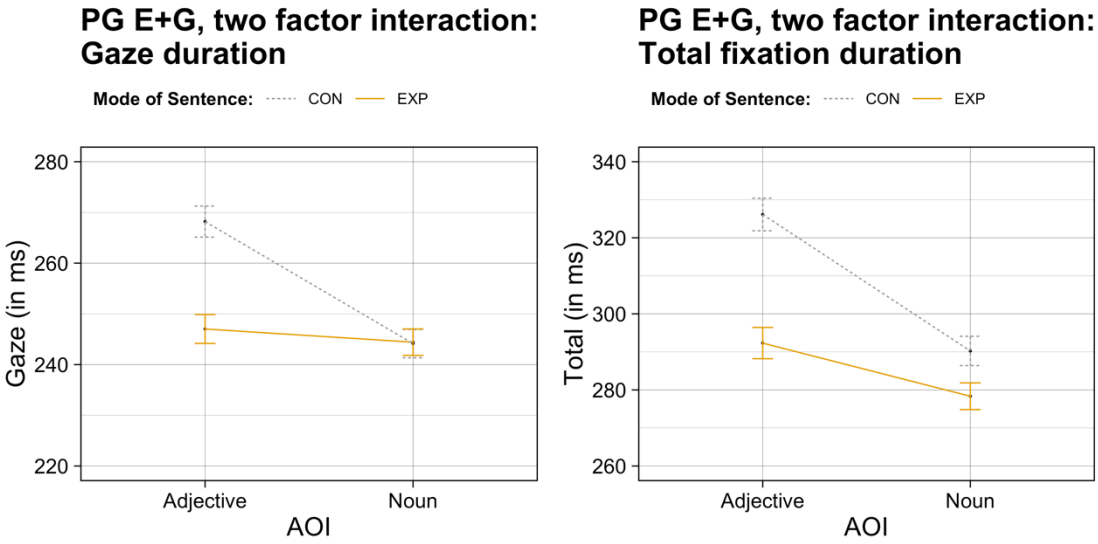

*Figure 5: Estimated values of the **two-factor interactions of SENTENCEMODE (EXP vs. CON) and POSITION (Adjective vs. Noun)** (cf. Table 4) in Gaze duration (to the left) and Total fixation duration (to the right); error bars represent the standard errors. The garden-path sentences (EXP) are represented by yellow solid lines and the control sentences (CON) are represented by grey dotted lines. AOI stands for Area of Interest (= Position).*

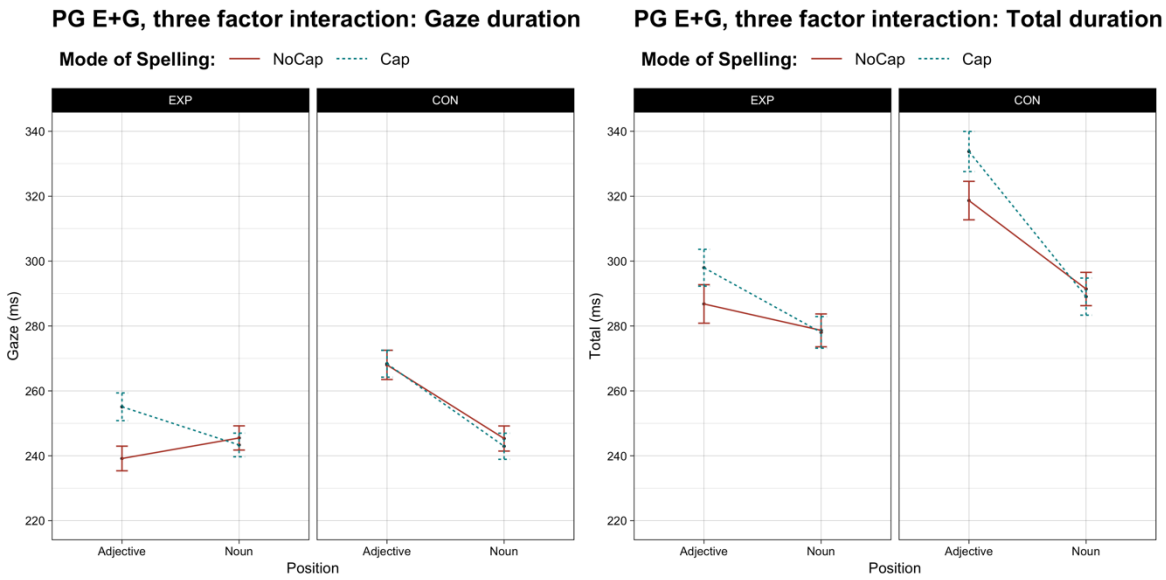

*Figure 6: Estimated values of the **three-way interactions of SPELLING (Cap vs. NoCap), SENTENCEMODE (EXP vs. CON) and POSITION (Adjective vs. Noun)** (cf. Table 4) in Gaze duration (to the left) and Total fixation duration (to the right); error bars represent the standard errors. The garden-path sentences (EXP) are shown to the left and the control sentences (CON) are represented to the right. The blue dotted lines represent sentences that follow German standard orthography; the red solid line represents sentences in which the nouns are not capitalized.*

IV.6.3.3 *Participant group E+G: Inter-word regression rate (Adjective and Noun)*

The inter-word regression rate (cf. Table 5), in which at least one regression is received from a word to the right, lies between 9.07% and 17.26%. Adjectives tend to receive more regressions compared to nouns. Adjectives are more likely to receive a regression in the Cap condition: the reverse is true for the noun, although it is misspelled.

Table 5: Descriptive Statistics: Probability of receiving regressions from higher interest areas (word from the right), colours are shaded from dark green (low value) via yellow (middle value) to red (high value).

	NoCap	Cap	Difference
all (Noun & Adj. in EXP & CON	11.99%	12.02%	0.04%
CON all	12.75%	13.65%	0.90%
EXP all	11.23%	10.42%	-0.80%
all Adjective	12.21%	15.02%	2.81%
CON Adjective	12.17%	17.26%	5.09%
EXP Adjective	12.24%	12.84%	0.60%
all Noun	11.76%	9.07%	-2.69%
CON Noun	13.32%	10.14%	-3.18%
EXP Noun	10.19%	8.01%	-2.18%

IV.6.4 Participant group G+E: Gaze, Total fixation duration, number of fixations and inter-word regression rate

IV.6.4.1 *Participant group G+E: Gaze and Total fixation durations (Adjective and Noun)*

Table 6 summarizes the model data of the main effects and interactions for Gaze and Total fixation durations.

Regarding the three systematically controlled main effects (spelling, sentence mode and position), two out of three main effects are significant in Gaze duration and Total fixation duration:

- **Spelling:** Fixation durations on the adjective/noun are significantly shorter in Gaze and Total when capitalization is (regularly) absent:
    - Gaze (in ms): NoCap: M: 275.3 SD: 88.7 vs. Cap: M: 283.5, SD: 92.4,
    - Total (in ms): NoCap M: 333.4, SD: 131.0 vs. Cap: M: 350.4, SD: 136.7.
- **Sentence mode:** The mode of the sentence also has a significant impact to the extent of shorter durations in the experimental sentences:
    - Gaze (in ms): EXP: M: 271.6, SD: 87.5 vs. CON: M: 287.4, SD: 93.7,
    - Total (in ms): EXP M: 326.4, SD: 125.7 vs. CON M: 357.9 SD: 142.5.
- **Position:** No effect of position is detectable:
    - Gaze (in ms): Adjective M: 277.0, SD: 94.3 vs. Noun 281.8, SD: 86.9,
    - Total (in ms): Adjective M: 345.8, SD: 141.0 vs. Noun 338.1, SD: 127.2.

Finally, a main effect for word length is provable for Gaze and Total.

Table 6: EXP 3: Gaze and Total, model data of the independent variables of the fixation duration and number of fixations

	Fixation Duration					
	GAZE			TOTAL		
	Estimate	Std. Error	t-value	Estimate	Std. Error	t-value
(Intercept)	5.583	0.024	229.423	5.763	0.033	177.137
SPELLING	0.029	0.011	2.55	0.050	0.017	3.00
SENTENCEMODE	-0.054	0.017	-3.16	-0.087	0.028	-3.06
POSITION	0.028	0.029	0.95	-0.008	0.028	-0.30
WORDFREQUENCY	-0.003	0.010	-0.31	-0.001	0.012	-0.11
WORDLENGTH	0.137	0.011	11.99	0.147	0.013	10.94
SPELLING:SENTENCEMODE	0.064	0.022	2.84	0.039	0.027	1.48
SPELLING:POSITION	-0.056	0.022	-2.48	-0.076	0.027	-2.86
SENTENCEMODE:POSITION	0.069	0.023	3.03	0.089	0.027	3.29
SPELLING:SENTENCEMODE:POSITION	0.007	0.045	0.16	-0.006	0.053	-0.12
	Number of Fixations					
	GAZE			TOTAL		
	Estimate	Std. Error	t-value	Estimate	Std. Error	t-value
(Intercept)	1.344	0.025	54.229	1.684	0.05	33.975
SPELLING	0.037	0.017	2.24	0.090	0.035	2.58
SENTENCEMODE	-0.052	0.017	-3.14	-0.098	0.041	-2.40
POSITION	-0.108	0.033	-3.23	-0.191	0.027	-7.09
WORDFREQUENCY	-0.006	0.012	-0.50	0.009	0.016	0.59
WORDLENGTH	0.213	0.012	17.15	0.279	0.017	16.48
SPELLING:SENTENCEMODE	0.054	0.033	1.62	0.041	0.052	0.79
SPELLING:POSITION	0.011	0.033	0.33	-0.02	0.051	-0.39
SENTENCEMODE:POSITION	-0.004	0.033	-0.11	0.052	0.052	1.01
SPELLING:SENTENCEMODE:POSITION	0.033	0.066	0.50	0.024	0.103	0.24

Regarding the two-factor interactions, all three interactions are significant in Gaze, while only two are significant in Total:

- **Spelling * Sentence mode** (cf. Figure 7, Gaze to the left, Totals to the right):
    - In contrast to the two other participant groups and exclusively for Gaze, there is now a significant interaction between spelling and sentence mode (cf. Table 6, Figure 7 to the left) to such an extent that the processing in CON seems to be completely independent of the mode of spelling, while there is a significantly longer processing in cases of the misspelled noun in EXP.
    - But, when looking at the non-significant three-factor interaction (cf. Figure 10 to the left, CON box), this conclusion must be put into perspective, since the lines in this figure are crossing each other. The explanatory power of this interaction is low.
- **Spelling * Position** (cf. Figure 8, Gaze to the left, Totals to the right):
    - The significance of this interaction is *similar* to participant groups E and E+G in Gaze and Total:
    - For Gaze *and* Total, it can be stated that
        - an adjective in the Cap sentences is fixated on significantly longer than in the correctly spelled NoCap sentences;

        - for the noun itself, astonishingly, there is no detectable difference between a correctly spelled and a misspelled noun.
    - In Gaze, the adjective in Cap is fixated on significantly longer and as long as the noun instead, while in NoCap the adjective is fixated on distinctly, but not for significantly less time compared to the noun.
    - In Total, the interaction is not only more pronounced, the characteristics have slightly changed as well:
        - since within the interaction (cf. Figure 8, to the right) the mean fixation durations of the adjectives in NoCap (plus 23.2%) and Cap (plus 26.4%) increase more than those of the nouns (NoCap: 19.4%, Cap: 20.8%), this leads to the effect that
            - adjectives in the Cap condition are fixated on significantly longer than the corresponding noun,
            - while adjectives in the NoCap condition are fixated on for the same length of time as the corresponding nouns.
        - To summarize, in the Total fixation duration the misspelled Cap condition is more affected, mainly due to more and longer regressions on the adjective.
- **Sentence mode * Position** (cf. Figure 9, Gaze to the left, Totals to the right):
    - The significance of this interaction is in line with the two other participant groups in Gaze and Total.
    - For Gaze *and* Total, it can be stated that the control sentences are fixated on longer. This effect mainly, but not only, stems from longer adjective durations.
    - In Gaze,
        - the EXP adjective is fixated on for distinctly less time than the EXP noun (t-value of 1.99 when calculating contrasts),
        - while in CON the adjective and noun are fixated on almost equally long.
    - Regarding the Totals,
        - we found the adjectives (EXP and CON) to receive longer regressions compared to the noun.

Considering the three-way interaction separately (cf. Figure 10), in both measures (Gaze and Total) significant differences in the noun based on its spelling can be detected in neither EXP nor CON.

Although no significance can be detected, there are indications that noun processing seems to be different in EXP vs. CON:

- in EXP the misspelled noun is fixated on longer (Gaze and Total).
- the reverse is true in CON, but only for Gaze. Identical durations can be found for the Total durations in CON.

A closer look at Gaze shows that

- the adjectives in EXP are fixated on for substantially less time in the NoCap condition compared to Cap.
- The same can be stated for the significant difference between the adjectives and the corresponding noun in EXP NoCap, while in Cap there is no such difference.

Regarding the Totals, in both sentence modes and both spelling modes the adjective receives longer regressions than the noun, which leads to the effect that

- in EXP NoCap (compared to Gaze) the difference between adjective and noun remains significant, but less distinct.
- In CON Cap, the difference between the two words becomes significant, albeit in the opposite direction.

IV.6.4.2 *Participant group G+E: Number of fixations (Adjective and Noun)*

Remarkable results regarding the number of fixations (cf. Table 6):

- **Main effects:** All three main effects are significant for both first-pass fixations and all fixations including regressions; they are even more pronounced regarding all fixations. The effects have the same characteristic as the corresponding duration measures.
- **Two-factor interactions:** As for participant group E+G, no two-factor interaction reached significance, for either first-pass or all fixations.

For this participant group, similarly to group E+G, the position (adjective vs. noun) seems to be the decisive factor regarding the number of fixations.

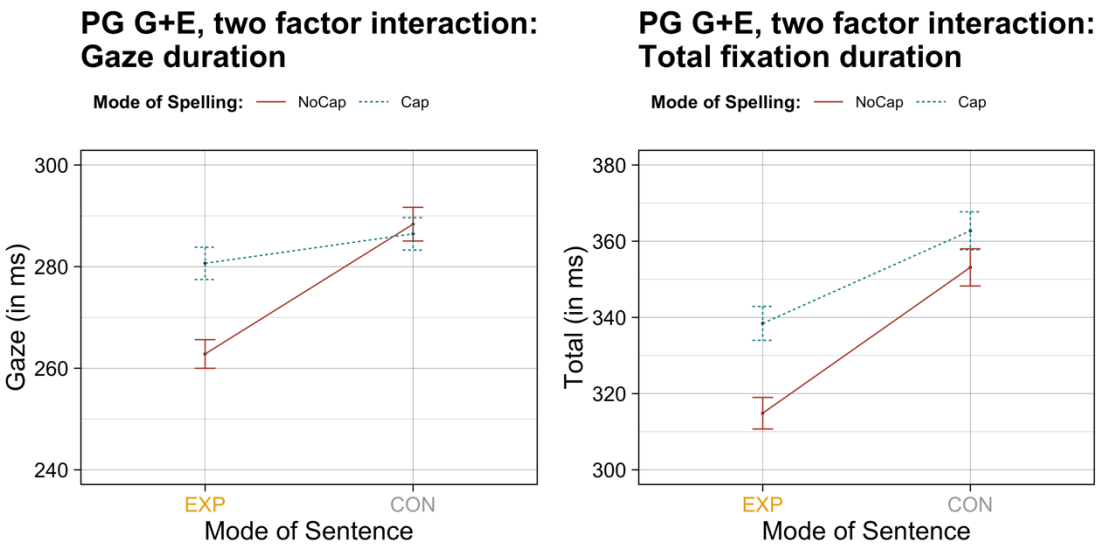

*Figure 7: Estimated values of the **two-factor interactions of SPELLING (Cap vs. NoCap) and SENTENCEMODE (EXP vs. CON)** (cf. Table 6) in Gaze duration (to the left) and in the Total fixation duration (to the right, n.s.); error bars represent the standard errors. The blue dotted lines represent sentences that follow German standard orthography; the red solid line represents sentences in which the nouns are not capitalized.*

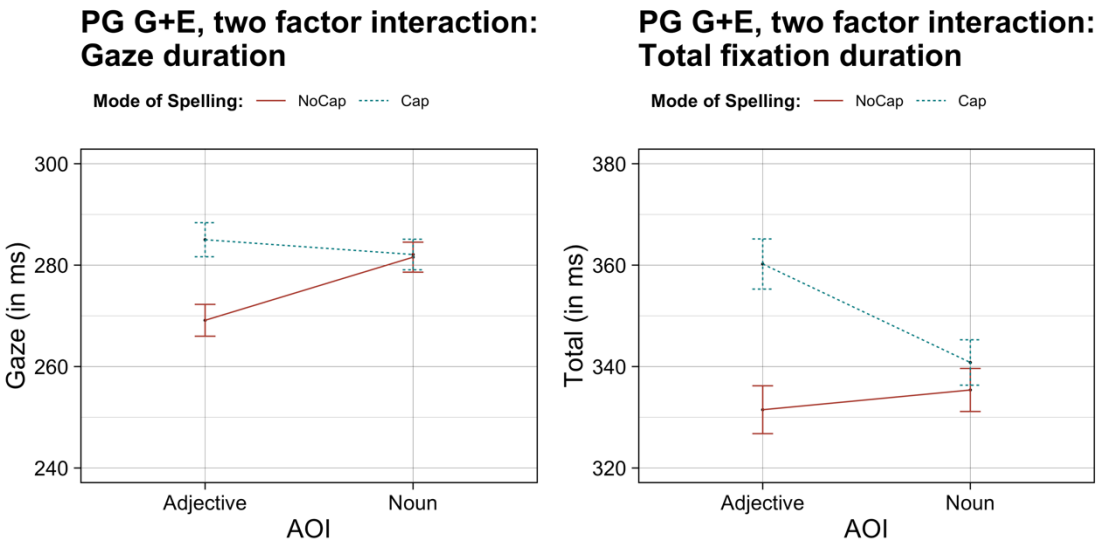

*Figure 8: Estimated values of the **two-factor interactions of SPELLING (Cap vs. NoCap) and POSITION (Adjective vs. Noun)** (cf. Table 6) in Gaze duration (to the left) and in the Total fixation duration (to the right); error bars represent the standard errors. The blue dotted lines represent sentences that follow German standard orthography; the red solid line represents sentences in which the nouns are not capitalized. AOI stands for Area of Interest (= Position).*

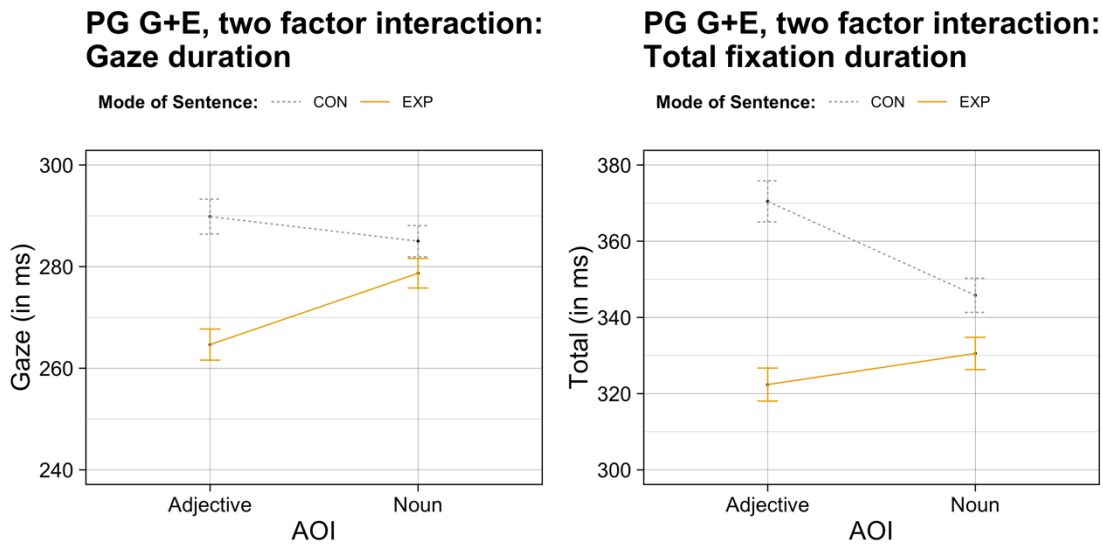

*Figure 9: Estimated values of the **two-factor interactions of SENTENCEMODE (EXP vs. CON) and POSITION (Adjective vs. Noun)** (cf. Table 6) in Gaze duration (to the left) and in the Total fixation duration (to the right); error bars represent the standard errors. The garden-path sentences (EXP) are represented by yellow solid lines and the control sentences (CON) are represented by grey dotted lines. AOI stands for Area of Interest (= Position).*

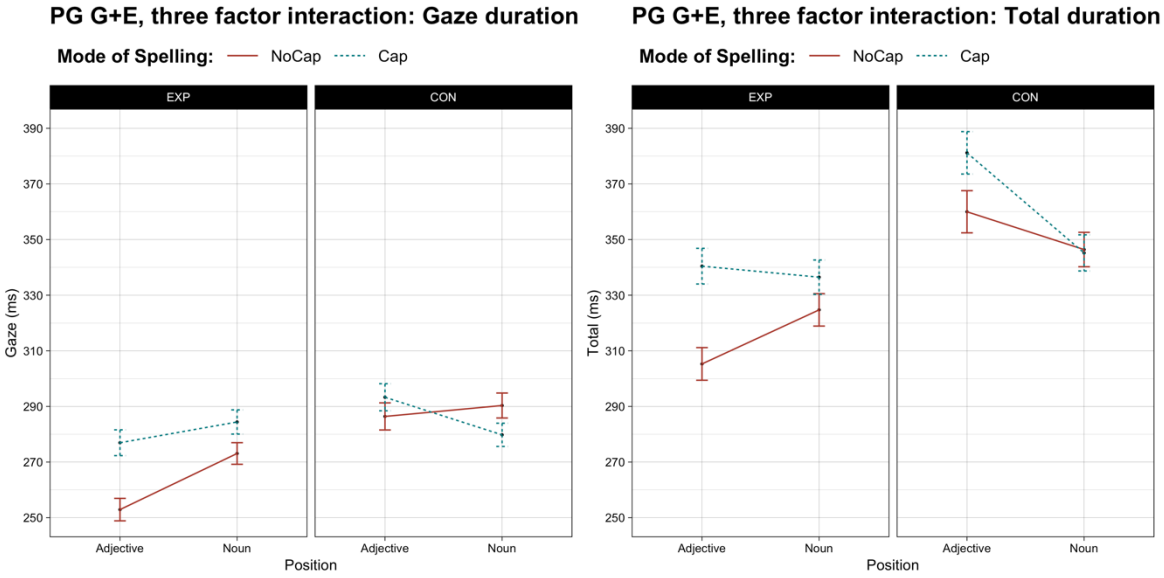

*Figure 10: Estimated values of the **three-way interactions of SPELLING (Cap vs. NoCap), SENTENCEMODE (EXP vs. CON) and POSITION (Adjective vs. Noun)** (cf. Table 6) in Gaze duration (to the left) and in the Total fixation duration (to the right); error bars represent the standard errors. The garden-path sentences (EXP) are shown to the left and the control sentences (CON) are represented to the right. The blue dotted lines represent sentences that follow German standard orthography; the red solid line represents sentences in which the nouns are not capitalized.*

IV.6.4.3 *Participant group G+E: Inter-word regression rate (Adjective and Noun)*

The inter-word regression rate (cf. Table 7) lies between 7.40% and 15.09%. As in the other groups, the adjectives receive more regressions than the nouns. Regressions towards adjectives are more likely in the Cap condition, but regressions towards nouns are more numerous in NoCap, although only slightly. Only in this group do the observed words in the EXP sentences receive slightly more regressions than the CON sentences, especially in the NoCap condition.

Table 7: Descriptive Statistics: Probability of receiving regressions from higher interest areas (word from the right), colours are shaded from dark green (low value) via yellow (middle value) to red (high value).

	NoCap	Cap	Difference
all (Noun & Adj. in EXP & CON	10.53%	11.30%	0.77%
CON all	9.85%	11.20%	1.36%
EXP all	11.20%	11.40%	0.19%
all Adjective	12.13%	15.04%	2.90%
CON Adjective	11.46%	15.09%	3.63%
EXP Adjective	12.79%	14.99%	2.20%
all Noun	8.93%	7.63%	-1.30%
CON Noun	8.25%	7.40%	-0.86%
EXP Noun	9.60%	7.85%	-1.75%

IV.7 Discussion of main results of the three participant groups

In the following, we discuss the major results regarding the similarities and differences between the three participant groups.

Effects on the noun:

Effects on the noun are not or hardly detectable, when comparing a capitalized with a regularly non-capitalized noun:

Regarding the participant group E, an astonishing effect is detectable in Gaze, in which in the two-factor interaction of spelling and position the first-pass durations on the non-capitalized noun are significantly longer compared to the capitalized ones. Due to slightly more, but not longer, regressions, the difference for the noun finally equalizes in the Total fixation duration among all conditions. This leads us to the conclusion that a (misspelled) capitalized noun influences the reading process, yet does not seem to slow down the process on the misspelled word itself, but rather leads to longer pre-processing while fixating on the adjective. One reason for this could be that the concept of capitalizing a noun is familiar (enough) to English readers, and hence, general irritation is avoided.

The missing effects on the noun for E+G confirm the global hypothesis that participants in this group, who are regularly exposed to both orthographical concepts, are either able to transfer the concept when reading their mother tongue or are at least less irritated, leading to the least amount of slowdown of all groups.

Regarding the German participants G+E, there is only one provable effect on the noun itself: EXP Cap nouns are fixated on significantly more often than EXP NoCap nouns in terms of the number of first-pass fixations. The processing duration is not significantly different, thus the mean values differ the most compared with the other two participant groups to the effect that the processing times for a misspelled capitalized noun are longer. This suggests a slight irritation from the misspelled noun, possibly promoted in the garden-path sentences.

Effect on the adjective:

Common to all three participant groups, when comparing Gaze and Total fixation durations the adjectives receive higher increases in the mean fixation duration compared to the noun. This is the case for both sentence and spelling modes.

Effect on the adjective and noun in the Total fixation duration:

Common to all three participant groups is that during the Total fixation processing when taking the adjective and noun together, the orthographically violated Cap condition is read significantly slower. Spelling in the Total fixation duration is a significant main effect for participant groups E and G+E, but not for E+G, which is in line with the assumption that this group is the least disturbed or partially transfers the concept of noun capitalization.
This is also mirrored in the global reading speed in words per minute.

Effect of position:

The effect of position (adjective vs. noun) at least in Total is a stable effect in the English native speaker participant groups E and E+G to the extent of longer durations on the adjective.
Since this effect is missing for the German participants G+E, this might indicate a different kind of processing of attributive adjectives preceding the head of a noun phrase compared with the first two groups. Regarding the number of fixations, however, the main effect of position is provable in Gaze and Total – for the latter with a high t-value of -7.09.

Garden-path parsing:

There is reason to believe that garden-path parsing, i.e. the experimental design, unfolded in general, but with different strengths and characteristics:

For participant group E, the effect is detectable, but only slightly. In the garden-path condition (EXP), there are neither significant differences in Gaze in terms of position, i.e. adjective or noun, nor in terms of spelling, i.e. capitalized or non-capitalized nouns.
However, in contrast to the other three slopes, the slope of EXP NoCap in Gaze (cf. Figure 3 to the left) rises. With a good deal of caution, this can be interpreted as an indicator for garden-path parsing in EXP NoCap because the fixation duration is longer on the noun compared to the adjective. This would be in line with our hypotheses. But, even in EXP Cap there is some evidence that the underlying processes differ from those in CON: in EXP Cap, the adjective receives 1.4 times more regressions from subsequent areas of interest than the adjective in NoCap EXP, while in CON this effect is distinctly smaller. In this participant group, it could be expected that effects regarding our design would not be very strong.

The results of participant group E+G allow for the conclusion that the experimental design unfolded less strongly than expected: the two-factor interaction of spelling and position (cf. Figure 4 to the left) is significant due to the NoCap/Cap difference for the adjective. The explanation of this difference unravels in the three-factor interaction of spelling, sentence mode and position (cf. Figure 6 to the left): three lines are pointing in the same direction (EXP Cap, CON NoCap, and CON Cap) in such a way that the adjective is processed longer than the noun. This difference is significant in CON, but not in EXP. While in CON the processing durations are almost identical on the noun and adjective when comparing the different spelling modes, this is only the case for the EXP noun. The EXP Cap adjective is fixated on significantly longer than the EXP NoCap adjective. As mentioned above, we explain this effect by the unfolding of our design. Some of the participants went into the garden-path trap, which led to longer, though not more, regressions on the NoCap adjective compared to Cap in the Totals (cf. Figure 6 to the right). This conclusion is supported by the fact that a NoCap EXP adjective is fixated on significantly more often than the corresponding noun in Total – which is not the case for Gaze. While in CON the adjective in Cap is regressed on longer compared to NoCap, this still does not lead to a significant difference between the adjectives. It seems as though this specific participant group could be prevented from garden-path parsing in case of an upcoming majuscule that acts as a noun marker. Hence, an attributive adjective noun sequel seems to be processed with longer durations on the noun, even longer when the noun is capitalized. The latter could occur due to preprocessing of the noun while fixating on the

adjective, i.e. the majuscule is recognized parafoveally. The fact that no differences for the noun itself are detectable when comparing Cap and NoCap, could indicate that the assumed preprocessing – which should lead to shorter durations on the noun – interacts with longer durations on the noun itself due to the violated spelling, so that in sum the contrary processes neutralize each other.

Exclusively for the German participants (G+E), an interaction of spelling and sentence mode reached significance in Gaze: while Cap/NoCap in CON shows no difference, Cap is processed almost 20 ms longer in EXP (cf. Figure 7, to the left). This difference mainly stems from a significant difference in the EXP adjectives; the difference in EXP nouns is not significant (cf. three-factor interaction, Figure 10 to the left, left panel). This difference is also clearly documented in the two-factor interaction of spelling and position (cf. Figure 8 to the left). We interpret this as a semantic priming effect, i.e. garden-path parsing, in Gaze. Since the difference between the adjective and noun is – in contrast to all other conditions (EXP Cap, CON Cap/NoCap) – significant in EXP NoCap (Figure 10 to the left, left panel), the participants seem to become aware of the garden-path parsing while fixating on the noun. When comparing Cap CON/EXP in Gaze (cf. Figure 10 to the left; cf. also two-factor interaction of spelling and position: Figure 8), there is reason to believe that the processing is slightly different: while EXP Cap and NoCap point in the same direction, for CON Cap quite the contrary is the case. In EXP Cap some participants might still be irritated, which becomes obvious on the noun. While in EXP and CON Cap a slight preprocessing on the adjective occurs, only in CON, where no garden-path parsing is possible, are the mean durations below the adjective. On the adjective itself, there is no difference.

