Der Gedächtnisvorteil für Belebtes gegenüber Unbelebtem: Eine Analyse der zugrunde-liegenden kognitiven Mechanismen

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Zusammenfassung

Der Begriff des Belebtheitseffekts bezieht sich auf den Gedächtnisvorteil für Wörter, die Belebtes bezeichnen, gegenüber Wörtern, die Unbelebtes bezeichnen. Belebtes besonders gut zu erinnern, könnte in unserer Evolutionsgeschichte adaptive Funktionen erfüllt haben. Die kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, sind bislang jedoch ungeklärt. Die reichhaltige Enkodierung und die attentionale Priorisierung wurden bei der Entdeckung des Belebtheitseffekts als potenzielle kognitive Mechanismen vorgeschlagen und werden seitdem breit diskutiert. Das Ziel der vorliegenden Dissertation ist es, eine fundierte Bewertung der Beiträge dieser Mechanismen zum Belebtheitseffekt zu ermöglichen. Dem kognitiven Mechanismus der reichhaltigen Enkodierung zufolge werden belebte Wörter besser erinnert als unbelebte Wörter, weil belebte Wörter bei der Enkodierung besonders viele Ideen stimulieren, die als Abrufhinweise die freie Reproduktion der Wörter erleichtern. Dem kognitiven Mechanismus der attentionalen Priorisierung zufolge werden belebte Wörter besser erinnert als unbelebte Wörter, weil belebte Wörter Aufmerksamkeitsressourcen auf Kosten von unbelebten Wörtern beanspruchen. In den Experimenten 1.1 und 1.2 wurde die von diesen beiden kognitiven Erklärungsansätzen implizierte Annahme geprüft, dass dem Belebtheitseffekt eine detailliertere Erinnerung und keine erhöhte Vertrautheit belebter Wörter im Vergleich zu unbelebten Wörtern zugrunde liegt. Multinomiale Modellierungen der Qualität der Erinnerung belebter und unbelebter Wörter zeigten, dass der Belebtheitsstatus der Wörter nicht alle Prozesse, die den subjektiven Urteilen in der Remember-Know-Guess-Prozedur oder der objektiven Aufgabenperformanz in der Prozessdissoziationsprozedur zugrunde liegen, in gleichem Maße beeinflusst, sondern selektiv den Prozess der detaillierten Erinnerung. Um Schlussfolgerungen über die kausalen Beiträge einer reichhaltigeren Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern sowie einer attentionalen Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern zum Belebtheitseffekt in der freien Reproduktion ziehen zu können, wurden die Reichhaltigkeit der Enkodierung und die Möglichkeit zur attentionalen Priorisierung experimentell manipuliert. Obwohl die Teilnehmenden spontan mehr Ideen zu belebten als zu unbelebten Wörtern berichteten, war der Belebtheitseffekt in keinem der Experimente 2.1 bis 2.4 in Bedingungen, die eine reichhaltige Enkodierung der Wörter fördern, größer als in Bedingungen, die eine reichhaltige Enkodierung der Wörter restringieren. Die Befunde liefern somit Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt. Obwohl die Möglichkeit zur attentionalen Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern sowohl zum Zeitpunkt der Enkodierung als auch während des Aufrechterhaltungsprozesses und sowohl unter der Wirkung als auch unter dem Ausschluss intentionaler Lernstrategien manipuliert wurde, war der Belebtheitseffekt in keinem der Experimente 3.1 bis 3.3 in Bedingungen, die eine attentionale Priorisierung ermöglichen, größer als in Bedingungen, die eine attentionale Priorisierung nicht ermöglichen. Die Befunde liefern somit Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt. Die Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung oder der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, muss daher zurückgewiesen werden.

Abstract

The animacy effect refers to the memory advantage for words denoting animate beings over words denoting inanimate objects. Remembering animate beings particularly well may have served adaptive functions in our evolutionary past. However, the cognitive mechanisms underlying the animacy effect have not yet been identified. Rich encoding and attentional prioritization were brought forward as potential cognitive mechanisms when the animacy effect was discovered and have since been widely discussed. The aim of the present dissertation is to provide a substantiated evaluation of the contributions of these mechanisms to the animacy effect. According to the cognitive mechanism of rich encoding, animate words are better remembered than inanimate words because animate words stimulate a particularly large number of ideas at encoding which serve as retrieval cues facilitating the free recall of the words. According to the cognitive mechanism of attentional prioritization, animate words are better remembered than inanimate words because animate words recruit attentional resources at the expense of inanimate words. In Experiments 1.1 and 1.2, the assumption implied by both of these cognitive accounts was tested that the animacy effect is driven by enhanced recollection but not by enhanced familiarity of animate words in comparison to inanimate words. Multinomial modeling of the quality of remembering animate and inanimate words showed that the animacy status of the words does not affect all processes underlying the subjective judgments in the remember-know-guess paradigm or the objective task performance in the process-dissociation procedure to the same extent but selectively affects the process of recollection. In order to draw conclusions about the causal contributions of a richer encoding of animate words in comparison to inanimate words and of an attentional prioritization of animate words at the expense of inanimate words to the animacy effect in free recall, the richness of encoding and the possibility for the attentional prioritization were experimentally manipulated. Although participants reported more ideas in response to animate than in response to inanimate words, in none of the Experiments 2.1 to 2.4 was the animacy effect larger in conditions that facilitate a rich encoding of the words than in conditions that restrict a rich encoding of the words. The findings thus provide evidence against a causal contribution of the cognitive mechanism of rich encoding to the animacy effect. Although the possibility for the attentional prioritization of animate words at the expense of inanimate words was manipulated both at the time of encoding and during the maintenance process and both under the effect and under the exclusion of intentional memorization strategies, in none of the Experiments 3.1 to 3.3 was the animacy effect larger in conditions that allow for an attentional prioritization than in conditions that do not allow for an attentional prioritization. The findings thus provide evidence against a causal contribution of the cognitive mechanism of attentional prioritization to the animacy effect. Hence, the assumption that the cognitive mechanism of rich encoding or the cognitive mechanism of attentional prioritization underlies the animacy effect has to be rejected.

Einleitung

Überlegungen zur adaptiven Funktion des Gedächtnisses (Nairne & Pandeirada, 2016) erlauben es, eine Priorisierung belebter Information gegenüber unbelebter Information in der kognitiven Verarbeitung vorherzusagen. Obwohl die Unterscheidung zwischen Belebtem und Unbelebtem eine zentrale Stufe in der frühen kognitiven Entwicklung darstellt (Opfer & Gelman, 2011) und sich als grundlegend für die Wahrnehmung (Gao et al., 2009; Scholl & Tremoulet, 2000), die Aufmerksamkeit (Altman et al., 2016; New et al., 2007), den Aufbau von Sprache (Comrie, 1989; Gennari et al., 2012) und die neuronale Verarbeitung und Repräsentation (Caramazza & Shelton, 1998; Rogers et al., 2021; Thorpe et al., 1996) erwiesen hat, ist eine systematische Untersuchung des Effekts der Belebtheit auf das Gedächtnis lange ausgeblieben. Nairne et al. (2013) haben erstmalig systematisch nachgewiesen, dass der Belebtheitsstatus eines Wortes in erheblichem Maße determiniert, ob das Wort in einem freien Reproduktionstest erinnert wird oder nicht (siehe auch Aka et al., 2021; Madan, 2021). Der *Belebtheitseffekt* (engl. *animacy effect*) bezeichnet den Gedächtnisvorteil für Belebtes (Lebewesen wie Frosch oder Matrose) gegenüber Unbelebtem (Objekte wie Umhang oder Zange). Wörter, die Belebtes bezeichnen (fortan belebte Wörter), werden auch dann besser erinnert als Wörter, die Unbelebtes bezeichnen (fortan unbelebte Wörter), wenn zahlreiche andere gedächtnisrelevante Worteigenschaften wie die Vorstellbarkeit oder die Konkretheit zwischen belebten und unbelebten Wörtern konstant gehalten werden. Der Belebtheitseffekt zählt zu den robustesten Phänomenen des adaptiven Gedächtnisses (ein Überblick findet sich bei Nairne et al., 2017). Trotz der Robustheit dieses Effekts sind die kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, bislang weitgehend ungeklärt. Eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern sowie eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern gelten als aussichtsreiche Kandidaten (siehe auch Nairne et al., 2013) für die kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen. Das Ziel der vorliegenden Dissertation ist es, eine fundierte Bewertung der Beiträge dieser Mechanismen zum Belebtheitseffekt zu ermöglichen.

Der Belebtheitseffekt ist seit seiner erstmaligen Beschreibung in der wissenschaftlichen Literatur (Nairne et al., 2013) unter verschiedenen experimentellen Bedingungen repliziert worden: Belebtes und Unbelebtes werden typischerweise über die Präsentation von belebten und unbelebten Wörtern enkodiert (wie in etwa 96 % der für diese Berechnung ausgewählten Experimente[1]). Neben einem Belebtheitseffekt unter Verwendung von englischem Wortmaterial (z. B. Popp & Serra, 2016) wie in der Studie von Nairne et al. (2013) zeigte sich der Effekt mit französischem (z. B. Bonin et al., 2014), chinesischem (z. B. Li et al., 2016), deutschem (z. B. Meinhardt et al., 2018) und portugiesischem Wortmaterial (z. B. Félix et al., 2019). Der Belebtheitseffekt wurde auch beobachtet, wenn bei der Enkodierung Strichzeichnungen, die Belebtes oder Unbelebtes visualisieren (Bonin et al., 2014), oder Pseudowörter präsentiert wurden, denen Merkmale zugeschrieben

[1] Am 9. März 2024 wurde eine Literaturrecherche durchgeführt, um in wissenschaftlichen Fachzeitschriften publizierte Studien zu identifizieren, in denen der Belebtheitseffekt in einem freien Reproduktionstest gemessen wurde. Diese Suche ergab 25 Studien mit insgesamt 53 Experimenten. Die Experimente der Einzelarbeiten 2 und 3 wurden in der Berechnung nicht berücksichtigt.

wurden, die charakteristisch für Belebtes oder Unbelebtes sind (VanArsdall et al., 2013). Der Belebtheitseffekt wurde nach intentionalem Enkodieren (z. B. Bonin et al., 2015; Félix et al., 2019; Gelin et al., 2017; Li et al., 2016; Meinhardt et al., 2018, 2020; Nairne et al., 2013; Popp & Serra, 2016, 2018; Rawlinson & Kelley, 2021; Serra, 2021; Serra & DeYoung, 2023a) und nach gerichtetem Vergessen (Murphy & Castel, 2022) sowie unter Verwendung diverser inzidenteller Enkodierungsaufgaben gefunden. Dazu zählen Aufgaben, die nur eine oberflächliche Verarbeitung der Wörter stimulieren (Leding, 2018), und solche, die eine tiefe Verarbeitung stimulieren, wie beispielsweise Aufgaben, in denen die Teilnehmenden belebte und unbelebte Wörter hinsichtlich ihres Belebtheitsstatus kategorisieren (z. B. Bonin et al., 2014; Bonin et al., 2015; Gelin et al., 2019), hinsichtlich ihrer Angenehmheit (z. B. Félix et al., 2019; Gelin et al., 2017; Leding, 2018) oder hinsichtlich ihrer Relevanz für das Überleben einschätzen (Gelin et al., 2017; Leding, 2018), oder Aufgaben, in denen die Teilnehmenden Ideen zu belebten und unbelebten Wörtern aufschreiben (Bonin et al., 2022; Meinhardt et al., 2020). Abgesehen von spezifischen Randbedingungen (Kazanas et al., 2020; Mah et al., 2023; Popp & Serra, 2016; Serra & DeYoung, 2023b) hat sich gezeigt, dass der Belebtheitseffekt nicht nur in freien Reproduktionstests (z. B. Bonin et al., 2014; Bonin et al., 2015; Bonin et al., 2022; Félix et al., 2019; Gelin et al., 2017; Leding, 2018; Li et al., 2016; Meinhardt et al., 2018, 2020; Popp & Serra, 2016, 2018; Rawlinson & Kelley, 2021; Serra, 2021; Serra & DeYoung, 2023a), sondern auch unter anderen Testbedingungen zu finden ist: Der Belebtheitseffekt wurde in Rekognitionstests (z. B. Bonin et al., 2014; Bugaiska et al., 2016; Rawlinson & Kelley, 2021; aber siehe Leding, 2020), Quellengedächtnistests (Gelin et al., 2018; Mieth et al., 2019), seriellen Reproduktionstests (Daley et al., 2020), geförderten Reproduktionstests nach bestimmten Formen des Paar-Assoziations-Lernens (DeYoung & Serra, 2021; Lhoste et al., 2024; VanArsdall et al., 2015) und prospektiven Gedächtnisaufgaben (Félix et al., im Druck) beobachtet. Angesichts der Robustheit des Belebtheitseffekts unter einer solchen Bandbreite an experimentellen Bedingungen erscheint es umso erstaunlicher, dass die kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, bislang weitgehend ungeklärt sind.

Aus evolutionärer Perspektive sollte unser Gedächtnis durch den natürlichen Selektionsdruck geformt sein, dem unsere Vorfahren in der Evolutionsgeschichte ausgesetzt waren (Nairne & Pandeirada, 2008). Informationen, die die Lösung überlebensrelevanter Probleme begünstigen, sollten besonders gut erinnert werden (Nairne, 2010, 2015; Nairne & Pandeirada, 2016). Eine funktionale Analyse des Gedächtnisses erlaubt die Vorhersage des Belebtheitseffekts als Produkt eines *adaptiven Gedächtnisses* (Nairne et al., 2017; Nairne et al., 2013), da der Gedächtnisvorteil für Belebtes wie Feinde, Beute, Sexual- oder Sozialpartner:innen gegenüber Unbelebtem die adaptive Funktion hat, Verhalten des Vermeidens oder Annäherns zu unterstützen und so die Überlebens- und Fortpflanzungschancen zu erhöhen.

Zum umfassenden Verständnis des Belebtheitseffekts müssen jedoch nicht nur evolutionäre Erklärungsansätze, sondern auch kognitive Erklärungsansätze herangezogen werden (Scott-Phillips et al., 2011). Die größten Fortschritte in der Analyse der kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, sind erzielt worden, indem einige dieser Mechanismen ausgeschlossen wurden. Die Hypothesen, dass dem Belebtheitseffekt Unterschiede zwischen Belebtem und Unbelebtem in der emotionalen Erregung (Meinhardt et al., 2018), wahrgenommenen Bedrohung (Leding, 2019), bildhaften Vorstellung ohne Selbstbezug (Blunt & VanArsdall, 2021; Gelin et al., 2019) oder kategorialen Organisation (VanArsdall et al., 2017) zugrunde liegen, mussten auf Basis der empirischen Evidenz zurückgewiesen werden.

Als die beiden aussichtsreichsten Kandidaten (siehe auch Nairne et al., 2013) für die kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, gelten die reichhaltige Enkodierung und die attentionale Priorisierung. Unter Verwendung verwandter Termini finden sich in der wissenschaftlichen Literatur zahlreiche Verweise auf diese beiden kognitiven Mechanismen (z. B. Bonin et al., 2014; Bugaiska et al., 2019; Félix et al., 2019; Meinhardt et al., 2020; Mieth et al., 2019; Popp & Serra, 2016). Auf Basis der verfügbaren empirischen Evidenz können jedoch noch keine Schlussfolgerungen über die kausalen Beiträge dieser Mechanismen zum Belebtheitseffekt gezogen werden. Wird Belebtes reichhaltiger enkodiert als Unbelebtes und deshalb besser erinnert? Wird Belebtes auf Kosten von Unbelebtem attentional priorisiert und deshalb besser erinnert? Die Analyse der kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, wird in der vorliegenden Dissertation auf diese beiden Fragestellungen fokussiert.

Der kognitive Mechanismus der *reichhaltigen Enkodierung* wurde ursprünglich von Craik und Tulving (1975) beschrieben. Demnach wird die Wahrscheinlichkeit, ein Wort in einem freien Reproduktionstest zu erinnern, nicht nur von der Verarbeitungstiefe (Craik & Lockhart, 1972), sondern vielmehr von der semantischen Reichhaltigkeit der enkodierten Information bestimmt. Umfasst die Gedächtnisrepräsentation eines Wortes distinkte reichhaltig elaborierte Assoziationen wie Ideen oder Gedanken, so erleichtern diese Assoziationen als Abrufhinweise die freie Reproduktion dieses Wortes (Moscovitch & Craik, 1976). Basierend darauf haben Meinhardt et al. (2020) vorgeschlagen, dass belebte Wörter spontan reichhaltiger enkodiert werden als unbelebte Wörter. Sie operationalisierten die Reichhaltigkeit der Enkodierung mit der Anzahl der Ideen, die die Teilnehmenden spontan zu belebten und unbelebten Wörtern aufschreiben. Sofern die Teilnehmenden spontan mehr Ideen zu belebten Wörtern (wie beispielsweise Frosch) als zu unbelebten Wörtern (wie beispielsweise Zange) aufschreiben, könnten belebte Wörter deshalb in freien Reproduktionstests besser erinnert werden als unbelebte Wörter, weil für belebte Wörter mehr Abrufhinweise verfügbar sind. Die Teilnehmenden berichteten tatsächlich spontan mehr Ideen zu belebten als zu unbelebten Wörtern (siehe auch Bonin et al., 2022). Durch diesen Befund ist eine zentrale Implikation der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung zugrunde liegt, bestätigt worden. Unklar ist jedoch, ob die reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern für den Gedächtnisvorteil für belebte Wörter gegenüber unbelebten Wörtern verantwortlich ist. Um einen solchen Kausalzusammenhang zu prüfen, sind experimentelle Manipulationen des postulierten Kausalfaktors – hier der Reichhaltigkeit der Enkodierung – erforderlich.

Der kognitive Mechanismus der *attentionalen Priorisierung* bildet eine plausible Grundlage des Belebtheitseffekts, weil die Wahrscheinlichkeit, ein Wort in einem freien Reproduktionstest zu erinnern, von der Aufteilung der Aufmerksamkeitsressourcen auf die zu enkodierenden Wörter bestimmt wird (z. B. Cowan et al., 2024; Craik et al., 1996). Bugaiska et al. (2019) haben Evidenz dafür geliefert, dass bei der Verarbeitung belebter Wörter mehr Aufmerksamkeitsressourcen auf

Kosten der Verarbeitung anderer Information beansprucht werden als bei der Verarbeitung unbelebter Wörter. In einer dem Stroop-Test ähnlichen Aufgabe waren die Teilnehmenden langsamer, die Schriftfarbe von belebten Wörtern als die Schriftfarbe von unbelebten Wörtern zu klassifizieren. Zwar ist durch diesen Befund eine zentrale Implikation der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, bestätigt worden. Studien, in denen der postulierte Kausalfaktor – hier die Verfügbarkeit von Aufmerksamkeitsressourcen für eine attentionale Priorisierung – experimentell manipuliert wurde, haben jedoch inkonsistente Befunde geliefert: In zwei Studien, in denen das Doppelaufgabenparadigma (siehe Craik et al., 1996) verwendet wurde, war der Belebtheitseffekt unabhängig davon, ob die Aufmerksamkeitsressourcen auf die Enkodierungsaufgabe und eine Zweitaufgabe aufgeteilt werden mussten oder nicht (Bonin et al., 2015; Rawlinson & Kelley, 2021). In einer anderen Studie war der Belebtheitseffekt unter kognitiver Belastung durch eine Zweitaufgabe reduziert (Leding, 2019).

Angesichts des Mangels an Studien, die es erlauben, eine Schlussfolgerung über den kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt zu ziehen, sowie angesichts der inkonsistenten Befundlage bezüglich des kausalen Beitrags des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt (Bonin et al., 2015; Leding, 2019; Rawlinson & Kelley, 2021; siehe auch Popp & Serra, 2016) ist eine experimentelle Prüfung dieser beiden Erklärungsansätze erforderlich. Tatsächlich sind die beiden kognitiven Mechanismen insofern miteinander kompatibel, als dass eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern einer reichhaltigeren Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern vorangehen könnte (ähnliche Argumentationen finden sich bei Meinhardt et al., 2020; Mieth et al., 2019). Dennoch erlaubt jeder der beiden kognitiven Mechanismen, spezifische Hypothesen abzuleiten, die der jeweils andere kognitive Mechanismus nicht abzuleiten erlaubt. Der kognitive Mechanismus der reichhaltigen Enkodierung erlaubt zum Beispiel die Ableitung der Hypothese, dass der Belebtheitseffekt durch eine experimentelle Manipulation der Anzahl der aufzuschreibenden Ideen zu belebten und unbelebten Wörtern moduliert werden sollte. Der kognitive Mechanismus der attentionalen Priorisierung erlaubt hingegen zum Beispiel die Ableitung der Hypothese, dass der Belebtheitseffekt durch eine experimentelle Manipulation der Zusammensetzung der Listen zu enkodierender Wörter, also ob belebte und unbelebte Wörter gemeinsam oder getrennt präsentiert werden, moduliert werden sollte.

Um den Belebtheitseffekt genauer zu charakterisieren und eine zentrale Implikation der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung oder der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, zu prüfen, wird in der vorliegenden Dissertation zunächst untersucht, ob Unterschiede zwischen belebten und unbelebten Wörtern in der Qualität der Erinnerung bestehen (Experimente 1.1 und 1.2). Anschließend werden die Reichhaltigkeit der Enkodierung und die Möglichkeit zur attentionalen Priorisierung experimentell manipuliert, um Schlussfolgerungen über die kausalen Beiträge einer reichhaltigeren Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern (Experimente 2.1 bis 2.4) sowie einer attentionalen Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern (Experimente 3.1 bis 3.3) zum Belebtheitseffekt ziehen zu können.

Multinomiale Modellierungen der Qualität der Erinnerung

Der Belebtheitseffekt hat sich als außerordentlich robust in freien Reproduktionstests erwiesen (z. B. Bonin et al., 2014; Bonin et al., 2015; Bonin et al., 2022; Félix et al., 2019; Gelin et al., 2017; Leding, 2018; Li et al., 2016; Meinhardt et al., 2018, 2020; Popp & Serra, 2016, 2018; Rawlinson & Kelley, 2021; Serra, 2021; Serra & DeYoung, 2023a), in denen die Teilnehmenden gebeten werden, möglichst viele der zuvor präsentierten belebten und unbelebten Wörter wiederzugeben. Der Effekt scheint allerdings weniger robust in Rekognitionstests zu sein, in denen zuvor präsentierte und zuvor nicht präsentierte belebte und unbelebte Wörter einzeln gezeigt werden und die Teilnehmenden gebeten werden zu beurteilen, ob das jeweilige Wort alt oder neu ist. Die Befunde einiger Studien deuten darauf hin, dass belebte Wörter besser wiedererkannt werden als unbelebte Wörter (z. B. Bonin et al., 2014; Bugaiska et al., 2016; Gelin et al., 2018; Rawlinson & Kelley, 2021), andere Studien haben jedoch dazu inkonsistente Befunde geliefert (Leding, 2020; Mieth et al., 2019). Zum Beispiel deuten die Befunde von Leding (2020) darauf hin, dass in Rekognitionstests bei belebten Wörtern eher geraten wird, ob das Wort zuvor präsentiert worden ist, und dass der Belebtheitsstatus der Wörter nicht die Genauigkeit der Rekognition beeinflusst. Ein möglicher Grund für die inkonsistente Befundlage könnte sein, dass der Belebtheitsstatus der Wörter nicht alle Prozesse, die den im Rekognitionstest beobachtbaren Urteilen für alte und neue Wörter zugrunde liegen, in gleichem Maße beeinflusst. Durch das Dekomponieren der im Rekognitionstest beobachtbaren Urteile für alte und neue belebte und unbelebte Wörter in die zugrundeliegenden Prozesse kann jedoch eine zentrale Implikation der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung oder der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, geprüft werden.

In Zwei-Prozess-Theorien der Rekognition (z. B. Mandler, 1980) wird postuliert, dass zuvor präsentierte Wörter in Rekognitionstests auf Basis einer *detaillierten Erinnerung* (engl. *recollection*) oder auf Basis von *Vertrautheit* (engl. *familiarity*) wiedererkannt werden können (ein Überblick findet sich bei Yonelinas, 2002). Eine Rekognition auf Basis einer detaillierten Erinnerung ermöglicht es, Details des Kontexts der Enkodierung abzurufen. Eine Rekognition auf Basis von Vertrautheit umfasst lediglich ein vom Kontext der Enkodierung losgelöstes Gefühl, dass ein Wort zuvor präsentiert worden ist. Es wird angenommen, dass eine Rekognition auf Basis einer detaillierten Erinnerung Aufmerksamkeit während der Enkodierung und des Abrufs erfordert, eine solch kontrollierte Verarbeitung allerdings weniger erforderlich ist für eine Rekognition auf Basis von Vertrautheit (z. B. Gardiner & Parkin, 1990; Jacoby & Kelley, 1992).

Nur eine detaillierte Erinnerung an Belebtes wie einen Pfeilgiftfrosch hat die adaptive Funktion, die Überlebenschancen zu erhöhen, weil die Erinnerung daran, wann und wo eine Begegnung mit dem giftigen Tier stattgefunden hat, und weniger die kontextunabhängige Vertrautheit, dass eine Begegnung stattgefunden hat, zukünftiges Verhalten des Vermeidens unterstützen kann (ähnliche Argumentationen finden sich bei Kroneisen & Bell, 2018; Nairne & Pandeirada, 2008, 2016). Sowohl die Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung zugrunde liegt, als auch die Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, impliziert einen Effekt der Belebtheit auf die Qualität der Erinnerung. Wenn dem Belebtheitseffekt eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern zugrunde liegt (Bonin et al., 2022; Meinhardt et al., 2020), sollten die Teilnehmenden belebte Wörter in Rekognitionstests nicht auf Basis von Vertrautheit besser erinnern als unbelebte Wörter, sondern auf Basis der Erinnerung assoziierter Ideen, die den Teilnehmenden während der Enkodierung der Wörter spontan eingefallen sind. Wenn dem Belebtheitseffekt eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern zugrunde liegt (Bugaiska et al., 2019), sollte ebenfalls selektiv die detaillierte Erinnerung belebter Wörter verbessert sein und nicht die Vertrautheit.

Während in der Mehrheit der bislang publizierten Studien die Menge der erinnerten belebten und unbelebten Wörter gemessen wurde, wurde die Qualität der Erinnerung belebter und unbelebter Wörter in den Experimenten 1.1 und 1.2 (siehe Einzelarbeit 1) anhand subjektiver Urteile in der Remember-Know-Guess-Prozedur (Gardiner et al., 1997) beziehungsweise anhand objektiver Aufgabenperformanz in der Prozessdissoziationsprozedur (Jacoby, 1991) erfasst. Zur Trennung zwischen Gedächtnisprozessen und Rateprozessen wurden multinomiale Verarbeitungsbaummodelle (siehe Batchelder & Riefer, 1999; Erdfelder et al., 2009) verwendet, die bereits in vielen Bereichen der kognitiven Psychologie und Sozialpsychologie erfolgreich eingesetzt wurden (z. B. Bayen et al., 1996; Buchner et al., 1995; Erdfelder et al., 2007; Mieth et al., 2021; Smith & Bayen, 2004; Unkelbach & Stahl, 2009; Winter et al., 2022). So war es möglich, die Wahrscheinlichkeit der Rekognition auf Basis einer detaillierten Erinnerung und die Wahrscheinlichkeit der Rekognition auf Basis von Vertrautheit ohne detaillierte Erinnerung unabhängig von Rateprozessen aus beobachtbaren kategorialen Daten der Remember-Know-Guess-Prozedur (Erdfelder et al., 2007) oder der Prozessdissoziationsprozedur (Buchner et al., 1995) zu schätzen und zwischen belebten und unbelebten Wörtern zu vergleichen. Die Verwendung verschiedener experimenteller Prozeduren und die Anwendung validierter multinomialer Verarbeitungsbaummodelle ermöglichte es zu prüfen, ob dem Belebtheitseffekt eine detailliertere Erinnerung und keine erhöhte Vertrautheit belebter Wörter im Vergleich zu unbelebten Wörtern zugrunde liegt.

Experiment 1.1 – Remember-Know-Guess-Prozedur

Als Ausgangspunkt zur Prüfung des potenziellen Effekts der Belebtheit auf die Qualität der Erinnerung diente eine Reihe von Studien, in denen die Remember-Know-(Guess)-Prozedur (Gardiner et al., 1997) als Erweiterung des klassischen Alt-Neu-Rekognitionstests verwendet wurde (Bonin et al., 2014; Bugaiska et al., 2023; Bugaiska et al., 2016; Rawlinson & Kelley, 2021). Wenn ein Wort als alt beurteilt worden ist, werden die Teilnehmenden in dieser experimentellen Prozedur gebeten, ein Urteil über die Qualität ihrer Erinnerung zu fällen. Ein *Remember*-Urteil soll gefällt werden, wenn die Teilnehmenden Details des Kontexts der Enkodierung abrufen können (z. B. die Ideen, die ihnen spontan eingefallen sind, als sie das Wort gelesen haben). Ein *Know*-Urteil soll gefällt werden, wenn den Teilnehmenden das Wort vertraut erscheint, sie aber nicht in der Lage sind, Details des Kontexts der Enkodierung abzurufen. Ein *Guess*-Urteil soll gefällt werden, wenn die Teilnehmenden weder eine detaillierte Erinnerung haben noch ein Gefühl der Vertrautheit verspüren, sondern lediglich raten, dass das Wort zuvor präsentiert worden ist.

Bonin et al. (2014) beobachteten mehr Remember-Urteile für alte belebte Wörter als für alte unbelebte Wörter, die korrekt als alt beurteilt worden waren (siehe auch Bugaiska et al., 2023; Bugaiska et al., 2016; Rawlinson & Kelley, 2021). Die Häufigkeit der Know- und Guess-Urteile unterschied sich dagegen jeweils nicht zwischen alten belebten und alten unbelebten Wörtern, die korrekt als alt beurteilt worden waren. Im Gegensatz zu der Studie von Leding (2020), in der in einem klassischen Alt-Neu-Rekognitionstest neue belebte Wörter häufiger als neue unbelebte Wörter fälschlicherweise als alt beurteilt wurden, hatte der Belebtheitsstatus der neuen Wörter in der Studie von Bonin et al. (2014) weder einen Einfluss auf die Häufigkeit, mit der diese fälschlicherweise als alt beurteilt wurden, noch auf die Häufigkeit der jeweiligen Urteile über die Qualität der Erinnerung. Allerdings dürfen die Häufigkeiten der verschiedenen Urteile über die Qualität der Erinnerung belebter und unbelebter Wörter nicht als reine Maße der zugrundeliegenden Prozesse interpretiert werden (Erdfelder et al., 2007). Zum Beispiel könnte einem Remember-Urteil für ein altes Wort, das korrekt als alt beurteilt wurde, entweder ein Gedächtnisprozess oder ein Rateprozess zugrunde liegen. Um zu prüfen, ob häufigeren Remember-Urteilen für alte belebte Wörter im Vergleich zu alten unbelebten Wörtern eine detailliertere Erinnerung belebter Wörter im Vergleich zu unbelebten Wörtern zugrunde liegt, wurde die Qualität der Erinnerung belebter und unbelebter Wörter in Experiment 1.1 auf Ebene der postulierten latenten Prozesse erfasst.

Das Wortmaterial bestand aus belebten und unbelebten Wörtern aus Schröder et al. (2012), zwischen denen zehn andere gedächtnisrelevante Worteigenschaften wie die Vorstellbarkeit oder die Konkretheit konstant gehalten wurden. Die Wörter wurden für jede teilnehmende Person in zwei Sets mit einer jeweils gleichen Anzahl von belebten und unbelebten Wörtern eingeteilt. In der inzidentellen Enkodierungsphase wurden die Teilnehmenden gebeten, belebte und unbelebte Wörter des ersten Sets hinsichtlich ihrer Belebtheit einzuschätzen. Nach einer kurzen Distraktoraufgabe wurden in der Testphase die nun alten belebten und unbelebten Wörter des ersten Sets sowie neue belebte und unbelebte Wörter des zweiten Sets präsentiert. Die Teilnehmenden wurden zunächst gebeten zu beurteilen, ob das Wort alt oder neu ist. Wenn ein Wort als alt beurteilt wurde, wurden die Teilnehmenden gemäß der Remember-Know-Guess-Prozedur (Gardiner et al., 1997) gebeten, zusätzlich ein Urteil über die Qualität ihrer Erinnerung zu fällen. Die Bezeichnungen der möglichen Urteile lauteten „Detaillierte Erinnerung“, „Gefühl der Vertrautheit“ und „Raten“. Um die Bedeutungen der einzelnen Urteile unmissverständlich zu vermitteln (siehe Umanath & Coane, 2020), wurden ausführliche Instruktionen präsentiert und auf wörtliche Übersetzungen der Bezeichnung des Remember-Urteils („ich erinnere mich“) und der Bezeichnung des Know-Urteils („ich weiß es“) verzichtet.

Zur Datenanalyse wurde das validierte *multinomiale Verarbeitungsbaummodell für die Remember-Know-Guess-Prozedur* (engl. *four-states model of memory retrieval experiences*) von Erdfelder et al. (2007) angewendet, um klar zwischen der Rekognition alter Wörter auf Basis einer detaillierten Erinnerung, der Rekognition alter Wörter auf Basis von Vertrautheit ohne detaillierte Erinnerung, verschiedenen Rateprozessen und der Detektion neuer Wörter zu trennen. Die Modellstruktur wird in Abbildung 1 visualisiert und beschrieben.

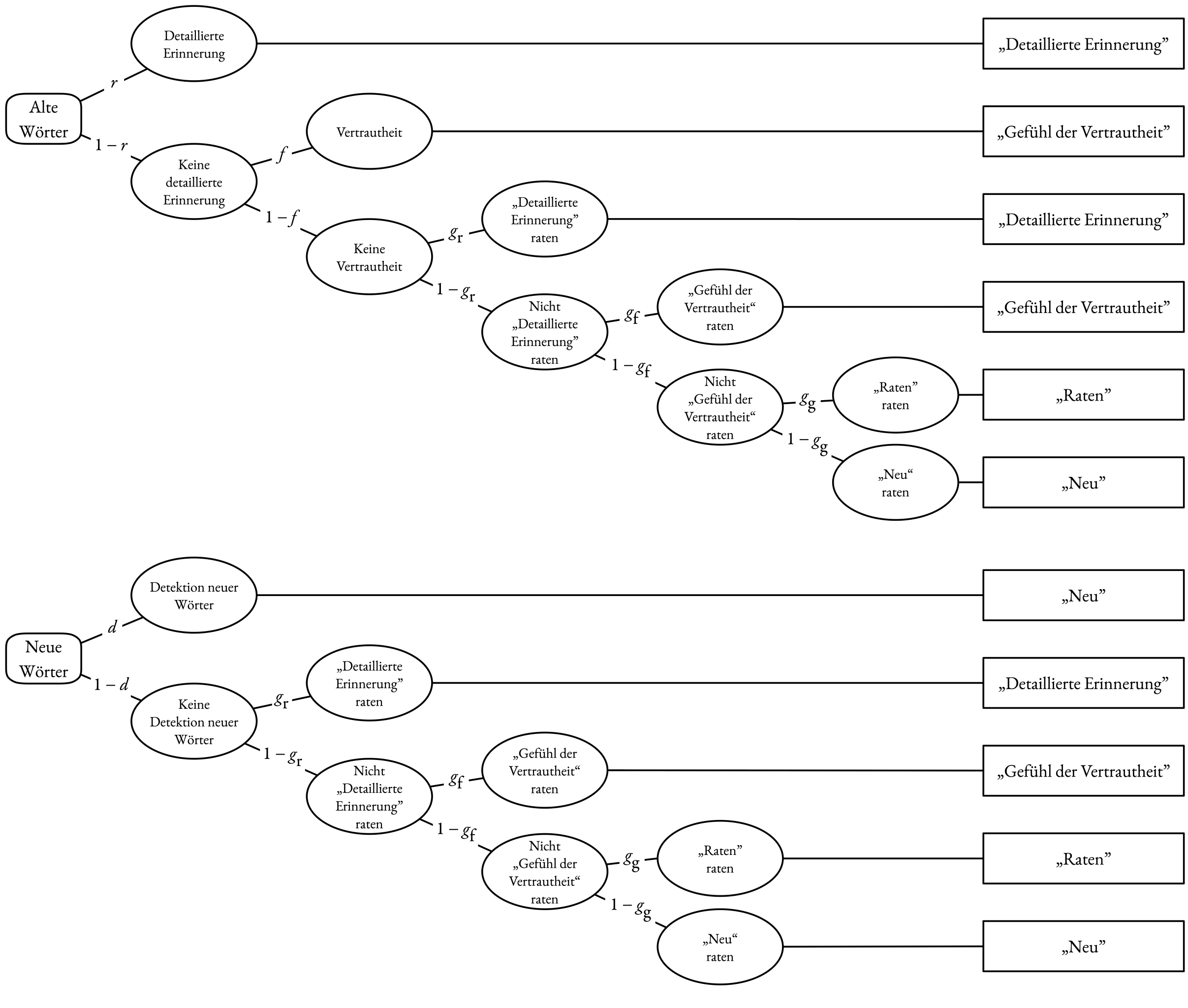

Abbildung 1. Grafische Darstellung des multinomialen Verarbeitungsbaummodells für die Remember-Know-Guess-Prozedur von Erdfelder et al. (2007), adaptiert für Experiment 1.1. Die abgerundeten Rechtecke auf der linken Seite repräsentieren die Wörter des Rekognitionstests. Die Rechtecke auf der rechten Seite repräsentieren die Kategorien der in der Remember-Know-Guess-Prozedur (Gardiner et al., 1997) beobachtbaren Urteile (an die deutsche Sprache angepasst). Die Modellparameter entlang der Äste repräsentieren die Wahrscheinlichkeiten der postulierten latenten Prozesse. Der Modellbaum oben repräsentiert die postulierten latenten Prozesse, die den beobachtbaren Urteilen für alte Wörter zugrunde liegen. Ein altes Wort wird mit der Wahrscheinlichkeit r auf Basis einer detaillierten Erinnerung wiedererkannt, was zu einem Detaillierte-Erinnerung-Urteil führt. Wenn ein altes Wort nicht auf Basis einer detaillierten Erinnerung wiedererkannt wird, was mit der Wahrscheinlichkeit $1 - r$ geschieht, wird das Wort mit der Wahrscheinlichkeit f auf Basis von Vertrautheit wiedererkannt, was zu einem Gefühl-der-Vertrautheit-Urteil führt. Wenn ein altes Wort weder auf Basis einer detaillierten Erinnerung noch auf Basis von Vertrautheit ohne detaillierte Erinnerung wiedererkannt wird, was mit der Wahrscheinlichkeit $(1 - r) \cdot (1 - f)$ geschieht, führen auch Rateprozesse mit der Wahrscheinlichkeit g_r zu einem Detaillierte-Erinnerung-Urteil, mit der Wahrscheinlichkeit g_f zu einem Gefühl-der-Vertrautheit-Urteil oder mit der Wahrscheinlichkeit g_g zu einem Raten-Urteil. Alternativ wird für ein altes Wort mit der Wahrscheinlichkeit $1 - g_g$ ein Neu-Urteil gefällt. Der Modellbaum unten repräsentiert die postulierten latenten Prozesse, die den beobachtbaren Urteilen für neue Wörter zugrunde liegen. Ein neues Wort wird mit der Wahrscheinlichkeit d als neu detektiert, was zu einem Neu-Urteil führt. Wenn ein neues Wort nicht als neu detektiert wird, was mit der Wahrscheinlichkeit $1 - d$ geschieht, werden die gleichen Rateprozesse angenommen wie für alte Wörter.

Um zu prüfen, ob der Belebtheitsstatus der Wörter die Modellparameter beeinflusst, wurden zwei Exemplare des in Abbildung 1 visualisierten Modells benötigt, ein Exemplar für belebte Wörter, ein Exemplar für unbelebte Wörter. Wenn dem Belebtheitseffekt eine detailliertere Erinnerung belebter Wörter im Vergleich zu unbelebten Wörtern zugrunde liegt, dann sollte selektiv die Wahrscheinlichkeit der Rekognition alter Wörter auf Basis einer detaillierten Erinnerung (Modellparameter r) höher sein für belebte als für unbelebte Wörter.

Zunächst wurde angenommen, dass sich die Wahrscheinlichkeit, auf Basis eines Rateprozesses ein Detaillierte-Erinnerung-Urteil zu fällen (Modellparameter g_r), auf Basis eines Rateprozesses ein Gefühl-der-Vertrautheit-Urteil zu fällen (Modellparameter g_f) und auf Basis eines Rateprozesses ein Raten-Urteil zu fällen (Modellparameter g_g), jeweils nicht zwischen belebten und unbelebten Wörtern unterscheidet. Das Modell mit diesen Parameterrestriktionen wies eine gute Modellpassung auf und wurde als Basismodell verwendet. Die Wahrscheinlichkeit der Rekognition alter Wörter auf Basis einer detaillierten Erinnerung (Modellparameter r) war signifikant höher für belebte als für unbelebte Wörter. Die Wahrscheinlichkeit der Rekognition alter Wörter auf Basis von Vertrautheit ohne detaillierte Erinnerung (Modellparameter f) unterschied sich dagegen nicht signifikant zwischen belebten und unbelebten Wörtern. Der Belebtheitseffekt war nicht beschränkt auf die Rekognition alter Wörter auf Basis einer detaillierten Erinnerung, sondern die Wahrscheinlichkeit der Detektion neuer Wörter (Modellparameter d) war ebenfalls signifikant höher für belebte als für unbelebte Wörter (siehe Glanzer & Adams, 1985). Experiment 1.1 liefert daher Evidenz für eine detailliertere Erinnerung belebter Wörter im Vergleich zu unbelebten Wörtern. Zugleich gibt es keine Evidenz dafür, dass für belebte Wörter die Wahrscheinlichkeit erhöht ist, auf Basis eines Rateprozesses ein Detaillierte-Erinnerung-Urteil zu fällen.

Eine mögliche Limitation des Experiments 1.1 ist, dass die Urteile über die Qualität der Erinnerung auf Introspektion beruhen und damit von den Teilnehmenden beim Fällen dieser Urteile ein direkter Zugang zu der Qualität ihrer Erinnerung verlangt wird. Da die Teilnehmenden beim Fällen dieser Urteile über die Qualität ihrer eigenen Erinnerung nachdenken müssen, können diese Urteile als metakognitive Urteile angesehen werden. Metakognitive Urteile sind jedoch anfällig für metakognitive Illusionen (z. B. Bell et al., 2023; Rhodes & Castel, 2008). Illustriert sei dies anhand von Befunden, die gezeigt haben, dass emotionale Information im Vergleich zu neutraler Information oft mit einem intensiveren subjektiven Erleben detaillierter Erinnerung assoziiert ist, auch wenn die objektive Detailliertheit der Erinnerung emotionaler Information im Vergleich zu neutraler Information nicht erhöht ist (z. B. Rimmele et al., 2011; Sharot et al., 2004; Talarico & Rubin, 2003). Obwohl die modellbasierte Datenanalyse es ermöglicht, die Qualität der Erinnerung unabhängig von Rateprozessen zu erfassen, ist es denkbar, dass korrekt wiedererkannte belebte Wörter lebhafter erlebt werden als korrekt wiedererkannte unbelebte Wörter und die Teilnehmenden dies als Hinweis auf eine detailliertere Erinnerung fehlinterpretieren. Um eine klare Schlussfolgerung darüber ziehen zu können, ob dem Belebtheitseffekt eine detailliertere Erinnerung belebter Wörter im Vergleich zu unbelebten Wörtern zugrunde liegt, ist es deshalb noch überzeugender, eine multinomiale Modellierung der Qualität der Erinnerung nicht nur anhand subjektiver Urteile, sondern auch anhand objektiver Aufgabenperformanz vorzunehmen.