To sum up, garden-path parsing occurs for participant group G+E; it is dependent on the spelling mode to the extent that it is inhibited in the case of capitalized nouns. Thus, this leads to a different kind of processing, not to shorter fixation durations.

IV.8 Digression: Fixation duration depending on the frequency of the noun

Parafovea on fovea effects of word frequency are highly controversial (for an overview: Hyönä, 2011; Drieghe, 2011). Since we found effects in an experiment conducted with German items but with the same experimental setup as the experiments reported here (Pauly and Nottbusch, 2016, 2020), we present the relevant results regarding the influence of the noun

frequency on processing. The effects indicate parafoveal preprocessing in cases where the noun is spelled with a majuscule, i.e. orthographically correct in German, and of high frequency.

Table 8: Gaze duration depending on the frequency of the noun

	EXP 1 PG E			EXP 2 PG E+G			EXP 3 PG G+E		
	Estimate	Std. Error	t-value	Estimate	Std. Error	t-value	Estimate	Std. Error	t-value
(Intercept)	5.507	0.024	234.05	5.474	0.023	242.15	5.582	0.025	227.82
SPELLING	0.000	0.012	-0.04	0.008	0.011	0.73	0.029	0.011	2.59
SENTENCEMODE	-0.039	0.012	-3.25	-0.040	0.011	-3.64	-0.052	0.011	-4.56
POSITION	-0.033	0.025	-1.28	-0.050	0.023	-2.18	0.027	0.028	0.98
FREQNOUN	-0.042	0.022	-1.93	-0.008	0.016	-0.48	0.013	0.024	0.55
LENGTH	0.065	0.011	5.79	0.072	0.008	9.25	0.133	0.011	11.84
SPELLING:SENTENCEMODE	0.005	0.024	0.23	0.027	0.022	1.23	0.063	0.023	2.79
SPELLING:POSITION	-0.065	0.024	-2.76	-0.045	0.022	-2.03	-0.056	0.023	-2.48
SENTENCEMODE:POSITION	0.089	0.024	3.74	0.093	0.022	4.19	0.068	0.023	2.99
SPELLING:FREQNOUN	0.007	0.024	0.30	-0.034	0.022	-1.56	0.012	0.023	0.54
SENTENCEMODE:FREQNOUN	-0.006	0.024	-0.26	-0.031	0.022	-1.38	-0.001	0.023	-0.03
POSITION:FREQNOUN	-0.066	0.042	-1.58	-0.086	0.038	-2.28	-0.090	0.047	-1.90
SPELLING:SENTENCEMODE:POSITION	0.086	0.047	1.83	-0.044	0.044	-1.00	0.008	0.045	0.17
SPELLING:SENTENCEMODE:FREQNOUN	0.021	0.047	0.44	0.009	0.044	0.20	0.031	0.045	0.68
SPELLING:POSITION:FREQNOUN	0.032	0.047	0.68	-0.052	0.044	-1.18	-0.063	0.045	-1.40
SENTENCEMODE:POSITION:FREQNOUN	0.016	0.048	0.34	-0.011	0.044	-0.24	0.056	0.045	1.23
SPELLING: SENTENCEMODE:POSITION:FREQNOUN	0.141	0.095	1.49	0.010	0.088	0.12	0.121	0.009	1.34

When relating the Gaze duration (cf. Table 8) of the adjective and the noun to the frequency of the noun (FREQNOUN, low vs. high frequency), the results differ for all three participant groups.

For participant group one (PG E, English natives, cf. Figure 11, left graph), the noun frequency does not have a significant effect on its position (t-value -1.93). When calculating contrasts, no effect of the noun frequency is detectable on the adjective (cf. Figure 11, left graph, left panels), lexical preprocessing does not seem to take place for this participant group, and an interaction of spelling and noun frequency is also not significant. For the noun itself, noun frequency is a significant main effect to the extent of longer durations for low frequency. Again, no interaction with spelling is detectable. Preprocessing might occur for this group, but independent of the noun frequency: Cap mean durations are roughly 10 ms higher on the adjective compared to NoCap and 10 ms lower for the corresponding noun.

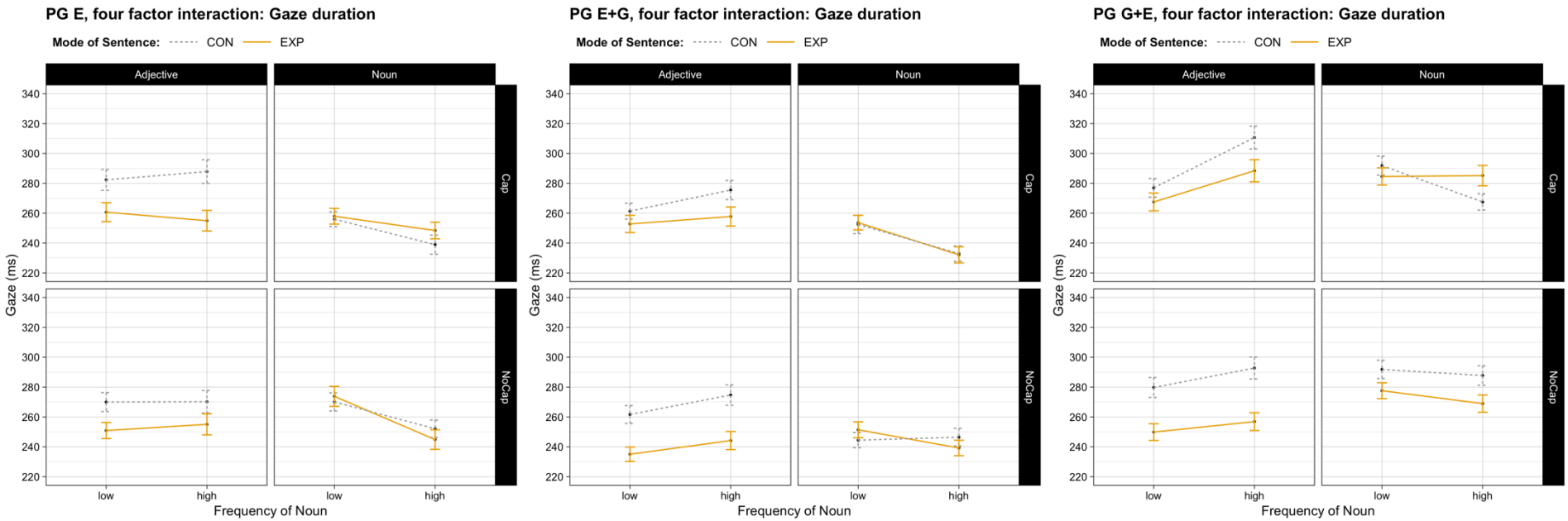

Figure 11: Gaze duration on the adjective and noun depending on the frequency of the noun for each of the participant groups (left graph: EXP 1, PG E = English natives without any knowledge of German; middle graph: EXP 2, PG E+G = English natives who regularly read German; right graph: EXP 3, PG G+E = German natives with high-level English). Estimated values of the ***four-way interactions of SPELLING (Cap vs. NoCap), SENTENCEMODE (EXP vs. CON), POSITION (Adjective vs. Noun) and FREQNOUN (Noun frequency)****, or in other words, the influence of the noun frequency on the fixation durations for the adjective and the noun itself, divided into two groups: low vs. high in Gaze duration; error bars represent the standard errors. In both panels, the adjective is shown to the left, the noun to the right. Sentences in which the standard orthography is violated (Cap) are shown in the upper part of the graph; the lower part represents sentences following English standard orthography, i.e. nouns with lowercase letters (NoCap). "Low" and "high" show the fixation duration depending on the noun frequency. The garden-path sentences (EXP) are represented by yellow solid lines and the control sentences (CON) are represented by grey dotted lines.*

For participant group E+G (English natives who regularly read German, cf. Figure 11, middle graph), the noun frequency also does not have a significant influence on fixations on the adjective and noun (t-value -0.48). Nevertheless, the position interacts with the frequency of the noun. When calculating contrasts, an effect of the noun frequency is detectable on the adjective (cf. Figure 11, middle graph, left panels, t-value of 2.04), to the extent that mean fixation durations in Gaze increase when the noun is of high frequency. Due to a missing interaction effect with the spelling mode, this seems to be independent of noun capitalization. However, we interpret the noun frequency effect as a sign of lexical preprocessing for these participants. For the noun itself, there is no main effect of frequency detectable. As preprocessing occurred on the adjective, typical frequency effects might no longer be distinct. Nevertheless, the interaction of spelling mode and noun frequency is almost significant (t-value -1.95). Comparing Cap (Figure 11, middle plot, upper right panel) and NoCap (middle plot, bottom right panel), frequency effects on the noun are clearly identifiable. In sum, high-frequency CON sentences are processed faster in Gaze Cap (508.4 ms) compared to NoCap (521.2 ms). For low-frequency CON sentences, the opposite is the case.

Finally, for participant group G+E (German natives with high-level English, cf. Figure 11, right graph), the noun frequency also does not have a significant influence on the processing of the adjective and noun (t-value 0.55). On the adjective itself, however, noun frequency is a significant main effect, i.e. in the case of an upcoming high-frequency noun, Gaze durations are longer. This effect is visibly higher in Cap (cf. Figure 11, right graph, cf. left panels), although an interaction of spelling and noun frequency is not significant. For the noun, there is no main effect of frequency, as well as no interaction of spelling and noun frequency. As with participant group E+G, this could mean that a frequency effect has already occurred on the adjective itself. When taking a more detailed look at the CON sentences (no semantical manipulation), it can be observed that a high-frequency CON sentence in Cap is processed 2 ms faster compared to NoCap. This is, of course, not statistically relevant, but there are still some differences: while the adjective in Cap is fixated on 18 ms longer (310.7 vs. 292.7 ms), the noun is fixated on 20 ms shorter (287.7 vs. 267.6 ms). Interestingly, in the case of a low noun frequency, the assumed preprocessing did not occur – durations are almost identical in Cap and NoCap on the adjective and noun. Astonishingly, they are even lower compared to a high-frequency sentence.

It seems as though lexical preprocessing (English native speakers only)

1) might occur independent of capitalization, but even stronger when capitalization is present,
2) might occur only for high frequency nouns,
3) might produce a cost, which cannot necessarily be compensated (cf. low frequency vs. high frequency).

Typical frequency effects, i.e. longer fixation durations on a lower-frequency noun (Broadbent, 1967; e.g. Becker, 1979), are more likely to be found in the Cap condition for participant groups E+G and G+E; only participant group E shows similar effects for both spelling modes.

IV.9 Problems with the Garden Path

The results of the control sentences show generally and consistently longer fixation durations without delivering other results regarding the direction of the effects. We think that this is primarily explainable in terms of the complexity of the experimental design: as described above, when designing the experimental sentences, besides the semantic requirements of ambiguity, many properties had to be taken into account. The CON items were created at the very end. They had to be of the same length (plus/minus one letter), matching semantically and matching a specific frequency corridor, and it needed to be impossible to misinterpret them as a noun of any kind. All of the CONs are proper English sentences in theory, but at least some of them must have appeared a little peculiar to the participants.

IV.10 General Discussion

The research aim was to get a better understanding of the function of systematic noun marking, which is exclusive to the German language. One tool was to compare different participant groups about which, based on their previous knowledge, different assumptions could be made.

With all the results taken together, the following can be stated:

1) Reading speed: The three different participant groups process capitalized sentences differently than those that are not regularly capitalized. This can already be seen in the reading speed. While English natives without knowledge of German (participant group E) and German participants with excellent English skills (participant group G+E) read regularly non-capitalized sentences significantly faster, processing is different for the English natives

who regularly read German (participant group E+G: PG E+G). They do not significantly read regularly non-capitalized sentences faster. While this group reads the fastest of all three, the difference in the two spellings is only three words per minute. This makes sense: while participant group E does not have implicit knowledge of systematic noun marking, which means that these are (almost) never saved in the syntactic/orthographic part of the mental lexicon, this makes it harder to process over the long term. Participant group G+E, as non-natives the slowest of all the groups, i.e. lacking processing efficiency, an effect often demonstrated (Kilborn, 1992; e.g. Fender, 2001; quotes after Roberts, 2012), possess this knowledge for sure, but are not able to transfer it to another language. While L1 orthography influences the build-up of L2 orthography (Koda, 2007), the less transparent orthography of English compared to German might inhibit the influence, which leads to a stronger orientation to the morpheme (or rhyme/syllable) level (cf. Psycholinguistic Grain Size theory: Ziegler and Goswami, 2005). This conclusion is supported by a cross-linguistic reading study (Morfidi et al., 2007) of Dutch (L1, an even more transparent orthography than German due to lesser morpheme consistency) and English (L2), in which L1 orthographic knowledge did not predict L2 reading. Consequently, for our experiment, a disturbance of the morpheme picture might lead to longer processing times. An L1 orthographic rule which speakers learned to inhibit when acquiring L2 and which is not in touch with the phonological level might be harder to transfer. On the other hand, it seems to be different for participant group E+G: this result is in line with the study cited above. The authors found that L2 orthographic knowledge offered some contribution (3%) to L1 reading (Morfidi et al., 2007, 778). Regarding the reading speed, the least irritation and maybe an antagonistic interaction of native English and German orthography lead to the smallest difference in reading speed. Relating the results with those of the study by Gfroerer et al. (1989), their results could not be reproduced, since the texts following standard orthography were read the fastest, but participant group E+G was most comparable to the Dutch participant group of their study, and their reading results showed the least and non-significant differences in reading speed. Relating this to the studies by Bock et al. (1989), the findings are more in line: the results of participant group E+G show, in our experiment as in Bock's experiments, the native Germans reading English with capitalized nouns. Although irregular and slower than the regular spelling, the difference between the two modes was not significantly different, whereas this is the case for our

participant group G+E, which did actually read the orthographic violation significantly slower. But, from an absolute point of view, the difference of 4.8 words per minute would lead to an advance of 144 words after half an hour, which is less than the reading speed of one minute.

2) Effect of position: Regarding the number of fixations, a main effect of position (adjective vs. noun) has to do with all first-pass and Total fixation measures to the extent that more fixations on the adjective compared to the noun are detectable. Apart from the Gaze duration of participant group E, the native English participants show consistently longer fixation durations on the adjective compared to the noun in Gaze and Total, especially in CON and when capitalization is present. This might be an indication for a general preprocessing of a noun for English native speakers. Apart from that, throughout the three experiments and all modes, the adjectives receive longer within-word regressions compared to the noun. A preprocessing of an attributive adjective-noun combination might be comparable with a spaced compound in English, since the second (noun) constituent is the actual semantic core. In a study by Juhasz et al. (2009), a parafoveal preview benefit was observed on the second constituent of a spaced compound. Besides that, it is of course grammatically also the core of the nominal phrase, which might emphasize the actual finding. The comparability of a spaced compound and an attributive adjective-noun combination can be reasoned by two characteristics of the English written language: 1) compounds are spaced like attributive adjective-noun combinations; 2) in contrast to German attributive adjectives, for example, they do not contain flectional morphemes but are pure, which means that in English they are only semantically but not formally distinguishable from compounds (e.g. “blue cheese” can be either a compound (more likely; in German: “Blauschimmelkäse”) or an attributive adjective-noun combination (less likely; depending on the context).
3) Garden-path effect: The garden-pathing, although mild, seems to take place for all participant groups, clearly observable only for participant groups E+G and G+E. This leads us to the conclusion that the knowledge of systematic noun marking influences the semantic processing, while a lack of it either makes a garden-path parsing unlikely or is at least not modulated by noun capitalization.
4) Spelling: The main effect of spelling compares three regularly spelled words with one manipulated one, which is even manipulated to the extent that phonology is not affected.

Effects on the noun itself when comparing the capitalized and non-capitalized varieties with one another is not detectable in any of the participant groups for the Total fixation duration; the fixation durations are almost identical. But, participant group E clearly seems to process the sentences differently. While no significant difference is detectable in Gaze for EXP, a significant difference of more than 10 ms is provable for the noun and the adjective, albeit different in terms of the direction. In contrast to that, the Total fixation durations, an absolute zero difference (even a bit longer for the capitalized nouns, which is in contrast to Gaze duration) can be detected. The Gaze processing of participant group E should, regarding the approximation for noun processing, not be consulted as a global judgement, since it equalizes in the Total fixation duration.

5) Interaction of spelling and position: Of particular note here is that for all participant groups and reported fixation time measures the interaction of spelling and position is significant. This is already implied in 4) because a difference between the spellings is hardly detectable for the noun itself. If there's no difference for the noun but for the adjective, the significant interaction is the consequence. A qualitative difference is detectable for all participant groups: while the processing of the adjective and noun seems to be on a similar level in the case of absent noun-capitalization for participant group E, the reverse is true for participant group G+E, for which this occurs in the capitalized sentences. Participant group E+G robustly processes adjectives longer than nouns, but even longer in the case of capitalization; this becomes even stronger in the Total fixation duration. The latter pattern can also be observed for participant group E in Total. Participant group G+E shows a different pattern in Total only for non-capitalized sentences, in which the adjectives are almost identical with the nouns.
6) Effect of noun frequency: Lexical preprocessing seems to occur. To what extent it is modulated by noun capitalization is speculative in terms of the post hoc analyses. Since in the study by Rayner and Schotter (2014) a modulation of semantic preview benefit was modulated by noun capitalization, lexical preprocessing also seems to be plausible. Further investigation is necessary.

Our results can be viewed within the context of the study by Rayner and Schotter (2014), in which it was the authors' major goal to examine semantic preview benefit in English modulated by a capital letter at the beginning of a noun. They were able to prove a) the semantic benefit effect in the case of noun capitalization and b) a significantly shorter noun

processing for the early fixation durations under the identical preview condition in the case of noun capitalization. Still, however, the results of this study are only partially transferable to our study. Since this study breaks new ground, we would like to demonstrate in four points why our results are not in line with their study, which used in contrast to our study the boundary paradigm:

1) First of all, in contrast to our study, the authors used compounds (one compound, depending on one's point of view, might also be included in our experiment: *lemon cupcake*) and nominal phrases followed by another nominal phrase, which were syntactically either parts of phrases, e.g. prepositional attributes (Hospital *for Experimental Surgery*) or appositions (Castle Winchester), or phrases themselves (seeing Cats *on Broadway*). From a syntactic point of view, this might not make much difference in the early fixation measures, but also complicates drawing a global conclusion regarding the processing of nominal phrases. However, what might be visible in the early time measures is the sequence of capitalized nouns (up to three, the majority two: *Airport of San Diego*, *Angel Food Cake*, *Black Student Association,* etc.) or a following number (only once: *Area 51*), which means that more than one capitalized letter can be parafoveally recognized, which draws more attention. Besides that, the authors were aware of comparing proper nouns (*Wall Street Journal*) – some of the items can probably be classified as collocations (e.g. *Trail of Tears*, *City of LA*) – with common nouns. There is reason to believe that common nouns, proper nouns and proper names, for example, are treated differently neurologically (e.g. Durso and O'Sullivan, 1983; Semenza et al., 1995), which might also result in different eye movements.

2) Apart from that, the whole processing might be more complex: The word group hypothesis, i.e. processing two words as one whole, has an unclear evidentiary status (e.g. Radach 1996; Kliegl 2007; Drieghe et al. 2008). Radach (1996) found this kind of processing for two-word groups (in German), in which the first one was short and the second one a five- to seven-letter long noun. Drieghe et al. (2008) were able to replicate these findings for English with a restriction to cases in which the first word was an article. As mentioned above, there is some evidence for this effect in the case of spaced compounds, in which a parafoveal preview benefit on the second constituent could be observed (Juhasz et al., 2009). Since compounds/collocations/proper nouns/proper names with several constituents were used in this experiment, some of the findings may simply be related to a different processing of the specific word class, e.g. when following the results of Juhasz et al.: longer processing times on

the first constituent of a compound could actually be a preprocessing of the following constituent, which is in the case of two constituents in total the semantic basis of the word. Assuming a similarity of spaced compounds and an attributive adjective-noun combination, the results are comparable with our consistent two-factor interaction of spelling and position.

3) Furthermore, the capitalized and non-capitalized sentences were not identical after the boundary, e.g.:

- *Jan looked through every **Wall** Street Journal article on finance for her honours thesis*.

vs.

- *Jan looked through every **wall** to see if there were any cracks*.

A difference in processing could be assumed in sentences that are syntactically different and not controlled in terms of the surrounding after the boundary. This could especially be seen in the Total fixation duration, which as in our experiments is identical on the noun for the identical condition (298 ms; Rayner & Schotter, 2014, p. 1620). Regarding the other two conditions, semantically related (338 ms vs. 328 ms; ibid.) and unrelated (344 ms vs. 334 ms; ibid.), the Total duration is 10 ms longer in cases where the noun was capitalized, which might suggest an ongoing irritation or a different syntactic processing of the sentence. This is in line with our result from participant group E, which is comparable with the English native participants in Rayner's study (see above: 4) spelling). The CON sentences showed the same pattern for Gaze as for Total. Unfortunately, the fixation durations for the word prior to the capitalized one are not available in Rayner and Schotter (2014)

4) Finally, the authors even emphasize that they are rather confident that the effect of first-letter capitalization they reported is quite reliable, as they observed exactly the same pattern of results (a numerical and marginally significant effect in Gaze duration and a fully significant effect in go-past time for capitalized words, but not for non-capitalized words) in two other studies (Schotter and Rayner, 2012), in which they unfortunately discovered problems with the timing of display changes. Regarding participant group E, we found the same pattern as Rayner and colleagues, but we come to a different overall conclusion since we doubt a benefit. It should also be mentioned that in a reanalysis of the data of Rayner and Schotter (2014) by Cutter et al. (2019) using Bayesian statistics instead of linear mixed models, the authors came to the conclusion that there was no parafoveal-on-foveal effect of capitalization provable.

For the individual participant groups, we come to the following conclusions:

For participant group E, a clear influence of noun capitalization in terms of processing becomes obvious, which finally leads to identical processing durations on the noun when comparing the processing time of the spelling modes with one another. However, in total, taking the adjective durations and the global reading speed into account, orthographically violated sentences are processed significantly more slowly. A beneficial adaption of an unknown orthographic rule and thus a systematic marker of a core of a nominal phrase can be doubted. As assumed, participant group E+G is the least disturbed by noun capitalization. The difference when comparing a capitalized with a non-capitalized noun is less than 5 ms difference for all time measures and interactions. But again, although small, a difference becomes visible on the adjective, which leads in sum to a longer processing. Nevertheless, noun capitalization seems to inhibit garden-path parsing in Gaze, which leads to a non-significant difference regarding the Total fixation durations of EXP. There are also indications that in the case of noun-capitalization and high noun frequency processing is faster compared to a lack of capitalization.

Participant group G+E, like the other two groups, ultimately does not show different processing durations on the noun in the Total fixation duration. The pattern of Gaze processing for CON (cf. Figure 10 to the left, right panel) seems to be similar to Germans reading German: longer processing durations on an adjective in Cap, shorter processing durations on the noun, i.e. preprocessing on the adjective; vice versa for NoCap. Due to the regular spelling of NoCap, the slope of the difference between the adjective and noun is distinctly smaller. For the Total fixation duration, this pattern leads to the result that the mean adjective fixation durations strongly increase. Processing of Gaze and Total CON hints at a mild transfer of noun-capitalization processing to the pattern we found in German natives reading German.

Overall, our study clearly shows an influence of noun capitalization on the reading process. Our study also shows clear differences between the participant groups. There is also evidence for parafoveal preprocessing. One major result unites all three participant groups: a final zero-difference on the manipulated noun, which indicates that this process is upstreamed to the actual manipulation. While there are indications of preprocessing, a systematic benefit of systematic noun marking in terms of processing and especially a language transfer of this

specific German rule cannot be proven. There are indications that this might be possible for English natives who regularly read German. Further investigation would be necessary.

IV.11 Outlook

To better point out parafoveal-on-foveal effects, we would like to conduct boundary paradigm experiments specifically examining the interaction of a noun's frequency and spelling on the previous word. Further investigation into the potential language transfer of noun capitalization knowledge or at least the beneficial use of an additional language comparison seems promising.

V. The interaction effect of noun frequency and noun capitalization during reading of German and English

V.1 Abstract

German orthography systematically marks nouns through capitalization. Our theory is that the reader benefits from the uppercase letter receiving the syntactic information, which makes the processing of sentences easier. We designed an experiment, first conducted in German (Pauly & Nottbusch, 2020) and then replicated in English (Pauly & Nottbusch, under review), in which the function of German capitalization rules/noun capitalization should become obvious in readers' eye movements. Results showed that under specific circumstances (e.g. high noun frequency) parafovea-on-fovea effects (PoF) were detectable on the preceding attributive adjective, which led to longer fixation durations on the adjective and shorter ones on the noun itself.

To further examine this finding, we designed a follow-up experiment using the boundary paradigm (Rayner, 1975) in German and English, in which we systematically manipulated the noun frequency. Participants' task was to read single sentences (40 total, all with a syntactically similar structure consisting of three noun phrases). The middle nominal phrase contained an (attributive) adjective noun array. The adjectives (N) were controlled regarding frequency and length, while the subsequent noun (N+1; controlled regarding length) was divided into two groups: 20 nouns were of high frequency (HF) and 20 of low frequency (LF). An invisible boundary was set between the adjective and noun, which led to a display change when crossing it in two conditions. The sentences were presented in 4 different ways (10 per participant):

awful [N] | [boundary]

1. phantom [N+1, LF] (NoCap, no change);
2. Phantom (Cap, no change);
3. P/phantom (Cap before boundary to NoCap after boundary);
4. p/Phantom (NoCap to Cap)

Not only PoF effects regarding frequency are controversial (for an overview: Hyönä, 2011; Drieghe, 2011); this is also the case for the possibility of transferring the assumed benefit of noun-marking to another language (Bock et al., 1989; Gfroerer et al., 1989; Rayner & Schotter, 2014).

To obtain a more detailed picture, we examined three different participant groups: Germans reading German (n=55), English natives reading English (n=50), and Germans with excellent English skills reading English (n=35).

Overall, noun capitalization influences the reading process of the three participant groups differently: While lexical PoF effects and effects of noun case change could not be detected in any of the experiments, three results in particular were remarkable:

1) In first-pass processing, the German readers showed almost identical durations on the adjective and noun independent of a noun case change.

2) The German and English readers reading English showed almost identical processing durations on the noun independently of the spelling; differences were only detectable on the preceding adjective, which was the case for first-pass and total fixation duration.

3) In the total fixation duration for the English readers, high-frequency nouns were processed substantially faster when presented with a majuscule.

V.2 Introduction

Systematic noun-marking with a capital letter (majuscule) is exclusive to German and Luxembourgish, but is – although less systematic – also known in English.

It is a research desideratum whether this also has systematic beneficial effects for readers of these languages. Studies specifically examining the effects of noun capitalization (e.g. Bock et al., 1985, 1989) have mainly measured and compared reading durations of systematically manipulated texts regarding spelling (five varieties total, e.g. complete initial lowercase or complete initial uppercase spelling). A major result is that the more the spelling varied from the regularities, the slower were the reading durations.

Bock et al. (1989) also conducted experiments in which they examined whether their findings were transferable to another language. Dutch readers read Dutch texts following their standard orthography the fastest, but texts with capitalized nouns (like in German) ranked second. Gfroerer et al. (1989) replicated the experiment described above using eye-tracking and reported the astonishing result that the Dutch participants read Dutch texts the fastest when they followed the German capitalization rules, i.e. violating the native orthography.

Since the Bock studies only measured reading durations and the Gfroerer et al. eye-tracking study was conducted with only 15 participants and reported technical problems, we conducted an eye-tracking study (Pauly & Nottbusch, 2020) to pin down the effect, examining whether readers benefit from the uppercase-letter syntactic and semantic information, which makes the processing of sentences easier. Our overall task was to find an answer to the question of whether the German Capitalization System serves a function for the reader, i.e., whether the additional syntactic information helps the reader parse the sentence. In order to test this hypothesis, we asked 54 German readers to read single sentences in German systematically manipulated at a target word (N). In the experimental condition (EXP), we used semantic priming (in the following example: sick → cold) in order to build up a strong expectation of a noun, which was actually an attribute of the following noun (N+1) (translated to English, e.g., “The sick writer had a cold (N) nose (N+1) …”). The sentences in the control condition were built analogously, but word N was purposefully altered (keeping word length and frequency constant) to make its interpretation as a noun extremely unlikely (e.g., “The sick writer had a blue (N) nose (N+1) …”). In both conditions, the sentences were presented either following German standard orthography (Cap) or in lowercase spelling (NoCap). The capitalized nouns in the EXP/Cap condition should have then prevented garden-path parsing, as capital letters can be recognized parafoveally. However, in the EXP/NoCap condition, we

expected a garden-path effect on word N+1 affecting first-pass fixations and the number of regressions, as the reader realizes that word N is instead an adjective. As the control condition does not include a garden path, we expected to find (small) effects of the violation of the orthographic rule in the CON/NoCap condition, but no garden-path effect. As a global result, it can be stated that reading sentences in which nouns are not marked by a majuscule slows a native German reader down significantly, but from an absolute point of view the effect is small.

However, we found an indication of grammatical pre-processing enabled by the majuscule in the regularly spelled sentences: In the case of high noun frequency, we post hoc located atypical (see below) parafovea-on-fovea effects, i.e., longer fixation durations, on the attributive adjective (word N). From this result, we drew up the hypotheses that (parafoveal) benefits of capitalization could only be detected under specific circumstances, i.e. a capitalized high-frequency noun.

To examine the language transfer of a beneficial processing of noun capitalization, we conducted the experiment reported above in English by creating English experimental and control sentences (Pauly & Nottbusch, under review). To obtain a more detailed picture, we examined three different participant groups: English natives without knowledge of German (group E, n = 48), English natives who regularly read German (group E+G, n = 49), and Germans with excellent English skills (group G+E, n = 47).

Overall, noun capitalization influences the reading process of the three participant groups differently. Group E is clearly influenced by noun capitalization, but a benefit can be doubted. Group E+G is the least disturbed by noun capitalization; under specific circumstances, there are indications of a benefit from noun capitalization. Group G+E shows signs of a mild transfer of noun capitalization processing to a foreign language. Significant effects on N/N+1 are detectable in Gaze and Total fixation durations and the number of fixations. As a global result, it can be stated that differences in the noun itself are mostly non-significant except for on the preceding adjective.

We also analysed post hoc the effect of noun frequency: There are indications that lexical preprocessing seems to occur. The extent to which it is modulated by noun capitalization in terms of the post hoc analyses is speculative. Since in a boundary paradigm (Rayner, 1975) study by Rayner and Schotter (2014) who examined the effect of initial letter capitalization on semantic preview benefit in English, the authors concluded that semantic preview benefit was

modulated by noun capitalization; lexical preprocessing also seems to be plausible, because lexical processing is on a lower level of representation than semantic processing (cf. Schotter et al., 2012).