Experiment 1.2 – Prozessdissoziationsprozedur

In Experiment 1.2 sollte die Qualität der Erinnerung anhand der objektiven Fähigkeit der Teilnehmenden erfasst werden, den spezifischen Instruktionen des Rekognitionstests zu folgen und zwischen in verschiedenen Kontexten enkodierten Wörtern zu diskriminieren. Im Rekognitionstest der Prozessdissoziationsprozedur (Jacoby, 1991) werden nämlich drei Arten von Wörtern präsentiert: Kritische Wörter, die in einer ersten Enkodierungsphase (Phase 1) präsentiert wurden, Wörter, die in einer zweiten Enkodierungsphase (Phase 2) präsentiert wurden, und neue Wörter, die zuvor nicht präsentiert wurden. Eine Gruppe von Teilnehmenden absolviert den *Inklusionstest* und wird instruiert, Wörter als alt zu beurteilen, die in der ersten oder zweiten Enkodierungsphase präsentiert wurden (kritische Wörter aus Phase 1 sollen im Inklusionstest inkludiert werden), und Wörter als neu zu beurteilen, die zuvor nicht präsentiert wurden. Eine andere Gruppe von Teilnehmenden absolviert den *Exklusionstest* und wird instruiert, nur Wörter als alt zu beurteilen, die in der zweiten Enkodierungsphase präsentiert wurden, und Wörter als neu zu beurteilen, die in der ersten Enkodierungsphase präsentiert wurden (kritische Wörter aus Phase 1 sollen im Exklusionstest exkludiert werden) oder zuvor nicht präsentiert wurden. Unter der Berücksichtigung, dass Urteile im Rekognitionstest der Prozessdissoziationsprozedur auch durch Rateprozesse zustande kommen können (Buchner et al., 1995), können folgende Annahmen über die Qualität der Erinnerung getroffen werden (Jacoby, 1991): Eine detaillierte Erinnerung fördert korrekte Alt-Urteile für kritische Wörter aus Phase 1 im Inklusionstest und hemmt falsche Alt-Urteile für diese Wörter im Exklusionstest. Vertrautheit ohne detaillierte Erinnerung fördert dagegen Alt-Urteile für kritische Wörter aus Phase 1 unabhängig davon, ob diese Urteile im Inklusionstest korrekt sind oder im Exklusionstest falsch sind.

Das Wortmaterial aus Experiment 1.1 wurde in Experiment 1.2 geringfügig modifiziert, um die Wörter für jede teilnehmende Person in drei Sets mit einer jeweils gleichen Anzahl von belebten und unbelebten Wörtern einteilen zu können. In der ersten inzidentellen Enkodierungsphase wurden die Teilnehmenden gebeten, belebte und unbelebte Wörter des ersten Sets, dargestellt in blauer Schriftfarbe, hinsichtlich ihrer Belebtheit einzuschätzen. In der zweiten intentionalen Enkodierungsphase wurden die Teilnehmenden gebeten, belebte und unbelebte Wörter des zweiten Sets, dargestellt in roter Schriftfarbe, auswendig zu lernen. Nach einer kurzen Distraktoraufgabe wurden in der Testphase die belebten und unbelebten Wörter aus der ersten und zweiten Enkodierungsphase sowie neue belebte und unbelebte Wörter des dritten Sets, alle dargestellt in schwarzer Schriftfarbe, präsentiert. Gemäß der Prozessdissoziationsprozedur (Jacoby, 1991) wurden im Rekognitionstest die spezifischen Instruktionen des Inklusionstests oder des Exklusionstests erteilt.

Die Qualität der Erinnerung belebter und unbelebter Wörter wurde in Experiment 1.2 unter Anwendung der validierten Zwei-Hochschwellen-Variante (siehe Erdfelder & Buchner, 1995) des *multinomialen Verarbeitungsbaummodells für die Prozessdissoziationsprozedur* (engl. *multinomial process-dissociation model*) von Buchner et al. (1995) erfasst, um klar zwischen der Rekognition kritischer Wörter aus Phase 1 auf Basis einer detaillierten Erinnerung, der Rekognition kritischer Wörter aus Phase 1 auf Basis von Vertrautheit ohne detaillierte Erinnerung, verschiedenen Rateprozessen und der Detektion neuer Wörter zu trennen. Die Modellstruktur wird in Abbildung 2 visualisiert und beschrieben.

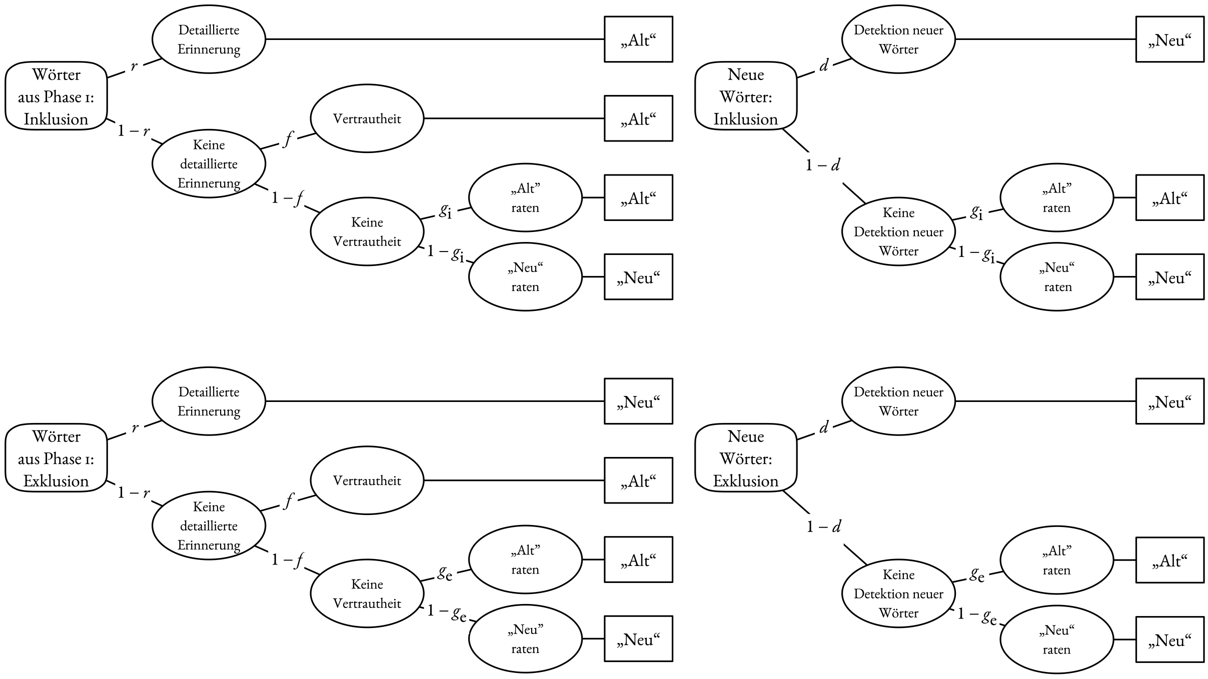

Abbildung 2. Grafische Darstellung der Zwei-Hochschwellen-Variante (siehe Erdfelder & Buchner, 1995) des multinomialen Verarbeitungsbaummodells für die Prozessdissoziationsprozedur von Buchner et al. (1995), adaptiert für Experiment 1.2. Die abgerundeten Rechtecke auf der linken Seite repräsentieren die Wörter des Rekognitionstests. Die Rechtecke auf der rechten Seite repräsentieren die Kategorien der in der Prozessdissoziationsprozedur (Jacoby, 1991) beobachtbaren Urteile. Die Modellparameter entlang der Äste repräsentieren die Wahrscheinlichkeiten der postulierten latenten Prozesse. Der Modellbaum oben links repräsentiert die postulierten latenten Prozesse, die den im Inklusionstest beobachtbaren Urteilen für Wörter aus Phase 1 zugrunde liegen. Ein Wort aus Phase 1 wird mit der Wahrscheinlichkeit r auf Basis einer detaillierten Erinnerung wiedererkannt. Da ein Wort aus Phase 1 im Inklusionstest inkludiert werden soll, führt dieser Prozess zu einem korrekten Alt-Urteil. Wenn ein Wort aus Phase 1 nicht auf Basis einer detaillierten Erinnerung wiedererkannt wird, was mit der Wahrscheinlichkeit $1 - r$ geschieht, wird das Wort mit der Wahrscheinlichkeit f auf Basis von Vertrautheit wiedererkannt, was ebenfalls zu einem korrekten Alt-Urteil führt. Wenn ein Wort aus Phase 1 weder auf Basis einer detaillierten Erinnerung noch auf Basis von Vertrautheit ohne detaillierte Erinnerung wiedererkannt wird, was mit der Wahrscheinlichkeit $(1 - r) \cdot (1 - f)$ geschieht, führt ein Rateprozess mit der Wahrscheinlichkeit g_i zu einem Alt-Urteil oder mit der Wahrscheinlichkeit $1 - g_i$ zu einem Neu-Urteil. Der Modellbaum unten links repräsentiert die postulierten latenten Prozesse, die den im Exklusionstest beobachtbaren Urteilen für Wörter aus Phase 1 zugrunde liegen. Ein Wort aus Phase 1 wird mit der Wahrscheinlichkeit r auf Basis einer detaillierten Erinnerung wiedererkannt. Da ein Wort aus Phase 1 im Exklusionstest exkludiert werden soll, führt dieser Prozess zu einem korrekten Neu-Urteil. Wenn ein Wort aus Phase 1 nicht auf Basis einer detaillierten Erinnerung wiedererkannt wird, was mit der Wahrscheinlichkeit $1 - r$ geschieht, wird das Wort mit der Wahrscheinlichkeit f auf Basis von Vertrautheit wiedererkannt, was zu einem falschen Alt-Urteil führt. Wenn ein Wort aus Phase 1 weder auf Basis einer detaillierten Erinnerung noch auf Basis von Vertrautheit ohne detaillierte Erinnerung wiedererkannt wird, was mit der Wahrscheinlichkeit $(1 - r) \cdot (1 - f)$ geschieht, führt ein Rateprozess mit der Wahrscheinlichkeit g_e zu einem Alt-Urteil oder mit der Wahrscheinlichkeit $1 - g_e$ zu einem Neu-Urteil. Die Modellbäume rechts repräsentieren die postulierten latenten Prozesse, die den im Inklusionstest beziehungsweise im Exklusionstest beobachtbaren Urteilen für neue Wörter zugrunde liegen. Ein neues Wort wird mit der Wahrscheinlichkeit d als neu detektiert, was zu einem Neu-Urteil führt. Wenn ein neues Wort nicht als neu detektiert wird, was mit der Wahrscheinlichkeit $1 - d$ geschieht, werden die gleichen Rateprozesse angenommen wie für Wörter aus Phase 1. Die postulierten latenten Prozesse, die den beobachtbaren Urteilen für Wörter aus Phase 2 zugrunde liegen, werden typischerweise nicht analysiert (siehe Buchner et al., 1995; Erdfelder & Buchner, 1995; Jacoby, 1991).

Im Gegensatz zur Ein-Hochschwellen-Variante des Modells von Buchner et al. (1995), die lediglich die Annahme eines Rateprozesses für neue Wörter beinhaltet, beinhaltet die Zwei-Hochschwellen-Variante des Modells zusätzlich die Annahme eines Detektionsprozesses für neue Wörter. Erdfelder und Buchner (1995) haben gezeigt, dass die Zwei-Hochschwellen-Variante eine noch bessere Modellpassung aufweist als die Ein-Hochschwellen-Variante, was mit dem üblichen Ergebnismuster aus Validierungsstudien kompatibel ist (siehe Bayen et al., 1996; Snodgrass & Corwin, 1988). Um zu prüfen, ob der Belebtheitsstatus der Wörter die Modellparameter beeinflusst, wurden zwei Exemplare des in Abbildung 2 visualisierten Modells benötigt, ein Exemplar für belebte Wörter, ein Exemplar für unbelebte Wörter. Wenn dem Belebtheitseffekt eine detailliertere Erinnerung belebter Wörter im Vergleich zu unbelebten Wörtern zugrunde liegt, dann sollte selektiv die Wahrscheinlichkeit der Rekognition kritischer Wörter aus Phase 1 auf Basis einer detaillierten Erinnerung (Modellparameter r) höher sein für belebte als für unbelebte Wörter.

Um ein identifizierbares Basismodell zu erhalten, wurde zunächst dem Vorschlag von Erdfelder und Buchner (1995) folgend die Annahme implementiert, dass sich die Wahrscheinlichkeit der Rekognition kritischer Wörter aus Phase 1 auf Basis einer detaillierten Erinnerung (Modellparameter r) nicht von der Wahrscheinlichkeit der Detektion neuer Wörter (Modellparameter d) unterscheidet. Es handelt sich dabei um eine in Zwei-Hochschwellen-Modellen häufig getroffene Annahme (siehe Bayen et al., 1996; Snodgrass & Corwin, 1988). Mit dieser Parameterrestriktion, die separat für belebte und unbelebte Wörter vorgenommen wurde, resultierte ein saturiertes Modell. Zusätzlich wurde parallel zu Experiment 1.1 angenommen, dass sich die Wahrscheinlichkeit, im Inklusionstest auf Basis eines Rateprozesses ein Alt-Urteil zu fällen (Modellparameter g_i) und im Exklusionstest auf Basis eines Rateprozesses ein Alt-Urteil zu fällen (Modellparameter g_e), jeweils nicht zwischen belebten und unbelebten Wörtern unterscheidet. Das Modell mit diesen Parameterrestriktionen wies eine gute Modellpassung auf und wurde als Basismodell verwendet. Die Wahrscheinlichkeit der Rekognition kritischer Wörter aus Phase 1 auf Basis einer detaillierten Erinnerung (Modellparameter r) war signifikant höher für belebte als für unbelebte Wörter. Die Wahrscheinlichkeit der Rekognition kritischer Wörter aus Phase 1 auf Basis von Vertrautheit ohne detaillierte Erinnerung (Modellparameter f) unterschied sich dagegen nicht signifikant zwischen belebten und unbelebten Wörtern. Experiment 1.2 liefert daher Evidenz für eine detailliertere Erinnerung belebter Wörter im Vergleich zu unbelebten Wörtern. Zugleich gibt es keine Evidenz dafür, dass für belebte Wörter die Wahrscheinlichkeit erhöht ist, auf Basis eines Rateprozesses ein Alt- oder Neu-Urteil zu fällen.

Diskussion

Angesichts der inkonsistenten Befundlage bezüglich des Belebtheitseffekts in Rekognitionstests liegt es zunächst nahe zu vermuten, dass der Belebtheitsstatus der Wörter nicht alle Prozesse, die den im Rekognitionstest beobachtbaren Urteilen für alte und neue Wörter zugrunde liegen, in gleichem Maße beeinflusst. In einer Reihe von Studien, in denen die Remember-Know-(Guess)-Prozedur (Gardiner et al., 1997) verwendet wurde (Bonin et al., 2014; Bugaiska et al., 2023; Bugaiska et al., 2016; Rawlinson & Kelley, 2021), wurden mehr Remember-Urteile für alte belebte

Wörter als für alte unbelebte Wörter, die korrekt als alt beurteilt worden waren, beobachtet. In der Studie von Leding (2020), in der lediglich ein klassischer Alt-Neu-Rekognitionstest verwendet wurde, deuten die Befunde darauf hin, dass bei belebten Wörtern eher geraten wird, ob das Wort zuvor präsentiert worden ist, und dass der Belebtheitsstatus der Wörter nicht die Genauigkeit der Rekognition beeinflusst. In einem von zwei Experimenten von Mieth et al. (2019) zeigte sich nur ein Effekt der Belebtheit auf das Quellengedächtnis, nicht aber auf die Itemrekognition. Sowohl evolutionäre Erklärungsansätze (Kroneisen & Bell, 2018; Nairne & Pandeirada, 2008, 2016) als auch kognitive Erklärungsansätze wie die reichhaltige Enkodierung (Bonin et al., 2022; Meinhardt et al., 2020) und die attentionale Priorisierung (Bugaiska et al., 2019) implizieren Unterschiede zwischen belebten und unbelebten Wörtern in der Qualität der Erinnerung. Dem Belebtheitseffekt sollte eine detailliertere Erinnerung und keine erhöhte Vertrautheit belebter Wörter im Vergleich zu unbelebten Wörtern zugrunde liegen.

Diese Implikation ist durch die vorliegenden Befunde bestätigt worden. In Experiment 1.1 wurden die Teilnehmenden gemäß der Remember-Know-Guess-Prozedur (Gardiner et al., 1997) gebeten, Urteile über die Qualität ihrer Erinnerung zu fällen. In Experiment 1.2 wurden die Teilnehmenden gemäß der Prozessdissoziationsprozedur (Jacoby, 1991) gebeten, den spezifischen Instruktionen des Rekognitionstests zu folgen und zwischen in verschiedenen Kontexten enkodierten Wörtern zu diskriminieren. Die Datenanalyse erfolgte nicht auf Ebene der beobachtbaren Urteile über die Qualität der Erinnerung oder der beobachtbaren Aufgabenperformanz unter den spezifischen Instruktionen des Rekognitionstests, sondern modellbasiert auf Ebene der postulierten latenten Prozesse. Multinomiale Modellierungen der Qualität der Erinnerung (Buchner et al., 1995; Erdfelder et al., 2007) liefern Evidenz dafür, dass der Belebtheitsstatus der Wörter nicht alle Prozesse, die den im jeweiligen Rekognitionstest beobachtbaren Urteilen zugrunde liegen, in gleichem Maße beeinflusst, sondern selektiv den Prozess der detaillierten Erinnerung. Diese Schlussfolgerung basiert auf konvergenter Evidenz aus zwei sich ergänzenden experimentellen Prozeduren, in denen die Qualität der Erinnerung entweder anhand subjektiver Urteile (Gardiner et al., 1997) oder anhand objektiver Aufgabenperformanz (Jacoby, 1991) erfasst wurde: Die Wahrscheinlichkeit der Rekognition auf Basis einer detaillierten Erinnerung war für belebte Wörter nicht nur höher als für unbelebte Wörter, wenn der entsprechende Modellparameter anhand subjektiver Urteile über die Qualität der Erinnerung geschätzt wurde, sondern auch, wenn der Modellparameter anhand der objektiven Fähigkeit der Teilnehmenden geschätzt wurde, die Zugehörigkeit von Wörtern zu einer von zwei diskriminierbaren Enkodierungsphasen abzurufen (siehe auch Gelin et al., 2018; Mieth et al., 2019). Prozesse der Rekognition auf Basis von Vertrautheit ohne detaillierte Erinnerung und Rateprozesse unterschieden sich nicht zwischen belebten und unbelebten Wörtern.

Es lässt sich spekulieren, ob eine detailliertere Erinnerung belebter Wörter im Vergleich zu unbelebten Wörtern beim Abrufprozess in freien Reproduktionstests stärker zum Tragen kommt als beim Abrufprozess in Rekognitionstests. Erinnerte Details des Kontexts der Enkodierung sollten besonders in freien Reproduktionstests nützlich sein, weil sie als Abrufhinweise das Generieren potenzieller Wort-Kandidaten erleichtern können (Moscovitch & Craik, 1976). In Rekognitionstests müssen diese Wort-Kandidaten nicht generiert werden, sondern werden zur Verfügung gestellt. Die Diskrimination alter und neuer Wörter wird zwar durch eine detaillierte Erinnerung gefördert, kann aber auch auf Basis von Vertrautheit ohne detaillierte Erinnerung gelingen (siehe Buchner et al., 1995; Erdfelder et al., 2007). Der Belebtheitseffekt könnte deshalb in freien Reproduktionstests robuster sein als in Rekognitionstests, weil der Abrufprozess in freien Reproduktionstests mehr als der Abrufprozess in Rekognitionstests von einer detaillierteren Erinnerung belebter Wörter im Vergleich zu unbelebten Wörtern profitiert.

Die Experimente 1.1 und 1.2 dienten dazu, den Belebtheitseffekt genauer zu charakterisieren und eine zentrale Implikation der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung oder der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, zu prüfen. Sowohl eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern (Bonin et al., 2022; Meinhardt et al., 2020) als auch eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern (Bugaiska et al., 2019) ist mit dem Befund einer detaillierteren Erinnerung belebter Wörter im Vergleich zu unbelebten Wörtern kompatibel. Der Befund stellt jedoch keinen Beleg für kausale Beiträge dieser kognitiven Mechanismen zum Belebtheitseffekt dar. Um Schlussfolgerungen über die kausalen Beiträge dieser Mechanismen zum Belebtheitseffekt ziehen zu können, ist es notwendig, die Reichhaltigkeit der Enkodierung und die Möglichkeit zur attentionalen Priorisierung jeweils experimentell zu manipulieren. Da der klassische Belebtheitseffekt (Nairne et al., 2013) unter den Testbedingungen freier Reproduktionstests gemessen wurde, erfolgt diese experimentelle Prüfung in den folgenden zwei Serien von Experimenten ebenfalls unter den Testbedingungen freier Reproduktionstests. Zunächst wird in den Experimenten 2.1 bis 2.4 die erste der beiden aussichtsreichsten Hypothesen (siehe auch Nairne et al., 2013) zu den kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, geprüft: Werden belebte Wörter reichhaltiger enkodiert als unbelebte Wörter und deshalb besser erinnert?

Experimentelle Manipulationen der Reichhaltigkeit der Enkodierung

Die reichhaltige Enkodierung gilt als einer der aussichtsreichsten Kandidaten (siehe auch Nairne et al., 2013) für die kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, da dieser Mechanismus einen erfolgreichen kognitiven Erklärungsansatz für ein anderes Phänomen bildet, das im Rahmen des adaptiven Gedächtnisses untersucht wird (Meinhardt et al., 2020). Der *Überlebensrelevanzeffekt* (engl. *survival-processing effect*) bezeichnet den Gedächtnisvorteil für Items nach Einschätzen ihrer Relevanz für das Überleben gegenüber der Verarbeitung dieser Items in einer Kontrollbedingung mit vergleichbarer Verarbeitungstiefe (Nairne et al., 2007). In einem Überlebensszenario werden die Teilnehmenden gebeten, sich vorzustellen, in der Steppe eines fremden Landes gestrandet zu sein. Die Teilnehmenden sollen Wörter jeweils danach einschätzen, wie relevant das bezeichnete Item wäre, um Nahrung und Trinkwasser zu besorgen und sich vor Raubtieren zu schützen. Wenn Wörter im Überlebensszenario enkodiert worden sind, werden sie in freien Reproduktionstests besser erinnert als wenn die gleichen Wörter in einer Kontrollbedingung (z. B. Einschätzen der Relevanz im Umzugsszenario, Einschätzen der Angenehmheit) enkodiert worden sind, in der der Aspekt des Überlebens ausgeklammert wird, die aber hinsichtlich der induzierten Verarbeitungstiefe vergleichbar mit dem Überlebensszenario ist (Nairne et al., 2008).

Kroneisen und Erdfelder (2011) haben postuliert, dass das Einschätzen der Relevanz im Überlebensszenario als besonders reichhaltige Form der Enkodierung die Teilnehmenden dazu anregt, viele verschiedene Ideen dafür zu generieren, wie die durch die Wörter bezeichneten Items hilfreich sein könnten, um in der Steppe zu überleben. Diese zahlreichen selbstgenerierten Ideen erleichtern dann als Abrufhinweise die freie Reproduktion der Wörter. Diese Theorie wird durch empirische Evidenz unterstützt (ein Überblick findet sich bei Erdfelder & Kroneisen, 2014): Röer et al. (2013) haben gezeigt, dass die Teilnehmenden spontan mehr Ideen zur Verwendung eines durch ein Wort bezeichneten Items im Überlebensszenario aufschreiben als in Kontrollszenarios (siehe auch Wilson, 2016). Die Ideen im Überlebensszenario waren nicht nur zahlreicher, sondern wurden auch als kreativer eingeschätzt (Bell et al., 2015). In Rekognitionstests zeigte sich der Überlebensrelevanzeffekt wie auch der Belebtheitseffekt in einer detaillierten Erinnerung der enkodierten Wörter (z. B. Forester et al., 2019; Kroneisen & Bell, 2018). Maßgeblich für die Bestätigung der reichhaltigen Enkodierung als einem dem Überlebensrelevanzeffekt zugrundeliegenden kognitiven Mechanismus ist es jedoch gewesen, dass Kroneisen und Erdfelder (2011) den Überlebensrelevanzeffekt durch experimentelle Manipulationen der Reichhaltigkeit der Enkodierung modulieren konnten. Sowohl eine Restriktion der Anzahl der aufzuschreibenden Ideen zur Verwendung eines durch ein Wort bezeichneten Items im Überlebens- oder Umzugsszenario als auch eine Restriktion der Anzahl der im Überlebensszenario erwähnten Ziele führte zu einer Reduktion des Überlebensrelevanzeffekts. Außerdem reduzierte sich der Überlebensrelevanzeffekt im Doppelaufgabenparadigma (siehe Craik et al., 1996) durch eine Zweitaufgabe, die zusätzlich zur Aufgabe des Einschätzens der Relevanz der durch die Wörter bezeichneten Items im Überlebens- oder Umzugsszenario bearbeitet wurde (Kroneisen et al., 2014, 2016). Andere Studien (z. B. Bell et al., 2015; Kroneisen et al., 2013; Kroneisen et al., 2021) haben ebenfalls experimentelle Evidenz für einen kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Überlebensrelevanzeffekt geliefert.

Angesichts der engen Verknüpfung des Belebtheitseffekts (Nairne et al., 2013) und des Überlebensrelevanzeffekts (Nairne et al., 2007) im Rahmen des adaptiven Gedächtnisses (siehe Nairne, 2015) haben Meinhardt et al. (2020, S. 424) vorgeschlagen, dass diesen Effekten grundsätzlich der kognitive Mechanismus der reichhaltigen Enkodierung zugrunde liegen könnte. Als die Teilnehmenden gebeten wurden, so viele Ideen zu einem belebten oder unbelebten Wort aufzuschreiben, wie ihnen spontan einfielen, berichteten sie mehr Ideen zu belebten als zu unbelebten Wörtern (Bonin et al., 2022; Meinhardt et al., 2020). Zwar sind durch diese korrelative Evidenz wie auch durch die Befunde einer detaillierteren Erinnerung belebter Wörter im Vergleich zu unbelebten Wörtern (siehe Experimente 1.1 und 1.2) zentrale Implikationen der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung zugrunde liegt, bestätigt worden. Eine Schlussfolgerung über den kausalen Beitrag dieses Mechanismus zum Belebtheitseffekt erfordert jedoch eine experimentelle Manipulation der Reichhaltigkeit der Enkodierung.

Diese experimentelle Prüfung sollte erstmalig Gegenstand der Experimente 2.1 bis 2.4 (siehe Einzelarbeit 2) sein. Experimentelle Manipulationen der Reichhaltigkeit der Enkodierung, von denen bereits bekannt ist, dass durch deren Einsatz der Überlebensrelevanzeffekt moduliert werden kann (Kroneisen & Erdfelder, 2011; Kroneisen et al., 2014, 2016), wurden auf den Belebtheitseffekt übertragen. Belebte und unbelebte Wörter wurden entweder inzidentell enkodiert in Bedingungen, die eine reichhaltige Enkodierung fördern, oder in Bedingungen, die eine reichhaltige Enkodierung restringieren. Der Anteil korrekt reproduzierter Wörter wurde in Abhängigkeit von dem Belebtheitsstatus der Wörter und der experimentellen Manipulation der Reichhaltigkeit der Enkodierung in freien Reproduktionstests gemessen. Die Interaktion zwischen dem Belebtheitsstatus der Wörter und der spezifischen experimentellen Manipulation der Reichhaltigkeit der Enkodierung wurde jeweils als kritischer Test des kausalen Beitrags des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt betrachtet. Wenn eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern kausal zum Belebtheitseffekt beiträgt, dann sollte der Belebtheitseffekt in reichhaltigen Enkodierungsbedingungen größer ausfallen als in restringierten Enkodierungsbedingungen.

Experiment 2.1 – Vier Ideen versus eine Idee

Als Ausgangspunkt der Serie von Experimenten zur Prüfung des potenziellen kausalen Beitrags des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt diente eine experimentelle Manipulation der Reichhaltigkeit der Enkodierung, mit der Kroneisen und Erdfelder (2011; Experiment 3) den Überlebensrelevanzeffekt modulieren konnten. Der Überlebensrelevanzeffekt war größer, wenn die Teilnehmenden gebeten wurden, vier Ideen zur Verwendung eines durch ein Wort bezeichneten Items im Überlebens- oder Umzugsszenario aufzuschreiben als wenn sie gebeten wurden, nur eine Idee aufzuschreiben. Die Restriktion, nur eine Idee aufzuschreiben, interferiert mutmaßlich mit der reichhaltigen Ideengenerierung im Überlebensszenario.

Diese experimentelle Manipulation der Reichhaltigkeit der Enkodierung wurde in Experiment 2.1 auf den Belebtheitseffekt übertragen. In der inzidentellen Enkodierungsphase wurden die Teilnehmenden gebeten, zu der Hälfte der belebten und unbelebten Wörter aus Meinhardt et al. (2020) jeweils vier Ideen aufzuschreiben, die ihnen spontan einfielen, und zu der anderen Hälfte der belebten und unbelebten Wörter jeweils eine Idee. Nach einer kurzen Distraktoraufgabe folgte die Testphase, in der die Teilnehmenden in einem freien Reproduktionstest gebeten wurden, die zuvor präsentierten belebten und unbelebten Wörter in einer beliebigen Reihenfolge aufzuschreiben. Wenn eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern kausal zum Belebtheitseffekt beiträgt, dann sollte der Belebtheitseffekt in der Bedingung mit vier Ideen größer ausfallen als in der Bedingung mit einer Idee.

Zwar wurden in der Bedingung mit vier Ideen signifikant mehr Wörter frei reproduziert als in der Bedingung mit einer Idee, die kritische Interaktion zwischen dem Belebtheitsstatus der Wörter und der Anzahl der Ideen war jedoch nicht signifikant und der Belebtheitseffekt war in beiden Bedingungen gleich groß. Experiment 2.1 liefert daher Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt.

Eine mögliche Limitation des Experiments 2.1 ist, dass die Teilnehmenden sowohl in der reichhaltigen als auch in der restringierten Enkodierungsbedingung instruiert wurden, eine festgelegte Anzahl von Ideen aufzuschreiben. Basierend auf dem kognitiven Mechanismus der reichhaltigen Enkodierung sollten belebte Wörter jedoch zur Generierung von mehr Ideen anregen als unbelebte Wörter, wenn die Anzahl der aufzuschreibenden Ideen nicht eingeschränkt wird.

Experiment 2.2 – Uneingeschränkte Anzahl von Ideen versus eine Idee

In Experiment 2.2 sollten potenzielle Unterschiede in der Reichhaltigkeit der Enkodierung zwischen belebten und unbelebten Wörtern in der reichhaltigen Enkodierungsbedingung durch die Aufgabe, eine uneingeschränkte Anzahl von Ideen aufzuschreiben, akzentuiert werden. Experiment 2.2 war identisch zu Experiment 2.1 mit der Ausnahme, dass die Bedingung mit vier Ideen durch eine Bedingung mit einer uneingeschränkten Anzahl von Ideen ersetzt wurde. Die Teilnehmenden wurden in dieser Bedingung gebeten, so viele Ideen zu dem präsentierten Wort aufzuschreiben, wie ihnen spontan einfielen. Wenn eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern kausal zum Belebtheitseffekt beiträgt, dann sollte der Belebtheitseffekt in der Bedingung mit einer uneingeschränkten Anzahl von Ideen größer ausfallen als in der Bedingung mit einer Idee.

In der Bedingung mit einer uneingeschränkten Anzahl von Ideen wurden signifikant mehr Ideen zu belebten als zu unbelebten Wörtern aufgeschrieben. Außerdem wurden in dieser Bedingung signifikant mehr Wörter frei reproduziert als in der Bedingung mit einer Idee. Die kritische Interaktion zwischen dem Belebtheitsstatus der Wörter und der Anzahl der Ideen war jedoch nicht signifikant und der Belebtheitseffekt war in beiden Bedingungen gleich groß. Experiment 2.2 liefert daher Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt.

Eine mögliche Limitation der Experimente 2.1 und 2.2 ist, dass die Teilnehmenden entgegen der Instruktion, nur eine Idee aufzuschreiben, spontan auch in dieser Bedingung mehr Ideen zu belebten als zu unbelebten Wörtern generiert haben könnten. In der restringierten Enkodierungsbedingung sollte deshalb das Generieren von Ideen nicht nur eingeschränkt, sondern möglichst unterbunden werden.

Experiment 2.3 – Uneingeschränkte Anzahl von Ideen versus Ablenkungsaufgabe

In Experiment 2.3 sollten potenzielle Unterschiede in der Reichhaltigkeit der Enkodierung zwischen belebten und unbelebten Wörtern in der restringierten Enkodierungsbedingung durch eine Ablenkungsaufgabe nivelliert werden. Kroneisen et al. (2014, 2016) haben gezeigt, dass sich der Überlebensrelevanzeffekt durch eine Zweitaufgabe reduzieren lässt, mutmaßlich weil die durch die Zweitaufgabe verursachte kognitive Belastung mit der reichhaltigen Ideengenerierung im Überlebensszenario interferiert.

Anders als in den Experimenten 2.1 und 2.2 wurde in Experiment 2.3 anstelle der Bedingung mit einer Idee eine Bedingung mit Ablenkungsaufgabe eingeführt, in der die Teilnehmenden durch mentale Arithmetikaufgaben davon abgehalten werden sollten, Ideen zu den für die Lösung der mentalen Arithmetikaufgaben irrelevanten belebten und unbelebten Wörtern zu generieren (siehe Lehman et al., 2014). Die Teilnehmenden wurden gebeten, zu der Hälfte der belebten und unbelebten Wörter jeweils 40 Sekunden lang eine uneingeschränkte Anzahl von Ideen aufzuschreiben und bei der anderen Hälfte der belebten und unbelebten Wörter jeweils 40 Sekunden lang mentale Arithmetikaufgaben zu lösen. Wenn eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern kausal zum Belebtheitseffekt beiträgt, dann sollte der Belebtheitseffekt in der Bedingung mit einer uneingeschränkten Anzahl von Ideen größer ausfallen als in der Bedingung mit Ablenkungsaufgabe.

In der Bedingung mit einer uneingeschränkten Anzahl von Ideen wurden signifikant mehr Ideen zu belebten als zu unbelebten Wörtern aufgeschrieben. In der Bedingung mit Ablenkungsaufgabe wurden im Durchschnitt nur 10 der 12 mentalen Arithmetikaufgaben innerhalb der vorgegebenen Zeit korrekt gelöst. Dies legt nahe, dass die Teilnehmenden erfolgreich davon abgehalten wurden, Ideen zu den belebten und unbelebten Wörtern zu generieren. Außerdem wurden in der Bedingung mit einer uneingeschränkten Anzahl von Ideen signifikant mehr Wörter frei reproduziert als in der Bedingung mit Ablenkungsaufgabe. Die kritische Interaktion zwischen dem Belebtheitsstatus der Wörter und der Anzahl der Ideen war jedoch nicht signifikant und der Belebtheitseffekt war in beiden Bedingungen gleich groß. Experiment 2.3 liefert daher Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt.

Experiment 2.4 – Ausführliches versus eingeschränktes Überlebensszenario

Zur Prüfung des potenziellen kausalen Beitrags des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt sollte die Reichhaltigkeit der Enkodierung in Experiment 2.4 innerhalb eines anderen experimentellen Paradigmas manipuliert werden. Kroneisen und Erdfelder (2011; Experiment 1) konnten den Überlebensrelevanzeffekt durch eine experimentelle Manipulation der Ausführlichkeit des von Nairne et al. (2007) entwickelten Überlebensszenarios modulieren. Der Überlebensrelevanzeffekt war größer in der Gruppe von Teilnehmenden, die gebeten wurden, die Relevanz der durch die Wörter bezeichneten Items für das Erreichen von drei Zielen (Nahrung besorgen, Trinkwasser besorgen, sich vor Raubtieren schützen) im ausführlichen Überlebensszenario einzuschätzen, als in der Gruppe von Teilnehmenden, die dies für das Erreichen von lediglich einem Ziel (Trinkwasser besorgen) im eingeschränkten Überlebensszenario tat. Das ausführliche Überlebensszenario bietet mutmaßlich mehr Gelegenheiten für eine reichhaltige Ideengenerierung als das eingeschränkte Überlebensszenario.

Diese experimentelle Manipulation der Reichhaltigkeit der Enkodierung wurde in Experiment 2.4 auf den Belebtheitseffekt übertragen. In der Gruppe mit ausführlichem Überlebensszenario wurden die Teilnehmenden gebeten, die belebten und unbelebten Wörter aus Meinhardt et al. (2020) jeweils danach einzuschätzen, wie relevant das bezeichnete Belebte oder Unbelebte wäre, um Nahrung und Trinkwasser zu besorgen und sich vor Raubtieren zu schützen. In der Gruppe mit eingeschränktem Überlebensszenario wurden die Teilnehmenden gebeten, die belebten und unbelebten Wörter jeweils danach einzuschätzen, wie relevant das bezeichnete Belebte oder Unbelebte wäre, um Trinkwasser zu besorgen. Wie zuvor folgte nach einer kurzen Distraktoraufgabe ein freier Reproduktionstest, in dem die Teilnehmenden gebeten wurden, die zuvor präsentierten belebten und unbelebten Wörter in einer beliebigen Reihenfolge aufzuschreiben. Wenn eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern kausal zum Belebtheitseffekt beiträgt, dann sollte der Belebtheitseffekt in der Gruppe mit ausführlichem Überlebensszenario größer ausfallen als in der Gruppe mit eingeschränktem Überlebensszenario.

Unerwartet zeigte sich in den Einschätzungen der Relevanz eine signifikante Interaktion zwischen dem Belebtheitsstatus der Wörter und der Ausführlichkeit des Überlebensszenarios. Im ausführlichen Überlebensszenario wurden die unbelebten Wörter als relevanter eingeschätzt als die belebten Wörter, im eingeschränkten Überlebensszenario war es genau umgekehrt. Da eine höhere wahrgenommene Relevanz eine höhere freie Reproduktionsleistung zur Folge haben könnte (siehe Butler et al., 2009), wurde die wahrgenommene Relevanz in der Analyse berücksichtigt (siehe auch Kroneisen & Erdfelder, 2011; Kroneisen et al., 2021)[2]. In der Gruppe mit ausführlichem Überlebensszenario wurden gleich viele Wörter frei reproduziert wie in der Gruppe mit eingeschränktem Überlebensszenario. Die kritische Interaktion zwischen dem Belebtheitsstatus der Wörter und der Ausführlichkeit des Überlebensszenarios war nicht signifikant und der Belebtheitseffekt war in beiden Gruppen gleich groß. Experiment 2.4 liefert daher Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt.

Diskussion

Angesichts der engen Verknüpfung des Belebtheitseffekts (Nairne et al., 2013) und des Überlebensrelevanzeffekts (Nairne et al., 2007) im Rahmen des adaptiven Gedächtnisses (siehe Nairne, 2015) liegt es zunächst nahe zu vermuten, dass diesen Effekten ähnliche kognitive Mechanismen zugrunde liegen (Meinhardt et al., 2020). Da sich der Überlebensrelevanzeffekt durch experimentelle Manipulationen der Reichhaltigkeit der Enkodierung modulieren lässt (Kroneisen & Erdfelder, 2011; Kroneisen et al., 2014, 2016), wurden in den Experimenten 2.1 bis 2.4 diese bereits etablierten experimentellen Manipulationen auf den Belebtheitseffekt übertragen, um eine Schlussfolgerung über den kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt ziehen zu können. Meinhardt et al. (2020) haben bereits korrelative Evidenz für eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten

[2] Tatsächlich wurden signifikant mehr Wörter frei reproduziert, die im jeweiligen Überlebensszenario als relevant eingeschätzt wurden, als Wörter, die als irrelevant eingeschätzt wurden. Überraschenderweise war auch die Interaktion zwischen dem Belebtheitsstatus der Wörter und der eingeschätzten Relevanz signifikant und der Belebtheitseffekt war reduziert für Wörter, die als relevant eingeschätzt wurden, im Vergleich zu Wörtern, die als irrelevant eingeschätzt wurden (ähnliche Befunde bezüglich des Überlebensrelevanzeffekts finden sich bei Kroneisen & Erdfelder, 2011; Kroneisen et al., 2021). Dies könnte ein Hinweis darauf sein, dass dem Belebtheitseffekt eine höhere wahrgenommene Relevanz von Belebtem im Vergleich zu Unbelebtem zugrunde liegt. Da die Modulation des Belebtheitseffekts durch die eingeschätzte Relevanz im Überlebensszenario jedoch keine Bestätigung einer a priori aufgestellten Hypothese darstellt, kann dieser Befund lediglich neue Hypothesen stimulieren, die zukünftig einer experimentellen Prüfung unterzogen werden könnten (siehe z. B. Bonin et al., 2024).

Wörtern geliefert (siehe auch Bonin et al., 2022). Unklar war bislang jedoch, ob diese reichhaltigere Enkodierung von belebten Wörtern für den Gedächtnisvorteil für belebte Wörter gegenüber unbelebten Wörtern verantwortlich ist. Wenn dem so ist, sollte der Belebtheitseffekt in reichhaltigen Enkodierungsbedingungen größer ausfallen als in restringierten Enkodierungsbedingungen.

Eine wichtige Implikation der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung zugrunde liegt, ist zunächst bestätigt worden. In den Experimenten 2.2 und 2.3 berichteten die Teilnehmenden mehr Ideen zu belebten als zu unbelebten Wörtern, wenn sie gebeten wurden, eine uneingeschränkte Anzahl von Ideen aufzuschreiben (siehe auch Bonin et al., 2022; Meinhardt et al., 2020).