Regarding the conclusions of our studies (i.e. Pauly & Nottbusch, under review, 2020), further investigation is necessary for several reasons: The analyses of the (parafoveal) effects of noun frequency were conducted, as mentioned above, post hoc. Although we had a sufficient number of participants (between 47 and 54 for the 4 experimental groups), the number of item sentences per participant was 40 in total in a 2-by-2-by-2 design (Position = adjective vs. noun, Spelling = noun capitalization yes vs. no, Sentence mode = experimental (semantic priming) vs. control sentence), which was cut in half post hoc (low vs. high noun frequency), i.e. the data basis was reduced. Moreover, our studies were not gaze-contingent studies. Furthermore, lexical PoF effects usually show a different pattern than our results reported above: While we found longer foveal fixation durations in the case of a parafoveal (capitalized) high-frequency noun compared to a low-frequency noun, the reverse effect is typically reported.

Another reason is that parafovea-on-fovea (PoF) effects are not only controversial in general (for an overview: Drieghe, 2011; Hyönä, 2011), but also regarding lexical PoF effects of word frequency are even more contentious in particular (cf. Degno et al., 2019) – more below. Quite the opposite is the case for foveal frequency effects, which are well-known (e.g. Becker, 1979; Broadbent, 1967): The mean fixation durations are significantly higher when the frequency is low compared to a higher frequency.

Therefore, we decided to further examine the interaction effect of noun frequency and capitalization by systematically manipulating the noun frequency and noun spelling in terms of capitalization in German and English using the boundary paradigm (Rayner, 1975).

The particular controversy around lexical PoF effects stems especially from the fact that proofs are only derived from corpus studies: Pynte and Kennedy (2006), who conducted a (corpus) study in English and French, only observed significant PoF effects in terms of lexical frequency for English to the extent of shorter foveal fixation durations in the case of a high-frequency parafoveal word. In an earlier corpus study by the authors (Kennedy & Pynte, 2005), the PoF effect was found for both languages with the same characteristic, but therefore restricted to specific cases, e.g. a short foveal word or matched parafoveal word lengths. Astonishingly, for long foveal words, although not significant, the effect was reversed, i.e. 5-ms longer durations

for upcoming parafoveal high-frequency words. The corpus study of Kliegl et al. (2006) replicated the effect of PoF frequency effects with the restriction to short (i.e. six characters or less) foveal words. Finally, Schad et al. (2010) report "strong, consistent, and highly reliable" (Schad et al., 2010, p. 2608) effects of PoF frequency on gaze and single fixation durations during normal and shuffled-text (i.e. digit-symbol substitution) reading. Absolute effect strength in the reported studies between a parafoveal high- and low-frequency word for significant gaze durations varied from 12 ms (Kennedy & Pynte, 2005) for short words to about 16 ms (Schad et al., 2010) for long words for normal text.

However, single eye-tracking studies in which the lexical frequencies were deliberately manipulated were not able to show these effects. In the following, we only report partial results of the studies (ignoring results of specific manipulations). Henderson and Ferreira (1993) manipulated three successive words in a sentence regarding the length, frequency, and syntactic class to examine PoF effects. For Gaze duration, the authors report an 8-ms difference for upcoming high-frequency words (252 ms vs. 244 ms each, i.e. the opposite direction compared to what was reported above) on the first two words, but this effect is not significant, so that the authors conclude that there was not "even a hint of an effect" (Henderson & Ferreira, 1993, p. 216). Rayner et al. (1998) report results from two experiments in which the participants read single sentences. In both experiments, the parafoveal frequency did not significantly influence foveal reading regarding single fixation duration, 3 ms and 5 ms in Experiment 1/2 (245/224 ms high frequency vs. 248/229 ms low frequency). In a study by Schroyens et al. (1999), which focused on another research question, words were presented in threes. Single-fixation durations were reported for word N, but results were inconclusive: For a three-character word N with low frequency, fixation duration was about 8 ms higher when parafoveal word N+1 had a low frequency, while the reverse was true in the case of a high-frequency word N (again 8 ms difference). For a high-frequency five-character word N, no difference regarding the parafoveal frequency was detected, while processing of a low-frequency N was marginally (< 5 ms) higher for low-frequency N+1s. Calvo and Meseguer (2002) conducted a single-sentence reading study under two priming-context conditions by examining the combined influence of word length, word frequency, and contextual predictability on eye movements. While they do not provide detailed results regarding the processing durations of PoF frequency effects, they report that neither of the parafoveal PoF measures seemed to be affected by the predictors. White (2008) conducted a sentence-

reading experiment with systematic manipulations regarding the frequency and orthographic familiarity. Absolute value differences between parafoveal high and low frequency were not larger than 1 ms each for single fixation, first fixation, and gaze duration, therefore this study also did not reveal any effect of word frequency on prior fixation durations.

Brothers et al. (2017) conducted four sentence-reading experiments with a total of 244 participants. In a first step, they built content word pairs (adjective, noun or verb) with identical word length (3 to 9 letters) of both high and low frequency, e.g. murder/impale, article/tabloid. In the first three experiments reported, one of these words (target) was included in a sentence following a short function word (pre-target; M: 2.9 letters); the fourth experiment consisted of two target words. Their results were clear; none of the experiments showed a PoF frequency effect on the pre-target word. In experiments 1, 2 and 4, differences between high and low frequency were a maximum of 3.7 ms on the pre-target for gaze duration (first fixation duration: max. 1.1 ms) each to the extent of longer durations in the case of an upcoming low-frequency word, while experiment 3 showed a 9.7-ms difference (4.9-ms first fixation duration), which, however, was not significant.

Since function words are skipped often – the authors report mean values on the pre-target word of 56.2% for an upcoming high-frequency word (HF) vs. 56.5% for low frequency (LF), it can be assumed that the processing depth of these words is lower. Interestingly, the skipping rate (44% HF vs. 45% LF) is lowest on the pre-target for experiment three, in which the absolute differences were highest. For comparison, the targets are skipped only in 19.3% of the cases (HF) vs. 15.3% (LF).

Apart from that, mean reading rates are lower for the shorter-content words – pre-target: 212.5 ms (HF)/213.9 ms (LF) vs. target: 226.7 ms (HF)/243.0 ms (LF).

Although short words seem to provide better chances to prove PoF frequency effects, the type of word might also play a role. Note that, for example, Kennedy and Pynte (2005) define in their corpus study, in which effects were found, “short” words as 5 and 6 characters in length (vs. 2.9 letters in the experiments reported before).

Apart from that report, the authors conducted a meta-analysis of 18 research articles (including their own four experiments), which report a total of 28 experiments and 988 participants. They conclude from the analyzed data that “the near-zero parafoveal-on-foveal effect is relatively constant across a variety of languages (English, Finnish, Thai, Spanish, German, Chinese) and experimental settings” (Brothers et al., 2017, p. 16). But, the authors

also acknowledge that they cannot rule out the possibility of a very small PoF word-frequency effect on the order of 4 to 5 ms, but they do not clarify whether this refers to first fixation or gaze duration.

Finally, Degno et. al (2019) examined among other things PoF frequency effects in two experiments using a similar method that used by Brothers et al. (2017): They also first matched high- and low-frequency pairs (5-6 characters) and integrated them into sentences, each containing two HF or two LF targets. The word class regarding the target or pre-target word was not reported, but the authors report at least the mean pre-target word length (5.32 characters). This makes it quite likely that there was at least a mixture of function and content words. In the example sentence, the authors mentioned that it was an adjective-noun combination. The authors conclude that there is no evidence for PoF frequency effects; the reported fixation duration measures (in the identity condition) exhibit marginal differences with a maximum of 6 ms for the single fixation duration (231 ms HF vs. 237 ms LF). In the first fixation duration, differences are only 4 ms (228 ms HF vs. 23s ms LF), while in gaze duration values are equal (259 ms). Moreover, the authors also measured electroencephalogram (EEG) signals – the authors also did not find any hints for PoF frequency effects in this data. However, the authors report that research with EEG measures regarding this effect is rare with two experiments and the results are contradictory.

Another type of PoF effect that might be taken into account for our experiment are visual and orthographic PoF effects (for an overview: Schotter et al., 2012). These effects are usually examined in boundary paradigm experiments in which the parafoveal preview is manipulated, e.g. completely masked upcoming parafoveal words using a sequel of x' or manipulated letter strings. Orthographic familiarity is best measured by the token frequency, which is the sum of the frequencies of words that contain a particular letter sequence (S. J. White, 2008, p. 206). In some studies only the type frequency was controlled, which is a less informative measure in terms of orthographic familiarity: The trigram *pne* has a low type frequency but can be considered highly informative due to a high predictability for words beginning with *pneu** like *pneumatic*, *pneumonia* (S. J. White, 2008, p. 206).

Since these effects were found (e.g. Drieghe et al., 2008; Inhoff et al., 2000; Pynte et al., 2004; S. J. White, 2008), then the more the parafoveal preview was either visually uncommon (like X sequels) and/or orthographically unfamiliar the longer were the fixation durations on the

currently fixated word. Other studies failed to prove these effects (e.g. Degno et al., 2019; Rayner et al., 2007; S. J. White & Liversedge, 2006; S. White & Liversedge, 2004).
Regarding our experiment, we consider orthographic familiarity to be negligible in terms of our hypotheses. Of course, monogram frequencies of majuscules and minuscules differ in German and English (e.g. Institut für Deutsche Sprache, 2020; Jones & Mewhort, 2004). But, in the case of an orthographically violated preview, the preview always consists of an allograph. Apart from that, the phonology is not affected. We expect the visual PoF effect of a majuscule, which draws greater attention to the word as superior compared to the minor deviation in terms of orthographic familiarity.

Finally, we include the assumptions of PoF effects in the two major models for the control of eye movements during reading, i.e. the E-Z reader (e.g. Erik D. Reichle et al., 2003; E. D. Reichle et al., 2009), which represents serial processing, and the SWIFT model (e.g. Engbert et al., 2005) representing parallel processing. Serial processing means that words are fully processed only word-by-word, while parallel processing expects that all words within the perceptual span are simultaneously lexically processed (cf. Degno et al., 2019). Regarding PoF effects, both models have in common that sublexical features of the parafoveally visible word, e.g. orthographic or phonological codes, can be processed foveally. Parallel processing models extend that to lexical features. This means that if lexical PoF effects are found, this would suggest parallel processing.

The work at hand reports an attempt to further examine lexical PoF effects and whether they might be promoted by systematic noun-marking in German and English. Furthermore, we examine language transfer in different participant groups with varying degrees of knowledge of German and English orthography.

V.3 Experiment

V.3.1 Preliminary Remarks and Hypotheses

In our study design, we systematically manipulated single sentences regarding the noun frequency (high vs. low) and varied noun spelling (upper- vs. lowercase) *while* sentence reading through the use of the boundary paradigm (cf. Table 1; for more details, see Materials section). The sentences were presented in regular German spelling (Cap) and in lowercase

spelling (like in English orthography; NoCap). For language comparison purposes and in order to measure the different grades of transfer between writing systems, we conducted the experiment in both German and English. In the English version, we also conducted the experiment with two different participant groups: English natives without knowledge of German and German natives with high proficiency in English (details below).

We created sentences containing an attributive adjective-noun combination (words N and N+1, details in Materials) in the second noun phrase. While the frequency of N was kept constistantly high, frequency of N+1 was divided into two groups: low and high frequency. Between N and N+1 was an invisible boundary, which led to four possible presentations of the noun before and after crossing the boundary (cf. Table 1): NoCap before the boundary, Cap after the boundary and vice versa, or no change, i.e. Cap before and after the boundary and vice versa.

Our hypotheses were the following:

German readers reading German:

- The German Capitalization System, i.e. systematic noun-marking, does serve a function for the reader, facilitating sentence processing through the systematic recognition of heads of noun phrases. This function is unfolded only in the case of parafoveally visible uppercase high-frequency nouns, which promotes lexical preprocessing on the preceding word.

Hypotheses regarding position (first-pass processing):

a. **Adjective:** When the upcoming noun is capitalized and the frequency of the noun is high, we expect longer fixation durations due to preprocessing of the noun. Regarding all other conditions, adjective durations should be identical, since lexical preprocessing is limited to a high frequency and the presence of an uppercase letter. This effect should be strongest for the group of German natives reading German, but should also occur for the other two participant groups. If any difference is detectable in the adjective, then only in the corresponding low-frequency uppercase condition, for which processing durations would be slightly higher due to preprocessing than for the lowercase condition.

b. Noun (**Germans reading German):** Uppercase presentation compared to an orthographically violated lowercase noun should be the fastest. Frequency effects should be visible, i.e. high-frequency nouns should be processed faster than low-frequency nouns. It remains inconclusive whether frequency effects or orthographic manipulations have a greater impact.

    - **High-frequency nouns:** An unchanged uppercase high-frequency noun should be processed the fastest; the same noun should be processed slower, but the second fastest when the spelling changes to lowercase because it has already been preprocessed on the adjective (see above). The change of a parafoveally lowercase high-frequency noun to an uppercase foveal noun should rank third due to the lack of preprocessing. Differences should be low, since this noun has the benefit of an orthographically correct foveal presentation. A consistently lowercase high-frequency noun should be processed the slowest out of the high-frequency ones.
    - **Low-frequency nouns:** An unchanged uppercase low-frequency noun should be processed the fastest out of all the low-frequency nouns; the same noun should be processed slower, but the second fastest when the spelling changes to uppercase because foveally it is correctly spelled. The change to a foveal lowercase noun should rank third due to misspelling. A consistently lowercase high-frequency noun should be processed the slowest of all the low-frequency ones, but only marginally compared to the noun, which changed from uppercase to lowercase since there no preprocessing benefit could be expected for the adjective.

Similar effects should be provable for the two participant groups:

1) **English natives reading English:** The English natives are aware of noun-marking, although not as systematically as in German. The uppercase letter should promote preprocessing as well for high-frequency nouns. Slight irritations, on the other hand, could occur when the noun is spelled with an orthographically violating uppercase letter.

2) **German natives reading English:** The hypotheses are identical with those of English natives reading English, but the effects should be stronger. The noun-marking with a majuscule is systematic in German. We expect a transfer of this concept while processing the English sentences.

In the following, we present a *very detailed* version of our assumptions:

We expected the following effects (on N and N+1) for **Germans reading German**:

- Cap/Cap (no display change, regular spelling):
    - High noun frequency (HF):
        - In general: Shortest fixation durations of all conditions: normal case – point of reference for all other conditions.
        - Adjective (N): The reader recognizes the majuscule of the following noun and due to the high frequency of this noun is able to preprocess it parafoveally, which should lead to longer fixation durations on the adjective.
        - Noun (N+1): Due to preprocessing on the adjective, the fixation durations on the noun, which is presented in standard orthography, should decrease.
    - Low noun frequency (LF):
        - Adjective (N): The reader recognizes the majuscule of the following noun, but due to the low frequency of this noun is not able to preprocess it parafoveally. This should lead to shorter fixation durations on the adjective compared to the high frequency.
        - Noun (N+1): Due to the lack of preprocessing on the adjective and the low noun frequency, the fixation durations on the noun should be substantially higher compared to the Cap/Cap high-frequency condition.
- NoCap/NoCap (no display change, irregular spelling of N+1):
    - High noun frequency:
        - Adjective (N): Due to the missing majuscule of the noun, a preprocessing of the noun is inhibited. The frequency of the upcoming noun does not influence the processing.

        - Noun (N+1): The word is presented either parafoveally or foveally in violated orthography, and the fixation durations should be longer in general. Due to the fact that the nouns are of high frequency, the fixations durations should be shorter compared to low noun frequency.
    - Low noun frequency:
        - In general: Longest fixation durations of all conditions.
        - Adjective (N): Identical with the adjective above (NoCap/NoCap, HF).
        - Noun (N+1): Similar to the noun above (NoCap/NoCap, HF), but even longer fixation durations due to low noun frequency.
- Cap/NoCap (display change, irregular spelling of N+1 after crossing boundary):
    - High noun frequency:
        - Adjective (N): Identical with Cap/Cap and high frequency on first pass.
        - Noun (N+1): The parafoveal preprocessing on the adjective should decrease the fixation durations, whereby violation of the orthography should increase them. This should lead to fixation durations that are longer than Cap/Cap and high frequency, but shorter than NoCap/NoCap when the word frequency is high.
    - Low noun frequency:
        - Adjective (N): Identical with Cap/Cap and LF in first-pass.
        - Noun (N+1): Identical with NoCap/NoCap and LF in first-pass.
- NoCap/Cap (display change, regular spelling of N+1 after crossing boundary):
    - High noun frequency:
        - Adjective (N): Identical with NoCap/NoCap and high frequency on first pass.
        - Noun (N+1): While a lack of parafoveal preprocessing should increase the fixation durations, the fact that the noun is presented in standard orthography and consists of a high frequency should limit the increase. Fixation durations should be longer than Cap/Cap and LF, but shorter than Cap/NoCap and HF because orthographic violations disturb the reader more than a lack of preprocessing.
    - Low noun frequency:
        - Adjective (N): Identical with NoCap/NoCap and HF on first pass.

        - Noun (N+1): Identical with Cap/Cap and LF on first pass; probably slightly shorter due to parafoveally unconscious recognition of the misspelled noun.

We expected the following effects (on N and N+1) for **English natives reading English**:

- NoCap/NoCap (no display change, regular spelling of N+1):
    - High noun frequency (HF):
        - In general: Shortest fixation durations of all conditions: normal case – point of reference for all other conditions.
        - Adjective (N): Slight preprocessing of the noun should occur in general. The frequency of the upcoming noun does not influence the processing.
        - Noun (N+1): The word is presented either parafoveally or foveally in standard orthography, the fixation durations should be longer in general. Due to the fact that the nouns are of high frequency, the fixation durations should be shorter compared to low noun frequency.
    - Low noun frequency (LF):
        - Adjective (N): Identical with the adjective above (NoCap/NoCap, HF).
        - Noun (N+1): Similar to the noun above (NoCap/NoCap, HF), but even longer fixation durations due to low noun frequency.
- Cap/Cap (no display change, irregular spelling):
    - High noun frequency (HF):
        - Adjective (N): The reader recognizes the majuscule of the following noun, which supports preprocessing and is facilitated by the high frequency of the noun. This should lead to longer fixation durations on the adjective.
        - Noun (N+1): Due to preprocessing on the adjective, the fixation durations on the noun should either decrease compared to NoCap/NoCap and high frequency or should at least be at the same level, if irritations due to the violated orthography and preprocessing compensate one another.
    - Low noun frequency (LF):

        - Adjective (N): The reader recognizes the majuscule of the following noun, but due to the low frequency of this noun is not able to preprocess it parafoveally. This should lead to shorter fixation durations on the adjective compared to the high frequency.
        - Noun (N+1): Due to the violated orthography and a lack of preprocessing on the adjective, the fixation durations on the noun should be higher compared to the NoCap/NoCap low-frequency condition.
- Cap/NoCap (display change, regular spelling of N+1 after crossing boundary):
    - High noun frequency:
        - Adjective (N): Identical with Cap/Cap and high frequency on first pass.
        - Noun (N+1): The parafoveal preprocessing on the adjective should decrease the fixation durations. Due to the high frequency and the correct orthography when fixating on the word, the fixation durations should be shorter than those of NoCap/NoCap and high frequency.
    - Low noun frequency:
        - Adjective (N): Identical with Cap/Cap and LF on first pass.
        - Noun (N+1): Identical with NoCap/NoCap and LF on first pass.
- NoCap/Cap (display change, irregular spelling of N+1 after crossing boundary):
    - High noun frequency:
        - Adjective (N): Identical with NoCap/NoCap and high frequency on first pass.
        - Noun (N+1): While the noun is presented in violated orthography, fixation durations should slightly increase. They should be longer than NoCap/NoCap and HF.
    - Low noun frequency:
        - In general: Longest fixation durations of all conditions.
        - Adjective (N): Identical with NoCap/NoCap and high frequency on first pass.
        - Noun (N+1): Slight increase in fixation duration compared to NoCap/NoCap and LF due to irregular orthography.

For effects (on N and N+1) for **German natives with very good command of English reading English,** see above (identical hypotheses with those of English natives reading English, but stronger effects).

V.4 Method

V.4.1 Material

V.4.1.1 *General remarks Material*

A total of 40 experimental sentences (EXP) were created. They consisted of a very similar structure: Position one was occupied by either a Nominal Phrase (NP) or an Adpositional Phrase (AP), which always contained a noun. The following position was occupied by the verb. Units three and four again were composed of either a NP or an AP.

The middle NP/AP always contained an attributive adjective-noun combination.

Position N, i.e. the adjective, (details below) was designed to be of a consistent length (5 to 7 letters) and of high frequency.

Position N+1, the noun, was consistently 7 letters long. Besides that, the noun was divided into two groups: 20 nouns were constructed to be of very low frequency (LF) and 20 to be of very high frequency (HF); details below.

The EXP was presented in four different spelling modes, two of them with a display change:

- Cap remained Cap: “Phantom” (example word) remained “Phantom” after the boundary
- NoCap remained NoCap: “phantom” remained “phantom” after the boundary
- Cap changed to NoCap: “Phantom” changed to “phantom” after the boundary
- NoCap changed to Cap: “phantom” changed to “Phantom” after the boundary.

Proper names within the sentence and compounds were avoided.

The mean frequencies were based on two different corpora. Word frequencies (i.e., frequencies of complete word forms) for the German experiment were based on “DLEXDB” (Corpus: DWDS [Digital Dictionary of the German Language]) with over 100 million running words (Heister et al., 2011). The English frequencies were extracted from “CELEX2” (Baayen et al., 1995). To make the experiments comparable, we calculated the absolute frequency

measures into frequencies per million words based on the details provided by the two corpora; both values will be provided below.

A total of 100 filler sentences were presented. The filler sentences were mainly extracted from the Potsdam Sentence Corpus (PSC) v. 1.0, which was "constructed with the goal to represent a large variety of grammatical structures" (Kliegl et al., 2004, p. 267; S. J. White et al., 2008, p. 1271). For the English experiment, the PSC sentences were translated.

In using a large range of syntactic constructions, we wanted to make sure that it was highly unlikely for participants to see through the syntactic scheme of the EXP (each participant read 2.5 times more filler sentences than experimental ones). As in the EXP sentences, partial minor modifications were made, e.g. avoiding proper names within the sentence, so that no necessity to capitalize them would occur.

V.4.1.2 *Detailed material, Experiment 1: Germans reading German*

Besides position N+1, the whole sentence was always presented following German standard orthography, i.e. the nouns in the two other NPs/APs were presented with a majuscule.

The experimental sentences (EXP) were 8 to 10 words in length (M: 8.85, SD: 0.73); word length varied within the sentences from 2 to 17 letters (M: 5.40, SD: 2.52). The sentences were 43 to 66 letters long (including spaces and final period; M: 55.6, SD: 4.90).

N had a length of 5 to 7 letters (M: 5.85, SD: 0.76) and varied from 2 to 3 syllables (M: 2.18, SD: 0.38).

N had a mean frequency of 34.95 (SD: 13.52) per million words (absolute mean value of DLEXDB: M: 4333.60, SD: 1657.83).

Relating N to the low-frequency nouns, the mean was 5.85 letters (SD: 0.79), syllable mean 2.2 (SD: 0.40), frequency mean per million words: 34.44 (SD: 13.67), and absolute DLEXDB mean value: 4212.60 (SD: 1672.54).

Relating N to the high-frequency nouns, the mean was 5.85 letters (SD: 0.73), syllable mean 2.15 (SD: 0.36), frequency mean per million words: 35.47 (SD: 13.35), and absolute DLEXDB mean value: 4454.60 (SD: 1634.06).

N+1 was consistently 7 letters long with a slight syllable variation of 2 to 3 (M: 2.20, SD, 0.40). The low-frequency (LF) items of N+1 had a mean frequency of 1.67 (SD: 0.71) per million words (absolute mean value of DLEXDB: M: 204.45, SD: 86.24). Syllable mean was: 2.25, SD: 0.43.

The high-frequency (HF) items of N+1 had a mean frequency of 74.55 (SD: 17.71) per million words (absolute mean value of DLEXDB: M: 9119.00, SD: 2166.80). Syllable mean was: 2.15, SD: 0.36.

The 100 filler sentences were presented half with regular spelling, and half including one noun within the sentence spelled irregularly with an initial minuscule.
The filler sentences were 5 to 11 words in length (M: 8.1, SD: 1.21), word length varied from 2 to 20 letters (M: 5.61, SD: 2.82), and the sentences were 43 to 69 letters long (including spaces and final period; M: 52.5, SD: 6.15).

V.4.1.3 *Detailed material, Experiments 2 and 3: English natives and German natives reading English*

Besides position N+1, the whole sentence was always presented following English standard orthography, i.e. the nouns in the two other NPs/APs were presented with a minuscule.
The experimental sentences (EXP) were 7 to 10 words in length (M: 9.0, SD: 0.67); word length varied within the sentences from 1 to 11 letters (M: 4.83, SD: 2.12). The sentences were 44 to 57 letters long (including spaces and final period; M: 51.5, SD: 3.65).
N had a length of 5 to 6 letters (M: 5.4, SD: 0.49) and varied from 1 to 3 syllables (M: 1.75, SD: 0.49.
N had an overall mean frequency of 47.80 (SD: 9.75) per million words (absolute mean value of CELEX2: M: 855.55, SD: 174.53). Relating N to the low-frequency nouns, the mean was 5.50 letters (SD: 0.50), syllable mean 1.75 (SD: 0.43), frequency mean per million words: 48.12 (SD: 10.22), and absolute CELEX2 mean value: 861.35 (SD: 182.95).
Relating N to the high-frequency nouns, the mean was 5.3 letters (SD: 0.46), syllable mean 1.75 (SD: 0.53), frequency mean per million words: 47.47 (SD: 9.25), and absolute CELEX2 mean value: 849.75 (SD: 165.48).
N+1 was consistently 7 letters long with a slight syllable variation of 2 to 3 (M: 2.20, SD, 0.40).
The low-frequency (LF) items of N+1 had a mean frequency of 1.79 (SD: 0.58) per million words (absolute mean value of CELEX2: M: 32.00, SD: 10.42). Syllable mean was: 2.25, SD: 0.43.
The high-frequency (HF) items of N+1 had a mean frequency of 79.29 (SD: 15.58) per million words (absolute mean value of CELEX2: M: 1419.35, SD: 278.80). Syllable mean was: 2.15, SD: 0.36.

The 100 filler sentences were presented half with regular spelling and half including one noun within the sentence spelled irregularly with an initial majuscule.

The filler sentences were 6 to 13 words in length (M: 9.01, SD: 1.29), word length varied from 1 to 15 letters (M: 4.71, SD: 2.36), and the sentences were 42 to 66 letters long (including spaces and final period; M: 50.42, SD: 5.40).

Table 1: Example sentence in all conditions (English for illustration only); the thick red line marks the invisible boundary, the second row of N+1 within a line shows the presentation of the word after crossing the boundary; Cap stands for uppercase letter, NoCap for lowercase

Noun case before boun-dary	Noun case change	Mode of Spelling				N-1	N Adjective	N+1 Noun (High/low frequency)			
			Noun Phrase		Verb	Noun Phrase			Adpositional Phrase		
Cap	No	Cap/ Cap	The	child	sees	the	awful	**P**hantom	in	his	dreams.
								Phantom			
NoCap		NoCap/ NoCap						**p**hantom			
								phantom			
Cap	Yes	Cap/ NoCap						**P**hantom			
								phantom			
NoCap		NoCap/ Cap						**P**hantom			

V.4.2 Participants

V.4.2.1 *Preliminary notes: Participants*

The experimental sessions lasted for about 30 minutes, after which the participants filled out an anonymous questionnaire asking for personal data and questions concerning spoken languages and possible problems with the mother tongue. All participants had normal or corrected-to-normal vision.

The German natives (participants in EXP 1 and EXP 3), in addition, had to answer questions regarding their exposure to (in reading) and production of text violating German capitalization rules, e.g. in digital form. In addition to that, they were asked to evaluate how disturbed they generally felt by spelling violations (especially non-capitalized nouns) during reading.

In the questionnaire and the personal conversation after the experiment, the participants were asked whether they recognized any display change, and if so, to describe it.

Participants who were able to describe the display change were asked how often they recognized it and if they remembered the items. More than two recognized sentences led to a complete exclusion of the participant. If the items could be named, the sentences were excluded. Around 8 percent of the participants recognized a display change in total. All participants left in the data only reported one instance of recognition.

V.4.2.2 *Participant group 1: German natives reading German (Group GG)*

Fifty-four participants, undergraduate students from Potsdam University (40 female, 14 male) with normal or corrected-to-normal vision took part in the experiment. All participants were German native speakers. The age-span ranged from 18 to 46 years; the mean age was 23.80 (SD: 5.57). Participation was mandatory to receive credit for an associated lecture.

V.4.2.3 *Participant group 2: English natives reading English (Group EE)*

Forty-seven participants, mostly undergraduate students of Nottingham Trent University (36 female, 11 male) took part in the experiment. All participants were fluent in English; forty-six of them were native speakers. One participant acquired English at the age of 2. The age-span ranged from 21 to 39 years; the mean age was 22.77 (SD: 3.70). Undergraduate participants received study credit for their participation. A requirement for participation was that they had no or at least very little knowledge of German. In the questionnaire, the participants were additionally interrogated regarding their knowledge of German in the questionnaire after the study.

V.4.2.4 *Participant group 3: German natives with high proficiency in English reading English (Group GE)*

Thirty-five participants (27 female, 8 male), mostly Master's students or Doctoral students majoring in English or studies taught in English, took part in the experiment. Other proof of language proficiencies in English were accepted too, e.g. a minimum TOEFL result of 100, an IELTS score of 7 corresponding to at least level B2 in the Common European Framework of Reference for Languages (CEFR), and longer stays abroad dating back no longer than two years, etc. All subjects were German native speakers. The age-span ranged from 19 to 34 years; the mean age was 25.90 (SD: 2.94).

In the questionnaire, the participants were additionally interrogated regarding stays abroad in English-speaking countries and whether problems occurred with sentences they read. In

total, 5 participants reported problems with single words, but no experimental sentences with identifiable unknown vocabulary were affected.

V.4.3 Apparatus

Eye movements of the subjects were recorded monocularly in a darkened laboratory with an SR EyeLink 1000 system (500 Hz); the experiment was programmed with Experiment Builder software by SR Research. Sentences occupied only one line on the screen and were presented one at a time at the 1/3 vertical position from the top of the screen.

Experiments 1 and 3 were conducted with a 22-in. TFT Monitor (1680 × 1050 resolution; frame rate 120 Hz) and Experiment 2 with a 17-in. CRT Monitor (1024 × 768 resolution; frame rate 85 Hz). Subjects were seated 60 cm (Exp. 1 and 3) / 55 cm (Exp. 2) in front of the monitor with their head positioned on a chin rest; participants' dominant eye was tracked. Texts were displayed using 26 pt. (Exp. 1 and 3) / 18 pt. (Exp. 2) bold font Courier New.

V.4.4 Procedure

Before the beginning of the main experiment, there was a pretest consisting of three sentences, so that the participants had a chance to ask questions to clarify any ambiguities if necessary. Each subject read 140 sentences in the main experiment: all 100 filler sentences, 40 experimental sentences (EXP); 20 of the sentences featured a high noun frequency, 20 a low noun frequency.

For 20 EXP sentences the display changed, while for the remaining counterpart of 20 sentences it did not. Every participant read 10 sentences in each of the following spelling modes:

- Cap remained Cap: "Phantom" (example word) remained "Phantom" after the boundary
- NoCap remained NoCap: "phantom" remained "phantom" after the boundary
- Cap changed to NoCap: "Phantom" changed to "phantom" after the boundary
- NoCap changed to Cap: "phantom" changed to "Phantom" after the boundary

The order was pseudo-randomized.

Subjects' measurements were calibrated with a standard nine-point grid. After the validation of calibration accuracy, a drift correction point appeared in the center of the screen. When the dot was fixated on, the fixation point re-appeared on the left side of the monitor. If the

eye tracker identified a fixation on the fixation spot within 2000 ms for at least 50 ms, the fixation point disappeared and a sentence was presented such that the center of the first letter in the sentence appeared to the right of the fixation-point position. If there was no identification, the calibrating procedure was repeated.

Subjects were instructed to read the sentences for comprehension and to signal the completion of a trial by fixating on a dot in the lower right corner which either automatically led to the next sentence or to a dual choice task regarding the content of the sentence they had just read. The reason for the question was to ensure that the participants read all the sentences attentively, supported by the fact that the questions appeared in a random order. The answer options were of similar but slightly different structures (e.g. different word classes; example question: “How was the game? A) Spectacular B) Boring”). The answer was given by a left (answer A) or right (answer B) mouse-click, which was supported by an image below the question to avoid confusion. Questions were already asked in the pretest mentioned above. A total of 35 questions were asked per subject (i.e. in 25% of the trials), and subjects correctly answered at least 98.04% per participant group, with a maximum of three wrong answers (only one occurrence, ten occurrences with two wrong answers, 23 with one wrong answer, 102 participants with only correct answers) per participant.

V.5 Data Analysis

Fixations were automatically determined by the EyeLink Data Viewer by SR Research. Outliers within the eye movement data were omitted in two steps: First, all potentially mislocated fixations (50 ms or less) were deleted. Second, fixations exceeding 2.5 SD of the mean for each eye-movement measure were deleted for each participant. The following measures were calculated:

- First fixation duration (the first of multiple fixations or the only fixation on a target),
- First-pass fixation duration (summation of the durations across all fixations of the first run within the current area of interest, excluding all cases in which the reader regressed to the left before crossing the boundary),
- Total fixation duration (all fixations on the target, including regressions),
- Regression duration (Total minus Gaze).

This left at least 98.1% of the data for each of the three participant groups remaining.

Apart from that, we calculated the reading speed (the start time of the first fixation on the first or second word within a sentence until the end of the last fixation, divided by the number of characters) in words per minute (wpm).

Bayesian linear mixed-effects models (BLMMs; Gelman, 2014; McElreath, 2016; Nicenboim and Vasishth, 2016) were used to determine the differences in first-pass fixation duration (FPFD), total fixation duration, and global reading speed. BLMMs were conducted in R using the R package “brms” (Bayesian Regression Models using 'Stan'; (Bürkner, 2017, 2018; Carpenter et al., 2017) v. 2.70.

Models were fitted with random intercepts for subjects and items (Bates et al., 2015). In each Bayesian LMM, we used a prior of Normal (μ= 200, σ= 1000) for the model intercept and Normal (0, 200) for the random-effects items and subjects. These priors would be considered weakly informative (Lemoine, 2019; McElreath, 2016), given that we were dealing with log-transformed data (Cutter et al., 2019). Models were run with three chains of 4,000 iterations per chain, 2,000 iterations warm-up.

Two types of Bayesian credible intervals are the most common: 1) the percentile interval and the highest posterior density interval (HPDI; Nicenboim & Vasishth, 2016). HPDIs were used, as opposed to percentile intervals, because HPDIs are more suitable for non-symmetric posteriors (Hyndman, 1996; Liu et al., 2015; Smith et al., 2019), as found in the results below.

The model was fitted with predictors for the main effects of

- Region (Adjective vs. Noun),
- Noun frequency (high vs. low),
- Noun spelling before boundary (lower vs. uppercase),
- Noun case change (i.e. crossing the invisible boundary after the adjective; yes vs. no)

and their interactions. The 95% highest posterior density intervals (HPDI) were calculated from the posterior samples.

Two criteria for evidence were used:

1) 95% HPDIs that do not contain zero are evidence for an effect of the predictor variable (Kruschke et al., 2012; Nicenboim & Vasishth, 2016; Sorensen et al., 2016).
2) The strength of support for a particular effect was expressed in Bayes Factors calculated using the Savage-Dickey method (Dickey & Lientz, 1970). The logic of BFs precludes the specific cut-off values that determine "statistical significance"; therefore, BFs around 10 or larger are considered to strongly support the alternative hypothesis, while small BFs (around 0.3 or smaller) are considered evidence against the alternative hypothesis (e.g. Wagenmakers et al., 2010; Roeser et al., 2018).

We also report the most probable effect estimate $\hat{\beta}$ to determine the size and direction of the effect and the absolute effect strength $\hat{\Delta}$.

In the following, we present results regarding the global reading speed, the first-pass fixation duration and the Total fixation duration (the latter for the unchanged conditions only).

V.6 Results

V.6.1 Global reading speed

V.6.1.1 *Global reading speed: Preliminary remarks*

The global reading speed was calculated using the time stamp of the beginning of the first fixation and the time stamp of the end of the fixation. Only sentences in which the first fixation was placed on the first – the first word was often an article – or second word were included. This left for each experiment at least 97.7% of the data remaining. Afterwards, the mean reading speed in words per minute for each sentence was calculated, which was used as a dependent variable for the model (for details, see above).

Global reading speed was included to serve as a quick overview of the influence of the manipulation of one word on the reading speed per minute. In the model, we included the three predictors of noun frequency, noun spelling before the boundary, and noun case change.

V.6.1.2 *Experiment 1: Global reading speed – Participant group 1 (Group GG): German natives reading German*

Regarding the reading speed, all main effects (frequency, noun case before boundary, and noun case change) are negligible, since the Bayes Factors (BF) are below 0.3.

Extrapolating noun frequency to the average word per minute reading speed, a difference is present but, due to high variance, negligible: 235.3 wpm for sentences including a high-frequency noun vs. 228.2 wpm for low-frequency ones.

Although negligible, the interaction of the noun case before the boundary and noun case change does not contain zero regarding the 95% HPDI. This might result, when looking into nested comparisons, from the contrast when the noun was spelled with an uppercase letter before the boundary, for which the 95% HPDI also does not contain zero, but here as well the BF is below 0.1. In that case, a change slows the reader down (229.9 wpm vs. 236.4 wpm), which makes sense because when fixating on the noun, it is misspelled. The reverse is true, albeit negligible, for a lowercase noun before the boundary: 232.3 wpm (changed, i.e. correct on the noun itself) vs. 228.6 wpm (unchanged). This also means that the two unchanged conditions influence reading speed in an expected way: 236.4 wpm for a regularly spelled sentence vs. 228.6 for a sentence containing one misspelled lowercase noun (BF < 0.1, but reportable because the upper HPDI is very close to zero).

The picture regarding the three-factor interaction of all predictors (cf. Table 2) is clear: Sentences including a low-frequency lowercase noun without any display change are read the slowest (223.2 wpm), while high-frequency uppercase noun sentences without a display change are read the fastest (238.8 wpm).

V.6.1.3 *Experiment 2: Global reading speed – Participant group 2 (Group EE): English natives reading English*

Just as for group GG, all main effects and interactions are negligible.

It is worth mentioning and in line with group GG – who read different sentences – that sentences including the low-frequency (LF) noun are read more than 10 words per minute slower than high-frequency (HF) ones: 213.7 vs. 224.0 wpm.

Looking into the interaction of the noun case before the boundary and the noun case change, it can be stated that regarding the unchanged conditions reading speed is almost identical: 218.6 wpm (regularly spelled lowercase noun, no change) vs. 220.2 wpm (irregularly spelled uppercase noun, no change). A marginal difference can also be stated for the conditions with

a case-change: 220.6 wpm (lowercase before boundary) vs. 216.1 (uppercase before boundary) wpm.

The three-factor interaction of all predictors (cf. Table 2) shows that sentences with a low-frequency noun case change from upper- to lowercase is read the slowest (211.1 wpm), while, interestingly, high-frequency unchanged uppercase sentences are read the fastest, at 227.4 wpm (cf. 223.8 wpm for regularly spelled high-frequency unchanged lowercase sentences).

V.6.1.4 *Experiment 3: Global reading speed – Participant group 3 (Group GE): German readers with excellent English skills reading English*

Again, all main effects and interactions are negligible.

As in the two other experiments, the frequency does have an absolute effect on the wpm, HF sentences are read at 228.4 wpm, while LF sentences are almost 10 words slower: 218.8 wpm, although the BF is less than 0.1.

The main effect "noun case change" should also be mentioned, since it has the biggest effect strength out of all the effects (but BF < 0.1). Unchanged sentences are read faster (225.8 wpm) than sentences with a display change (221.4 wpm).

When presenting the values for the interaction of *noun case before boundary * noun case change* it becomes obvious that unchanged sentences have almost the same reading speed (226.2 wpm for uppercase nouns vs. 225.4 wpm for lowercase nouns), while a change from lowercase to uppercase is at 223.4 wpm less disturbing than uppercase to lowercase: 219.5 wpm.

The three-factor interaction of all predictors (cf. Table 2) shows that sentences with low-frequency unchanged lowercase sentences are read the slowest (217.4 wpm), while the corresponding high-frequency unchanged lowercase sentences are read the fastest (233.3 wpm).

V.6.1.5 *Discussion, global reading speed of all participant groups*

All three experiments have in common that systematic effects are hardly detectable. As only the middle nominal phrase was controlled regarding the frequency, the comparison could be seen to be of low explanatory value. However, since this effect influences reading speed in all three experiments with two different item sets with at least seven words per minute, it can be interpreted as a clear sign of the impact of frequency effects. This is underlined by the fact that all low-frequency sentences in all three experiments (one minor exception: group GE with 221.5 wpm, low-frequency and no display change uppercase noun vs. 221.1 wpm in the high

frequency condition with a display change from upper to lower) are read more slowly than all high-frequency ones, which is another clear sign of the impact of frequency.

Apart from that, differences in the reading speed are detectable in terms of the reading speed per minute, but from a statistical point of view are negligible. The reading speed is in line with what was expected, e.g. unchanged conditions are faster than changed ones. A reason for the negligible differences might be that in the whole sentences only one position is manipulated marginally.

Table 2: Means and 95% HPDI in words per minute of the calculated reading speed for all three experiments.

			EXP 1: Group GG			EXP 2: Group EE			EXP 3: Group GE		
Noun case change?	**Noun fre-quency**	**Noun case before boun-dary**	**Mean**	**Upper HPDI**	**Lower HPDI**	**Mean**	**Upper HPDI**	**Lower HPDI**	**Mean**	**Upper HPDI**	**Lower HPDI**
No	**high**	**lower**	233.9	217.9	250.0	223.8	203.2	246.6	233.3	211.4	254.2
No	**high**	**upper**	238.8	222.6	255.0	227.4	205.8	249.8	230.9	210.2	253.0
No	**low**	**lower**	223.2	208.9	238.6	213.5	193.2	233.7	217.4	197.3	238.0
No	**low**	**upper**	233.9	218.9	249.9	213.0	193.6	234.5	221.5	200.4	241.6
Yes	**high**	**lower**	237.1	220.7	253.6	223.7	202.8	245.6	228.3	207.6	249.2
Yes	**high**	**upper**	231.6	216.4	248.1	221.1	199.9	243.0	221.1	200.2	241.1
Yes	**low**	**lower**	227.6	212.9	243.2	217.4	197.2	238.8	218.6	198.0	238.5
Yes	**low**	**upper**	228.2	213.4	243.5	211.1	192.2	232.0	217.9	197.8	238.3

V.6.2 Results and Discussion Experiment 1 (Group GG): German natives reading German

V.6.2.1 *Experiment 1: First-pass fixation duration (Adjective and Noun)*

The model (cf. Figure 1, Table 3) revealed substantial support for a main effect of region (Adj. vs. Noun; BF > 100) to the extent of longer fixation durations on the noun (values in ms; Adjective: M: 229.4, 95% HPDI[213.4, 246.0] vs. Noun: M: 255.3, 95% HPDI[219.4, 288.1]). Although the Bayes factor is below 0.3, the main effect of noun frequency does not contain zero regarding the 95% HPDI: As expected, high-frequency (HF) adjective-noun series are processed more quickly than low-frequency (LF) ones (HF: M: 236.3, 95% HPDI[217.3, 259.7] vs. LF: M: 248.5, 95% HPDI[211.7, 288.0]). The main effect of the noun case before the boundary (i.e. on the adjective) reveals (BF > 1; 95% HPDI does not contain zero) an effect to the extent of shorter durations in case the noun was presented with an uppercase on the adjective (uppercase: M: 238.0, 95% HPDI[214.8, 273.4] vs. lowercase: M: 246.7, 95% HPDI[213.4, 288.1]). The main effect of a case change is negligible (BF < 0.01).

When looking at nested comparisons, the two-way interaction of region and frequency (cf. Figure 2 to the left) reveals (BF > 100) that the frequency has its main impact on the noun itself (BF > 1) to the extent of longer fixation durations on a low-frequency noun, while durations on the adjective are almost equal in terms of frequency. Nested effects also show support for a substantial difference (BF > 100) between the adjective and noun in the case of low frequency to the extent of longer durations on the noun, while there is no difference (BF < 0.1) for high-frequency sentences.

The two-way interaction of region and noun case before the boundary (cf. Figure 2 to the right) reveals (BF > 0.8, 95% HPDI does not contain zero) very weak model (BF > 0.1) support for longer noun fixation durations in cases where it was presented with a lowercase letter (minuscule) on the adjective. Model support (BF > 0.3; 95% HPDI does not contain zero) is given for longer fixation durations on a noun compared to an adjective for a minuscule noun presentation on the adjective, while no difference is reported for a majuscule noun presentation on the adjective.

The other interactions are negligible, with a BF below 0.1.

In order to aid a better understanding of the experiment, we also show the figure of the three-way interaction of *region* * *noun case before boundary* * *noun case change* (cf. Figure 3) and the 4-way interaction of all predictors (cf. Figure 4):

In Figure 3, it becomes obvious that for first-pass processing, the noun case change has no influence on either the adjective or the noun. Only one nested comparison is reportable (BF > 0.5, 95% HPDI does not contain zero): In the unchanged condition, a lowercase noun is fixated on longer than an uppercase noun.

Figure 4 shows that differences in terms of region are present for all low-frequency conditions to the extent of substantially longer durations on the noun. For high-frequency nouns, this is only the case (BF > 1) for a lowercase noun with a boundary change, which might be the result of an unconscious irritation from the display change to a majuscule noun. No differences among all conditions can be revealed for the adjective. Apart from that, the figure shows that the spelling of the noun on the adjective is the predictor for the first-pass noun-processing independent of the noun case change, with the one exception reported above (a high-frequency noun is fixated on longer when the noun case changes from lower to upper). Frequency effects are only detectable on the noun. This effect is present for all four noun conditions, but weakest for a lowercase noun before the boundary with a display change (BF

> 0.1; 95% HPDI does not contain zero); regarding the other three conditions, the effect is more distinct, with BF > 10.

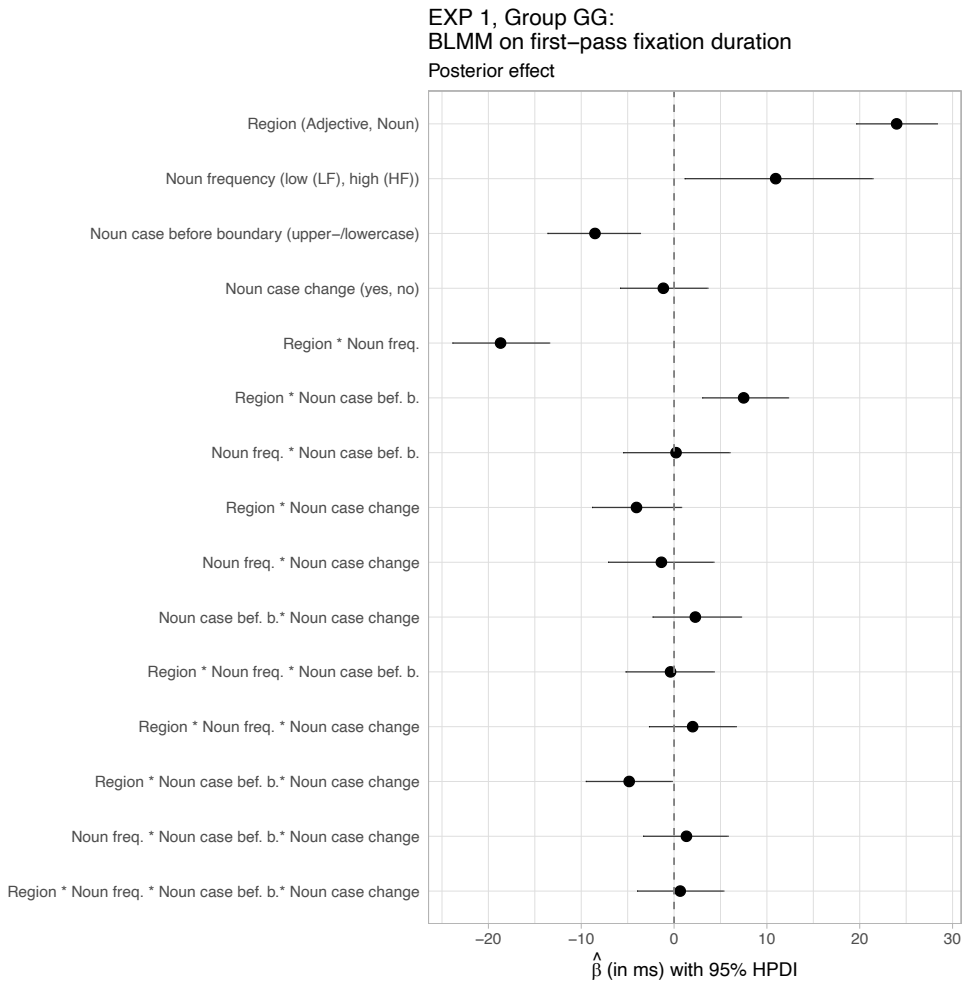

Figure 1: EXP 1, Group GG: Mean and 95% HPDI for the absolute estimated effect sizes $\hat{\beta}$ in ms of main effects and interactions of the first-pass fixation duration, output of Bayesian linear mixed models (BLMM)

Table 3: EXP 1, Group GG: Absolute effect strength $\hat{\Delta}$ and Bayes factor of main effects and interactions of the first-pass fixation duration

EXP 1, Group GG: FPFD	$\hat{\Delta}$	**Bayes factor**
Region (Adjective, Noun)	10.60	387737156.594
Noun frequency (LF, HF)	2.10	0.109
Noun case before boundary (upper-/lowercase)	3.37	1.294
Noun case change (yes, no)	0.47	0.006
Region * Noun freq.	7.05	103745.113
Region * Noun case before boundary	3.17	0.813
Noun freq.* Noun case bef. b.	0.07	0.006
Region * Noun case change	1.64	0.021
Noun freq.* Noun case change	0.46	0.007
Noun case bef. boundary * Noun case change	0.95	0.008
Region * Noun freq.* Noun case before boundary	0.16	0.005
Region * Noun freq.* Noun case change	0.84	0.007
Region * Noun case bef. b. * Noun case change	2.01	0.039
Noun freq. * Noun case bef. b. * Noun case change	0.56	0.006
Region * N. freq * Noun case bef. b. * Noun case change	0.28	0.005

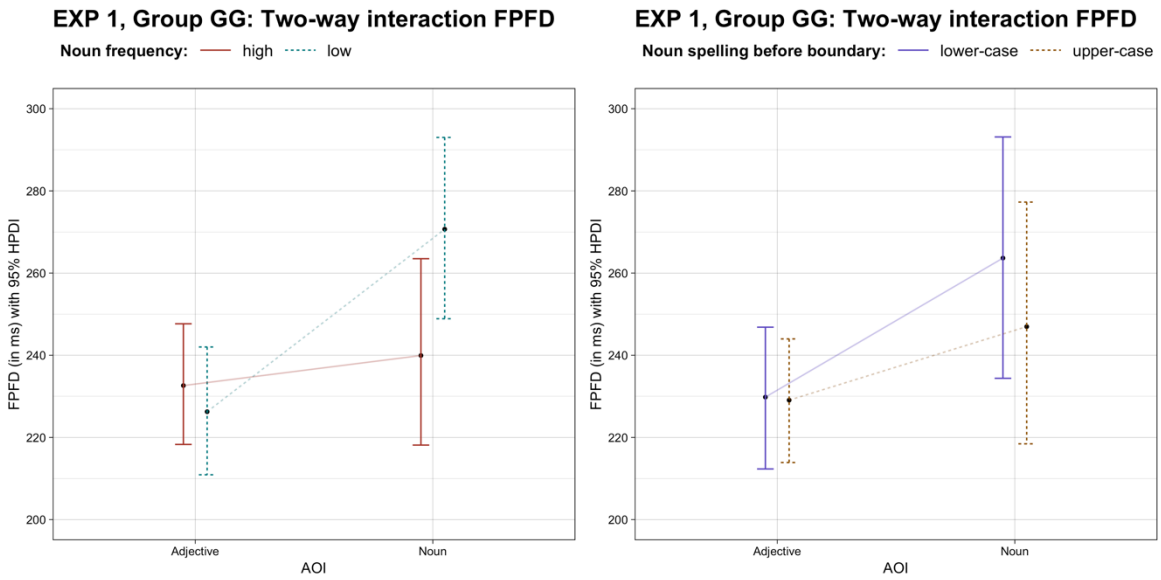

*Figure 2: EXP 1, Group GG: Estimated values of the two-way interactions **Region** [Adjective vs. Noun] *** Noun frequency** [high vs. low], left graph and **Region * Noun case before boundary** [upper- vs. lowercase], right graph, in the first-pass fixation duration (FPFD); error bars represent 95% HPDI. The blue dotted lines represent sentences containing nouns that are of low frequency; the red solid line represents sentences in which the nouns are of low frequency (graph to the left). The brown dotted lines represent sentences containing nouns spelled with an uppercase letter before the boundary; the dark purple solid line represents sentences with lowercase nouns before the boundary (graph to the right). AOI stands for "area of interest".*

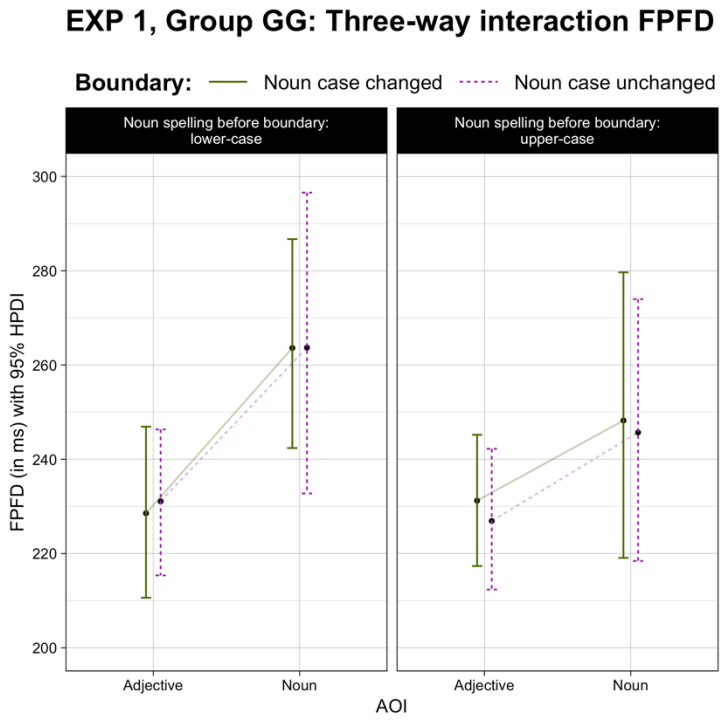

*Figure 3: EXP 1, Group GG: Estimated values of the three-way interaction **Region** [Adjective vs. Noun] *** Noun case before boundary** [upper- vs. lowercase] *** Noun case change** [changed vs. unchanged] in the first-pass fixation duration; error bars represent 95% HPDI. Lowercase noun sentences (before boundary crossing) are shown to the left and uppercase noun sentences (before boundary crossing) are represented to the right. The bright purple dotted lines represent sentences without any noun case change; the green solid line represents sentences in which the noun case changed. AOI stands for "area of interest".*

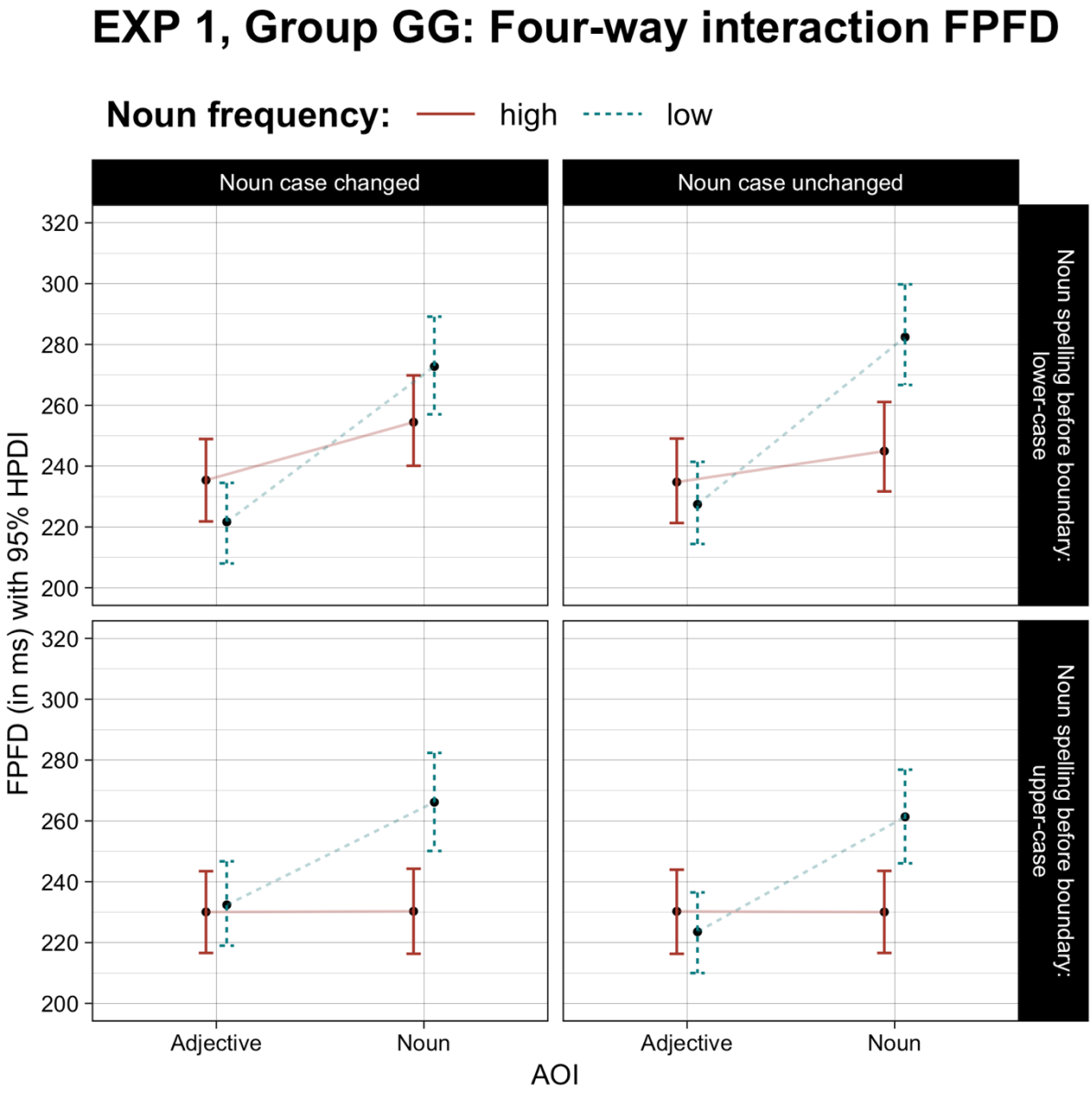

Figure 4: Exp 1, Group GG: Estimated values of the 4-way interaction (i.e. ***Region*** *[Adjective vs. Noun]* **** Noun frequency*** *[high vs. low]* **** Noun case before boundary*** *[upper- vs. lowercase]* **** Noun case change*** *[yes vs. no]) or, in other words, the influence of the noun frequency and noun spelling on the first-pass fixation durations for the adjective and the noun itself. Adjective and noun depend on the frequency of the noun (red solid lines = high noun frequency, blue dotted lines = low noun frequency); error bars represent 95% HPDI. The two left panels show the sentences with a change of noun spelling after crossing the boundary after the adjective, the two right panels document sentences in which the noun spelling did not change at all. Sentences in which the noun was presented with an initial lowercase letter on the adjective before crossing the boundary are shown in the upper part of the graph, while the lower part represents sentences with an initial uppercase letter of the noun on the adjective. In every single panel, the adjective is shown to the left and the noun to the right. AOI stands for "area of interest".*

V.6.2.2 *Experiment 1: Total fixation duration (Adjective and Noun) for unchanged conditions*

The model (cf. Figure 5, Table 4) revealed, like in FPFD, substantial support for a main effect of region (Adj. vs. Noun; BF > 100) to the extent of longer fixation durations on the noun (Adjective: M: 251.4, 95% HPDI[232.3, 272.1] vs. Noun: M: 279.8, 95% HPDI[233.7, 328.7]). The absolute difference between the adjective and noun is comparable (increase of only 2.7

ms) with the values for FPFD, i.e. both regions received similar mean regression durations, which increased the mean fixation duration by about 10%.

The main effect of noun frequency is negligible for the unchanged conditions in terms of the Total fixation durations: high-frequency (HF) adjective-noun series are still processed faster than low-frequency (LF) ones (HF: M: 259.0, 95% HPDI[232.4, 292.0] vs. LF: M: 272.2, 95% HPDI[231.7, 328.7]), which means an increase of 9-10% for both frequencies. The main effect of the noun case reveals (BF > 10) a stronger effect to the extent of shorter durations in cases where the noun was presented orthographically correct with an uppercase letter (uppercase: M: 255.2, 95% HPDI[229.8, 289.0] vs. lowercase: M: 276.0, 95% HPDI[236.9, 328.6]). Regarding an uppercase noun, the increase amounts to 8%, but for a lowercase noun the increase is even higher at 11.6%.