Reichhaltig enkodierte Wörter sollten deshalb besonders gut erinnert werden, weil die während der Enkodierung generierten Ideen als Abrufhinweise die freie Reproduktion der Wörter erleichtern. In den Experimenten 2.1 bis 2.3 wurden in den reichhaltigen Enkodierungsbedingungen, in denen die Teilnehmenden gebeten wurden, mehr Ideen aufzuschreiben, mehr Wörter frei reproduziert als in den restringierten Enkodierungsbedingungen. In Experiment 2.4 hatte die experimentelle Manipulation der Ausführlichkeit des Überlebensszenarios, anders als in Kroneisen und Erdfelder (2011), keinen Effekt auf die freie Reproduktionsleistung. Dies legt nahe, dass diese spezielle experimentelle Manipulation der Reichhaltigkeit der Enkodierung zu subtil war, um zu beeinflussen, wie gut die Wörter erinnert werden. Insgesamt zeigen die vorliegenden Befunde dennoch eine gedächtnisfördernde Wirkung reichhaltiger Enkodierung (siehe auch Craik & Tulving, 1975; Moscovitch & Craik, 1976).

Eine reichhaltige Enkodierung der Wörter erhöhte die freie Reproduktionsleistung jedoch unabhängig von dem Belebtheitsstatus der Wörter. In Experiment 2.1 wurden die Teilnehmenden gebeten, vier Ideen oder eine Idee zu belebten und unbelebten Wörtern aufzuschreiben. In Experiment 2.2 wurden die Teilnehmenden gebeten, eine uneingeschränkte Anzahl von Ideen oder eine Idee zu belebten und unbelebten Wörtern aufzuschreiben. In Experiment 2.3 wurden die Teilnehmenden gebeten, eine uneingeschränkte Anzahl von Ideen zu belebten und unbelebten Wörtern aufzuschreiben oder das Generieren von Ideen zu belebten und unbelebten Wörtern wurde durch eine Ablenkungsaufgabe unterbunden. In Experiment 2.4 wurden die Teilnehmenden gebeten, belebte und unbelebte Wörter hinsichtlich ihrer Relevanz für ein ausführliches oder ein eingeschränktes Überlebensszenario einzuschätzen. Trotz einer sukzessiven Erhöhung der Stärke der experimentellen Manipulation der Reichhaltigkeit der Enkodierung und einer Variation des experimentellen Paradigmas war das in diesen Enkodierungsbedingungen erzielte Befundmuster stets identisch: Der Belebtheitseffekt war in reichhaltigen Enkodierungsbedingungen genauso groß wie in restringierten Enkodierungsbedingungen.

Da jedes der Experimente 2.1 bis 2.4 Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt liefert, ergibt sich eine klare Schlussfolgerung: Die Hypothese, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung zugrunde liegt, muss zurückgewiesen werden. Genau wie es maßgeblich für die Bestätigung der reichhaltigen Enkodierung als einem dem Überlebensrelevanzeffekt zugrundeliegenden kognitiven Mechanismus gewesen ist, dass sich der Überlebensrelevanzeffekt durch experimentelle Manipulationen der Reichhaltigkeit der Enkodierung modulieren lässt (Kroneisen & Erdfelder, 2011; Kroneisen et al., 2014, 2016), ist es maßgeblich für die Zurückweisung der reichhaltigen Enkodierung als einem dem Belebtheitseffekt zugrundeliegenden kognitiven Mechanismus, dass sich der Belebtheitseffekt nicht durch diese bereits etablierten experimentellen Manipulationen der Reichhaltigkeit der Enkodierung modulieren lässt. Trotz einer engen Verknüpfung des Belebtheitseffekts (Nairne et al., 2013) und des Überlebensrelevanzeffekts (Nairne et al., 2007) im Rahmen des adaptiven Gedächtnisses (siehe Nairne, 2015) scheinen diesen Effekten unterschiedliche kognitive Mechanismen zugrunde zu liegen (siehe auch Gelin et al., 2017; Leding, 2018). Nachdem die Experimente 2.1 bis 2.4 Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt geliefert haben, wird in den Experimenten 3.1 bis 3.3 die zweite der beiden aussichtsreichsten Hypothesen (siehe auch Nairne et al., 2013) zu den kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, geprüft: Werden belebte Wörter auf Kosten von unbelebten Wörtern attentional priorisiert und deshalb besser erinnert?

Experimentelle Manipulationen der Möglichkeit zur attentionalen Priorisierung

Die attentionale Priorisierung gilt als eine der aussichtsreichsten Kandidaten (siehe auch Nairne et al., 2013) für die kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, da die Wahrscheinlichkeit, ein Wort in einem freien Reproduktionstest zu erinnern, von der Aufteilung der Aufmerksamkeitsressourcen auf die zu enkodierenden Wörter bestimmt wird (z. B. Cowan et al., 2024; Craik et al., 1996). Bugaiska et al. (2019) haben Evidenz dafür geliefert, dass bei der Verarbeitung belebter Wörter mehr Aufmerksamkeitsressourcen auf Kosten einer dem Stroop-Test ähnlichen Aufgabe beansprucht werden als bei der Verarbeitung unbelebter Wörter. Zwar ist durch diesen Befund eine zentrale Implikation der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, bestätigt worden. Eine Schlussfolgerung über den kausalen Beitrag dieses Mechanismus zum Belebtheitseffekt erfordert jedoch eine experimentelle Manipulation des postulierten Kausalfaktors. Drei Studien, in denen die Verfügbarkeit von Aufmerksamkeitsressourcen für eine attentionale Priorisierung im Doppelaufgabenparadigma (siehe Craik et al., 1996) experimentell manipuliert wurde, haben inkonsistente Befunde geliefert: Der Belebtheitseffekt war entweder unabhängig (Bonin et al., 2015; Rawlinson & Kelley, 2021) oder abhängig (Leding, 2019) davon, ob zusätzlich zur Enkodierungsaufgabe eine Zweitaufgabe bearbeitet werden musste oder nicht.

Eine bislang wenig genutzte Methode (aber siehe Popp & Serra, 2016) zur Prüfung des potenziellen kausalen Beitrags des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt ist der Vergleich des Belebtheitseffekts zwischen gemischten Listen zu enkodierender Wörter, in denen belebte und unbelebte Wörter gemeinsam präsentiert werden, und reinen Listen zu enkodierender Wörter, in denen belebte und unbelebte Wörter getrennt präsentiert werden. Ähnlich wie in der dem Stroop-Test ähnlichen Aufgabe (siehe Bugaiska et al., 2019) und im

Doppelaufgabenparadigma (siehe Craik et al., 1996) basiert dieser Vergleich auf der Annahme, dass Aufmerksamkeitsressourcen begrenzt sind und aufgeteilt werden.

Eine Vielzahl von Gedächtnisphänomenen konnte durch die experimentelle Manipulation der Zusammensetzung der Listen zu enkodierender Wörter moduliert werden (ein Überblick findet sich bei McDaniel & Bugg, 2008). Zum Beispiel hat sich gezeigt, dass der Effekt der emotionalen Erregung auf die Rekognitionsleistung und die freie Reproduktionsleistung oft größer ist, wenn emotional erregende und neutrale Wörter oder Bilder gemeinsam in gemischten Listen präsentiert werden als wenn emotional erregende und neutrale Wörter oder Bilder getrennt in reinen Listen präsentiert werden (z. B. Barnacle et al., 2016; Dewhurst & Parry, 2000; Schmidt & Saari, 2007). Ein kognitiver Erklärungsansatz des Effekts der emotionalen Erregung auf die Gedächtnisleistung ist die asymmetrische Aufteilung der begrenzten Aufmerksamkeitsressourcen auf emotional erregende und neutrale Stimuli (Talmi, 2013; Talmi et al., 2007): In gemischten Listen beanspruchen emotional erregende Stimuli Aufmerksamkeitsressourcen auf Kosten von neutralen Stimuli mit dem Ergebnis, dass mehr emotional erregende Stimuli als neutrale Stimuli erinnert werden. In reinen Listen ist eine attentionale Priorisierung von emotional erregenden Stimuli auf Kosten von neutralen Stimuli nicht möglich, sodass sich der Effekt der emotionalen Erregung auf die Gedächtnisleistung reduziert. Eine Akzentuierung des Effekts der emotionalen Erregung auf die Gedächtnisleistung in gemischten Listen im Vergleich zu reinen Listen lässt sich also auf eine attentionale Priorisierung von emotional erregenden Stimuli auf Kosten von neutralen Stimuli, die nur in gemischten Listen, nicht aber in reinen Listen möglich ist, zurückführen.

Eine Schlussfolgerung über den kausalen Beitrag des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt erfordert eine entsprechende experimentelle Manipulation der Möglichkeit zur attentionalen Priorisierung. Diese experimentelle Prüfung sollte Gegenstand der Experimente 3.1 bis 3.3 (siehe Einzelarbeit 3) sein. Belebte und unbelebte Wörter wurden entweder enkodiert in Bedingungen, die eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern ermöglichen, oder in Bedingungen, die eine solche Priorisierung nicht ermöglichen. Der Anteil korrekt reproduzierter Wörter wurde in Abhängigkeit von dem Belebtheitsstatus der Wörter und der experimentellen Manipulation der Möglichkeit zur attentionalen Priorisierung in freien Reproduktionstests gemessen. Die Interaktion zwischen dem Belebtheitsstatus der Wörter und der spezifischen experimentellen Manipulation der Möglichkeit zur attentionalen Priorisierung wurde jeweils als kritischer Test des kausalen Beitrags des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt betrachtet. Wenn eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern kausal zum Belebtheitseffekt beiträgt, dann sollte der Belebtheitseffekt – analog zum Effekt der emotionalen Erregung – in Bedingungen, die eine attentionale Priorisierung ermöglichen, größer ausfallen als in Bedingungen, die eine solche Priorisierung nicht ermöglichen.

Experiment 3.1 – Intentionale Enkodierung von gemischten versus reinen Listen

Als Ausgangspunkt der Serie von Experimenten zur Prüfung des potenziellen kausalen Beitrags des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt diente die Beobachtung einer deskriptiven Akzentuierung des Belebtheitseffekts unter Verwendung gemischter Listen, in denen belebte und unbelebte Wörter gemeinsam präsentiert wurden, im Vergleich zu reinen Listen, in denen belebte und unbelebte Wörter getrennt präsentiert wurden (Popp & Serra, 2016; Experiment 1). Zwar wurde die Verwendung reiner Listen in einem Zwischensubjektdesign bereits als Ursache für den Nulleffekt der Belebtheit auf die Leistung im statistischen Lernen visueller Information diskutiert (Cox et al., 2022; Cox et al., 2024). Da der Effekt der Belebtheit auf die freie Reproduktionsleistung jedoch fast ausschließlich unter Verwendung gemischter Listen gemessen wurde (aber siehe Popp & Serra, 2016), gibt es kaum empirische Evidenz, ob der Belebtheitseffekt von der Zusammensetzung der Listen abhängt. Ein Vergleich des Effekts der Belebtheit auf die freie Reproduktionsleistung zwischen gemischten und reinen Listen war lediglich ein Bestandteil eines Experiments von Popp und Serra (2016). Die kritische Interaktion zwischen dem Belebtheitsstatus der Wörter und der Zusammensetzung der Listen war zwar statistisch nicht signifikant, bei der vergleichsweise kleinen Stichprobe von 64 Teilnehmenden könnte dies jedoch auch einfach auf eine mangelnde Sensitivität des statistischen Tests der kritischen Interaktion zurückzuführen sein. Auf deskriptiver Ebene war der Belebtheitseffekt in der Gruppe mit gemischten Listen fast doppelt so groß wie in der Gruppe mit reinen Listen.

In Experiment 3.1 sollte Popp und Serras (2016) Vergleich des Effekts der Belebtheit auf die freie Reproduktionsleistung zwischen gemischten und reinen Listen repliziert werden, jedoch mit zwei methodischen Veränderungen: Erstens wurde eine Stichprobengröße angestrebt, mit der eine ausreichend hohe Sensitivität des statistischen Tests der kritischen Interaktion zwischen dem Belebtheitsstatus der Wörter und der Zusammensetzung der Listen erzielt werden kann. Zweitens wurde die Komplexität des experimentellen Designs durch eine Reduktion der Anzahl der präsentierten Listen auf zwei und eine Fokussierung auf freie Reproduktionstests verringert.

Die Teilnehmenden wurden in Großbritannien rekrutiert, damit das englische Wortmaterial der Originalarbeit von Popp und Serra (2016) genutzt werden konnte. Für jede teilnehmende Person wurde eine Teilmenge von belebten und unbelebten Wörtern aus dem Wortmaterial ausgewählt. In der einen Gruppe wurden für jede teilnehmende Person zwei gemischte Listen erstellt, jeweils zusammengesetzt aus einer gleichen Anzahl von belebten und unbelebten Wörtern. In der anderen Gruppe wurden für jede teilnehmende Person zwei reine Listen erstellt, die eine zusammengesetzt aus belebten Wörtern, die andere zusammengesetzt aus unbelebten Wörtern. Experiment 3.1 bestand aus zwei intentionalen Enkodierungsphasen und zwei Testphasen. In der Gruppe mit reinen Listen wurde ausbalanciert, welche der beiden Listen in der ersten und welche in der zweiten Enkodierungsphase präsentiert wurde. In der ersten Enkodierungsphase wurden die Wörter der ersten Liste jeweils einzeln präsentiert und die Teilnehmenden wurden gebeten, die Wörter auswendig zu lernen. Direkt im Anschluss an die erste Enkodierungsphase wurden die Teilnehmenden in der ersten Testphase in einem freien Reproduktionstest gebeten, die Wörter der ersten Liste in einer beliebigen Reihenfolge aufzuschreiben. Es folgte die zweite Enkodierungsphase und die zweite Testphase für die Wörter der zweiten Liste. Wenn eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern kausal zum Belebtheitseffekt beiträgt, dann sollte der Belebtheitseffekt in der Gruppe mit gemischten Listen größer ausfallen als in der Gruppe mit reinen Listen.

Die kritische Interaktion zwischen dem Belebtheitsstatus der Wörter und der Zusammensetzung der Listen war nicht signifikant und der Belebtheitseffekt war in der Gruppe mit gemischten Listen genauso groß wie in der Gruppe mit reinen Listen. Experiment 3.1 liefert daher Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt.

Eine mögliche Limitation des Experiments 3.1 ist, dass die Wörter sequenziell präsentiert wurden und belebte und unbelebte Wörter in gemischten Listen zwar während des Aufrechterhaltungsprozesses um begrenzte Aufmerksamkeitsressourcen konkurrieren konnten, jedoch nicht direkt zum Zeitpunkt der Enkodierung. Auch wenn die zu enkodierenden belebten und unbelebten Wörter typischerweise sequenziell präsentiert werden (z. B. Nairne et al., 2013), stellt sich die Frage, ob der Belebtheitseffekt moduliert werden kann, wenn belebte und unbelebte Wörter simultan präsentiert und enkodiert werden.

Experiment 3.2 – Intentionale Enkodierung von gemischten versus reinen Paaren

In Experiment 3.2 sollte eine potenziell asymmetrische Aufteilung der begrenzten Aufmerksamkeitsressourcen auf belebte und unbelebte Wörter durch ein simultanes Präsentationsformat akzentuiert werden (siehe Calvo et al., 2007; Middlebrooks & Castel, 2018; Ravizza et al., 2016). Wenn ein belebtes Wort und ein unbelebtes Wort als Paar präsentiert werden, sollte das belebte Wort zum Zeitpunkt der Enkodierung Aufmerksamkeitsressourcen auf Kosten des unbelebten Wortes beanspruchen. Wenn ein belebtes Wort und ein anderes belebtes Wort oder ein unbelebtes Wort und ein anderes unbelebtes Wort als Paar präsentiert werden, kann ein belebtes Wort zum Zeitpunkt der Enkodierung keine Aufmerksamkeitsressourcen auf Kosten eines unbelebten Wortes beanspruchen. Dieses simultane Präsentationsformat weicht zwar von dem typischen sequenziellen Präsentationsformat ab (verwendet in 100 % der für diese Berechnung ausgewählten Experimente[3]), eine experimentelle Manipulation der Zusammensetzung der Paare stellt dennoch eine wertvolle Ergänzung zur Prüfung des potenziellen kausalen Beitrags des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt dar.

Anders als in Experiment 3.1 wurden die belebten und unbelebten Wörter gepaart in einer einzigen Enkodierungsphase präsentiert. Gemischte Paare waren zusammengesetzt aus einem belebten Wort und einem unbelebten Wort, wobei die Position (links oder rechts) von belebten und unbelebten Wörtern in gemischten Paaren ausbalanciert war. Reine Paare waren zusammengesetzt aus zwei belebten Wörtern oder aus zwei unbelebten Wörtern. In der intentionalen Enkodierungsphase wurden die Teilnehmenden gebeten, die einzelnen Wörter auswendig zu lernen. Die Teilnehmenden wurden darüber informiert, dass es nicht erforderlich sein würde, gepaarte Wörter als Paar zu erinnern. In einer einzigen Testphase wurden die Teilnehmenden in einem

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[3] Am 9. März 2024 wurde eine Literaturrecherche durchgeführt, um in wissenschaftlichen Fachzeitschriften publizierte Studien zu identifizieren, in denen Belebtes und Unbelebtes über die Präsentation von belebten und unbelebten Wörtern enkodiert wurden und der Belebtheitseffekt in einem freien Reproduktionstest gemessen wurde. Diese Suche ergab 24 Studien mit insgesamt 51 Experimenten. Die Experimente der Einzelarbeiten 2 und 3 wurden in der Berechnung nicht berücksichtigt.

freien Reproduktionstest gebeten, die einzelnen Wörter in einer beliebigen Reihenfolge aufzuschreiben. Wenn eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern zum Zeitpunkt der Enkodierung kausal zum Belebtheitseffekt beiträgt, dann sollte der Belebtheitseffekt in der Bedingung mit gemischten Paaren größer ausfallen als in der Bedingung mit reinen Paaren.

Die kritische Interaktion zwischen dem Belebtheitsstatus der Wörter und der Zusammensetzung der Paare war nicht signifikant und der Belebtheitseffekt war in der Bedingung mit gemischten Paaren genauso groß wie in der Bedingung mit reinen Paaren. Experiment 3.2 liefert daher Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt.

Eine mögliche Limitation der Experimente 3.1 und 3.2 ist, dass die Teilnehmenden – wie in der Originalarbeit von Popp und Serra (2016) – die belebten und unbelebten Wörter intentional enkodiert haben. Eine potenziell asymmetrische Aufteilung der begrenzten Aufmerksamkeitsressourcen auf belebte und unbelebte Wörter sollte jedoch in einer inzidentellen Enkodierungsaufgabe stärker ausgeprägt sein.

Experiment 3.3 – Inzidentelle Enkodierung von gemischten versus reinen Paaren

In Experiment 3.3 sollte eine potenziell asymmetrische Aufteilung der begrenzten Aufmerksamkeitsressourcen auf belebte und unbelebte Wörter durch eine inzidentelle Enkodierungsaufgabe akzentuiert werden. Intentionales Enkodieren erfordert es, Aufmerksamkeit auf alle zu erinnernden Wörter – unabhängig von ihrem Belebtheitsstatus – zu lenken. In einer inzidentellen Enkodierungsaufgabe, in der die Teilnehmenden die Wörter beiläufig und ohne die Intention enkodieren, die Wörter später zu erinnern, wird die Aufteilung der begrenzten Aufmerksamkeitsressourcen auf belebte und unbelebte Wörter mutmaßlich stärker von den Eigenschaften der Wörter selbst – wie beispielsweise von ihrem Belebtheitsstatus – bestimmt. Félix et al. (2019) haben gezeigt, dass der Belebtheitseffekt nach inzidentellem Enkodieren größer ist als nach intentionalem Enkodieren (aber siehe Gelin et al., 2017). Als Erklärung dieses Befundes haben die Autor:innen vorgeschlagen, dass eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern in inzidentellen Enkodierungsaufgaben stärker ausgeprägt sein könnte als in intentionalen Enkodierungsaufgaben.

Experiment 3.3 war identisch zu Experiment 3.2 mit der Ausnahme, dass eine inzidentelle Enkodierungsaufgabe verwendet wurde. In der inzidentellen Enkodierungsphase wurden die Teilnehmenden gebeten, die Summe der in dem Paar von Wörtern enthaltenen Buchstaben so genau wie möglich zu bestimmen und aufzuschreiben. Wenn eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern zum Zeitpunkt der Enkodierung kausal zum Belebtheitseffekt beiträgt, dann sollte der Belebtheitseffekt in der Bedingung mit gemischten Paaren größer ausfallen als in der Bedingung mit reinen Paaren.

Die kritische Interaktion zwischen dem Belebtheitsstatus der Wörter und der Zusammensetzung der Paare war nicht signifikant und der Belebtheitseffekt war in der Bedingung mit gemischten

Paaren genauso groß wie in der Bedingung mit reinen Paaren. Experiment 3.3 liefert daher Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt.

Diskussion

Angesichts der inkonsistenten Befundlage bezüglich des kausalen Beitrags einer attentionalen Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern zum Belebtheitseffekt (Bonin et al., 2015; Leding, 2019; Popp & Serra, 2016; Rawlinson & Kelley, 2021) wurden in den Experimenten 3.1 bis 3.3 bislang im Rahmen des Belebtheitseffekts kaum oder gar nicht genutzte experimentelle Manipulationen der Möglichkeit zur attentionalen Priorisierung verwendet, um eine Schlussfolgerung über den kausalen Beitrag dieses kognitiven Mechanismus zum Belebtheitseffekt auf Basis neuer empirischer Evidenz ziehen zu können. Da der Effekt der Belebtheit auf die freie Reproduktionsleistung fast ausschließlich unter Verwendung gemischter Listen gemessen wurde (aber siehe Popp & Serra, 2016), in denen eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern ermöglicht wird, war es unklar, ob der Belebtheitseffekt von der Zusammensetzung der Listen abhängt. Wenn eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern kausal zum Belebtheitseffekt beiträgt, dann sollte der Belebtheitseffekt in Bedingungen, die eine attentionale Priorisierung ermöglichen, größer ausfallen als in Bedingungen, die eine solche Priorisierung nicht ermöglichen.