Two of the three two-way interactions are reportable. The interaction of region and noun frequency (cf. Figure 6, to the left, BF > 30) has the same characteristic in Total as in FPFD, i.e. no frequency effect on the adjective but on the noun (BF > 1), and a regional effect for low-frequency sentences: substantially longer fixation durations on the noun (BF > 30).

The same holds true for the interaction of region and noun case (cf. Figure 6, to the right): no difference detectable on the adjective, but rather on the noun to the effect of longer durations for a lowercase noun BF > 30); for the latter, also a regional effect between the adjective and noun (BF > 2).

Inspecting the three-way interaction (cf. Figure 7, BF < 0.1), the picture becomes more precise: The non-difference between the conditions for the adjective persists, but the following can be stated:

1) A frequency effect on the noun is detectable independently of noun-spelling, but is even higher when spelling is violated and the noun case did not change. In contrast to that, the frequency effect on the noun is lowest in the changed condition, when presentation in the adjective was lowercase.
2) When comparing HF and LF nouns in the two spelling modes with one another, BFs are higher than 20, i.e. a HF or LF noun is fixated on substantially longer when it is misspelled.
3) An orthographically violated noun is fixated on longer than an adjective independent of the frequency, but of course even longer when frequency is low (BF contrast: HF > 1, LF > 100).

4) An orthographically correct LF noun is fixated on longer than the corresponding adjective (BF > 9), but equally long when the frequency is high (BF < 0.1).

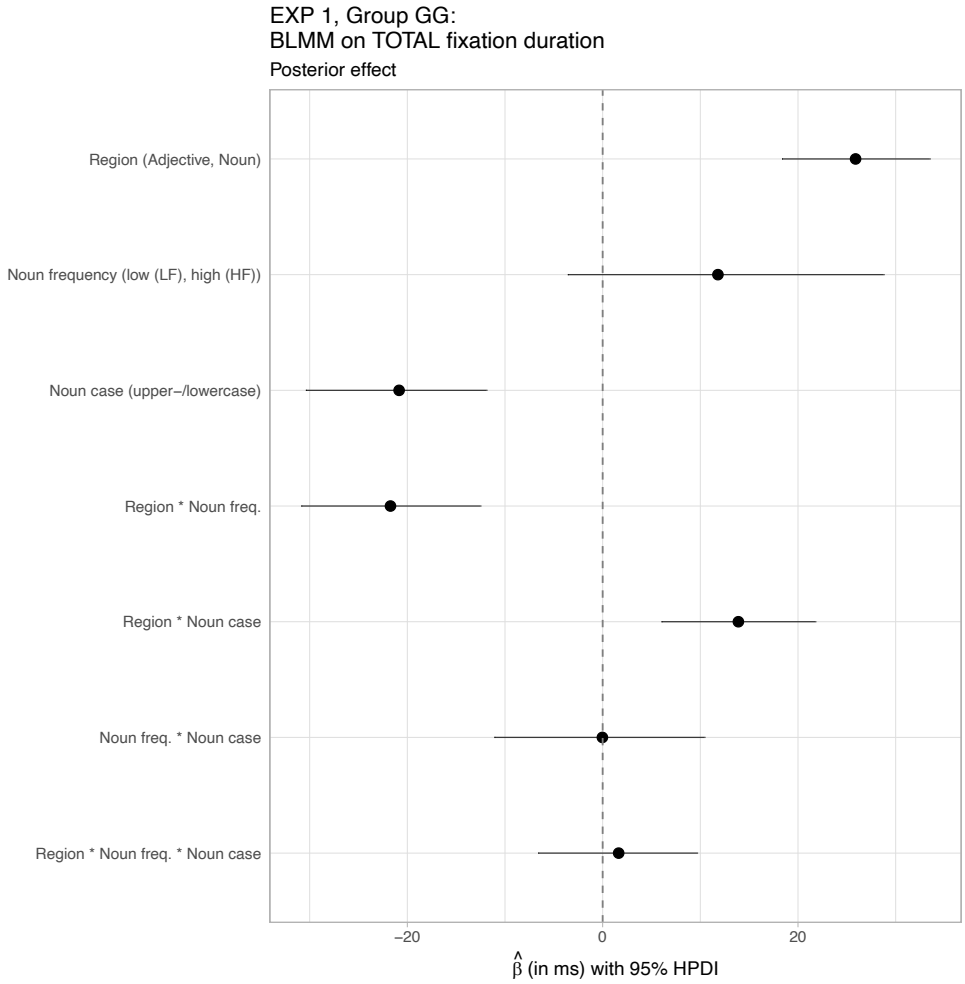

Figure 5: EXP 1, Group GG: Mean and 95% HPDI for the absolute effect sizes in ms of main effects and interactions of the Total fixation duration for the unchanged conditions, output of Bayesian linear mixed models (BLMM)

Table 4: EXP 1, Group GG: Absolute effect strength $\hat{\Delta}$ and Bayes factor of main effects and interactions of the Total fixation duration for Experiment 1

EXP 1, Group GG: Total	$\hat{\Delta}$	Bayes factor
Region (Adjective, Noun)	6.59	4457.252
Noun frequency (LF, HF)	1.44	0.044
Noun case (upper-/lowercase)	4.45	21.885
Region * Noun freq.	4.60	34.120
Region * Noun case	3.45	1.882
Noun freq.* Noun case	0.01	0.010
Region * Noun freq.* Noun case	0.40	0.008

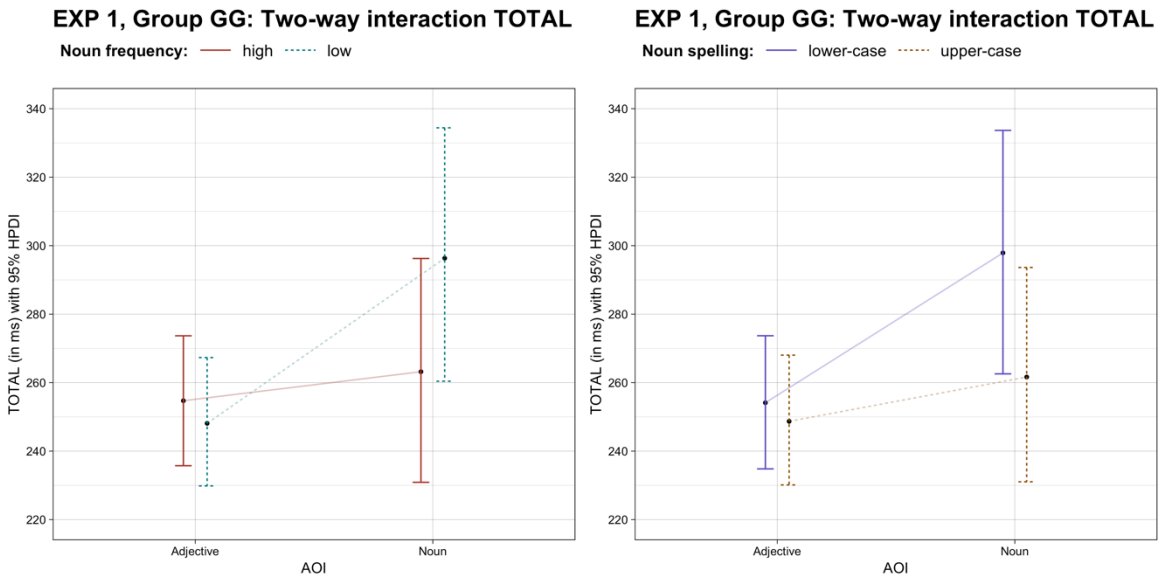

*Figure 6: EXP 1, Group GG: Estimated values of the two-way interactions **Region** [Adjective vs. Noun] *** Noun frequency** [high vs. low], left graph and **Region * Noun case** [upper- vs. lowercase], right graph, in the Total fixation duration; error bars represent 95% HPDI. The blue dotted lines represent sentences containing nouns that are of low frequency; the red solid line represents sentences in which the nouns are of a high frequency (graph to the left). The brown dotted lines represent sentences containing nouns spelled with an uppercase letter; the dark purple solid line represents sentences with lowercase nouns (graph to the right). AOI stands for "area of interest".*

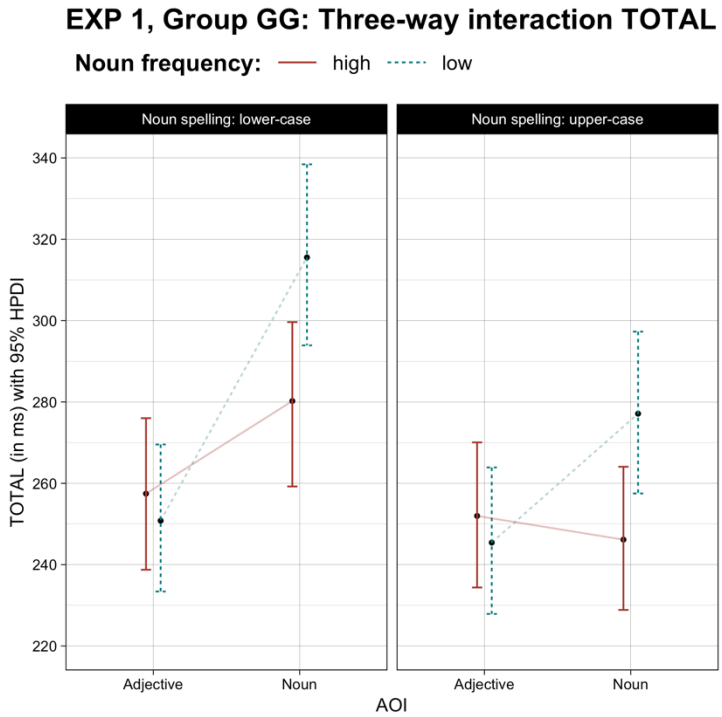

*Figure 7: EXP 1, Group GG: Estimated values of the three-way interaction (i.e. **Region** [Adjective vs. Noun] *** Noun frequency** [high vs. low] *** Noun case** [upper- vs. lowercase]) in the Total fixation duration; error bars represent 95% HPDI. Lowercase noun sentences are shown to the left and uppercase noun sentences are represented to the right. The blue dotted lines represent sentences containing nouns that are of low frequency; the red solid line represents sentences in which the nouns are of a high frequency. AOI stands for "area of interest".*

V.6.2.3 *Discussion Experiment 1, Group GG*

Three main effects are meaningful for first-pass fixation durations:

1) Nouns are fixated on longer than adjectives.
2) The sum of fixation durations for the adjective and noun is lower when noun frequency is high.
3) Overall processing is shorter when the noun case before the boundary is an orthographically correct majuscule.

It is of course worth mentioning that no main effect of a noun case change is detectable.

The two-factor interaction of region and noun frequency clearly shows that the main effect of noun frequency stems from the difference in the noun itself.
The other two-factor interaction worth mentioning is the region and noun case before the boundary, which also brings to light that differences are only detectable in the noun to the extent that nouns are processed longer when noun-spelling on the adjective is lowercase.
We conclude that the simple recognition of the majuscule on the adjective does not lead to longer processing times – in terms of preprocessing – on the adjective, but simplifies processing on the noun itself.
The explanation that an irritation occurs at the noun because a noun was not expected can be excluded because of the zero difference in the noun, when adding in the factor of the noun case change (cf. Figure 3): Processing duration is independent of the actual spelling of the noun.

In general, when contrasting all the interactions, it can be stated that effects on the adjective itself are not detectable, which excludes a lexical preprocessing in general or is at least so minimal that it is not provable.

Looking at the revealed four-factor interaction, it becomes obvious that typical frequency effects are detectable for the noun. They can be detected for all nouns in all modes, but are weakest when the noun case has changed to an uppercase noun. Frequency effects seem to be modulated by the orthographic representation on the adjective, i.e. the fastest processing of a high-frequency noun is when a majuscule is parafoveally visible on the adjective. Again, the spelling of the noun itself is irrelevant – independent of the noun frequency. The effect is

stronger when the noun is presented with a majuscule on the adjective. While low-frequency noun processing is quite independent of any other mode tested, the difference between high and low frequency on the noun itself is reportable in cases where the noun case changed and a minuscule was visible on the adjective, because the change seems to be irritating. In that case, low- and high-frequency noun processing approach each other. One explanation might be that, although the differences are low, the following interplay occurs: For a low-frequency noun, the majuscule is still beneficial even if it was missing on the adjective; the irritation from the noun case change seems to be intercepted, since processing is 10 ms faster compared to an unchanged lowercase low-frequency noun (cf. Figure 4, both upper panels: blue dotted line on the noun).

This is not the case for a high-frequency noun, since a high-frequency noun is already processed faster, i.e. only irritation occurs.

The modes “noun case before boundary” and “noun case change” both show that a substantial processing difference between the adjective and noun to the extent of longer duration times on the noun is detectable for all low-frequency nouns. As reported above, this can also be shown for a high-frequency noun, when the case changed and was lowercase on the adjective. This underlines the high impact of the low or – depending on the point of view – of the high word frequency, which is stronger than any orthographic change, as long as it is not too extreme.

Regarding the total fixation duration, considering the elimination of the noun case change as an effect, the impact of noun frequency as a main effect becomes negligible.

Apart from that, the following can be stated: As with FPFD, no effect on the adjective is detectable; the adjective is statistically irrelevant for the German readers in terms of our experimental manipulation. Orthographic misspelling slows the reader down substantially at the noun. Interestingly, the misspelling modulates the frequency effects on the noun to the extent of longer processing durations, but the ratios between a low- and a high-frequency noun remain almost identical when comparing upper- and lowercase nouns, which is visible in the two-factor interaction of frequency and noun case, which has the weakest effect strength and is negligible (cf. Table 4).

To summarize the findings regarding the Total fixation duration,

1) No effect on the adjective of any kind is detectable.

2) Typical frequency effects regarding longer durations on a low-frequency noun are provable.
3) Longer fixation durations on a misspelled noun compared to a correctly spelled one are detectable.
4) Orthographic misspelling leads to absolute longer durations, but ratios between a high- and a low-frequency noun remain almost identical when compared with correctly spelled nouns.

V.6.3 Results and Discussion Experiment 2 (Group EE): English natives reading English

V.6.3.1 *Experiment 2: First-pass fixation duration (Adjective and Noun)*

The model (cf. Figure 8, Table 5) does not reveal support for any main effect. Frequency has the highest absolute effect strength $\hat{\Delta}$, but also a high variance; BF is almost 0.1. Regarding the fixation durations in ms, high-frequency (HF) adjective-noun series are processed faster than low-frequency (LF) ones (values in ms; HF: M: 236.0, 95% HPDI[213.3, 259.0] vs. LF: M: 248.7, 95% HPDI[226.1, 270.5]).

The two-way interaction of region and frequency (cf. Figure 9, to the left) reveals (BF > 1) when looking at nested comparisons that the frequency has an impact on the noun itself (BF > 0.3, 95% HPDI does not contain zero) to the extent of longer fixation durations on a low-frequency noun, while durations on the adjective are almost equal in terms of frequency. No nested effects regarding the position (adjective vs. noun) are detectable.

Although the 95% HPDI of the two-way interaction of region and noun case before the boundary (cf. Figure 9, to the right) does not contain zero, the interaction is negligible (BF < 0.1); no relevant nested effects are provable. However, there are weak indications for longer fixation durations on the adjective when an uppercase noun is parafoveally visible.

The other interactions are negligible, with a BF below 0.1.

In order to present results that make all three experiments comparable, we also illustrate the three-way interaction of *region * noun case before boundary * noun case change* (cf. Figure 10) and the 4-way interaction of all predictors (cf. Figure 11):

Regarding first-pass processing, in Figure 10 it becomes obvious that the noun case change has no influence on either the adjective or the noun, just as for group GG. No nested comparison is reportable.

Figure 11 shows that differences in terms of region are detectable in the unchanged conditions: Both high-frequency nouns are fixated on for a distinctly shorter amount of time than the adjective; the effect is even stronger for the uppercase noun (BF > 1 uppercase vs. BF > 0.5 lowercase). The reverse is true for the low-frequency noun in the lowercase unchanged condition, which is fixated on longer than the adjective (BF > 0.2, 95% HPDI does not contain zero). No differences among all conditions can be revealed for the adjective. Frequency effects are only detectable on the noun. This effect is not present for a noun that changed from lowercase on the adjective to uppercase, but for the other three noun conditions: It is weakest for an uppercase noun without a display change (BF > 0.3; 95% HPDI does not contain zero); as far as the other two conditions, the effect is more distinct (noun changed, uppercase BF > 0.9; noun unchanged, lowercase: BF > 2). The nested noun-case or boundary effects are negligible.

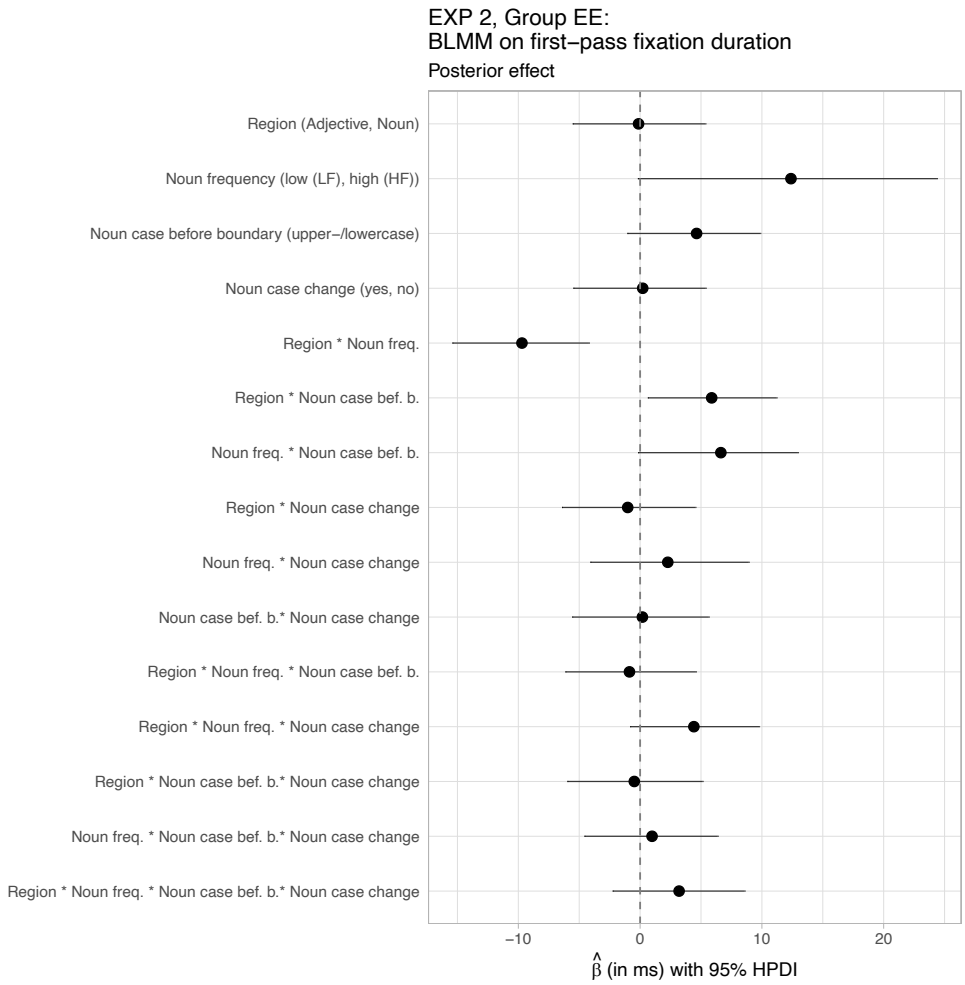

Figure 8: EXP 2, Group EE: Mean and 95% HPDI for the absolute effect sizes in ms of main effects and interactions of the first-pass fixation duration, output of Bayesian linear mixed models (BLMM)

Table 5: EXP 2, Group EE: Absolute effect strength $\hat{\Delta}$ and Bayes factor of main effects and interactions of the first-pass fixation duration for Experiment 2

EXP 2, Group EE: FPFD	$\hat{\Delta}$	Bayes factor
Region (Adjective, Noun)	0.05	0.006
Noun frequency (LF, HF)	1.99	0.095
Noun case before boundary (upper-/lowercase)	1.67	0.022
Noun case change (yes, no)	0.08	0.006
Region * Noun freq.	3.37	1.605
Region * Noun case before boundary	2.19	0.061
Noun freq.* Noun case bef. b.	1.95	0.049
Region * Noun case change	0.37	0.006
Noun freq.* Noun case change	0.68	0.009
Noun case bef. boundary * Noun case change	0.07	0.006
Region * Noun freq.* Noun case before boundary	0.32	0.006
Region * Noun freq.* Noun case change	1.61	0.021
Region * Noun case bef. b. * Noun case change	0.17	0.006
Noun freq. * Noun case bef. b. * Noun case change	0.35	0.006
Region * N. freq * Noun case bef. b. * Noun case change	1.14	0.012

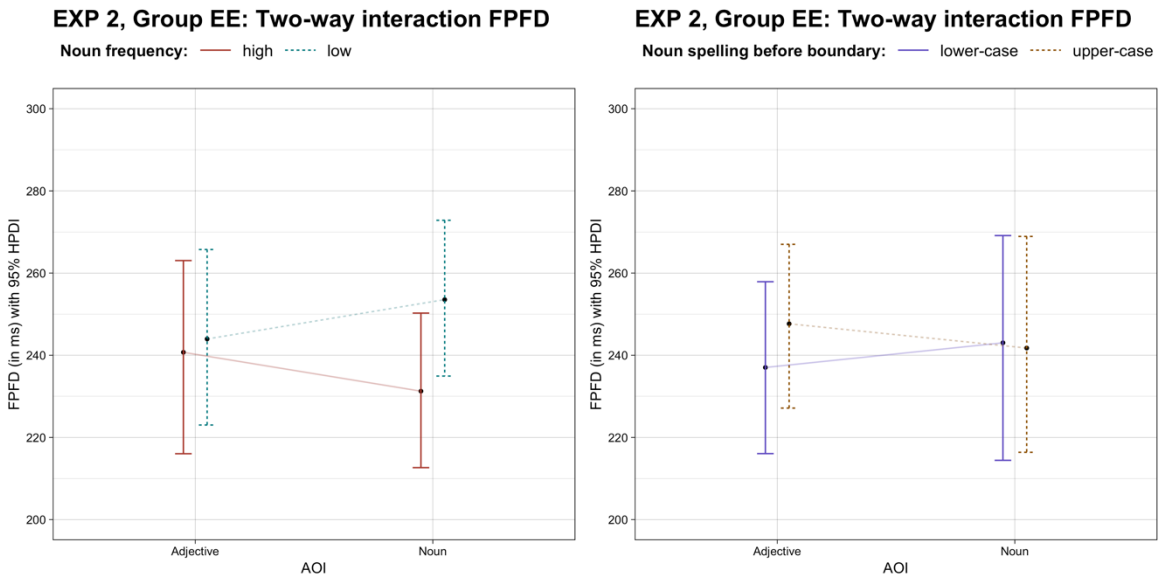

*Figure 9: EXP 2, Group EE: Estimated values of the two-way interactions **Region** [Adjective vs. Noun] *** Noun frequency** [high vs. low], left graph and **Region * Noun case before boundary** [upper- vs. lowercase], right graph, in the first-pass fixation duration (FPFD); error bars represent 95% HPDI. The blue dotted lines represent sentences containing nouns that are of low frequency; the red solid line represents sentences in which the nouns are a high frequency (graph to the left). The brown dotted lines represent sentences containing nouns spelled with an uppercase letter before the boundary; the dark purple solid line represents sentences with lowercase nouns before the boundary (graph to the right). AOI stands for "area of interest".*

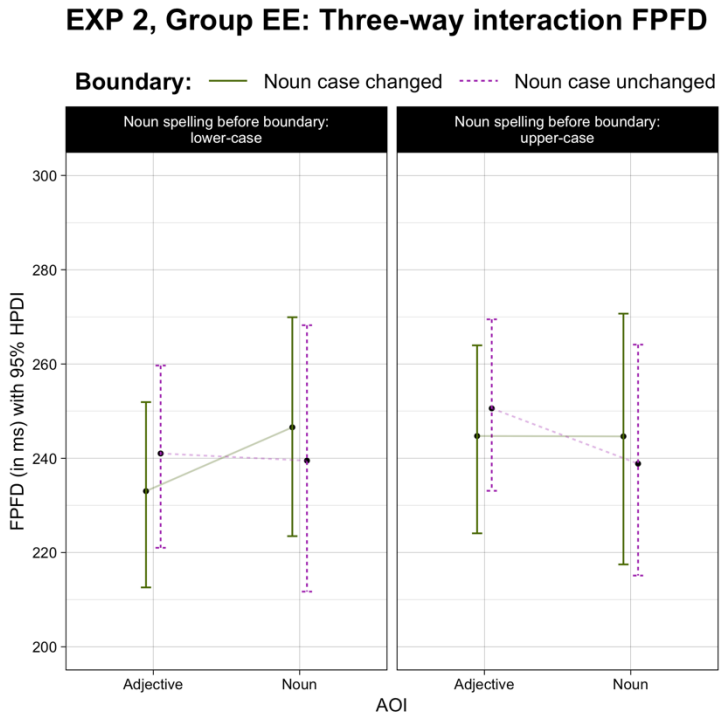

*Figure 10: EXP 2, Group EE: Estimated values of the three-way interaction (i.e. Region [Adjective vs. Noun] * Noun case before boundary [upper- vs. lowercase] * Noun case change [changed vs. unchanged]) in the first-pass fixation duration; error bars represent 95% HPDI. Lowercase noun sentences (before boundary crossing) are shown to the left and uppercase noun sentences (before boundary crossing) are represented to the right. The bright purple dotted lines represent sentences without any noun case change; the green solid line represents sentences in which the noun case changed. AOI stands for "area of interest".*

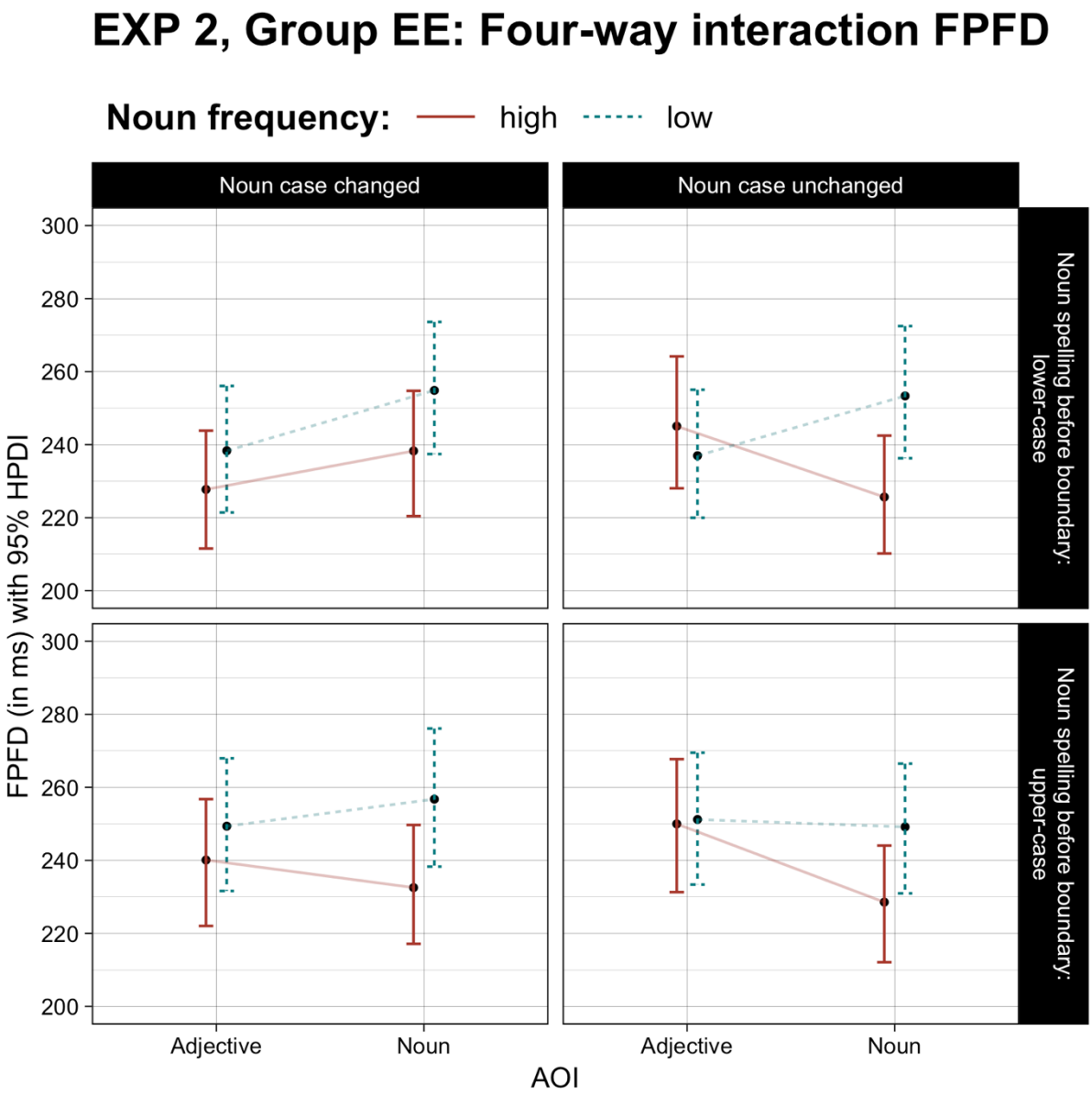

Figure 11: EXP 2, Group EE: Estimated values of the 4-way interaction (i.e. ***Region*** *[Adjective vs. Noun]* **** Noun frequency*** *[high vs. low]* **** Noun case before boundary*** *[upper- vs. lowercase]* **** Noun case change*** *[yes vs. no]) or in other words, the influence of the noun frequency and noun spelling on the first-pass fixation durations for the adjective and the noun itself. The adjective and noun depend on the frequency of the noun (red solid lines = high noun frequency, blue dotted lines = low noun frequency); error bars represent 95% HPDI. The two left panels show the sentences with a change of noun spelling after crossing the boundary after the adjective; the two right panels document sentences in which the noun spelling did not change at all. Sentences in which the noun was presented with an initial lowercase letter on the adjective before crossing the boundary are shown in the upper part of the graph, while the lower part represents sentences with an initial uppercase letter of the noun on the adjective. In every single panel, the adjective is shown to the left and the noun to the right. AOI stands for "area of interest".*

V.6.3.2 *Experiment 2: Total fixation duration (Adjective and Noun) for unchanged conditions*

The model (cf. Figure 12, Table 6) revealed, just as for FPFD, no support for any main effect; differences between the characteristics of the main effects lie within 7.5 ms.

The only reportable two-way interaction is between the region and the noun frequency (cf. Figure 13, to the left, BF > 100). The characteristic in Total has changed compared to FPFD, i.e. no frequency effect is detectable on either the adjective or the noun (BF < 0.3). However, a

regional effect is now detectable for low-frequency sentences: substantially longer fixation durations on the noun (BF > 1.5).

The interaction of region and noun case (cf. Figure 13, to the right) is negligible; absolutely no difference is detectable, i.e. regarding the total fixation duration the noun case is irrelevant for the adjective and noun.

For the full picture of the processing by this participant group, inspecting the three-way interaction of *region * noun freq. * noun case* is necessary (cf. Figure 14, BF < 0.1). No case effect is detectable at all. Regarding the frequency, only the difference on an uppercase noun (BF > 0.6, 95% HPDI does not contain zero) persists – compared to FPFD; however, the frequency effect for a regularly spelled noun has disappeared. Additionally, a frequency effect is observable on the adjective in the lowercase condition (BF > 0.5, 95% HPDI does not contain zero) to the extent that the reader regressed to the adjective for a longer period of time when the noun frequency was high (LF plus 15.2% mean increase vs. HF plus 25.9%). For the nouns themselves, the difference is smaller, but does exist: LF plus 25.4% mean increase vs. HF plus 30.4%.

The differences in the region have partially changed in Total: Now, both low-frequency nouns are fixated on for distinctly longer than the adjective; the effect is even stronger for the lowercase noun (BF > 32 vs. BF > 0.8, 95% HPDI does not contain zero). In FPFD, absolutely no regional difference was detectable between the LF adjective and the noun in the uppercase condition. The regional effect for the HF lowercase noun has disappeared, which is a result of the longer adjective regressions. The effect persists in the uppercase condition (BF > 1).

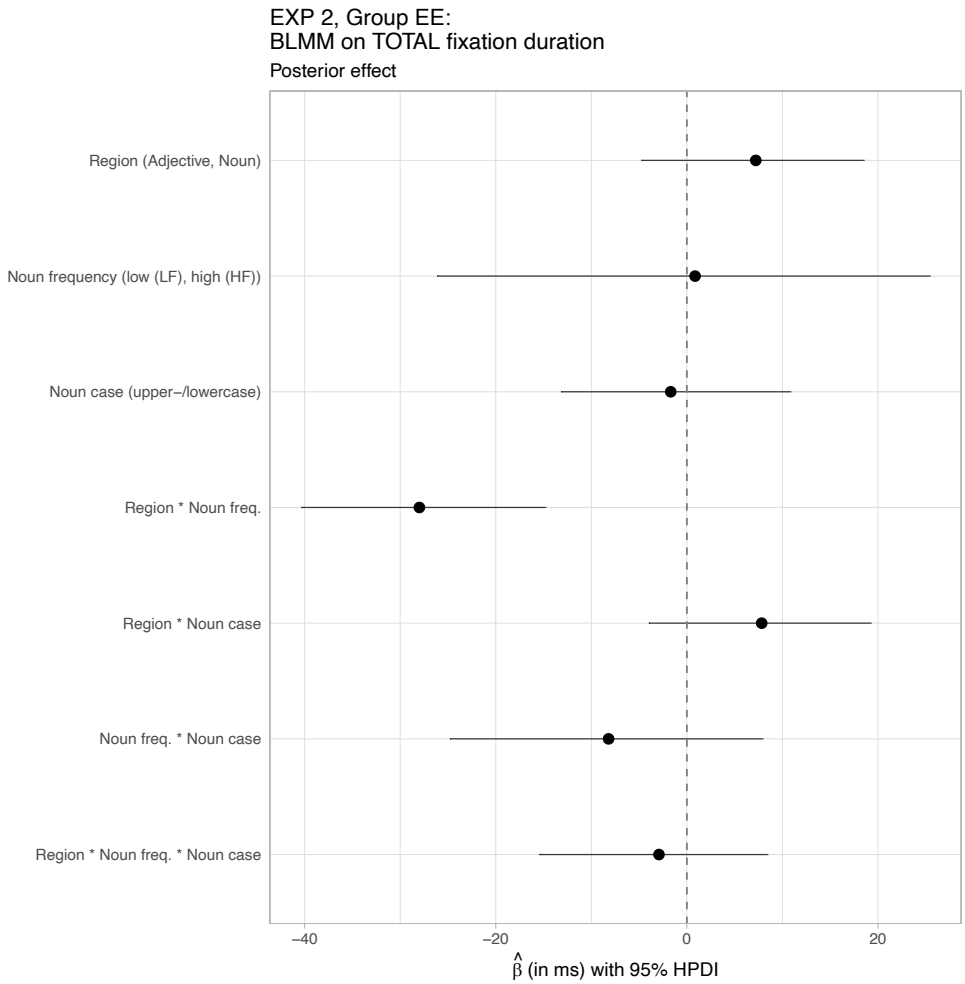

Figure 12: EXP 2, Group EE: Mean and 95% HPDI for the absolute effect sizes in ms of main effects and interactions of the Total fixation duration for the unchanged conditions, output of Bayesian linear mixed models (BLMM)

Table 6: EXP 2, Group EE: Absolute effect strength $\hat{\Delta}$ and Bayes factor of main effects and interactions of the TOTAL fixation duration

EXP 2, Group EE: Total	$\hat{\Delta}$	**Bayes factor**
Region (Adjective, Noun)	1.21	0.021
Noun frequency (LF, HF)	0.07	0.022
Noun case (upper-/lowercase)	0.28	0.011
Region * Noun freq.	4.22	190.724
Region * Noun case	1.31	0.024
Noun freq.* Noun case	0.99	0.023
Region * Noun freq.* Noun case	0.48	0.011

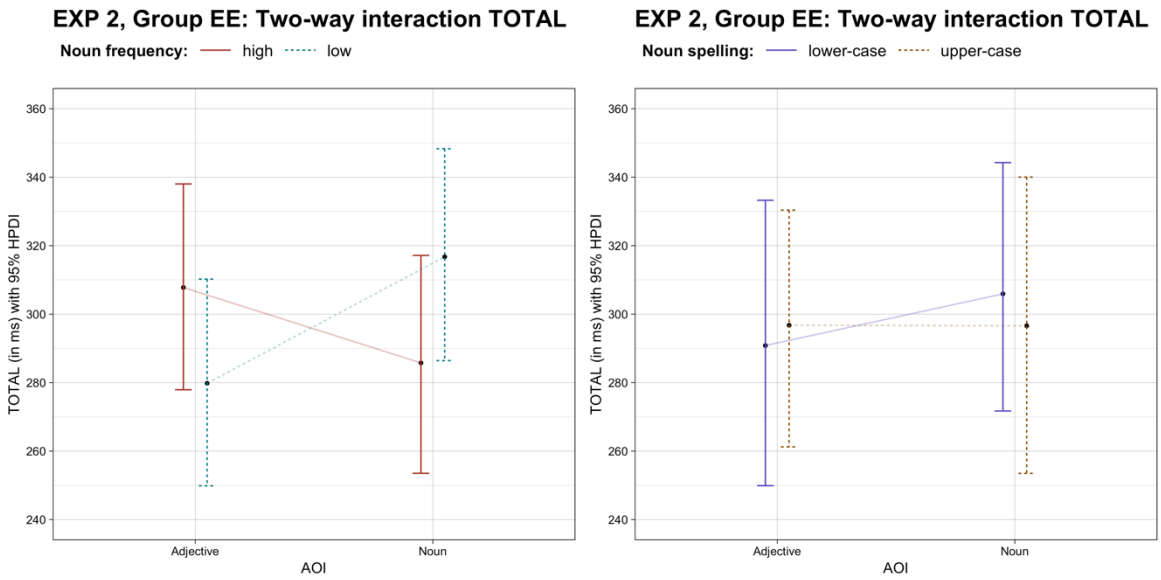

*Figure 13: EXP 2, Group EE: Estimated values of the two-way interactions **Region** [Adjective vs. Noun] *** Noun frequency** [high vs. low], left graph and **Region * Noun case** [upper- vs. lowercase], right graph, in the Total fixation duration; error bars represent 95% HPDI. The blue dotted lines represent sentences containing nouns that are of low frequency; the red solid line represents sentences in which the nouns are of a high frequency (graph to the left). The brown dotted lines represent sentences containing nouns spelled with an uppercase letter; the dark purple solid line represents sentences with lowercase nouns (graph to the right). AOI stands for "area of interest".*

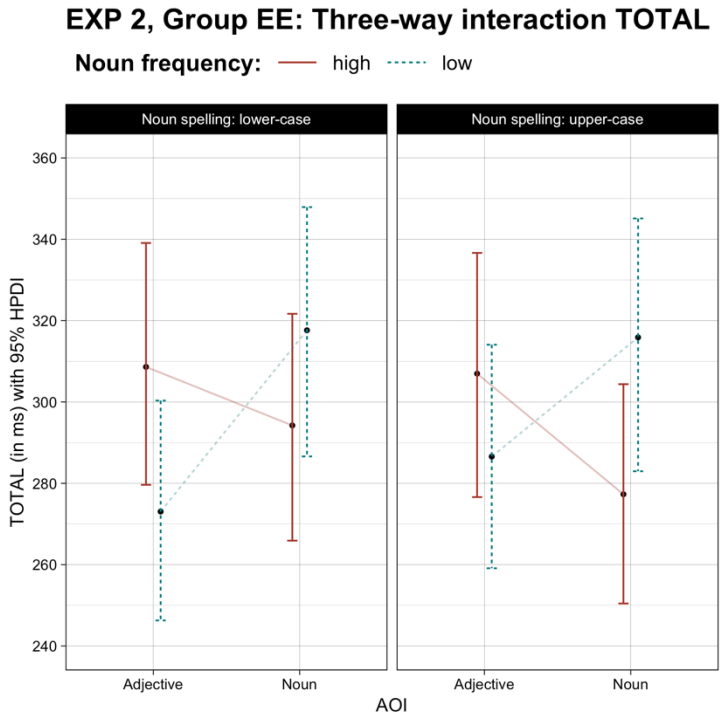

*Figure 14: EXP 2, Group EE: Estimated values of the three-way interaction (i.e. **Region** [Adjective vs. Noun] *** Noun frequency** [high vs. low] *** Noun case** [upper- vs. lowercase]) in the Total fixation duration; error bars represent 95% HPDI. Lowercase noun sentences are shown to the left and uppercase noun sentences are represented to the right. The blue dotted lines represent sentences containing nouns that are of low frequency; the red solid line represents sentences in which the nouns are of a high frequency. AOI stands for "area of interest".*

V.6.3.3 *Discussion Experiment 2, Group EE*

This participant group seems to be very robust regarding the experimental conditions in FPFD, since all main effects are negligible. The only relevant interaction is *position * frequency* to the extent of noun frequency effects on the noun itself, which was expected in advance. It can be clearly stated for all conditions that neither are effects on the adjective detectable nor does the noun case change have any influence on processing. Merely hinted is an effect of slightly longer processing on the adjective when the noun case is a majuscule, which might be a result of either the attention the majuscule draws or irritation or even preprocessing. It does not lead to changed processing durations on the noun, so conclusions would be speculative. For FPFD, the research hypothesis must be rejected.

Regarding the Total fixation duration, an interplay between frequency and position is revealed: An adjective is processed substantially longer when the noun frequency is high compared to an upcoming low-frequency noun, while on the reverse is true for the noun. The latter was already the case in FPFD. Astonishingly, the whole processing duration of these adjective-noun combinations is almost identical now, as the noun-frequency effects are eliminated.

When adding the noun case as a factor, a slight shift is observable; high-frequency nouns are processed 15 ms faster when capitalized, while no difference is detectable for low-frequency nouns. This 15-ms difference is statistically negligible, which again would lead to speculation regarding a potential processing benefit. However, this result is remarkable, since it could be explained by an overall reading benefit caused by noun capitalization dependent on the noun frequency.

To sum up, besides the frequency effects on the noun, this participant group shows no systematic effects regarding FPFD. This is also the case for the Total duration.

V.6.4 Results and Discussion Experiment 3 (Group GE): German natives reading English

V.6.4.1 *Experiment 3: First-pass fixation duration (Adjective and Noun)*

The model (cf. Figure 15, Table 7) reveals support for a main effect of the region (BF > 0.1, 95% HPDI does not contain zero) to the extent of longer fixation durations on the noun (Adjective:

M: 263.2, 95% HPDI[235.7, 290.6] vs. Noun: M: 271.5, 95% HPDI[244.3, 299.5]). All other main effects are negligible (BF < 0.1).

No evidence was found regarding the two-way interaction of region and frequency (cf. Figure 16, to the left, BF < 0.1); all nested comparisons are negligible, i.e. no difference between LF and HF nouns is detectable. However, Figure 16 (to the left), which is displayed to aid the comparability of all the experimental results, at least indicates a difference to the extent of longer durations for a LF noun.

The two-way interaction of region and noun case before the boundary (cf. Figure 16, to the right, BF > 12) shows strong evidence for an interaction effect. Thus, all nested comparisons have BFs < 1, and the interaction may indicate that there is a case effect on the adjective to the extent of longer fixation durations for a parafoveally upcoming uppercase noun. Besides that, a regional effect seems likely, i.e. if the noun case before the boundary is low, durations are substantially higher on the noun compared to the adjective.

The other interactions are negligible, with a BF below 0.1.

Again, in order to present the results and make all three experiments comparable, we also show the figures for the three-way interaction of *region * noun case * noun case change* (cf. Figure 17, to the left) and the 4-way interaction of all predictors (cf. Figure 18). Additionally, we present the negligible three-way interaction of *region * noun case * frequency* (cf. Figure 17, to the right).

In Figure 17 (to the left), it becomes obvious that in terms of first-pass processing – like in EXP 1 and EXP 2 – the noun case change has absolutely no influence on either the adjective or the noun. Relating to the nested effects, a noun case effect is detectable on the adjective only in the changed condition (BF > 0.2; 95% HPDI does not contain zero), i.e. longer durations for a noun that changed from lower- to uppercase. Besides that, there is evidence (BF > 1) for a regional effect of a lowercase noun before the boundary in the changed condition, i.e. longer durations on the noun compared to the adjective. There are indications of these two differences for the unchanged condition as well, but the BF or 95% HPDI criteria were just barely not reached. Irritation from the display change on the noun might be the reason for the finally reportable nested effects in the changed condition. A systematic effect is not the reason.

In Figure 17 to the right, it becomes obvious that frequency is negligible here, since no nested effects are provable. A regional effect is only detectable for a lowercase letter and low

frequency to the extent of longer durations on the noun (BF > 4.3; 95% HPDI does not contain zero). The noun case effect in the reported form is detectable for both adjectives (LF condition: BF > 0.2; 95% HPDI contains zero; HF condition: BF > 0.2; 95% HPDI does not contain zero).

The four-way interaction (cf. Figure 18) shows that regional differences are only detectable for the lowercase condition to the extent of longer fixation durations on the noun. Effect strength and BFs (> 3.5) are highest for the two changed and unchanged LF conditions, but even higher when the noun case has changed during reading. In the changed lowercase condition, the HF is also reportable (BF > 0.7; 95% HPDI does not contain zero). Differences in the uppercase condition are negligible. In sum: An uppercase letter at the adjective prohibits regional differences in general, while LF has a higher impact than a noun case change in the lowercase conditions, but a noun case change promotes regional differences because even a HF shows longer durations on the noun. Nested comparisons in terms of frequency are hardly detectable, with the exception of an unchanged lowercase noun (BF > 1.5), i.e. a frequency effect only unfolds when no manipulation/irritation occurs and only on the noun.

A boundary effect regarding BFs and the criterion “95% HPDI does not contain zero” is only detectable for a changed HF adjective (BF >1.5) and an unchanged LF adjective (BF > 0.5). Since a change does not affect the adjective itself, it can be stated that all adjective groups are represented (i.e. changed/unchanged and LF/HF). The picture is pretty similar (three of four effect sizes are highest on the adjectives) for the two other adjectives (unchanged HF and changed LF). Since the “95% HPDI does not contain zero” criterion was just barely not reached and only 25% of the data is included in each nested effect, there are weak indicators that, for group GE, the noun case presented in the adjective seems to affect processing on the adjective itself to the effect of longer durations for an uppercase noun. For the noun itself, only the difference for an unchanged LF noun seems to be of interest (BF > 0.1) because the effect size is the third highest and the “95% HPDI does not contain zero” was just barely not reached: An uppercase LF noun is processed for a shorter time than a regularly spelled lowercase LF noun.

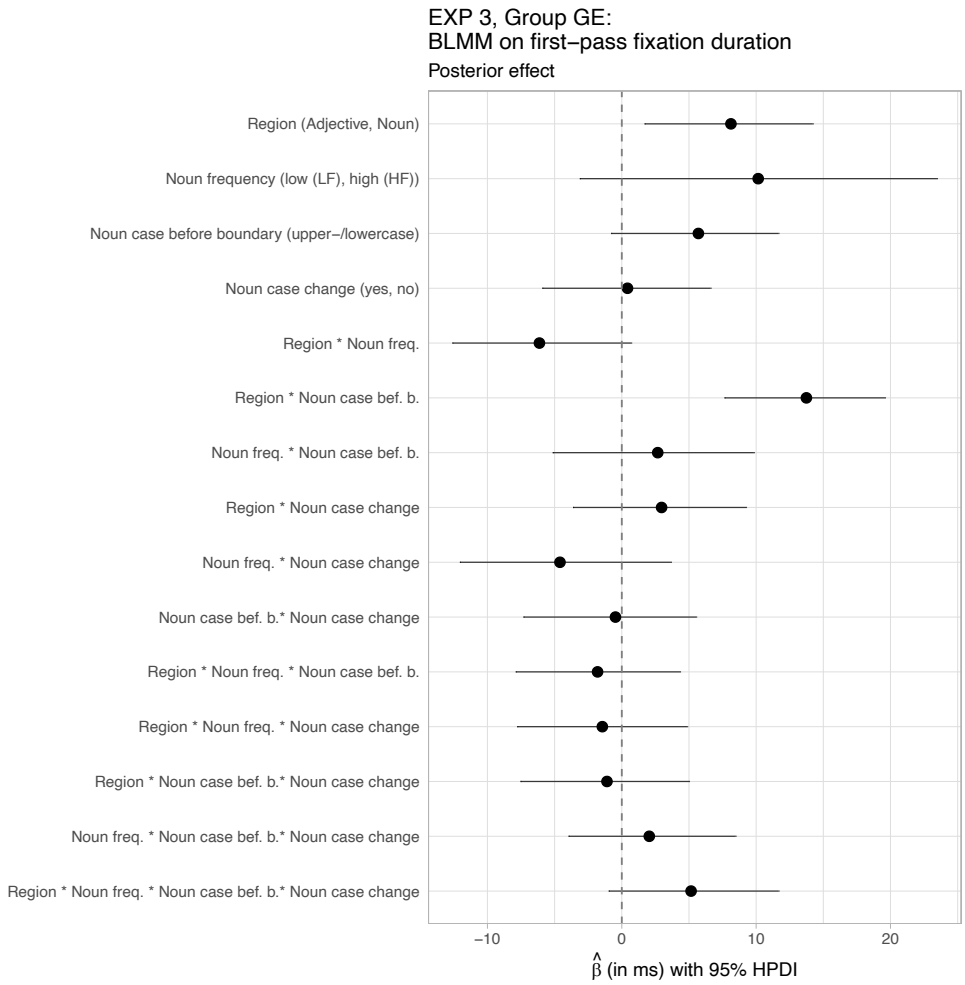

Figure 15: EXP 3, Group GE: Mean and 95% HPDI for the absolute effect sizes in ms of main effects and interactions of the first-pass fixation duration, output of Bayesian linear mixed models (BLMM)

Table 7: EXP 3, Group GE: Absolute effect strength $\hat{\Delta}$ and Bayes factor of main effects and interactions of the first-pass fixation duration

EXP3, Group GE: FPFD	$\hat{\Delta}$	**Bayes factor**
Region (Adjective, Noun)	2.55	0.143
Noun frequency (LF, HF)	1.48	0.040
Noun case before boundary (upper-/lowercase)	1.80	0.029
Noun case change (yes, no)	0.13	0.006
Region * Noun freq.	1.82	0.034
Region * Noun case before boundary	4.42	12.015
Noun freq.* Noun case bef. b.	0.69	0.009
Region * Noun case change	0.90	0.009
Noun freq.* Noun case change	1.15	0.015
Noun-case bef. boundary * Noun case change	0.14	0.006
Region * Noun freq.* Noun case before boundary	0.56	0.007
Region * Noun freq.* Noun case change	0.44	0.007
Region * Noun case bef. b. * Noun case change	0.34	0.006
Noun freq. * Noun case bef. b. * Noun case change	0.64	0.008
Region * N. freq * Noun case bef. b. * Noun case change	1.59	0.022

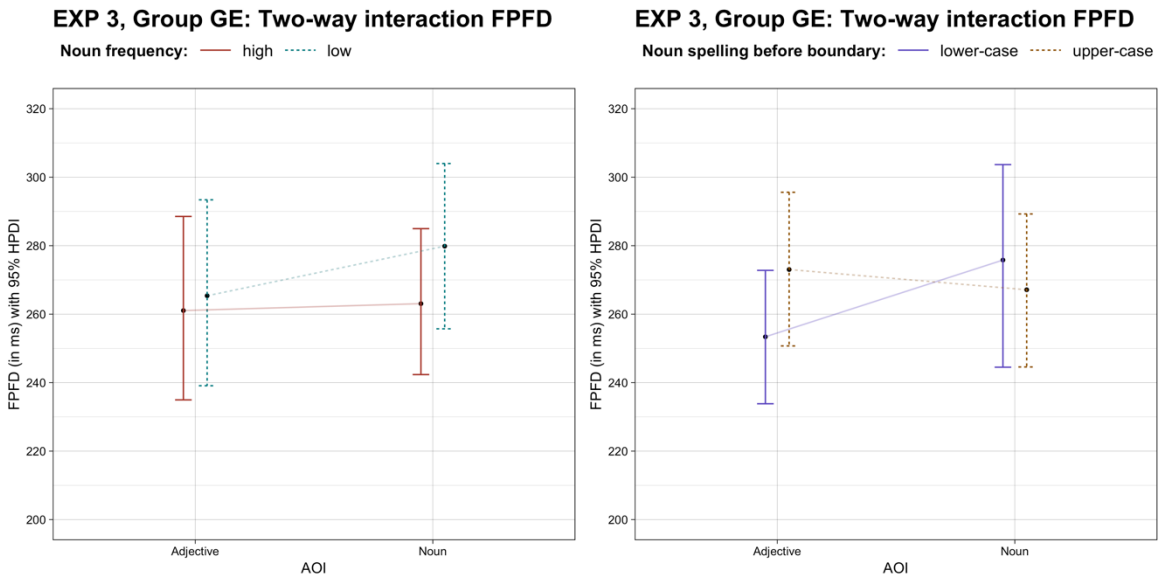

*Figure 16: EXP 3, Group GE: Estimated values of the two-way interactions **Region** [Adjective vs. Noun] *** Noun frequency** [high vs. low], left graph and **Region * Noun case before boundary** [upper- vs. lowercase], right graph, in the first-pass fixation duration (FPFD); error bars represent 95% HPDI. The blue dotted lines represent sentences containing nouns that are of low frequency; the red solid line represents sentences in which the nouns are of a high frequency (graph to the left). The brown dotted lines represent sentences containing nouns spelled with an uppercase letter before the boundary; the dark purple solid line represents sentences with lowercase nouns before the boundary (graph to the right). AOI stands for "area of interest".*

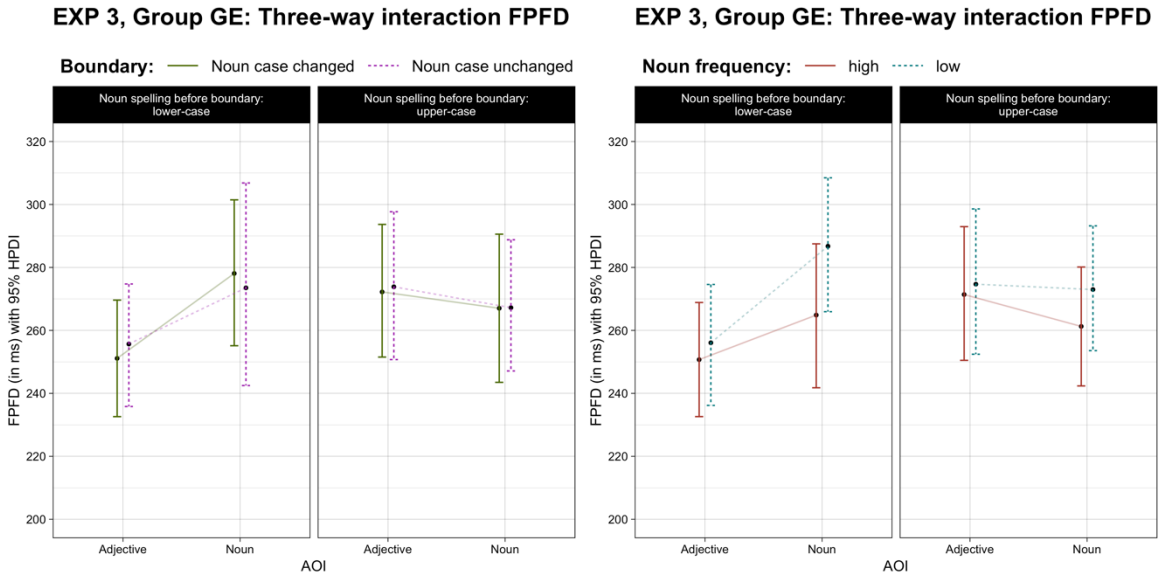

*Figure 17: EXP 3, Group GE: Estimated values of the three-way interactions **Region** [Adjective vs. Noun] *** Noun case before boundary** [upper- vs. lowercase] *** Noun case change** [changed vs. unchanged], graph to the left, and **Region * Noun frequency** [high vs. low] *** Noun case before boundary**, to the right, in the first-pass fixation duration; error bars represent 95% HPDI. Graph to the left: Lowercase noun sentences (before boundary crossing) are shown in the left panel and uppercase noun sentences (before boundary crossing) are represented in the right panel. The bright purple dotted lines represent sentences without any noun case change; the green solid line represents sentences in which the noun case changed. Graph to the right: Lowercase noun sentences are shown to the left and uppercase noun sentences are represented in the right panel. The blue dotted lines represent sentences containing nouns that are of low frequency; the red solid line represents sentences in which the nouns are of a high frequency. AOI stands for "area of interest".*

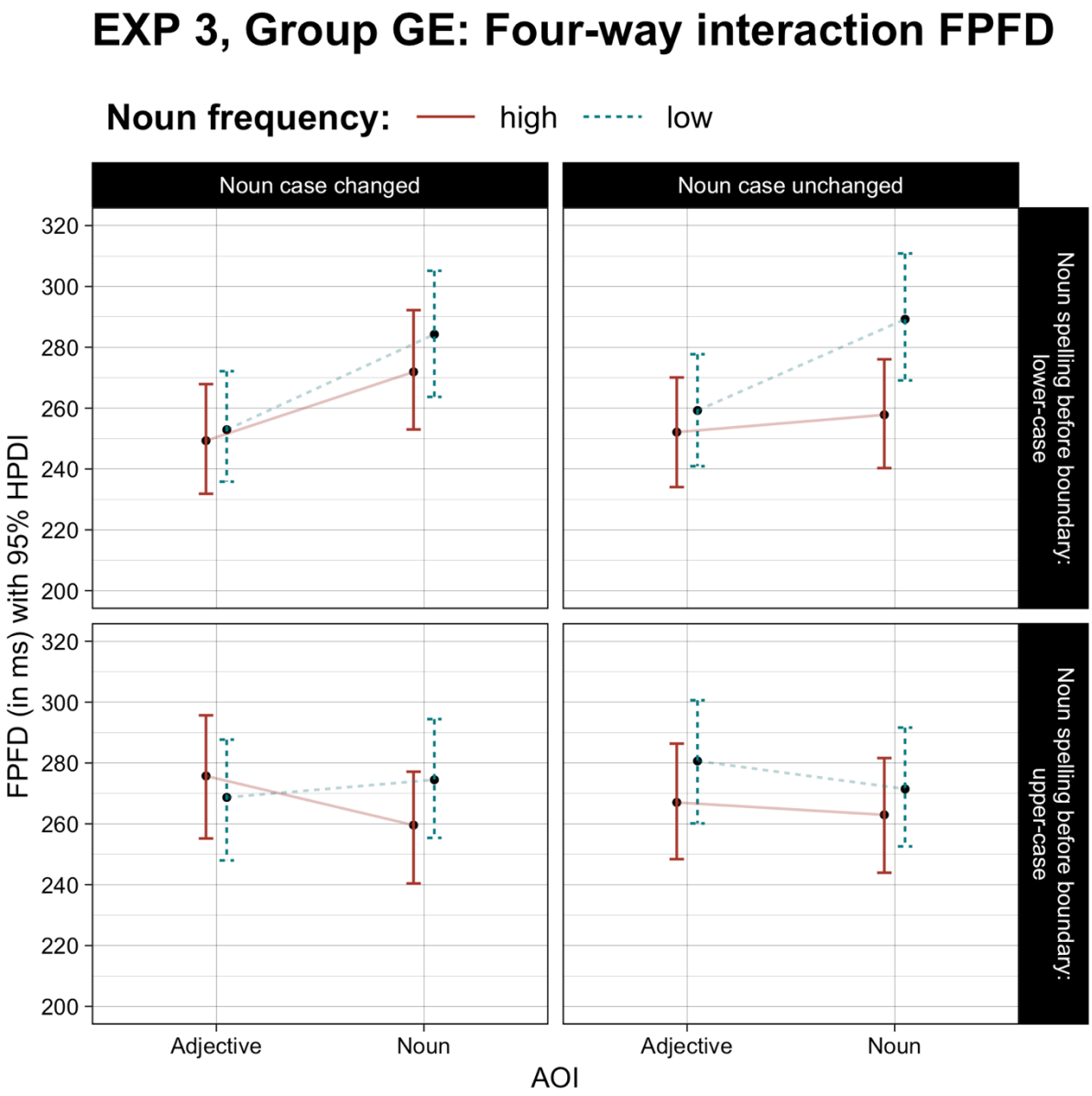

Figure 18: EXP 3, Group GE: Estimated values of the 4-way interaction (i.e. ***Region*** *[Adjective vs. Noun]* **** Noun frequency*** *[high vs. low]* **** Noun case before boundary*** *[upper- vs. lowercase]* **** Noun case change*** *[yes vs. no]) or in other words, the influence of the noun frequency and noun spelling on the first-pass fixation durations for the adjective and the noun itself. The adjective and noun depending on the frequency of the noun (red solid lines = high noun frequency, blue dotted lines = low noun frequency); error bars represent 95% HPDI. The two left panels show the sentences with a change of noun spelling after crossing the boundary after the adjective, the two right panels document sentences in which the noun spelling did not change at all. Sentences in which the noun was presented with an initial lowercase letter on the adjective before crossing the boundary are shown in the upper part of the graph, while the lower part represents sentences with an initial uppercase letter of the noun on the adjective. In every single panel, the adjective is shown to the left and the noun to the right. AOI stands for "area of interest".*

V.6.4.2 *Experiment 3: Total fixation duration (Adjective and Noun) for unchanged conditions*

For the unchanged conditions, the model (cf. Figure 19, Table 8) revealed no support for the main effects of region and noun case (BF < 0.1, differences between the characteristics of main effects lie within 9.5 ms.), but it did for frequency (BF > 0.2; 95% HPDI does not contain zero), which is substantial: HF: M: 275.2, 95% HPDI[245.4, 305.6] vs. LF: M: 300.2, 95% HPDI[258.3, 335.5].