Obwohl die Zusammensetzung der Listen eine stringente experimentelle Manipulation der Möglichkeit zur attentionalen Priorisierung darstellt und eine Vielzahl von Gedächtnisphänomenen von der Zusammensetzung der Listen abhängt (McDaniel & Bugg, 2008; Talmi, 2013), wurde diese experimentelle Manipulation nach bestem Wissen bislang nur von Popp und Serra (2016) herangezogen, um den Effekt der Belebtheit auf die freie Reproduktionsleistung zu vergleichen zwischen gemischten Listen, in denen belebte und unbelebte Wörter gemeinsam präsentiert werden, und reinen Listen, in denen belebte und unbelebte Wörter getrennt präsentiert werden. Die kritische Interaktion zwischen dem Belebtheitsstatus der Wörter und der Zusammensetzung der Listen war statistisch nicht signifikant. Die Beobachtung, dass der Belebtheitseffekt unter Verwendung gemischter Listen stärker ausgeprägt war als unter Verwendung reiner Listen, war jedoch Anlass für eine Replikation mit erhöhter Stichprobengröße. Trotz einer ausreichend hohen Sensitivität des statistischen Tests der kritischen Interaktion unterschied sich der Belebtheitseffekt jedoch in Experiment 3.1 auch nicht signifikant zwischen der Gruppe mit gemischten Listen und der Gruppe mit reinen Listen. Unter den Präsentations- und Testbedingungen, unter denen der klassische Belebtheitseffekt (Nairne et al., 2013) gemessen wurde, liefert die experimentelle Manipulation der Zusammensetzung der Listen also Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt.

Abweichend von dem typischen sequenziellen Präsentationsformat wurde in den Experimenten 3.2 und 3.3 ein simultanes Präsentationsformat verwendet, um die Konkurrenz um begrenzte Aufmerksamkeitsressourcen zwischen belebten und unbelebten Wörtern zum Zeitpunkt der Enkodierung zu manipulieren. Abweichend von der intentionalen Enkodierungsaufgabe, die in der

Originalarbeit von Popp und Serra (2016) sowie in den Experimenten 3.1 und 3.2 verwendet wurde, wurde in Experiment 3.3 eine inzidentelle Enkodierungsaufgabe verwendet, um eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern losgelöst von intentionalen Lernstrategien zu ermöglichen. Der Belebtheitseffekt war in der Bedingung mit gemischten Paaren, in denen ein belebtes und ein unbelebtes Wort simultan präsentiert wurden, genauso groß wie in der Bedingung mit reinen Paaren, in denen zwei belebte Wörter oder zwei unbelebte Wörter simultan präsentiert wurden, und zwar unabhängig davon, ob die Enkodierungsaufgabe intentional oder inzidentell war.

Zusammen mit der bis dato verfügbaren empirischen Evidenz (Bonin et al., 2015; Popp & Serra, 2016; Rawlinson & Kelley, 2021; aber siehe Leding, 2019) liefert jedes der Experimente 3.1 bis 3.3 Evidenz gegen einen kausalen Beitrag des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt. Daraus ergibt sich eine klare Schlussfolgerung: Die Hypothese, dass dem Belebtheitseffekt der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, muss zurückgewiesen werden.

Allgemeine Diskussion

Während eine funktionale Analyse des Gedächtnisses die Vorhersage des Belebtheitseffekts aufgrund der adaptiven Funktion des Gedächtnisvorteils für Belebtes gegenüber Unbelebtem ermöglicht hat (Nairne et al., 2017; Nairne et al., 2013), sind die zugrundeliegenden kognitiven Mechanismen bislang weitgehend ungeklärt. In der vorliegenden Dissertation wurden die beiden aussichtsreichsten Hypothesen (siehe auch Nairne et al., 2013) zu den kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, experimentell geprüft, um fundierte Antworten auf die Fragen zu erhalten, ob Belebtes besser erinnert wird als Unbelebtes, weil Belebtes reichhaltiger enkodiert wird als Unbelebtes oder ob Belebtes besser erinnert wird als Unbelebtes, weil Belebtes auf Kosten von Unbelebtem attentional priorisiert wird. In den Experimenten 1.1 und 1.2 wurde über multinomiale Modellierungen der Qualität der Erinnerung eine zentrale Implikation der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung oder der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, geprüft. Belebte Wörter sollten in Rekognitionstests detaillierter erinnert werden als unbelebte Wörter. In den Experimenten 2.1 bis 2.4 und 3.1 bis 3.3 wurden über experimentelle Manipulationen der Reichhaltigkeit der Enkodierung beziehungsweise der Möglichkeit zur attentionalen Priorisierung die potenziellen kausalen Beiträge dieser kognitiven Mechanismen zum Belebtheitseffekt in freien Reproduktionstests geprüft.

Zunächst wurde die folgende Implikation geprüft, die sowohl mit der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung zugrunde liegt, als auch mit der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, kompatibel ist: Der Belebtheitsstatus der Wörter sollte nicht alle Prozesse, die den im Rekognitionstest beobachtbaren Urteilen für alte und neue Wörter zugrunde liegen, in gleichem Maße beeinflussen, sondern selektiv den Prozess der detaillierten Erinnerung.

Multinomiale Modellierungen der Qualität der Erinnerung (Buchner et al., 1995; Erdfelder et al., 2007), die in Experiment 1.1 anhand subjektiver Urteile in der Remember-Know-Guess-Prozedur (Gardiner et al., 1997) und in Experiment 1.2 anhand objektiver Aufgabenperformanz in der Prozessdissoziationsprozedur (Jacoby, 1991) vorgenommen wurden, liefern konvergente Evidenz für diese Implikation. Belebte Wörter wurden in Rekognitionstests detaillierter erinnert (siehe auch Bonin et al., 2014; Bugaiska et al., 2023; Bugaiska et al., 2016; Gelin et al., 2018; Mieth et al., 2019; Rawlinson & Kelley, 2021). Prozesse der Rekognition auf Basis von Vertrautheit ohne detaillierte Erinnerung und Rateprozesse unterschieden sich nicht zwischen belebten und unbelebten Wörtern.

Eine andere zentrale Implikation der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung zugrunde liegt, ist durch die Befunde von Meinhardt et al. (2020) und Bonin et al. (2022) bestätigt worden. Die Teilnehmenden berichteten spontan mehr Ideen zu belebten als zu unbelebten Wörtern. Eine andere zentrale Implikation der Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, ist durch den Befund von Bugaiska et al. (2019) bestätigt worden. Die Teilnehmenden waren in einer dem Stroop-Test ähnlichen Aufgabe langsamer, die Schriftfarbe von belebten Wörtern als die Schriftfarbe von unbelebten Wörtern zu klassifizieren. Diese Befunde wie auch die Befunde der Experimente 1.1 und 1.2 sind wertvoll, weil sie es erlauben, den Belebtheitseffekt genauer zu charakterisieren und zentrale Implikationen der zu prüfenden kognitiven Erklärungsansätze des Belebtheitseffekts zu bestätigen. Um Schlussfolgerungen über die kausalen Beiträge einer reichhaltigeren Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern und einer attentionalen Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern zum klassischen Belebtheitseffekt (Nairne et al., 2013) ziehen zu können, ist es jedoch notwendig, die postulierten Kausalfaktoren unter den Testbedingungen freier Reproduktionstests jeweils experimentell zu manipulieren.

In den Experimenten 2.1 bis 2.4 wurden experimentelle Manipulationen der Reichhaltigkeit der Enkodierung, entlehnt aus Studien zum Überlebensrelevanzeffekt (Kroneisen & Erdfelder, 2011; Kroneisen et al., 2014, 2016), auf den Belebtheitseffekt übertragen. Obwohl eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern repliziert werden konnte (siehe auch Bonin et al., 2022; Meinhardt et al., 2020), war diese reichhaltigere Enkodierung von belebten Wörtern nicht für den Gedächtnisvorteil für belebte Wörter gegenüber unbelebten Wörtern verantwortlich. In keinem der Experimente 2.1 bis 2.4 war der Belebtheitseffekt in Bedingungen, die eine reichhaltige Enkodierung der Wörter fördern, größer als in Bedingungen, die eine reichhaltige Enkodierung der Wörter restringieren. Die Experimente 2.1 bis 2.4 erlauben damit erstmalig, eine Schlussfolgerung über den kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt zu ziehen: Obwohl die reichhaltige Enkodierung als einer der beiden aussichtsreichsten Kandidaten (siehe auch Nairne et al., 2013) für die kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, gilt, muss die Hypothese, dass dem Belebtheitseffekt eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern zugrunde liegt, zurückgewiesen werden.

In den Experimenten 3.1 bis 3.3 wurden bislang im Rahmen des Belebtheitseffekts kaum oder gar nicht genutzte experimentelle Manipulationen der Möglichkeit zur attentionalen Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern verwendet, um Schlussfolgerungen über den kausalen Beitrag des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt ziehen zu können. Obwohl eine Vielzahl von Gedächtnisphänomenen davon abhängt, ob die Wörter in gemischten oder reinen Listen präsentiert wurden (McDaniel & Bugg, 2008; Talmi, 2013), wurde der Belebtheitseffekt fast ausschließlich unter Verwendung gemischter Listen gemessen (aber siehe Popp & Serra, 2016), in denen eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern ermöglicht wird. Die experimentelle Manipulation der Zusammensetzung der Listen führte bei Popp und Serra (2016) zwar zu keiner statistisch signifikanten Modulation des Belebtheitseffekts, der Belebtheitseffekt war jedoch unter Verwendung gemischter Listen deskriptiv größer als unter Verwendung reiner Listen. Trotz einer ausreichend hohen Sensitivität des statistischen Tests der kritischen Interaktion unterschied sich der Belebtheitseffekt jedoch auch in keinem der Experimente 3.1 bis 3.3 signifikant zwischen Bedingungen, die eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern ermöglichen, und Bedingungen, die eine solche Priorisierung nicht ermöglichen. Die Möglichkeit zur attentionalen Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern stand weder zum Zeitpunkt der Enkodierung noch während des Aufrechterhaltungsprozesses sowie weder unter der Wirkung noch unter dem Ausschluss intentionaler Lernstrategien in kausalem Zusammenhang mit dem Belebtheitseffekt. Konsistent mit diesen Befunden war der Belebtheitseffekt in drei anderen Studien, in denen die Verfügbarkeit von Aufmerksamkeitsressourcen für eine attentionale Priorisierung im Doppelaufgabenparadigma (siehe Craik et al., 1996) experimentell manipuliert wurde, unabhängig von der kognitiven Belastung durch eine Zweitaufgabe (Bonin et al., 2015; Rawlinson & Kelley, 2021) oder unter kognitiver Belastung nur reduziert, aber nicht komplett eliminiert (Leding, 2019). Zusammen mit der bis dato verfügbaren empirischen Evidenz (Bonin et al., 2015; Popp & Serra, 2016; Rawlinson & Kelley, 2021; aber siehe Leding, 2019) erlauben die Experimente 3.1 bis 3.3, eine Schlussfolgerung über den kausalen Beitrag des kognitiven Mechanismus der attentionalen Priorisierung zum Belebtheitseffekt zu ziehen: Obwohl die attentionale Priorisierung als einer der beiden aussichtsreichsten Kandidaten (siehe auch Nairne et al., 2013) für die kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, gilt, muss die Hypothese, dass dem Belebtheitseffekt eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern zugrunde liegt, zurückgewiesen werden.

Im Gegensatz zum Überlebensrelevanzeffekt (Nairne et al., 2007), für den sich gezeigt hat, dass der Effekt abhängig von der Reichhaltigkeit der Enkodierung (Kroneisen & Erdfelder, 2011) und der Verfügbarkeit von Aufmerksamkeitsressourcen ist (Kroneisen et al., 2014, 2016), wurde der Belebtheitseffekt weder von experimentellen Manipulationen der Reichhaltigkeit der Enkodierung (Experimente 2.1 bis 2.4) noch von experimentellen Manipulationen der Möglichkeit zur attentionalen Priorisierung (Experimente 3.1 bis 3.3) moduliert. Weder eine reichhaltigere Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern noch eine attentionale Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern scheint kausal zum Belebtheitseffekt beizutragen. Auch wenn der Überlebensrelevanzeffekt (Nairne et al., 2007) und der Belebtheitseffekt (Nairne et al., 2013) Phänomene des adaptiven Gedächtnisses sind (siehe Nairne, 2015) und ähnliche kognitive Mechanismen plausibel scheinen (Meinhardt et al., 2020), weisen die Ergebnisse der experimentellen Prüfungen darauf hin, dass diesen Effekten unterschiedliche kognitive Mechanismen zugrunde liegen (siehe auch Gelin et al., 2017; Leding, 2018).

Nairne et al. (2017) haben vorgeschlagen, dass Belebtes im semantischen Gedächtnis eine größere Anzahl von semantischen Merkmalen aufweisen könnte als Unbelebtes. Die Befunde der Experimente 1.1 und 1.2 sowie die Befunde zahlreicher anderer Studien deuten darauf hin, dass Belebtes im Vergleich zu Unbelebtem mit *reichhaltigeren Gedächtnisrepräsentationen* assoziiert ist: Im Vergleich zu unbelebten Wörtern (1) wiesen belebte Wörter mehr semantische Merkmale auf (Rawlinson & Kelley, 2021), (2) waren belebte Wörter häufiger mit Remember-Urteilen in der Remember-Know-(Guess)-Prozedur assoziiert (Bonin et al., 2014; Bugaiska et al., 2023; Bugaiska et al., 2016; Rawlinson & Kelley, 2021), was sehr wahrscheinlich auf eine detailliertere Erinnerung belebter Wörter im Vergleich zu unbelebten Wörtern zurückzuführen ist (Experiment 1.1), und (3) wurden für belebte Wörter wahrscheinlicher assoziierte Details des Kontexts der Enkodierung in der Prozessdissoziationsprozedur (Experiment 1.2) oder in Quellengedächtnistests (Gelin et al., 2018; Mieth et al., 2019) erinnert. Die Experimente 2.2 und 2.3 zeigen zusätzlich, dass belebte Wörter reichhaltiger enkodiert wurden als unbelebte Wörter (siehe auch Bonin et al., 2022; Meinhardt et al., 2020). Diese Befunde könnten auf itemspezifische Unterschiede zwischen belebten und unbelebten Wörtern hindeuten, die auch dann bestehen, wenn zahlreiche lexikalische und semantische Worteigenschaften zwischen belebten und unbelebten Wörtern konstant gehalten wurden (siehe auch Serra & DeYoung, 2023a). Experimentelle Manipulationen von Enkodierungsprozessen könnten sich auch deshalb unterschiedlich auf den Belebtheitseffekt und den Überlebensrelevanzeffekt auswirken, weil diese itemspezifischen Unterschiede nur bei der Messung des Belebtheitseffekts möglich sind, jedoch bei der Messung des Überlebensrelevanzeffekts ausgeschlossen sind. Die Hinweise auf unterschiedlich reichhaltige Gedächtnisrepräsentationen von belebten und unbelebten Wörtern stellen damit wichtige Restriktionen für die Entwicklung und Prüfung neuer kognitiver Erklärungsansätze des Belebtheitseffekts dar.

Ausblick

Vor dem Hintergrund der Robustheit des Belebtheitseffekts wäre es von großer Bedeutung, wenn sich der Effekt für praktische Anwendungen nutzbar machen ließe (Blunt & VanArsdall, 2021; Nairne, 2022). Voraussetzung für die Nutzbarkeit in der Praxis ist allerdings das Verständnis der kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen. Sparsame kognitive Mechanismen wie die in der vorliegenden Dissertation fokussierten kognitiven Mechanismen der reichhaltigen Enkodierung oder der attentionalen Priorisierung haben sich empirisch als wenig aussichtsreich erwiesen. Es erscheint deshalb bereits jetzt plausibel, dass dem Belebtheitseffekt kognitive Mechanismen mit höherer Komplexität zugrunde liegen. Hinweise darauf liefern Studien, in denen sich gezeigt hat, dass bestimmte Formen der bildhaften Vorstellung bei der Enkodierung von Wortmaterial ohne klar erkennbare kategoriale Organisation kausal zum Belebtheitseffekt in freien Reproduktionstests beitragen könnten (Blunt & VanArsdall, 2021; Bonin et al., 2015; Gelin et al., 2019). Anhand dieser Befunde lässt sich spekulieren, ob die kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, weder allein von der Art der durch die Enkodierungsaufgabe angeregten Verarbeitung der Wörter noch allein von der Art der durch die Organisation des Wortmaterials angeregten Verarbeitung der Wörter bestimmt werden, sondern entscheidend von deren Kombination geprägt sind (siehe Einstein & Hunt, 1980; Hunt & Einstein, 1981).

Abgesehen davon gibt es Hinweise auf eine neuronale Spezialisierung in der Verarbeitung und Repräsentation von Belebtem (z. B. Caramazza & Shelton, 1998; Mormann et al., 2011; Thorpe et al., 1996; Warrington & Shallice, 1984). Daher ist nicht auszuschließen, dass die Suche nach *bereichsübergreifenden* (engl. *domain-general*) kognitiven Mechanismen, wie sie in der vorliegenden Dissertation geprüft oder vorgeschlagen wurden, erfolglos bleibt, weil unser Gedächtnis in der Evolutionsgeschichte mit *bereichsspezifischen* (engl. *domain-specific*) kognitiven Mechanismen zur vermehrten und detaillierteren Erinnerung an Belebtes im Vergleich zu Unbelebtem ausgestattet wurde.

Zukünftige Forschung sollte diese Vorschläge prüfen. Das Ziel der vorliegenden Dissertation war es, Schlussfolgerungen über die kausalen Beiträge der kognitiven Mechanismen der reichhaltigen Enkodierung und der attentionalen Priorisierung zum Belebtheitseffekt zu ermöglichen. Fortschritte in der Analyse der kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, sind bislang nur durch Zurückweisung postulierter Kausalfaktoren erzielt worden. Es wurde keine empirische Evidenz für kausale Beiträge der emotionalen Erregung (Meinhardt et al., 2018), wahrgenommenen Bedrohung (Leding, 2019), bildhaften Vorstellung ohne Selbstbezug (Blunt & VanArsdall, 2021; Gelin et al., 2019) oder kategorialen Organisation (VanArsdall et al., 2017) zum Belebtheitseffekt gefunden. Die reichhaltige Enkodierung und die attentionale Priorisierung können nun zu dieser Liste bereits ausgeschlossener kognitiver Mechanismen hinzugefügt werden.

Bei einer Analyse der kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, werden evolutionäre Erklärungsansätze des Gedächtnisvorteils für Belebtes gegenüber Unbelebtem (Nairne et al., 2017; Nairne et al., 2013) nicht infrage gestellt. Es erübrigt sich dabei auch keine funktionale Analyse, warum die kognitiven Mechanismen für Belebtes effizienter sind als für Unbelebtes (Nairne & Pandeirada, 2016). Hätten die Experimente 2.1 bis 2.4 beispielsweise Evidenz für einen kausalen Beitrag des kognitiven Mechanismus der reichhaltigen Enkodierung zum Belebtheitseffekt geliefert, wäre zum umfassenden Verständnis des Belebtheitseffekts immer noch eine Antwort auf die Frage erforderlich, inwiefern eine reichhaltigere Enkodierung von Belebtem im Vergleich zu Unbelebtem die Überlebens- und Fortpflanzungschancen erhöht. Sowohl die Identifikation der kognitiven Mechanismen, die für die quantitativen und qualitativen Unterschiede in der Erinnerung zwischen belebten und unbelebten Wörtern verantwortlich sind, als auch die Integration dieser kognitiven Mechanismen in eine funktionale Analyse des Gedächtnisses bleibt daher eine Herausforderung für zukünftige Forschung.

Fazit

Die durch die vorliegende Dissertation erzielten Fortschritte in der Analyse der kognitiven Mechanismen, die dem Gedächtnisvorteil für Belebtes gegenüber Unbelebtem zugrunde liegen, sind wie folgt zusammenzufassen: Eine zentrale Implikation der von Nairne et al. (2013) schon bei der Entdeckung des Belebtheitseffekts in Betracht gezogenen und vielfach diskutierten Annahme, dass dem Belebtheitseffekt der kognitive Mechanismus der reichhaltigen Enkodierung oder der kognitive Mechanismus der attentionalen Priorisierung zugrunde liegt, ist zwar zunächst bestätigt worden. Belebte Wörter wurden detaillierter erinnert als unbelebte Wörter. Dennoch hatten die entscheidenden experimentellen Manipulationen der Reichhaltigkeit der Enkodierung und der Möglichkeit zur attentionalen Priorisierung jeweils keine Modulation des Belebtheitseffekts zur Folge, sodass kausale Zusammenhänge zwischen einer reichhaltigeren Enkodierung von belebten Wörtern im Vergleich zu unbelebten Wörtern oder einer attentionalen Priorisierung von belebten Wörtern auf Kosten von unbelebten Wörtern und dem Belebtheitseffekt unwahrscheinlich sind. Angesichts der Tatsache, dass der Belebtheitsstatus eines Wortes in erheblichem Maße determiniert, ob das Wort in einem freien Reproduktionstest erinnert wird oder nicht (Aka et al., 2021; Madan, 2021; Nairne et al., 2013), bleibt die Frage nach den kognitiven Mechanismen, die dem Belebtheitseffekt zugrunde liegen, weiter bestehen.

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Einzelarbeiten

Einzelarbeit 1

Komar, G. F., Mieth, L., Buchner, A. & Bell, R. (2023). Animacy enhances recollection but not familiarity: Convergent evidence from the remember-know-guess paradigm and the process-dissociation procedure. *Memory & Cognition*, *51*(1), 143–159. https://doi.org/10.3758/s13421-022-01339-6

Die Einzelarbeit 1 beinhaltet die Experimente 1.1 und 1.2.