The two-way interaction of region and noun frequency (cf. Figure 20, to the left, BF < 0.1) is negligible, although the nested comparison within this interaction between a LF and a HF noun is reportable (BF > 0.8, 95% HPDI does not contain zero). The characteristic in Total is comparable to FPFD but even more pronounced on the noun.

The interaction of region and noun case (cf. Figure 20, to the right) is mentionable (BF > 1.7); a noun case effect is detectable on the adjective (BF = 1; 95% HPDI does not contain zero), i.e. regarding the total fixation duration the noun case is relevant for the adjective. This finding is already suggestively demonstrable for FPFD.

Inspecting the three-way interaction (cf. Figure 21, BF < 0.1), the picture becomes more precise:

Frequency effects are detectable on both nouns; the effect is even higher for the uppercase condition (lowercase: BF > 0.5 vs uppercase: BF > 1.6; in both conditions 95% HPDI does not contain zero). While the LF noun is processed equally long independent of the spelling, a high-frequency noun is processed for an even shorter time when it is presented with a majuscule.

The noun case only has an effect on the adjective (LF: BF > 0.5 vs HF: BF > 3.5; in both conditions 95% HPDI does not contain zero), but not on the noun itself.

Two regional effects are detectable: Lowercase LF nouns (BF > 23) are fixated on distinctly longer than the corresponding adjective, while the reverse is true for uppercase HF nouns (BF > 0.3, 95% HPDI does not contain zero).

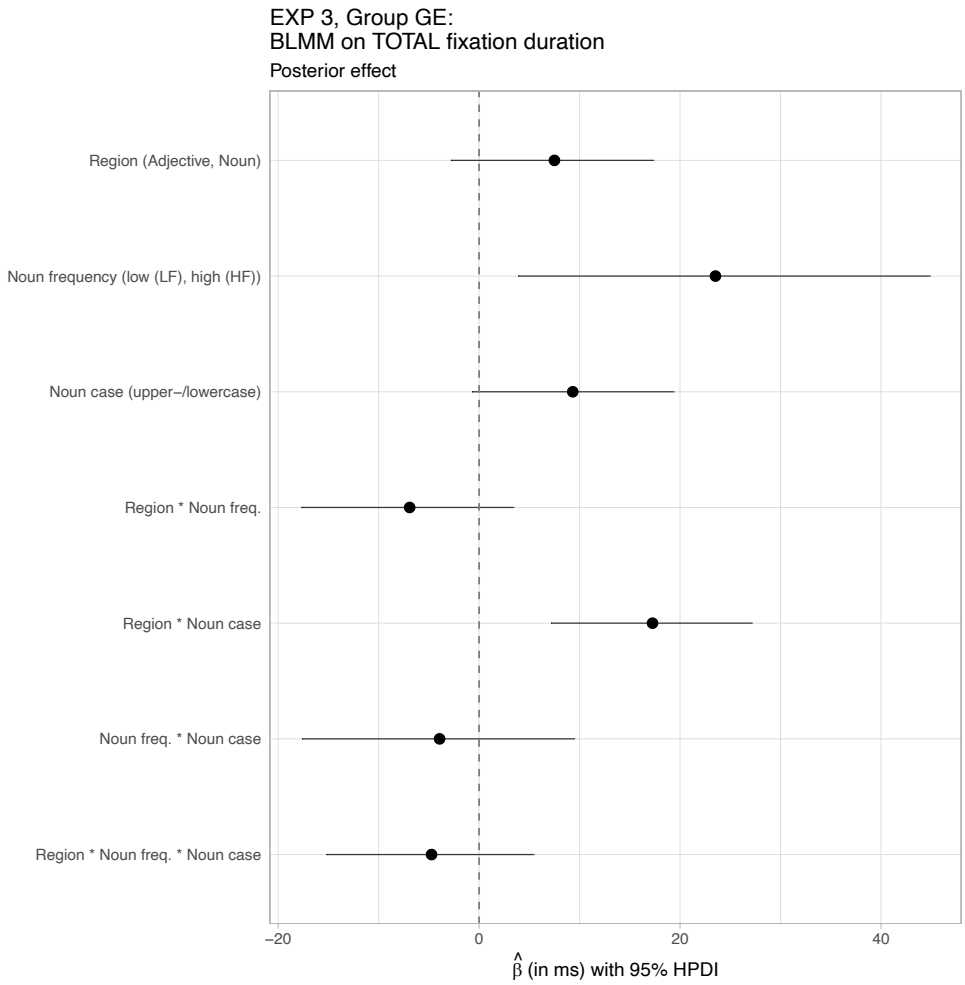

Figure 19: EXP 3, Group GE: Mean and 95% HPDI for the absolute effect sizes in ms of main effects and interactions of the Total fixation duration for the unchanged conditions, output of Bayesian linear mixed models (BLMM)

Table 8: EXP 3, Group GE: Absolute effect strength $\hat{\Delta}$ and Bayes factor of main effects and interactions of the TOTAL fixation duration

EXP 3, Group GE: Total	$\hat{\Delta}$	Bayes factor
Region (Adjective, Noun)	1.45	0.025
Noun frequency (LF, HF)	2.24	0.222
Noun case (upper-/lowercase)	1.80	0.046
Region * Noun freq.	1.27	0.020
Region * Noun case	3.40	1.729
Noun freq.* Noun case	0.56	0.014
Region * Noun freq.* Noun case	0.89	0.013

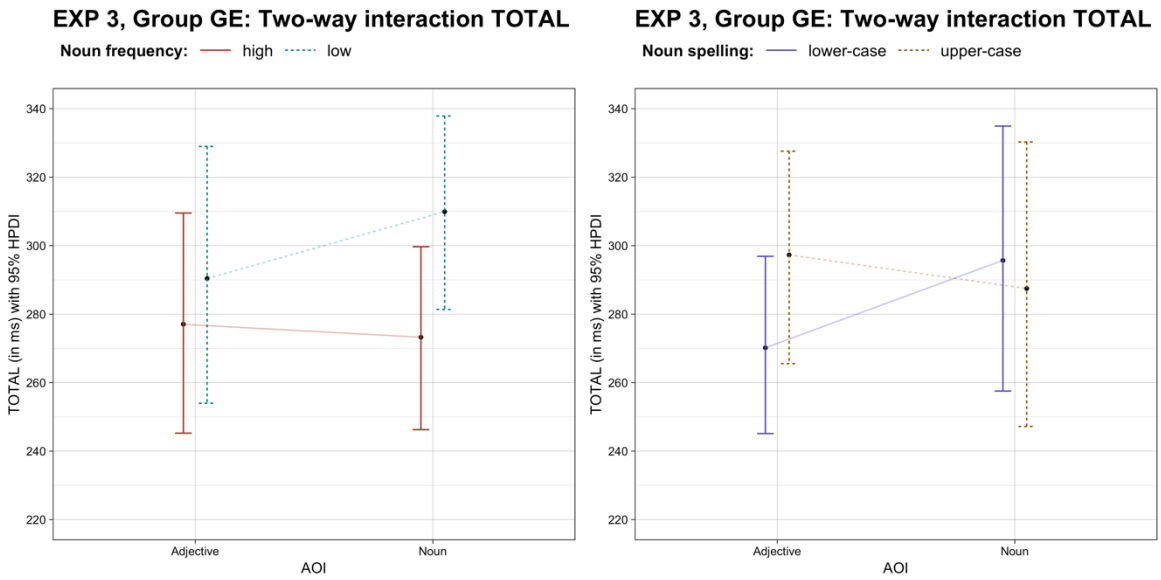

Figure 20: EXP 3, Group GE: Estimated values of the two-way interactions ***Region*** *[Adjective vs. Noun]* **** Noun frequency*** *[high vs. low], left graph and* ***Region * Noun case*** *[upper- vs. lowercase], right graph, in the Total fixation duration; error bars represent 95% HPDI. The blue dotted lines represent sentences containing nouns that are of low frequency; the red solid line represents sentences in which the nouns are of a high frequency (graph to the left). The brown dotted lines represent sentences containing nouns spelled with an uppercase letter; the dark purple solid line represents sentences with lowercase nouns (graph to the right). AOI stands for "area of interest".*

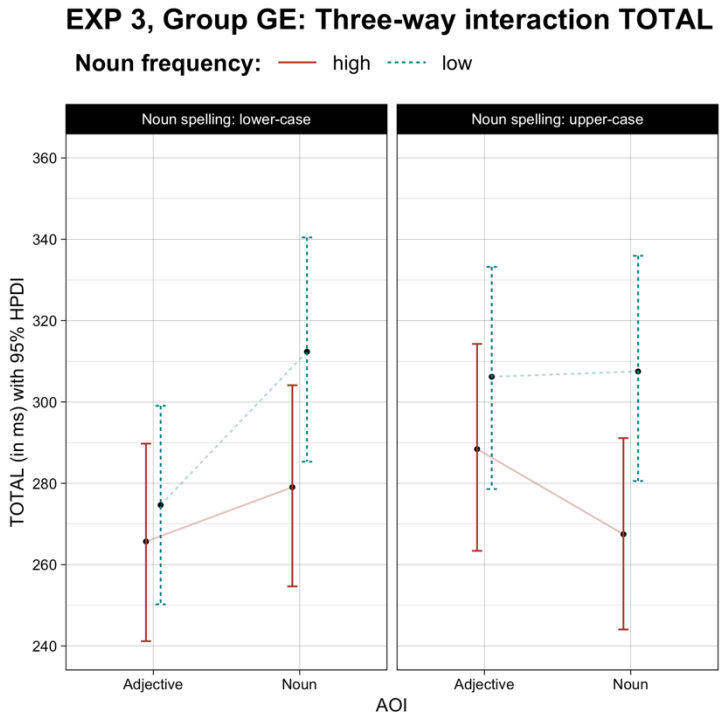

Figure 21: EXP 3, Group GE: Estimated values of the three-way interaction (i.e. ***Region*** *[Adjective vs. Noun]* **** Noun frequency*** *[high vs. low]* **** Noun case*** *[upper- vs. lowercase]) in the Total fixation duration; error bars represent 95% HPDI. Lowercase noun sentences are shown to the left and uppercase noun sentences are represented to the right. The blue dotted lines represent sentences containing nouns that are of low frequency; the red solid line represents sentences in which the nouns are of a high frequency. AOI stands for "area of interest".*

V.6.4.3 *Discussion Experiment 3, Group GE*

In contrast to the other two participant groups, the German natives with excellent English skills show effects on the adjective depending on the spelling of the upcoming noun: In the case of a parafoveally visible uppercase noun, the fixation durations increase on the adjective,

which does not lead to systematically different noun processing. The main effect of the region stems from the latter. Noun case change as a variable is completely negligible.
It is noteworthy that an overall frequency effect on the noun is not clearly provable, only as a nested effect for an unchanged lowercase noun in the four-way interaction. The case effect on the adjective, not on the noun itself, is the dominating effect for this participant group in first-pass processing, which leads to the astonishing result that in all the fixation durations on the adjective and noun the uppercase and lowercase noun presentations on the adjective lead to almost identical durations for the adjective and low-frequency noun combination. This is not detectable for the HF conditions, since noun durations, in contrast to the adjective, are almost identical independent of noun case and/or noun case change.

Regarding the total fixation duration, frequency effects on the noun finally become obvious. The noun case effect is captured as in FPFD, but is even more pronounced, since both adjective effects (almost 30 ms) and non-existent (less than 10 ms) noun differences are confirmed.
Compared to FPFD, processing substantially changes, since the equal adjective and LF noun processing durations independent of the noun case are counteracted due to longer adjective (25 ms uppercase vs. 16 ms lowercase) and noun (37 ms uppercase vs. 23 ms lowercase) regressions with uppercase spelling. This leads to an overall identical noun processing (4 ms difference) when comparing the two spelling conditions with each other, but to a total regularly spelled lowercase benefit of 27 ms when totaling the adjective and noun processing.

In contrast to that, HF shows a 10-ms overall benefit of lowercase spelling, but even more notable is the difference in processing: While the adjective in the uppercase condition is fixated on more than 22 ms longer, the orthographically violated noun is fixated on for 12 ms less.
This difference was only marginally implied in the FPFD: The adjective and noun are on a similar level in the unchanged conditions (6 ms differences in NoCap vs. 4 ms in Cap). The only implication that is manifested in Total is the fact that in NoCap the adjective is below the noun, which is reversed in Cap. Besides that, while the comparison of the HF nouns shows only a 5-ms difference to the extent of longer durations in the orthographically violated Cap condition, the substantial difference in the adjective is even more pronounced at 15ms, which altogether means a 20-ms malus in FPFD.

While the absolute difference for the adjective between NoCap und Cap slightly increases in Total, quite the opposite is the case for the noun, in which a 5-ms malus changes to a 12-ms bonus. It should be kept in mind that the remarks regarding HF processing are statistically negligible.

In sum, it can be stated that a noun case effect is only detectable on the adjective independent of the noun frequency.

However, there are hints that a high noun frequency leads to a different processing of adjective-noun combinations to the extent of longer durations on the adjective compared to the noun for uppercase spelling, while it is reversed or at least equally long for lowercase spelling. This suggests, with considerable caution, a faster total noun processing in the case of a high-frequency uppercase noun for this participant group, which is familiar with noun-marking. Regarding low frequencies, the uppercase letter at least does not slow down the noun processing itself.

V.7 Overall Discussion and Conclusion

The research aim was to get a better understanding of parafoveal preprocessing of systematic noun-marking, which is exclusive to the German language. The idea was that lexical parafoveal preprocessing is promoted by an uppercase letter. One tool was to compare different participant groups about which, based on previous knowledge, different assumptions could be made.

With all the results taken together, the following can be stated:

1) Noun case change: One major result of these three experiments is that the change of the noun case has absolutely no systematic influence on the first-pass processing durations. This observation does not exclude particular nested effects. Overall, all three experiments would have shown similar results without a boundary paradigm setup.

2) Noun case: Noun case effects are detectable, but differ between languages. While, predictably, in the German experiment the noun case before the boundary is even a main effect, no differences in the adjective are detectable, i.e. effects are limited to the noun. However, the effects are driven by the presentation of the noun *on* the adjective, i.e. the

actual spelling when fixating on the noun is almost irrelevant, especially when the noun was parafoveally regularly spelled with a majuscule, in which case noun processing was the fastest. In the Total fixation duration, this effect persists.

For the English participants reading English, effects on the noun are not detectable. But, processing durations on the adjective are longer, in the case of a parafoveally visible majuscule – albeit statistically negligible. These differences are completely balanced in the Total fixation duration, but an interplay between an uppercase noun and high frequency seems to be visible, as described in more detail below.

The German participants reading English show the same pattern in FPFD as group EE, i.e. no effects on the noun but longer durations on the adjective in the case of an upcoming majuscule noun, but are again negligible from a statistical point of view. This pattern is manifested and becomes statistically relevant for the adjective in the Total fixation duration.

3) Effect of frequency: For all three participant groups, no effect on the adjective itself was detectable in FPFD. Typical frequency effects on the noun are detectable for groups GG and EE. For group GE, these effects are suggestively detectable, but are only provable in one condition, i.e. an unchanged lowercase noun. For this group, frequency effects seem to depend on sentences with regular lowercase spelling.

Analyzing the frequency effects in Total (changed conditions are excluded), the characteristic for group GG is confirmed and group GE finally shows the same characteristic, too, i.e. no differences on the adjective but notably longer fixation durations for low-frequency nouns. For group EE, it changes slightly and frequency effects are only detectable for an irregularly spelled uppercase noun.

For the individual participant groups, we come to the following conclusions:

German natives reading German, group GG, were quite sensitive regarding the experimental manipulations, which makes sense, since noun capitalization is systematic in German. Effects on the adjective in general are hardly detectable, and noun frequency effects are limited to the noun. Spelling effects are also limited to the noun, i.e. longer processing in the case of misspelling. However, the most astonishing result is that in first-pass processing not the actual spelling of the noun itself is decisive, but its presentation when fixating on the adjective. Due to missing effects on the adjective, lexical PoF effects do not occur, but it seems as though the

presence of the majuscule in the parafovea is the decisive factor for noun processing and not the spelling of the noun itself, at least for first-pass processing. The conclusion that this effect is exclusive to first-pass processing is underlined by the fact that the reading durations differ for both frequency conditions:

- High frequency, uppercase before boundary: 238.8 words per minute (no change) vs. 231.6 wpm (changed),
- Low frequency, uppercase before boundary: 233.9 wpm (no change) vs. 228.2 wpm (changed).

The Total fixation duration shows the same pattern as first-pass processing: No differences in the adjective, frequency effects on the noun, and longer fixation durations in the case of violated spelling of the noun.

English natives reading English, group EE, were quite robust regarding the experimental manipulations, which makes sense, since noun capitalization is non-systematic but present in English. In first-pass processing, noun case effects are exclusively detectable on the adjective, i.e. longer durations in the case of a parafoveally visible noun. This result is in line with Pauly and Nottbusch (under review), in which for a similar participant group effects on the noun itself were hardly detectable. Frequency effects are detectable on the noun. The noun case change has no systematic effect, but is the most influential compared with the other two participant groups.

The most astonishing result, however, is the interaction effect between the position and the noun frequency regarding the total fixation duration to the extent of substantially longer – due to regressions – processing durations on the adjective when the noun frequency is high and shorter fixations on the noun, which is reversed for low-frequency adjective-noun pairs. This crossing ultimately leads overall to an almost identical processing of the adjective and noun when comparing low and high frequencies with each other. Taking the noun case into account, there is a 16-ms overall benefit for orthographically violated high-frequency uppercase nouns in the Total fixation duration. This result is supported by the fact that, at 227.4 words per minute, the reading speed was fastest for unchanged high-frequency uppercase sentences (vs. 223.8 wpm for the corresponding regularly spelled lowercase sentences).

As far as German natives reading English, group GE, again, a noun case change has no systematic effect. Typical frequency effects on the noun are visible, but generally not substantial. Interestingly, a substantial frequency effect (30 ms) is only detectable for an unchanged lowercase noun, which leads us to the conclusion that as soon as an irritation occurs, in the form of either a display change and/or an orthographic violation, the frequency effects strongly decrease. This changes in the Total fixation duration, where the frequency effect is highlighted on the noun, but also has an impact on the preceding adjective, i.e. low-frequency nouns and the preceding adjective receive longer regressions. Just as for group EE, noun case differences are only visible for the adjective (i.e. longer durations when majuscule is visible), which grows even stronger in the Total fixation duration. It is worth mentioning that in the Total duration the uppercase high-frequency nouns are fixated on 11 ms less than the corresponding orthographically correct lowercase noun. This effect is also visible for group EE, but in contrast group GE does not process high-frequency adjective-noun combinations faster when they are spelled with an uppercase letter, since the adjective is fixated on longer, which leads to an overall malus of 12 ms.

The results lead us to the following overall conclusions:

1) All three experiments clearly and independently show that lexical parafovea-on-fovea effects do not occur 1) in general and 2) in particular not in the form of an interplay with noun capitalization. This result is in line with previous non-corpus studies (e.g. Degno et al., 2019).
2) Lexical effects on the noun are clearly demonstrable: Low-frequency words generally led to substantially longer reading times than high-frequency words (e.g. Broadbent, 1967). However, these effects are partially modulated by noun capitalization, so that they are present but when calculating contrasts not in all cases as a substantial effect.
3) A change of noun case does not lead to systematic effects regarding noun processing. Nevertheless, the noun case itself, i.e. whether upper- or lowercase, is an important factor for processing, especially when it is visible in the parafovea, but the change itself does not decisively influence first-pass processing. The parafoveal processing of the noun case is consistent with previous evidence that readers obtain at least visual information from

words in the parafovea before fixating on it (Degno et al., 2019; for an overview: Schotter et al., 2012).

4) German processing: The result that for first-pass processing the presence of the majuscule in the parafovea appears to be the decisive factor for noun processing and not the spelling of the noun itself points toward the theory that a syntactic category becomes activated by the parafoveal recognition of the majuscule (Pauly & Nottbusch, 2020). In the current experiment, this is not connected with a time cost for the word prior to the noun, as assumed in Pauly & Nottbusch (2020). It seems as though the simple recognition is sufficient, and no deeper processing is necessary. This result requires further research.
5) English processing: Both participant groups show in FPFD and in Total a final zero-difference for the noun, which indicates that this process is upstreamed to the actual manipulation i.e. uppercase vs. lowercase nouns. This result is in line with Pauly & Nottbusch (under review), in which similar participant groups were examined. Regarding Total, it is also in line with Rayner and Schotter (2014), who found the exact same processing durations when comparing capitalized and non-capitalized words. Apart from that, both participant groups benefit from the uppercase letter on the noun in the Total fixation duration when frequency is high. The English natives even benefit when adding together the adjective and noun durations. This result was already implied in Pauly & Nottbusch (under review), but analyses were post hoc and limited to first-pass processing. The current study does not satisfyingly answer the question of whether there is an overall benefit of uppercase processing which is promoted by a high frequency. The same is the case for the question of whether a language transfer of noun-marking in the case of a high frequency occurs for the German natives reading English. The reason for the lack of answers to these two questions is that the research question of the current study focused on first-pass processing. In terms of first-pass processing, then, the answer is that there is no evidence for a beneficial use and/or language transfer, which was also found regarding reading durations – as mentioned above – in the studies of Bock et al. (1989) for Dutch participants, but is in contrast to the studies of Gfroerer et al. (1989). Another unanswered question stems from the finding that the English readers showed an interaction of region and frequency in the Total fixation duration. An explanation for this effect might be that in the case of a low-frequency noun, the reader regresses to an attributive adjective for a longer time to gain a better understanding of the whole noun phrase, since the adjective,

which occurs at a high frequency, is therefore easier to process than the noun itself and specifies the noun, which makes reparsing of the whole adjective-noun combination a promising strategy.

6) Regarding serial or parallel processing, this study does not provide answers, since the results fit into both models particularly due to the missing evidence of lexical PoF effects.

VI. Fazit und Schluss

Reduziert man die Forschungsfrage des Dissertationsprojekts darauf, ob die wortinitiale Substantivgroßschreibung des Deutschen beim Lesen deutscher Texte einen Lesevorteil bringt, fällt die Antwort nicht so eindeutig positiv aus wie im Falle der in der Einleitung erwähnten Bock-Studien.
Die Ergebnisse unserer Studien lassen jedoch keine eindeutige Antwort zu. Sofern ein Vorteil vorliegt, für den es durchaus Anhaltspunkte gibt, dann ist dieser sehr klein.

Erweitert man die Frage dahingehend, ob eine parafoveale Aktivierung der syntaktischen Kategorie des Kerns einer Nominalgruppe durch eine Majuskel stattfindet, sind die Ergebnisse und Hinweise, die die Experimente dieses Dissertationsprojektes liefern, schon eindeutiger. Während Studie 1 (Kapitel III) Hinweise auf eine Vorverarbeitung auf dem Adjektiv gab, konnte das im deutschen Experiment der Studie 3 (Kapitel V) so nicht bestätigt werden, wohl aber die Tatsache, dass es für die Verarbeitung des Substantivs entscheidend ist, ob das Substantiv auf dem vorigen Wort normgerecht groß (=schnellere Verarbeitung) oder normwidrig klein präsentiert wurde. Aber auch hier sind die Unterschiede klein. Das erstaunlichste Ergebnis ist jedoch, dass bei der fovealen Verarbeitung des Substantivs im ersten Lesedurchgang nicht die tatsächliche Schreibweise des Substantivs entscheidend war, sondern eben genannte parafoveale Darstellung während der Fixation des Adjektivs. Dieses Ergebnis zu replizieren, wäre ein Ansatzpunkt für weitere Forschungen.

Darüber hinaus, das gilt auch für die englischsprachigen Ergebnisse, liefert diese Dissertation keine Antworten darauf, wie die Substantivgroßschreibung zu bewerten ist, wenn das vorige Wort kein attributiv gebrauchtes und somit inhaltstragendes Adjektiv ist. So stehen Funktionswörter wie etwa Präpositionen und/oder Artikel sehr häufig vor Substantiven, werden im Rahmen des Lesevorgangs auch häufig übersprungen.
Weitet man die Ergebnisse auf das Lesen englischsprachiger Texte aus, lässt sich als Gesamtergebnis konstatieren, dass im Fall eines Vergleichs der Gesamtfixationsdauern normwidrig großgeschriebener mit normgerechten kleingeschriebenen Substantiven ein Unterschied nicht bzw. kaum nachweisbar ist, gleichwohl die Manipulation der Substantivschreibung eine Veränderung der Leseverarbeitung bewirkt. Dieses Ergebnis liefert Hinweise darauf, dass die Verarbeitung nominaler Gruppen in Verbindung mit einer

Großschreibung nicht nur hauptsächlich auf dem Kern erfolgt bzw. man könnte daraus die These formulieren, dass die Verarbeitung nominaler Gruppen ähnlich wie bei der Wortgruppenhypothese ganzheitlich betrachtet werden könnte und nicht wortweise. Dies wäre ein Ansatz, den man weiter untersuchen könnte.

Die Beantwortung der Frage, ob ein Sprachtransfer der systematischen Substantivgroßschreibung auf das Englische stattfindet, der einen Lesevorteil bringt, deutete sich am ehesten für die Versuchspersonengruppe der englischen L1-Sprecher, die regelmäßig Deutsch lesen, an (Studie 2, Kapitel IV). Fasst man die Ergebnisse zusammen, so ist bei deutschen L1-Sprechern, die Englisch lesen, dieser potentielle Transfer schwach bis gar nicht ausgeprägt.

Darüber hinaus lieferten die Experimente Hinweise darauf, dass eine hohe Substantivfrequenz in Verbindung mit der normwidrigen Substantivgroßschreibung einen kleinen Verarbeitungsvorteil auf dem Substantiv bringen könnte (deutsche L1-Sprecher lesen Englisch), teilweise sogar einen kleinen Gesamtverarbeitungsvorteil (englische L1-Sprecher lesen Englisch). Dieses Ergebnis zu replizieren, wäre ein Ansatzpunkt für weitere Forschungen.

Zusammengefasst: Die Substantivgroßschreibung hat eindeutig einen Einfluss auf die Satzverarbeitung sowohl im Deutschen als auch im Englischen. Dass dieser einen substanziell entscheidenden Vorteil bringt, kann nicht bestätigt werden.

VII. Literaturverzeichnis

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VIII. Abbildungsverzeichnis

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X. Appendix

X.1 Appendix zu Kapitel III: The Influence of the German Capitalization Rules on Reading

X.1.1 Items (mit Substantivgroßschreibung)

	Sentence	Adjective EXP	Adjective CON	Noun	Sub-type
1	Auf dem Petersplatz trafen sich **gläubige** Christen zum Gebet.	gläubige	libysche	Christen	I
2	Aus gesundheitlichen Gründen meidet man **fette** Jogurts mit viel Zucker.	fette	saure	Jogurts	II
3	Die Sommerpartys sind **feste** Höhepunkte im Kalender.	feste	wahre	Höhepunkte	II
4	Auf Bier trinkt man **klaren** Schnaps in der Kneipe.	klaren	warmen	Schnaps	I
5	Die Lehrerin lobt die **klasse** Leistung der fleißigen Schüler.	klasse	genaue	Leistung	II
6	Der Archäologe erforscht die **antike** Uhr in seinem Büro.	antike	braune	Uhr	II
7	Die Beine lassen den **armen** Patienten im Stich.	armen	zähen	Patienten	II
8	Der Lokführer mag die **weichen** Gesichtszüge der Frau.	weichen	sanften	Gesichtszüge	II
9	Der Juwelier begutachtet den **brillanten** Edelstein mit seiner Lupe.	brillanten	gelblichen	Edelstein	I
10	Die Offensive schlägt die **defensive** Taktik des Gegners.	defensive	veraltete	Taktik	I
11	Der Physiker überprüft die **dichte** Struktur des Gesteins.	dichte	blanke	Struktur	II
12	Der Kapitän kommandiert die **flotte** Mannschaft mit aller Strenge.	flotte	übrige	Mannschaft	II
13	Der Morgen versprüht **frische** Frühlingsluft über die Dächer.	frische	heftige	Frühlingsluft	I
14	Die Senioren beschimpfen **jugendliche** Kinder auf der Straße.	jugendliche	gewöhnliche	Kinder	I
15	Traditionelle Kneipen sind **lokale** Treffpunkte in den Dörfern.	lokale	ideale	Treffpunkte	II
16	In der Gymnastikhalle liegen die **matten** Sportler auf dem Boden.	matten	steten	Sportler	II
17	Die Kinder sprechen mit den **weisen** Männern über Psychologie.	weisen	naiven	Männern	I
18	Der strenge Vater zeigt **milde** Züge im höheren Alter.	milde	nette	Züge	II
19	Die Mutter hält das **neugeborene** Baby im Arm.	neugeborene	verbliebene	Mannschaft	I
20	Das Ordnungsamt vertreibt den **obdachlosen** Mann aus dem Park.	obdachlosen	störrischen	Mann	I

21	Die Monteure reparierten den **platten** Hinterreifen in der Werkstatt.	platten	uralten	Hinterreifen	I
22	Der Affe ist kein **primitiver** Repräsentant der Säugetiere.	primitiver	alleiniger	Repräsentant	I
23	Der Terrorist ist ein **radikaler** Vertreter politischer Ansichten.	radikaler	tödlicher	Vertreter	I
24	Der Heranwachsende findet **reife** Früchte auf dem Tisch.	reife	kühle	Früchte	II
25	Unter dem Dach stören die **schrägen** Fenster den Hausmeister.	schrägen	unnützen	Fenster	II
26	Die Polizei fasst den **schuldigen** Täter auf der Autobahn.	schuldigen	armseligen	Täter	I
27	Der Radius halbiert die **senkrechte** Strecke auf dem Papier.	senkrechte	lückenlose	Strecke	I
28	Das Gericht bestraft **untreue** Bürger mit Gefängnis.	untreue	lästige	Bürger	II
29	Der Arzt behandelt den **kranken** Mann mit Vorsicht.	kranken	stillen	Mann	I
30	Der Detektiv stellt den **kriminellen** Dieb im Kaufhaus.	kriminellen	vierzehnten	Dieb	I
31	Die Sprache besteht aus **lauten** Tönen mit und ohne Stimmeinsatz.	lauten	groben	Tönen	I
32	Das Biest mag die schöne **Uhr** aus der Sammlung.	schöne	äußere	Uhr	II
33	An Weihnachtsbäumen sind die **spitzen** Anhänger in der Mitte.	spitzen	starren	Anhänger	I
34	Der gestresste Arbeiter genießt die **stille** Atmosphäre am Sonntag.	stille	aktive	Atmosphäre	I
35	Der Mathematiker berechnet die **variablen** Zinssätze am Computer.	variablen	fallenden	Zinssätze	II
36	Nach dem Anschlag kommen die **verwundeten** Soldaten auf die Intensivstation.	verwundeten	kanadischen	Soldaten	I
37	Im Krankenhaus genesen die **verletzten** Opfer des Unfalls.	verletzten	gemeldeten	Opfer	I
38	Der Teufel ist der **leibhaftige** Vertreter des Bösen.	leibhaftige	mörderische	Vertreter	I
39	Die Länge übertrifft die **breite** Seite um mehrere Zentimeter.	breite	offene	Seite	I
40	Die Krankenschwester findet den **toten** Körper in der Sonne.	toten	roten	Körper	I

X.1.2 Füllersätze (mit Substantivgroßschreibung)

1 Den Ton gab der Künstler seinem Gehilfen gerne.
2 Der Hof lag weit außerhalb des eigentlichen Dorfes.
3 Die Wanderer sahen Rehe auf einer Lichtung im Wald stehen.
4 Den Kopf hieb man früher nur Mördern und Verrätern ab.
5 Vorne am Bug sah man eine prächtige Galionsfigur.
6 Sogar aus Raps lässt sich Kraftstoff herstellen.