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Animacy enhances recollection but not familiarity: Convergent evidence from the remember-know-guess paradigm and the process-dissociation procedure

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Abstract

Words representing living beings are better remembered than words representing nonliving objects, a robust finding called the animacy effect. Considering the postulated evolutionary-adaptive significance of this effect, the animate words' memory advantage should not only affect the quantity but also the quality of remembering. To test this assumption, we compared the quality of recognition memory between animate and inanimate words. The remember-know-guess paradigm (Experiment 1) and the process-dissociation procedure (Experiment 2) were used to assess both subjective and objective aspects of remembering. Based on proximate accounts of the animacy effect that focus on elaborative encoding and attention, animacy is expected to selectively enhance detailed recollection but not the acontextual feeling of familiarity. Multinomial processing-tree models were applied to disentangle recollection, familiarity, and different types of guessing processes. Results obtained from the remember-know-guess paradigm and the process-dissociation procedure convergently show that animacy selectively enhances recollection but does not affect familiarity. In both experiments, guessing processes were unaffected by the words' animacy status. Animacy thus not only enhances the quantity but also affects the quality of remembering: The effect is primarily driven by recollection. The results support the richness-of-encoding account and the attentional account of the animacy effect on memory.

Keywords Animacy advantage · Recollection · Familiarity · Remember-know-guess paradigm · Process-dissociation procedure

Introduction

An evolutionary-adaptive, function-based account of human cognition (Nairne & Pandeirada, 2016) predicts that animate beings are prioritized in cognitive processing relative to inanimate objects (Nairne et al., 2013; Nairne et al., 2017). The distinction between animate beings and inanimate objects is fundamental for perception and attention (New et al., 2007), occurs early in development (Opfer & Gelman, 2011), and is present at the neurorepresentational level (Caramazza & Shelton, 1998). Extending this line of research, animacy has been established as an important determinant of memory (Nairne et al., 2017). Specifically, it has been reported that words referring to animate beings (henceforth animate words) are better remembered than words referring to inanimate objects (henceforth inanimate words). This finding has become known as the *animacy effect* on memory (Nairne et al., 2013). While the animacy effect has robustly been found in free-recall paradigms (Bonin et al., 2014; Leding, 2019; Meinhardt et al., 2018, 2020; Popp & Serra, 2016, 2018), it is less clear whether there is a robust animacy advantage in recognition paradigms. Some researchers have reported enhanced recognition of animate in comparison to inanimate words (Bonin et al., 2014), but inconsistent results have also been obtained (Leding, 2020; Mieth et al., 2019). For instance, Leding (2020) reported that animacy induced a guessing bias towards believing the words had occurred before, but the animacy status did not affect memory accuracy. A potential reason for these inconsistent findings is that animacy might not equally enhance all processes underlying observable recognition memory performance. Theories with a focus on elaborative encoding (Meinhardt et al., 2020) and

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attention (Bugaiska et al., 2019) allow predicting animacy to specifically enhance recollection but not familiarity. The present study serves to test this hypothesis by examining both subjective and objective aspects of remembering using the remember-know-guess paradigm (Gardiner et al., 1996; Gardiner et al., 1997) and the process-dissociation procedure (Jacoby, 1991), respectively. Furthermore, we will adopt a multinomial modeling approach to capture process-pure measures of recollection and familiarity and to clearly distinguish between memory and guessing processes.

Since the animacy effect on memory was first introduced (Nairne et al., 2013), enhanced free recall of animate as compared to inanimate words has been demonstrated with different types of intentional (Bonin et al., 2015; Félix et al., 2019; Nairne et al., 2013) and incidental encoding conditions, such as pleasantness-rating or animacy-categorization tasks (Bonin et al., 2014; Félix et al., 2019; Gelin et al., 2017). An animacy advantage has been found with words in different languages (in French, Bonin et al., 2014; in Portuguese, Félix et al., 2019; in German, Meinhardt et al., 2018; in English, Nairne et al., 2013), pictures (Bonin et al., 2014), and pseudowords that were associated with properties characteristic of animate beings or inanimate objects (VanArsdall et al., 2013). Although there seem to be some boundary conditions (Kazanas et al., 2020; Popp & Serra, 2016), the effect has been demonstrated to generalize to different types of memory tests, such as paired-associate recall (VanArsdall et al., 2015), serial-order recall (Daley et al., 2020), and source-memory tests (Gelin et al., 2018; Mieth et al., 2019). Only recently, a large-scale study on word memorability (Madan, 2021) confirmed the original finding of Nairne et al. (2013) that a word's animacy status explains more variance in free recall than other dimensions, such as concreteness or age of acquisition, and thus may be one of the most relevant semantic word dimensions for predicting memory performance.

Based on the adaptive-memory framework proposed by Nairne and co-workers (for a review, see Nairne & Pandeirada, 2016), it has been postulated that cognitive systems have been evolutionarily tuned to solve adaptive problems. Prioritizing information about animate beings over information about inanimate objects might have increased the inclusive fitness of our ancestors because animate beings, such as predators, prey, and mating partners, entail a high significance for achieving specific adaptive goals related to survival and reproduction (Nairne & Pandeirada, 2008). Regardless of the animacy effect's potential evolutionary-adaptive value, however, there is still much to learn about the immediate proximate mechanisms underpinning its expression (for how to distinguish ultimate and proximate explanations in evolutionary theory, see Scott-Phillips et al., 2011). Several such mechanisms have already been ruled out as they failed to gain empirical support, including categorical recall strategies (Nairne et al., 2013; Serra, 2021; VanArsdall et al., 2017), emotional arousal (Meinhardt et al., 2018; Popp & Serra, 2018), and mental imagery (Blunt & VanArsdall, 2021; Gelin et al., 2019).

By contrast, both the *richness-of-encoding account* and the *attentional account* have received some empirical support and thus offer promising explanations of the animacy effect. Following a proposition by Nairne et al. (2017), Meinhardt et al. (2020) found that animate words spontaneously stimulated participants to generate more ideas than inanimate words. Already established as a proximate mechanism underlying the survival-processing effect (Erdfelder & Kroneisen, 2014; Kroneisen et al., 2013; Kroneisen et al., 2014, 2016; Kroneisen & Erdfelder, 2011; Röer et al., 2013), the richness-of-encoding account may thus also provide a proximate explanation of the animacy effect. Specifically, animate items may benefit from a richer encoding context that may provide more distinctive memory traces and thus a larger set of retrieval cues at test (see also Bonin et al., 2022). According to the attentional account (Bugaiska et al., 2019), animate items are more likely to draw attention during encoding than inanimate items. Bonin et al. (2015) did not find evidence for the animacy effect to decrease under cognitive load but reported in one of three experiments that secondary task performance suffered when target words denoted animate items, consistent with the idea that animate items capture attention. In line with these results, Bugaiska et al. (2019) showed that participants were slower to name the font color of animate words than that of inanimate words in the Stroop paradigm, further supporting the idea that attentional resources are drawn to the animate words. Leding (2019) required her participants to perform the encoding task and the secondary task simultaneously. Unlike Bonin et al. (2015), who administered the primary and secondary task consecutively, she found a reduced animacy effect on free recall under divided attention compared to the full-attention condition, suggesting that at least part of the processing advantage of animate words is attributable to an increased allocation of attentional resources to the animate words. This finding is at odds with that from a study by Rawlinson and Kelley (2021), who also used a simultaneous dual-task paradigm but found that the word-type-by-attention interaction was not significant in both free recall and recognition. However, Rawlinson and Kelley provided evidence suggesting that animate beings are more richly represented than inanimate objects.

While the results are still rather mixed, the richness-of-encoding and the attentional account converge in that animacy should affect not only the quantity of remembering but also its quality. For instance, the richness-of-encoding account implies that animate compared to inanimate items elicit more ideas during encoding that later serve as retrieval cues at test. This implies that participants should remember not only the items themselves but also the cognitions that were active while encoding the item. In recognition tests, memory for previously encountered animate items should therefore be enhanced not only by feelings of familiarity but also by the recollection of associated thoughts. Similarly, increased attentional prioritization during encoding should selectively enhance recollection but not familiarity (Gardiner & Parkin, 1990).

To understand potential moderators of the animacy effect, it thus seems promising to examine how animacy affects the quality of recognition. According to dual-process theories (for a review, see Yonelinas, 2002), recognition memory is composed of a controlled retrieval process referred to as *recollection* and an automatic process yielding an item's *familiarity*. Only in the memory state of recollection are participants able to recall specific contextual details of the encoding episode (e.g., the thoughts that came to mind while reading a word). Familiarity-based recognition solely involves an acontextual feeling that an item occurred before. Recollection is assumed to require attention during encoding and retrieval, while familiarity may be less likely to rely on such controlled processing (Gardiner et al., 1996; Gardiner & Parkin, 1990; Yonelinas, 2002).

To date, studies examining animacy effects on recognition are scarce and rely predominantly on the *remember-know paradigm* introduced by Tulving (1985) and further developed by Gardiner (1988). The remember-know paradigm is considered as an extension of the classical old-new recognition paradigm and requires participants to qualify their experiential retrieval states following an "old" judgment as "remembered" or "known." "Remember" judgments are reserved for those memories that involve rich recollections of the encoding episodes. "Know" judgments, by contrast, are to be given when participants experience only feelings of familiarity but do not have rich and vivid experiences of remembering. In the *remember-know-guess paradigm*, participants are also allowed to indicate that they classified a word as "old" based on guessing (Gardiner et al., 1996; Gardiner et al., 1997).

Regarding the animacy effect, Bonin et al. (2014) found a higher number of "remember" judgments for recognized animate than inanimate words, while neither the number of "know" judgments nor the number of "guess" judgments differed between animate and inanimate words. These findings were replicated in two additional studies (Bugaiska et al., 2016; Rawlinson & Kelley, 2021) in which animacy selectively enhanced "remember" judgments without affecting "know" judgments, while false-alarm rates were unaffected. However, Leding (2020) found an increase in false-alarm rates for animate words. Beyond that, the animacy effect on recognition was eliminated once response bias was taken into account, suggesting that animacy primarily affected guessing but not recognition accuracy. Stimulated by these inconsistencies, the present study serves to reassess the effect of animacy on the quality of experiential retrieval states with the remember-know-guess paradigm involving a new set of words. Remember-know paradigms, however, are not free from criticism. For instance, emotional events are often associated with an intensified subjective experience of recollection compared to neutral events even if the accuracy of the objective memory for contextual details is not enhanced (Sharot et al., 2004; Talarico & Rubin, 2003). The enhanced rate of "remember" judgments for emotional words may thus reflect a more intense emotional experience without affecting memory accuracy. Analogously, it is possible that animate words are more likely to be judged as being "remembered" only because they elicit subjective feelings of vividness which, however, may be unrelated to the mnemonic status of the words. Simply providing a "guess" category is unlikely to solve the problem that animate words may be experienced as more vivid at test.

The present study offers two remedies to these issues. First, in Experiment 1, we reapply the remember-know-guess paradigm to establish a link to prior research (e.g., Bonin et al., 2014) but use the well-validated multinomial *four-states model of memory retrieval experiences* (Erdfelder et al., 2007) to separately measure recollection-based memory processes (experiencing memory of an item including the circumstances in which the item has been encountered), familiarity-based memory processes (experiencing memory of an item without detailed contextual integration), guessing (selecting an item in the absence of memory), and the detection of new words (as not having been encountered before). The model yields parameters that reflect recollection and familiarity without being contaminated by guessing. Recollection and familiarity can thus be measured and compared at the level of the postulated latent memory processes underlying the words' observable classification in the memory test. A major advantage of the four-states model is that it has been empirically validated: The model's recollection parameter has been shown to be sensitive to depth-of-encoding manipulations while remaining unaffected by response-bias manipulations that only affect the model's guessing parameters (Erdfelder et al., 2007). A second extension of prior studies is that we do not rely on the remember-know-guess paradigm alone but complement this approach using the process-dissociation procedure (Jacoby, 1991) in Experiment 2 to objectively distinguish between contributions of recollection, familiarity, and guessing processes to performance in recognition memory tasks. Specifically, we use the well-validated *multinomial process-dissociation model* (Buchner et al., 1995) to separately measure memory and guessing processes. By examining animacy effects on both subjectively experienced retrieval states (Experiment 1) and objective memory performance (Experiment 2), we aim to test whether these two approaches provide convergent evidence

Table 1 Dimensions on which animate and inanimate word lists were matched in Experiment 1

Dimension (range of the rating scale)	Animate		Inanimate		Comparison
	M	*SD*	*M*	*SD*	
Semantic typicality (1–7)	2.37	0.94	2.58	1.36	$t(140.12) = 1.11, p = .267, d = 0.18$
Age of acquisition (1–7)	3.35	1.21	3.40	1.18	$t(158) = 0.25, p = .806, d = 0.04$
Conceptual familiarity (1–5)	3.19	0.57	3.34	0.83	$t(140.65) = 1.34, p = .183, d = 0.21$
Word frequency	9.54	17.65	9.00	18.27	$t(158) = 0.19, p = .850, d = 0.03$
Number of phonemes	5.05	1.57	4.90	1.36	$t(158) = 0.65, p = .518, d = 0.10$
Number of syllables	2.03	0.81	1.99	0.67	$t(152.21) = 0.32, p = .750, d = 0.05$
Number of letters	6.15	1.66	5.74	1.52	$t(158) = 1.64, p = .104, d = 0.26$
Concreteness (1–7)	5.17	0.51	5.08	0.54	$t(158) = 1.09, p = .276, d = 0.17$
Meaningfulness (1–7)	3.66	0.72	3.60	0.75	$t(158) = 0.51, p = .614, d = 0.08$
Imagery (1–7)	5.47	0.96	5.46	1.00	$t(158) = 0.11, p = .912, d = 0.02$

Norms provided by Schröder et al. (2012) were taken to determine semantic typicality, age of acquisition, conceptual familiarity, word frequency (based on dlexDB database, Heister et al., 2011), number of phonemes, and number of syllables of the animate and inanimate words. Values for the number of letters, concreteness, meaningfulness, and imagery were taken from the norming study by Meinhardt et al. (2020). Words were selected so as to minimize, for each dimension, the mean differences between the lists of animate and inanimate words. The rightmost column shows that the lists of animate and inanimate words did not differ significantly on any of the controlled dimensions

on the effect of animacy on recognition. Both the richness-of-encoding account (Meinhardt et al., 2020) and the attentional account (Bugaiska et al., 2019) allow us to derive the prediction that the animacy effect should be primarily driven by the enhanced recollection of animate compared to inanimate words. These accounts thus lead to the hypothesis that animacy should selectively enhance recollection but not familiarity.

Experiment 1

Method

Participants

The online experiment was implemented using SoSci Survey (Leiner, 2020) and made available through https://www.soscisurvey.de. Participation was only possible with a desktop or laptop computer, not with a smartphone or tablet. The experiment was advertised on social media and via email. All participants were students. The final sample consisted of 110 participants (99 female) with a mean age of 22 years (*SD* = 5). Twenty-nine additional data sets could not be included in the analysis: 26 participants did not complete the experiment (ten participants dropped out even before they had given informed consent, presumably following our instructions to close the browser window if they were not in a distraction-free environment; six dropped out when they were asked about their demographic data; ten dropped out after they had started the encoding task), and three participants were under 18 years old and thus not of legal age in Germany (which is a requirement for consenting on the use of their data). We aimed for a sample size of at least 100 valid data sets and stopped data collection at the end of the day on which this criterion was reached. A sensitivity analysis with G*Power (Faul et al., 2007) revealed that, with a sample size of $N = 110$, 160 responses in the recognition test, and $\alpha = .05$, an effect of animacy on the four-states model's recollection and familiarity parameters of the size $w = 0.03$ could be detected with a statistical power of $1 - \beta = .95$. Participation was compensated by course credit or the chance to win a € 20 voucher for a popular online store. All participants gave written informed consent prior to participation. Approval was obtained from the ethics committee of the Faculty of Mathematics and Natural Sciences at Heinrich Heine University Düsseldorf for a series of animacy experiments to which the present experiment belongs. However, minor adjustments were necessary due to the COVID-19 pandemic that did not require additional ethics approval. The experiment was conducted in accordance with the Declaration of Helsinki.

Materials

Following the procedure of Meinhardt et al. (2020), we obtained the word materials from the database of German words by Schröder et al. (2012). Lists of animate and inanimate words (80 words each) were matched on ten mnemonically relevant dimensions (see Table 1). The norming data were taken from the norming studies by Schröder et al. (2012) and Meinhardt et al. (2020).

Procedure

In the incidental encoding phase, a mixed list of 40 animate and 40 inanimate words was presented in random order. These words were randomly selected from the set of 80 animate and 80 inanimate words for each participant; the remaining 80 words were used as new words in the unexpected recognition test (see below). The present experiment was modeled after a study by Bonin et al. (2014) in which an animacy-categorization task was used. In the present experiment, participants had to rate the animacy status of each word on a seven-point scale ranging from *certainly inanimate* (1) to *certainly animate* (7). Each word was displayed in 20-point Arial font at the center of the browser window until participants initiated the presentation of the next word. Recording of the response times at encoding began when the word was presented and ended when the participant clicked on the "next" button.

The recognition test was separated from the encoding phase by a short distractor task lasting 44 s (SD = 14) on average, in which participants completed ten simple mathematical equations such as "15 – 7 = ?" (M = 98 % correct). In the recognition test, the 80 old words from the encoding phase were randomly intermixed with 80 new words (40 animate, 40 inanimate), resulting in 160 words being presented. The participants were instructed to indicate for each word whether it was "old" or "new." Conditional upon a word being judged as "old," participants were also asked to indicate the quality of their memory according to the remember-know-guess paradigm (Gardiner et al., 1996; Gardiner et al., 1997). The instructions read:

> For some words, you will recollect exact details of the circumstances in which you saw the word. For example, you may precisely recollect the type face or the thoughts that crossed your mind while reading the word. Then you have a "detailed recollection" of the word. For other words, however, you will have a "feeling of familiarity." You then only know that the word is old without recollecting details of the circumstances in which you learned the word. Still other words you will judge as "old" based on "guessing." You then have neither a detailed recollection nor a feeling of familiarity but merely guess that the word may have been present in the first phase.

For each word classified as "old," participants indicated whether their classification was based on a "detailed recollection," a "feeling of familiarity," or "guessing." These labels were chosen because the present experiment served to measure recollection and familiarity. In fact, participants do not always seem to intuitively understand the labels of the remember-know-guess paradigm in its canonical form (Umanath & Coane, 2020). In German, the language in which the experiment was conducted, the literal translation of "I know" conveys a particularly strong confidence in one's memory, while "I remember" indicates a relatively lower level of confidence in one's memory. However, the labels "detailed recollection" and "feeling of familiarity" reflect the to-be-measured constructs less ambiguously and were thus used, together with detailed instructions. The "guessing" response category was included because it has been found to improve the precision of parameter estimation in the four-states model (Erdfelder et al., 2007). Participants clicked the "next" button to proceed.

After the recognition test, participants were asked to report whether they had followed the instructions and whether all stimuli had been accurately presented.[1] Thereafter, participants were compensated, debriefed, and thanked for their time. The experiment took about 30 min.

Results

Ratings and response times

As expected, animacy ratings were higher for animate words (M = 6.45, SE = 0.07) than for inanimate words (M = 1.97, SE = 0.11), $t(109) = 26.39$, $p < .001$, $d_z = 2.52$. After applying an outlier correction (excluding response times that deviated by ± 3 SD from the individual mean), it was found that participants rated animate words (M = 3,442 ms, SE = 106 ms) faster than inanimate words (M = 3,738 ms, SE = 125 ms), $t(109) = 4.58$, $p < .001$, $d_z = 0.44$, which is in line with previous studies (Bonin et al., 2014; Gelin et al., 2018; Mieth et al., 2019).

Recollection, familiarity, guessing, and detection of new words

To facilitate comparisons with prior research, the mean proportions of the different types of judgments by word type and animacy status are provided in Table 2. However, note that the hypotheses that are tested in the present experiment do not directly refer to these proportions but instead refer to the latent cognitive states into which these raw performance measures are decomposed as specified in the model-based analysis reported below.

In Experiment 1, the results were analyzed with the multinomial four-states model by Erdfelder et al. (2007), shown in Fig. 1, to clearly distinguish between recollection, familiarity, guessing, and the detection of new words. Multinomial

[1] Based on their responses, it would have been possible to exclude the data of two more participants. However, this would not have changed any statistical conclusions, so we decided to include these data sets into the final analysis, following a recommendation of Elliott et al. (2022).