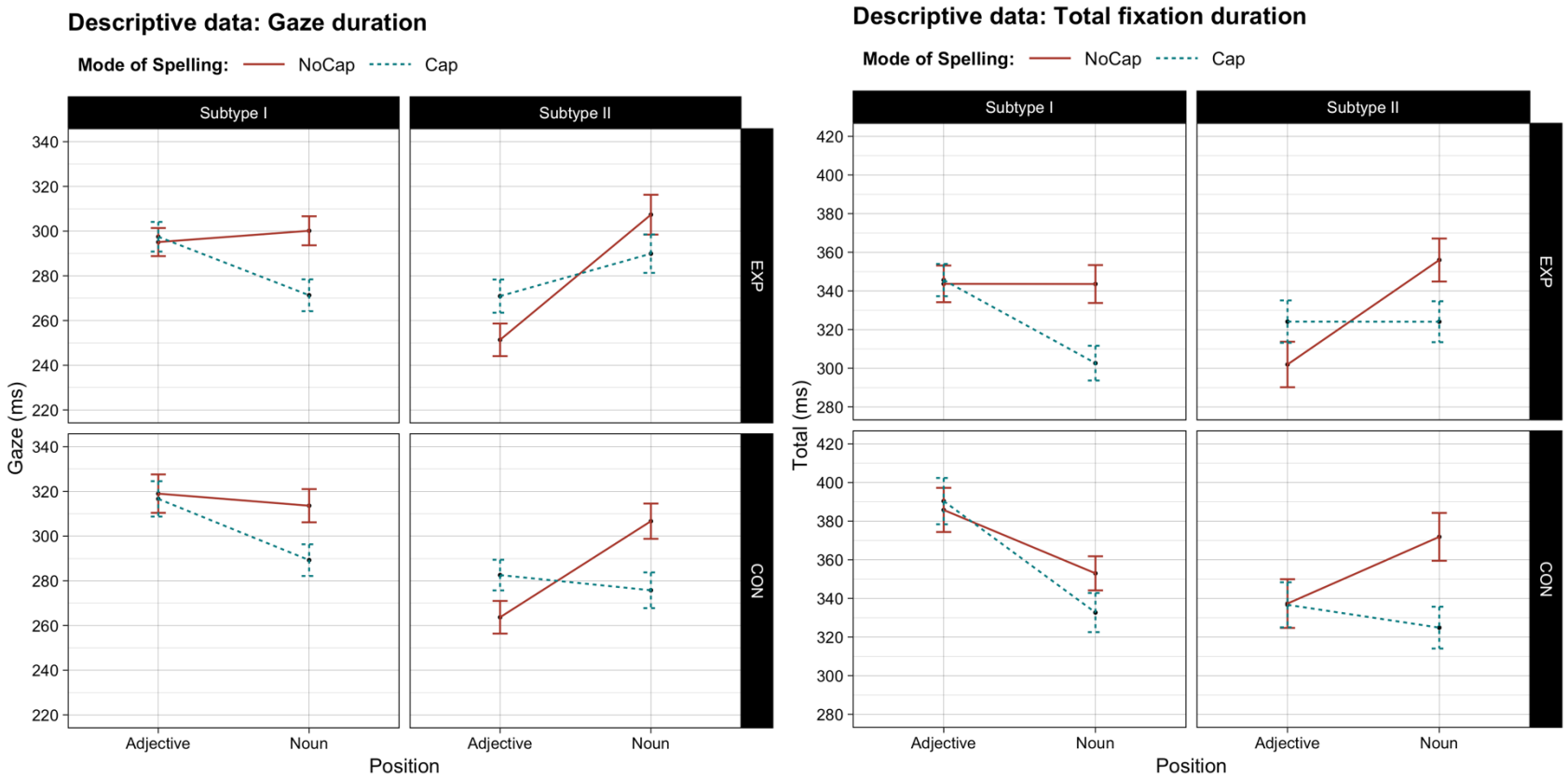
7 Der schüchterne kleine Gnom mied die Nähe der Elfen.
8 Claudia hatte ihr Fahrrad auf der Straße stehen lassen.
9 Die Eltern konnten ihre Kinder im Garten raufen hören.
10 Er hätte nicht auch noch am Telefon nörgeln sollen.
11 Wegen ihrer Diät hatte die Gräfin leider keine Auster nehmen dürfen.
12 Die meisten Hamster bleiben bei Tag in ihrem Häuschen.
13 Man sollte nie Geschirr mit einem dreckigen Lappen spülen müssen.
14 Man kann Spargel dämpfen oder in viel Wasser kochen.
15 Manchmal sagen Opfer vor Gericht nicht die volle Wahrheit.
16 Die meisten Befragten hören Musik zur Entspannung.
17 Kinder essen Quark am liebsten mit Früchten.
18 Die Platzwarte ebnen Stück für Stück den Rasen nach dem Spiel.
19 Die Förster küren Ahorn zum Baum des Jahres.
20 Wolfgangs Töchter studieren Literatur und Maschinenbau.
21 In der Klosterschule herrschen die Ordensschwestern.
22 Im Aussehen gleichen Bratsche und Geige sich sehr.
23 Angeblich flunkern Künstler oft bezüglich ihrer Einnahmen.
24 Manchmal krakeelen Politiker genauso wie Demonstranten.
25 Die Armen plündern Speicher und Vorratskeller der reichen Bauern.
26 Die Richter der Landwirtschaftsschau prämieren Rhabarber und Mangold.
27 Schon immer war der Besitz von Land sehr wichtig.
28 Ein berühmter Maler hat sich selbst ein Ohr abgeschnitten.
29 Das Pferd ist seinem Reiter auf den Fuß getreten.
30 Es fiel kein einziges Tor im gestrigen Spiel.
31 Der Skandal hat dem Ruf des Politikers deutlich geschadet.
32 Als Kapitalanlage ist Gold nicht zu empfehlen.
33 Markus klettert gern auf den alten Baum im Garten.
34 Medizinisch gesehen ist das Herz ein Hohlmuskel.
35 Jede Sprache der Welt besitzt eine Grammatik.
36 Unsere Küche müsste dringend neu gestrichen werden.

37 Der Politiker reagierte auf keine Frage der Journalisten.
38 Die Insel ist nur mit dem Flugzeug zu erreichen.
39 Es sollte mehr Strom mit Solarenergie erzeugt werden.
40 Die monotone Arbeit machte den Angestellten keinen Spaß.
41 In dem kleinen Zimmer standen viel zu viele Möbel.
42 Das Fenster im Flur klemmt seit ein paar Tagen.
43 Die Sekretärin informierte den Kanzler erst am nächsten Morgen.
44 Vielleicht gibt es bald im Winter Ostereier zu kaufen.
45 Das kleine Unternehmen konnte sich die teure Maschine nicht leisten.
46 Jan hat sich zum dritten mal die Schulter ausgekugelt.
47 Der Bischof erschien mit seinem neuen Sekretär auf der Konferenz.
48 Das Schicksal führte die Freunde wieder zusammen.
49 Vor Gericht wurde die Situation nachgestellt.
50 Das Wetter im September spielte ziemlich verrückt.
51 Die diesjährige Konferenz der Wissenschaftler dauerte vier Tage.
52 Der Hirte wanderte mehrere Kilometer durch die Wüste.
53 Yvonne trat unglücklicherweise auf eine Tube Klebstoff.
54 Manuela reagiert auf süßen Senf sehr allergisch.
55 Der Kapitän goss stets ein wenig Rum in seinen Tee.
56 Für den Faden ist die schmale Öse ist zu klein.
57 Die Tänzer probten ihre Kür besonders intensiv.
58 Nach dem Streit schien alles wieder im Lot zu sein.
59 Die Schneiderin steckte die Naht sorgfältig ab.
60 Auf dem höchsten Mast hielt der Pirat Wache.
61 Claudia kann Salatsoßen mit viel Essig nicht ausstehen.
62 Die Torte erwies sich als ein wahrer Leckerbissen.
63 Sie machten einen Spaziergang am Deich entlang.
64 Ulf hat schon wieder eine Niete aus dem Eimer gezogen.
65 Der Giebel des alten Hauses drohte einzustürzen.
66 Das Karamellbonbon blieb Julia am Gaumen kleben.

67 Tamara führte mit der Hebamme mehrere Gespräche.
68 Nach der Trauung wartete eine Kutsche vor der Kirche.
69 Robert ließ sich den Schinken in Scheiben schneiden.
70 Die Kinder hüpften auf der alten Matratze herum.
71 Laura stellte eine Schüssel Kirschen auf den Tisch.
72 Das entscheidende Telefonat verzögerte sich um einige Minuten.
73 Der Teppich mit dem Schnörkel gefiel ihr nicht.
74 Der majestätische Gletscher wurde schon oft bestiegen.
75 Der Großvater fand in seinem Pantoffel eine Wäscheklammer.
76 Johannes wollte unbedingt Karussell fahren.
77 Die Olympiade findet dieses Jahr in Australien statt.
78 Der alte Mann zog einen Karren zum Marktplatz.
79 Heute morgen saß auf unserer Terrasse ein Frosch.
80 Der Wandersmann bat den Wirt um etwas Wasser.
81 Der Waffenstillstand hält seit fast vier Monaten.
82 Die Mutter gibt ihren Kindern jeden Montag Taschengeld.
83 Die meisten Kinder gehen gerne morgens in die Schule.
84 Viele Kinder lesen nur noch selten dicke Bücher.
85 Die Journalisten fragen den Bürgermeister nach seiner Meinung.
86 Kevin und seine Schwester spielen oft im Garten miteinander.
87 Die Geschworenen glauben dem Beklagten bestimmt alles.
88 Am besten stellen wir das Klavier nicht direkt ans Fenster.
89 Meistens wünschen sich Kinder Spielzeug zu Weihnachten.
90 Einige Häftlinge sprechen nicht gern miteinander.
91 Nur wenige Menschen brauchen ein Handy wirklich.
92 Einige der Angestellten arbeiten nur vormittags.
93 Die meisten Geschäfte schließen samstags früher als unter der Woche.
94 Die Astronauten antworten seit Tagen nicht mehr.
95 Die Schüler schreiben ihrer kranken Lehrerin einen Brief.
96 Die Beschuldigten schweigen zu den Vorwürfen.

97 Die beiden Mädchen schütteln sich vor Lachen.
98 Dorothea log oft bei Fragen nach ihrem Alter.
99 Die Großmutter wog die Zutaten beim Backen sehr genau.
100 Der Gehilfe des Gärtners sät Kresse und Radieschen.
101 Die zwei jungen Nichten öden sich gegenseitig an.
102 Achim misst mit dem Zollstock die Tiefe des Regals aus.
103 Die streikenden Fahrer konnte man kilometerweit hupen hören.
104 Die Gärtner mähen jeden Mittwoch den Rasen im Park.
105 Gute Beziehungen ebnen vielen Unternehmern den Weg zum Erfolg.
106 Mäuse und Ratten nagen gerne an Stromkabeln.
107 Tierärzte impfen keine Kaninchen gegen Tollwut.
108 Die Hunde der Wächter bellen beim geringsten Anlass.
109 Affen kraulen sich oft stundenlang das Fell.
110 Die Forscher stapfen durch den Schnee zurück zum Lager.
111 Viele Babys schielen nach der Geburt eine Weile lang.
112 Die Bäume in den Wäldern speichern sehr viel Wasser.
113 Die meisten Leute schummeln beim Spielen gelegentlich.
114 Nach dem Spiel massieren die Therapeuten den Spielern die Beine.
115 Die beiden Mädchen tuscheln während des Unterrichts.
116 Die Häuser am Horizont flimmern in der Sonne.
117 Den ganzen Tag über konnte man die Raben krächzen hören.
118 Vor dem Auftritt schminken sich die Schauspieler.
119 Die zwei frechen Jungs heucheln Unschuld bei ihrer Mutter.
120 Manche Menschen stottern bei großer Nervosität.

X.1.3 Deskriptive Plots Subtypen I und II, Gaze und Total



Descriptive data showing the interaction of SPELLING (Cap vs. NoCap), SENTENCEMODE (EXP vs. CON), POSITION (Adjective vs. Noun) and SUBTYPE (Subtype I vs. Subtype II), in Gaze duration (left panel) and in the Total fixation duration (right panel); error bars represent the standard errors. Within each graph, Subtype I is shown to the left, Subtype II to the right. The garden-path sentences (EXP) are shown in the upper part of the graph and the lower part represents the control sentences (CON), in which subtypes are not present; plots show the corresponding sentences to EXP. The red solid line represents sentences in which the nouns are not capitalized, the blue dotted lines represent sentences which follow German standard orthography.

X.2 Appendix zu Kapitel IV: The effect of noun capitalization on reading of English for English and German participants

X.2.1 Items (ohne Substantivgroßschreibung)

	Sentence	Adjective EXP	Adjective CON	Noun	Noun fre-quency
1	The sick writer had a cold nose throughout the winter.	cold	blue	nose	high
2	The chemist poured the acid mixture into the beaker.	acid	salty	mixture	high
3	The burglar was a criminal genius since his youth.	criminal	charming	genius	low
4	The director filmed a documentary series about dying animals.	documentary	complicated	series	high
5	The team reached the final challenge of the season.	final	extra	challenge	low
6	The soldiers respected the major obstacle of the desert.	major	large	obstacle	low
7	The doctor treats the patient girl at the hospital.	patient	excited	girl	high
8	The rich dominate the poor people in the town.	poor	aged	people	high
9	The candidate showed potential failings at his interview.	potential	worrying	failings	low
10	The psychologist tested the variable rate on his computer.	variable	optional	rate	high
11	The bank invests capital amounts in the project.	capital	limited	amounts	low
12	The worker entered the complex construction by the river.	complex	insecure	construction	high
13	The torch lit up the dark corners of the house.	dark	tiny	corners	low
14	The undertaker buries the dead citizens of the town.	dead	late	citizens	high
15	The good defeat the evil masters of this world.	evil	crazy	masters	low
16	The electrician is an expert footballer in his spare time.	expert	clumsy	footballer	low
17	The children enjoy the fair sunset from the rooftop.	fair	pink	sunset	low
18	The burglar cracks the safe door after midnight.	safe	weak	door	high
19	The magician reveals the secret casket to his audience.	secret	golden	casket	low
20	The new tax hurt the unemployed workers during a hard time.	unemployed	optimistic	workers	high
21	The soldiers wear the uniform clothing during the manoeuvre.	uniform	useless	clothing	high

22	The charity supports the homeless pensioners with food.	homeless	immobile	pensioners	low
23	The woman eats an orange carrot during the afternoon.	orange	sliced	carrot	low
24	The lion roamed the wild jungle in the morning.	wild	loud	jungle	low
25	The captain commands the fleet officers with calm control.	fleet	lousy	officers	high
26	~~The statistican calculated the mean values for the experiment.~~	~~mean~~	~~used~~	~~values~~	high
27	The child reads a comic story during the holidays.	comic	naive	story	high
28	The station broadcasted a commercial announcement last night.	commercial	surprising	announcement	low
29	The manager became an executive member of the board.	executive	promising	member	high
30	Lenin was a communist politician in the last century.	communist	~~skilfully~~	politician	low
31	Dynamite is an explosive material with hazardous properties.	explosive	murderous	material	high
32	The broker sells the flat shoes for little money.	flat	grey	shoes	high
33	The archaeologist found the fossil skeleton in the mountains.	fossil	mighty	skeleton	low
34	The sorcerer foretold the future opportunities in his life.	future	entire	opportunities	low
35	God created the human eye within a single day.	human	first	eye	high
36	~~The spectactors attended a musical performance in the city.~~	~~musical~~	~~shining~~	~~performance~~	high
37	The illusionist uses magic skills for many things.	magic	given	skills	high
38	The woman bought a lemon cupcake at the shop.	lemon	plain	cupcake	low
39	The barman broke the glass ornament with his elbow.	glass	awful	ornament	low
40	The farmer lifted the stone statue with his bare hands.	stone	dusty	statue	low

X.2.2 Füllersätze (ohne Substantivgroßschreibung)

1	The assistant enjoyed helping the old artist with his work.
2	The farm was far away from the next village with electricity.
3	The hiker saw deer standing in a glade in the forest.
4	Fuel for cars can even be made out of plants.
5	The shy young man avoided talking to girls of his age.
6	Claudia left her new bike on the dirty street.

7 The parents listened to the arguing children in the garden.
8 He should not have complained on the telephone.
9 The secretary should not have eaten the bad oyster.
10 Most hamsters stay in their tiny house throughout the day.
11 Cleaning the dishes with a dirty cloth is not very efficient.
12 It is possible to boil and to steam fresh asparagus.
13 Most of the people in the survey listened to music for relaxation.
14 Victims sometimes lie in court because they are anxious.
15 Children prefer eating sweetened fruit in the afternoon.
16 Peter's daughters study literature and mathematics.
17 Many nuns live in a convent for the whole of their lives.
18 Violas and violins sound and look very similar.
19 Owning land has always been very important.
20 Artists sometimes forget to declare their earnings.
21 Centuries ago a famous artist cut off his own ear.
22 Yesterday the horse trod on the foot of his rider.
23 The music of the choir can be a spiritual experience.
24 Her boyfriend doesn't like the way she dresses.
25 Taxes are usually higher than people expect.
26 Every language of the world has a grammar.
27 No one scored a goal in yesterday's boring game.
28 They took a long walk beside the golden river.
29 Our kitchen urgently needs fresh paint on its walls.
30 Investing your savings in gold is not recommended.
31 Mark climbed on the old tree in the garden.
32 The heart is from a medical perspective a muscle.
33 The politician did not react to any of the questions.
34 You can only reach the green island by plane.
35 More electricity should be produced by wind.
36 There is too much furniture in the small room.

37 The secretary informed the minister the next day.
38 Fate brought the old friends back together.
39 Jacob has broken his right leg for the third time.
40 The company cannot afford to buy new machines.
41 The weather was very changeable in the winter.
42 Many people have an allergic reaction to pollen.
43 The scientists debated at the conference for five days.
44 The adventurer hiked for thousands of kilometres.
45 Drinking tea with rum is only for alcoholics.
46 The dancers practised hard to appear good on stage.
47 The striking drivers asked for more money.
48 The gardeners cut the lawn in the park every week.
49 Jason again drew a blank out of the bucket.
50 Dennis measures the depth of the shelf in the kitchen.
51 The two nurses talked about the unfriendly doctors.
52 The children jump on the mattresses in their bedroom.
53 Laura puts a cup of red cherries on the table.
54 Grandpa found his lost shoe in the basement.
55 The butcher cuts the bacon into small slices.
56 The roof of the old house is very unstable.
57 A carriage was waiting next to the church after the wedding.
58 The mother gives allowance to her children every month.
59 The majestic glacier was climbed frequently by tourists.
60 This morning we found a frightened frog on our terrace.
61 Most children enjoy leaving school in the afternoon.
62 Few children read thick books in their leisure.
63 It would be best to place the piano next to the window.
64 Some prisoners do not like talking to their relatives.
65 Children often want to get toys for their birthday.
66 Compared to weekdays most shops close earlier on the weekends.

67 The pupils send a letter to their sick teacher.
68 The lawyer told the defendants to remain silent.
69 We haven't heard anything from the astronauts for days.
70 The cook weighs the ingredients before mixing them.
71 Many people lie if they are asked for their age.
72 Good relationships are necessary for a successful company.
73 Mice and rats like to gnaw and chew cables.
74 Vets do not vaccinate rabbits against rabies.
75 Hannibal was a large man with dark skin and blue eyes.
76 Apes spend hours picking fleas from their fur.
77 The tourists trudged back to their camp through the snow.
78 Many babies squint for a good while after birth.
79 The trees in the forest store lots of water.
80 Most people cheat when playing games with their friends.
81 The physiotherapist massages the legs of the players.
82 The two girls whisper secretly during the lesson.
83 The actors put on makeup before going on stage.
84 You could hear the ravens croak in the park.
85 Some people hesitate when asked to speak publicly.
86 The green bottle stands alone in the dark room.
87 Even many expensive speakers are too quiet.
88 Reading scientific books can be very exhausting.
89 The files on the desk are very important for the company.
90 The psychologist wrote the questions on a sheet of paper.
91 The train arrives late because of the stormy weather.
92 The girl has little animals on her new dress.
93 The newer camera takes better pictures when it is dark.
94 The black hat doesn't keep your head very warm.
95 Writing on this tiny keyboard is very hard work.
96 The words in this song ring true for many people.

97	The couple had been married for a long time but had no children.
98	This is a selection of many amusing stories.
99	The teacher will tell us the story at school tomorrow.
100	The family usually takes a vacation close to the sea.

X.3 Appendix zu Kapitel V: The interaction effect of noun frequency and noun capitalization during reading of German and English

X.3.1 Items, Experiment I: German natives reading German

	Sentence	Adjective (N)	Noun (N+1)	Noun frequency
1	Der Sammler bewundert die weiße Wanduhr im Esszimmer.	weiße	Wanduhr	low
2	Die Biologin bestaunt den größten Habicht der Welt.	größten	Habicht	low
3	Die Großmutter trägt das schwere Armband am Handgelenk.	schwere	Armband	low
4	Der Bauer verteilt das gesamte Saatgut auf dem Feld.	gesamte	Saatgut	low
5	Der Junge erträgt das bloße Gespött seiner Mitschüler.	bloße	Gespött	low
6	Der Weg macht eine starke Biegung nach der Abzweigung.	starke	Biegung	low
7	Der Arbeiter meißelt das feste Mineral aus dem Gestein.	feste	Mineral	low
8	Die Tochter fällt über die tiefe Kommode im Wohnzimmer.	tiefe	Kommode	low
9	Der Darsteller stolpert über die äußere Kulisse auf der Bühne.	äußere	Kulisse	low
10	Die Köchin serviert einen roten Pudding als Nachtisch.	roten	Pudding	low
11	Die Religionen brauchen einen wahren Erlöser für ihre Anhänger.	wahren	Erlöser	low
12	Der Gläubige betet in der leeren Moschee auf dem Boden.	leeren	Moschee	low
13	Die Krankenschwester setzt eine volle Spritze mit Impfstoff.	volle	Spritze	low
14	Das Mädchen greift nach dem oberen Joghurt im Schrank.	oberen	Joghurt	low
15	Der Arzt verwendet die dunkle Tinktur zur Wundheilung.	dunkle	Tinktur	low
16	Das Kind besitzt ein kleines Gefährt zum Spielen.	kleines	Gefährt	low

17	Die Bank verlangt wegen des höheren Kredits mehr Geld.	höheren	Kredits	low
18	Die Hausfrau mag den klaren Extrakt aus frischen Kräutern.	klaren	Extrakt	low
19	Der Mann vertreibt das linke Gesinde aus seinem Garten.	linke	Gesinde	low
20	Der Besucher bestaunt die echte Kutsche im Museum.	echte	Kutsche	low
21	Die Politiker wollen die beste Bildung für alle Bürger.	beste	Bildung	high
22	Der Altbau hat schöne Fenster in der Küche.	schöne	Fenster	high
23	Die Wohnung ist in einem reinen Zustand bei der Übergabe.	reinen	Zustand	high
24	Der Junge träumt von einer grünen Gestalt in der Nacht.	grünen	Gestalt	high
25	Der Bürgermeister eröffnet ein neues Theater im Stadtkern.	neues	Theater	high
26	Die Frau geht an einem festen Sonntag in die Kirche.	festen	Sonntag	high
27	Die Tabletten entfalten nur die halbe Wirkung gegen die Schmerzen.	halbe	Wirkung	high
28	Der Fotograf arbeitet bei einer freien Zeitung im Nebenberuf.	freien	Zeitung	high
29	Der Soldat bittet den dicken General um Hilfe.	dicken	General	high
30	Der Verein geht unter alter Führung ins neue Jahr.	alter	Führung	high
31	Der Vermieter schließt einen kurzen Vertrag mit den Bewohnern.	kurzen	Vertrag	high
32	Der Prominente bekämpft den harten Angriff der Presse.	harten	Angriff	high
33	Der Aktienkurs schwankt in einem engen Bereich von einigen Euro.	engen	Bereich	high
34	Der Gewinn hilft der armen Familie aus ihrer Not.	armen	Familie	high
35	Gekochtes Huhn ist ein gutes Gericht für die Mittagszeit.	gutes	Gericht	high
36	Der Forscher begutachtet das fremde Zeichen in einer Höhle.	fremde	Zeichen	high
37	Der Minister gründet eine moderne Einheit zur Terrorbekämpfung.	moderne	Einheit	high
38	Der Angestellte schreibt den dritten Bericht an seinen Chef.	dritten	Bericht	high
39	Der Lehrer hat eine geringe Meinung von seinen Schülern.	geringe	Meinung	high
40	Der Anwalt streitet mit dem älteren Richter um das Strafmaß.	älteren	Richter	high

X.3.2 Items, Experiments 2 and 3: English natives & German natives with high English proficiency reading English

	Sentence	Adjective (N)	Noun (N+1)	Noun frequency
1	The colleague helps the dirty plumber in the bathroom.	dirty	plumber	low
2	The manager praises the honest cashier for his sincerity.	honest	cashier	low
3	Most insurers recommend a thick padlock for protection.	thick	padlock	low
4	The detective observes the lucky gambler in the casino.	lucky	gambler	low
5	The viewers fear the bloody vampire in the movie.	bloody	vampire	low
6	The boy puts the yellow sticker into his little bag.	yellow	sticker	low
7	The old chef buys a cheap pumpkin for the soup.	cheap	pumpkin	low
8	Many visitors love the rural brewery for its tasty beer.	rural	brewery	low
9	The child sees the awful phantom in his dreams.	awful	phantom	low
10	The mother helps a tired swimmer in the stormy lake.	tired	swimmer	low
11	The company regrets the active boycott of their products.	active	boycott	low
12	The girl imagines a pretty unicorn in her daydream.	lovely	unicorn	low
13	The beginner worries about a loose binding on his skis.	loose	binding	low
14	The judge treats the guilty suspect with respect.	guilty	suspect	low
15	The carpenter cuts a wooden collage in the morning.	wooden	collage	low
16	The couple feeds the hungry pilgrim with brown bread.	hungry	pilgrim	low
17	The woman fears the angry terrier for good reason.	angry	terrier	low
18	The coach teaches stupid tactics to the team.	stupid	tactics	low
19	The prisoner lived in the square dungeon for decades.	square	dungeon	low
20	Some children enjoy sweet caramel every day.	sweet	caramel	low
21	The group laughs about the funny picture on the wall.	funny	picture	high
22	The mayor talks about urban poverty in the lecture.	urban	poverty	high
23	The politician promises proper housing for every citizen.	proper	housing	high
24	The tourists bring some vital culture to the city.	vital	culture	high
25	The strong worker operates the solid machine with ease.	solid	machine	high

26	The pupils ignore the silly teacher in the classroom.	silly	teacher	high
27	The lawyer sends a formal message to his client.	formal	message	high
28	The employee expresses a minor concern to his boss.	minor	concern	high
29	Influenza is an annual disease for many people.	annual	disease	high
30	The passenger meets the tough captain in the restaurant.	tough	captain	high
31	The man has brief contact with his former wife.	brief	contact	high
32	The broker had quick success with his shares.	quick	success	high
33	The young artist creates a rough pattern in his studio.	rough	pattern	high
34	The new factory brought rapid welfare to the people.	rapid	welfare	high
35	Married couples have a legal benefit in their taxation.	legal	benefit	high
36	A young boy asks the silent officer for help.	silent	officer	high
37	Tidy people always want a clean kitchen in their house.	clean	kitchen	high
38	The janitor opens the closed station in the morning.	closed	station	high
39	The professor kisses the pretty student in a pub.	pretty	student	high
40	The sister helps the naked brother with his clothes.	naked	brother	high

X.3.3 Füllersätze, Experimente 1-3

Die Füllersätze entsprechen im Wesentlichen denen der Experimente, die im Appendix zu den Kapiteln III und IV beschrieben sind.

X.3.4 Häufigkeiten und visuelle Ähnlichkeit der Majuskeln im Vergleich mit den Minuskeln (Schriftart: Courier New, bold) in den Experimenten 1 (Deutsch) und 2/3 (Englisch)

	Deutsches Experiment			Englisches Experiment		
Nummer	Häufigkeit	Majuskel	Minuskel	Häufigkeit	Majuskel	Minuskel
1	2	A	a	5	b	B
2	4	B	b	7	c	C
3	3	E	e	2	d	D
4	3	F	f	1	g	G
5	6	G	g	1	h	H
6	1	H	h	1	k	K
7	1	J	j	2	m	M
8	4	K	k	1	o	O
9	3	M	m	8	p	P
10	1	P	p	6	s	S
11	1	R	r	3	t	T
12	3	S	s	1	u	U
13	2	T	t	1	v	V
14	1	V	v	1	w	W
15	2	W	w			
16	3	Z	z			
Summe	40			40		

XI. Danksagung

Ich bedanke mich bei all denjenigen, die mich unterstützt haben, die mir mit Rat und Tat zur Seite standen und die mir gut zugeredet haben.

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