Table 2 Mean proportions of "detailed recollection," "feeling of familiarity," "guessing," and "new" judgments by word type and animacy status in Experiment 1

The old and new words' animacy status	Judgment							
	"Detailed recollection"		"Feeling of familiarity"		"Guessing"		"New"	
Old animate	.53	(.02)	.23	(.01)	.06	(.01)	.19	(.01)
Old inanimate	.48	(.02)	.25	(.01)	.07	(.01)	.20	(.01)
New animate	.02	(< .01)	.07	(.01)	.05	(.01)	.86	(.01)
New inanimate	.03	(< .01)	.09	(.01)	.06	(.01)	.82	(.01)

Values in parentheses represent standard errors

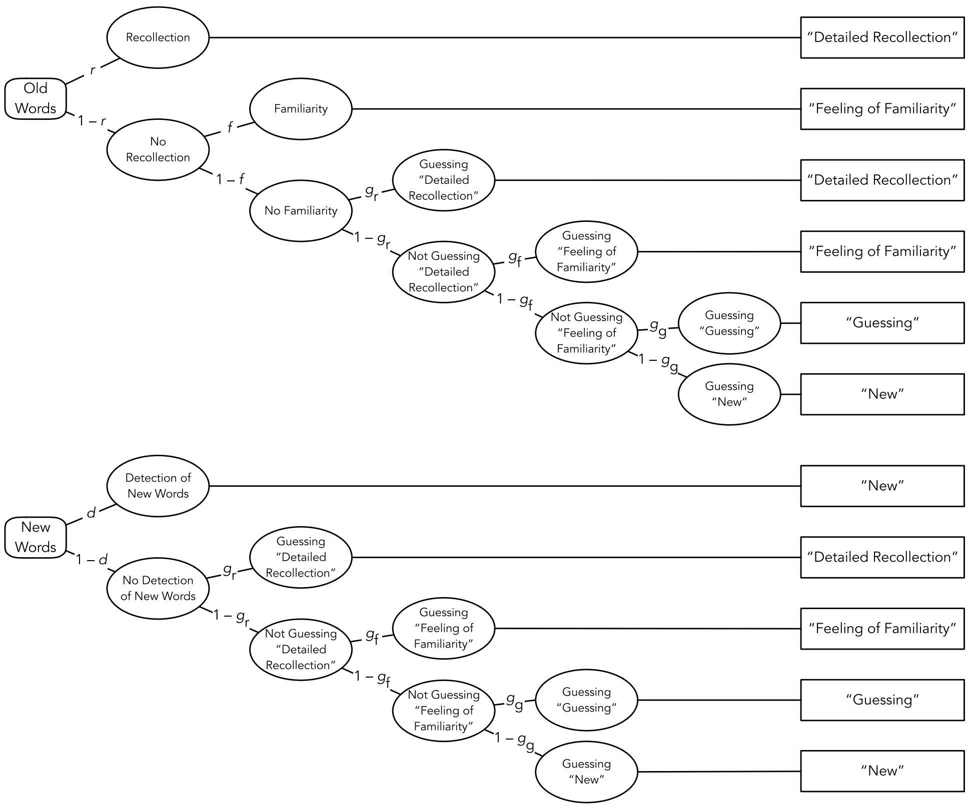

Fig. 1 The four-states model by Erdfelder et al. (2007), adapted to the present experiment. Rounded rectangles on the left represent the words presented in the recognition test (old or new with respect to the encoding phase). The parameters attached to the branches of the trees denote transition probabilities between sequences of latent cognitive states (*r*: probability of recollection; *f*: conditional probability of familiarity in case of recollection failure; g_r: conditional probability to guess "detailed recollection" in an uncertainty state; g_f: probability to guess "feeling of familiarity" in an uncertainty state, conditional on not having guessed "detailed recollection"; g_g: probability to choose "guessing" in an uncertainty state, conditional on not having guessed "detailed recollection" or "feeling of familiarity"; *d*: probability of detecting new words as new). The rectangles on the right represent the categories of observable responses

processing-tree models, to which class the applied model belongs, are stochastic models that explain observable response frequencies as a function of the postulated latent cognitive states or processes (for reviews, see Batchelder & Riefer, 1999; Erdfelder et al., 2009). The model's parameters reflect these processes and are represented as probabilities varying between 0 and 1. Importantly, the model's parameters for recollection and familiarity can be interpreted as reflecting only the processes they were intended to measure, since they are uncontaminated by the guessing processes that are represented by separate parameters for guessing "detailed recollection" and "feeling of familiarity" (Erdfelder et al., 2007).

To illustrate, the upper tree of Fig. 1 refers to the processing of old words presented during the encoding phase. An old word is recollected with probability *r*, resulting in a "detailed recollection" judgment. If participants do not have a detailed recollection of the word, which occurs with probability $1 - r$, it may still appear familiar with the conditional probability f, triggering a "feeling of familiarity" judgment.[2] If an old word is neither recollected nor familiar, which occurs with probability $(1 - r) \cdot (1 - f)$, guessing processes lead to a "detailed recollection" judgment with the conditional probability g_r, to a "feeling of familiarity" judgment with the conditional probability $(1 - g_r) \cdot g_f$, or to a "guessing" judgment with the conditional probability $(1 - g_r) \cdot (1 - g_f) \cdot g_g$. Alternatively, participants may guess that the word was "new" with the conditional probability $1 - g_g$.

The lower tree of Fig. 1 refers to new words not presented in the encoding phase. New words can be correctly detected as new and thus be rejected with probability d. Detection fails with probability $1 - d$, in which case guessing processes occur in the same way as for old words and result in "detailed recollection," "feeling of familiarity," "guessing," or "new" judgments with the conditional probabilities g_r, g_f, g_g, or $1 - g_g$, respectively.

To examine how animacy affects the parameters of the four-states model, two sets of the processing trees displayed in Fig. 1 were needed, one for animate and one for inanimate words. Parameter estimates and goodness-of-fit tests were calculated using multiTree (Moshagen, 2010). The four-states model is saturated (Erdfelder et al., 2007).

One advantage of multinomial processing-tree models is that they allow testing hypotheses directly at the level of the postulated processes. To illustrate, it is possible to formulate the to-be-tested hypothesis that recollection, reflected in parameter r, should differ between animate and inanimate words. This hypothesis can be implemented as an equality restriction by setting parameter r to be equal between animate and inanimate words. If the model including this equality restriction provides a significantly worse fit to the data than the base model not including this equality restriction, then it is necessary to conclude that recollection differs between animate and inanimate words.

We started the analysis by examining whether guessing differed between animate and inanimate words. The assumption that, in a state of uncertainty, guessing "detailed recollection" (g_r), guessing "feeling of familiarity" (g_f), and guessing "guessing" (g_g) each do not differ between animate and inanimate words was compatible with the data; the model incorporating these restrictions fit the data, $G^2(3) = 3.90$, $p = .272$, and was used as the base model for the following comparison of the recollection and the familiarity parameters between animate and inanimate words.

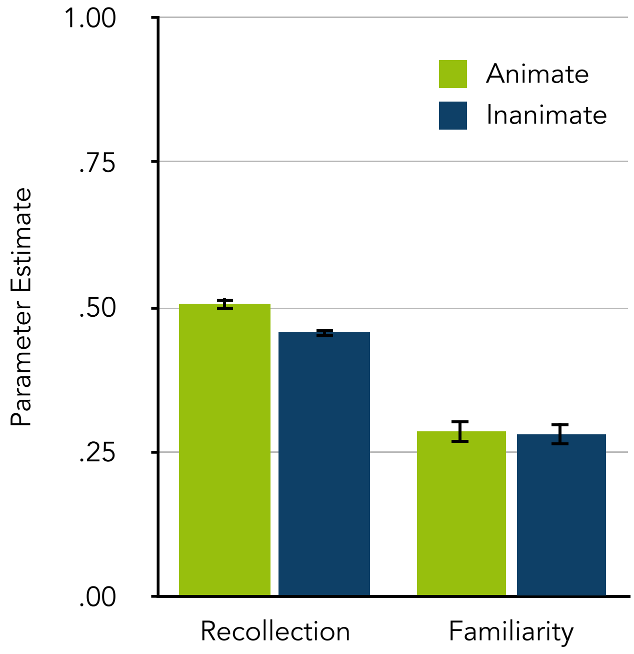

Fig. 2 The quality of memory retrieval experiences according to the four-states model by Erdfelder et al. (2007), as estimated in Experiment 1. The parameter estimates of recollection (r) and familiarity-based (f) processes are shown separately for animate and inanimate words. The error bars represent standard errors

Figure 2 shows the estimates of the parameters representing recollection (r) and familiarity-based (f) processes for animate and inanimate words. Animate words were more likely to be recollected than inanimate words, $\Delta G^2(1) = 19.68$, $p < .001$, $w = 0.03$. Familiarity, by contrast, did not differ between animate and inanimate words, $\Delta G^2(1) = 0.02$, $p = .877$, $w < 0.01$.

However, the animacy advantage was not restricted to the recollection of words that had been present in the encoding phase. New animate words were also more likely to be detected as new than new inanimate words, $\Delta G^2(1) = 26.06$, $p < .001$, $w = 0.04$. Parameter d was significantly higher for animate (.71, $SE = .01$) than for inanimate words (.62, $SE = .02$). The estimates of the guessing parameters are reported in Table 3.

Discussion

The results of Experiment 1 confirm the hypothesis derived from the richness-of-encoding account (Meinhardt et al., 2020) and the attentional account (Bugaiska et al., 2019) that animacy selectively enhances recollection. Even though animate words were encoded for a shorter period of time compared to inanimate words, animate words were more likely to be recollected than

[2] Note that parameter f and the corresponding guessing parameter g_f refer to the parameters k and g_k of the original model by Erdfelder et al. (2007). The parameter labels were adapted to the labels of the recollection and familiarity judgments used in the present experiment, which also allows us to maintain consistency when referring to the recollection and familiarity-based processes across our two experiments.

Table 3 Estimates of the guessing parameters in Experiments 1 and 2

The words' animacy status	Experiment 1			Experiment 2	
	g_r	g_f	g_g	g_i	g_e
Animate	.07 (.01)	.26 (.01)	.24 (.01)	.32 (.01)	.26 (.01)
Inanimate					

Experiment 1: Estimates of the guessing parameters of the four-states model by Erdfelder et al. (2007). The guessing parameters g_r, g_f, and g_g (see text for details) were each set to be equal between animate and inanimate words. Experiment 2: Parameters of guessing "old" in the inclusion test (g_i) and in the exclusion test (g_e) of the two-high threshold variant of the multinomial process-dissociation model by Buchner et al. (1995) were each set to be equal between animate and inanimate words within the base model. Values in parentheses represent standard errors

inanimate words (for a discussion of the relationship between response times and the richness of a word's semantic representation, see Bonin et al., 2019). The animacy effect on the detection of new words was parallel to the animacy effect on the recollection of old words, as it should be (Glanzer & Adams, 1985). The parameters reflecting familiarity, by contrast, remained unaffected by animacy. Unlike Leding (2020), who found that animacy increased false-alarm rates, we did not find animacy effects on any of the three guessing parameters, allowing us to equate each of them between animate and inanimate words in our base model without significantly reducing the model fit. The present model-based analyses thus confirmed previous evidence (Bonin et al., 2014; Bugaiska et al., 2016; Rawlinson & Kelley, 2021) of animacy improving recognition memory by enhancing recollection but not familiarity.

Although we took guessing into account by applying the four-states model (Erdfelder et al., 2007) to the data of the remember-know-guess paradigm, the most important limitation of Experiment 1 is that the conclusions rest on self-reports of the participants' experiential retrieval states. The results thus depend on the participants' interpretation of what the response labels "detailed recollection" and "feeling of familiarity" were supposed to convey. To what extent, for example, the familiarity-based memory process as captured by the label "feeling of familiarity" corresponds to the process captured by the label "know" is open to debate (e.g., Pereverseff & Bodner, 2020; Williams & Lindsay, 2019; Williams & Moulin, 2015). Moreover, subjective experiences of recollection and familiarity may not invariably reflect objective memory accuracy. Research on memory of emotional events (Sharot et al., 2004; Talarico & Rubin, 2003) suggests that a subjectively intensified experience of recollection, which may result from increased arousal, does not always imply increased accuracy of memory. The natural vividness of animate beings may likewise make participants believe they are remembering vivid details when in fact they misinterpret these subjective feelings of vividness as enhanced recollection, yet without memory accuracy actually being enhanced. Our results do not support such an interpretation, since the four-states model (Erdfelder et al., 2007) was designed to provide process-pure measures of recollection and familiarity, and animacy was not associated with an increased tendency to guess "detailed recollection." However, to arrive at clear conclusions about the link between animacy and recollection, it does not seem optimal to rely solely on measures that depend on the participants' subjective interpretation of their experiential retrieval states.

Hence, Experiment 2 served to test whether the evidence for the enhanced recollection of animate words could be conceptually replicated using a procedure that allows for a performance-based measurement of the quality of recognition: the process-dissociation procedure (Jacoby, 1991). Similar to the remember-know(-guess) paradigm, the process-dissociation procedure serves to dissociate recollection from familiarity-based processes. However, rather than relying on subjectively experienced retrieval states and associated metacognitive beliefs about remembering, estimates of recollection and familiarity are derived from the participants' objective capacity to follow the instructions in the memory test. Specifically, participants are confronted with three types of words in a recognition test: Critical words learned in a first encoding phase (Phase 1), words learned in a second encoding phase (Phase 2), and new words not presented during encoding (cf. Buchner et al., 1995). Two types of test instructions are given: In the *inclusion test*, participants have to respond "old" to all words presented during encoding and "new" to words that were not seen during encoding. In the *exclusion test*, the "old" response is reserved for words from Phase 2. Participants have to reject (or exclude) all critical words from Phase 1 and call them "new," just like the words not encountered before. Once guessing is taken into account, correct "old" responses to Phase-1 words are assumed to arise from both recollection and familiarity in the inclusion test. In the exclusion test, by contrast, recollection facilitates but familiarity impedes avoiding false "old" responses to Phase-1 words. From these assumptions, measures of recollection and familiarity are derived (Jacoby, 1991). Parallel to the methodological approach taken in Experiment 1, we used multinomial modeling to disentangle recollection, familiarity, and guessing processes by applying a variant of the well-validated multinomial process-dissociation model (Buchner et al., 1995). The predictions for the recollection and familiarity parameters are identical to those for the subjective measures in Experiment 1: Animacy should selectively enhance recollection but not familiarity.

Table 4 Dimensions on which animate and inanimate word lists were matched in Experiment 2

Dimension (range of the rating scale)	Animate		Inanimate		Comparison
	M	*SD*	*M*	*SD*	
Semantic typicality (1–7)	2.39	0.94	2.61	1.36	$t(137.17) = 1.21$, $p = .228$, $d = 0.19$
Age of acquisition (1–7)	3.35	1.20	3.42	1.18	$t(154) = 0.36$, $p = .718$, $d = 0.06$
Conceptual familiarity (1–5)	3.19	0.58	3.33	0.82	$t(138.11) = 1.29$, $p = .199$, $d = 0.21$
Word frequency	9.33	17.82	8.89	18.46	$t(154) = 0.15$ $p = .878$, $d = 0.02$
Number of phonemes	5.03	1.55	4.92	1.37	$t(154) = 0.44$, $p = .661$, $d = 0.07$
Number of syllables	2.03	0.81	2.00	0.66	$t(148.64) = 0.22$, $p = .829$, $d = 0.03$
Number of letters	6.14	1.63	5.77	1.53	$t(154) = 1.47$, $p = .144$, $d = 0.24$
Concreteness (1–7)	5.17	0.48	5.09	0.49	$t(154) = 1.07$, $p = .285$, $d = 0.17$
Meaningfulness (1–7)	3.64	0.73	3.59	0.76	$t(154) = 0.47$, $p = .637$, $d = 0.08$
Imagery (1–7)	5.48	0.94	5.48	0.96	$t(154) < 0.01$, $p = .998$, $d < 0.01$

In Experiment 2, two animate and two inanimate words were excluded from the stimulus set used in Experiment 1. Norming data were taken from Schröder et al. (2012) and Meinhardt et al. (2020). Words were selected so as to minimize, for each dimension, the mean differences between the lists of animate and inanimate words. The rightmost column shows that the lists of animate and inanimate words did not differ significantly on any of the controlled dimensions

Experiment 2

Method

Participants

Experiment 2 was made available online using SoSci Survey (Leiner, 2020). Participation was only possible with a desktop or laptop computer. The experiment was advertised on social media and via email. All participants but one were students. The final sample contained data from 163 participants (125 female) with a mean age of 24 years ($SD = 7$). They were randomly assigned to either the inclusion test ($n = 81$) or the exclusion test ($n = 82$). Eighty-three additional data sets could not be included in the analysis because the participants did not complete the experiment (30 participants dropped out even before they had given informed consent, presumably following our instructions to close the browser window if they were not in a distraction-free environment; 18 dropped out when they were asked about their demographic data; 35 participants – 18 assigned to the inclusion and 17 to the exclusion test – dropped out after they had started the encoding task). We used all but four of the words used in Experiment 1 to achieve comparability between the experiments. Given that in the process-dissociation procedure the analysis is based only on Phase-1 words and new words (while Phase-2 words are typically not included in the analysis; see Buchner et al., 1995; Jacoby, 1991), it was necessary to use a slightly larger sample of $N = 163$ participants to compensate for the lower number of data points in the recognition test to achieve the same level of sensitivity of the model-based statistical analysis. A sensitivity analysis indicated that with this sample size, 104 relevant data points in the recognition test, and $\alpha = .05$, an effect of animacy on the multinomial process-dissociation model's recollection and familiarity parameters of the size $w = 0.03$ could be detected with a statistical power of $1 - \beta = .95$ (Faul et al., 2007). Participation was compensated by course credit or the chance to win a € 20 online voucher. All participants gave written informed consent prior to participation. Approval was obtained from the ethics committee of the Faculty of Mathematics and Natural Sciences at Heinrich Heine University Düsseldorf for a series of animacy experiments to which the present experiment belongs. Minor adjustments were necessary due to the COVID-19 pandemic that did not require additional ethics approval. The experiment was conducted in accordance with the Declaration of Helsinki.

Materials

The stimulus set was created by excluding two animate and two inanimate words from the stimulus set used in Experiment 1 to ensure that three equally sized, non-overlapping stimulus subsets could be created. These subsets consisted of 26 animate and 26 inanimate words each, were randomly selected without replacement for each participant from the lists of 78 animate and 78 inanimate words, and were presented in two encoding phases and as new words in the test phase. The animate and inanimate word lists were matched on ten mnemonically relevant dimensions (see Table 4).

Procedure

In Phase 1, the critical encoding phase, a mixed list of 26 animate and 26 inanimate words was presented in random order. As in Experiment 1, participants incidentally learned the words while performing a self-paced animacy-rating task. In Phase 2, participants were instructed to intentionally learn a new mixed list of 26 animate and 26 inanimate words. As in Phase 1, Phase-2 words were shown in random order at the center of the browser window in 20-point Arial font. In each trial of the intentional learning task, participants saw the word for 1 s before a "next" button appeared. The word was displayed until the participant pressed the button to proceed. To facilitate discrimination between Phase-1 words and Phase-2 words, Phase-1 words were shown in blue font color and Phase-2 words in red font color.

The recognition test was separated from Phase 2 by a short distractor task with a mean duration of 37 s (*SD* = 13), in which participants completed ten simple mathematical equations (*M* = 98 % correct). In the test phase, the 104 words from both encoding phases were randomly intermixed with 26 new animate words and 26 new inanimate words, resulting in 156 words being presented in black font color. Depending on the test condition, participants completed one of two different recognition tests conforming to Jacoby's (1991) process-dissociation procedure. Inclusion versus exclusion tests were manipulated between subjects because the multinomial process-dissociation model had been validated using between-subjects designs (Buchner et al., 1995), and we did not want to confuse participants with varying test instructions. Participants performing the inclusion test were instructed to choose "old" for the blue words rated in Phase 1 *and* for the red words intentionally learned in Phase 2. Words they had not seen before had to be judged "new." Participants performing the exclusion test were instructed to select "old" *only* for the red words they had intentionally learned in Phase 2. Blue words from Phase 1 had to be rejected and called "new," just like the words they had not seen before. Participants were instructed that if a word had been presented in blue font color in the rating task, the same word could not have been among the words that had to be retained for the recognition test. In each trial of the recognition test, a word (presented at the center of the browser window) had to be classified as "old" or "new." At the bottom of the browser window, condition-specific instructions remained visible throughout the test. Once the word was classified as "old" or "new," participants clicked a "next" button to proceed to the next word.

After the recognition test, participants were asked to report whether they remembered the instructions, whether they followed the instructions, and whether all stimuli were accurately presented.[3] Thereafter, participants were compensated, debriefed, and thanked for their time. The experiment lasted roughly 30 min.

[3] Based on their responses, it would have been possible to additionally exclude data from 23 participants. However, this would not have changed any statistical conclusions, so we decided to include these data sets into the final analysis, following a recommendation of Elliott et al. (2022).

Results

Ratings and response times

As expected, animacy ratings were higher for animate words ($M = 6.34$, $SE = 0.07$) than for inanimate words ($M = 1.96$, $SE = 0.08$), $t(162) = 30.37$, $p < .001$, $d_z = 2.38$. After applying an outlier correction (excluding response times that deviated by ± 3 *SD* from the individual mean), it was again found that participants rated animate words ($M = 3{,}324$ ms, $SE = 97$ ms) faster than inanimate words ($M = 3{,}572$ ms, $SE = 107$ ms), $t(162) = 3.96$, $p < .001$, $d_z = 0.31$.

Recollection, familiarity, and guessing

To facilitate comparisons with prior research, the mean proportions of "old" and "new" judgments are presented as a function of word type, animacy status, and test condition in Table 5. However, note that our hypotheses do not directly refer to these proportions but instead refer to the latent cognitive states into which these raw performance measures are decomposed as specified in the model-based analysis reported below.

To disentangle recollection, familiarity, and guessing processes, we used a variant of the well-established multinomial process-dissociation model proposed and validated by Buchner et al. (1995) as presented in Fig. 3. Following the process-dissociation procedure (Buchner et al., 1995; Jacoby, 1991), only the cognitive processes that occur in response to Phase-1 words and new words are displayed. The sequences of processes that lead to "old" or "new" judgments in the inclusion and exclusion tests are illustrated in the upper and lower trees, respectively.

A Phase-1 word in the inclusion test (upper left tree in Fig. 3) is assumed to be recollected with probability r, resulting in an "old" judgment. If participants do not recollect a Phase-1 word, which occurs with probability $1 - r$, the word may still appear familiar with the conditional probability f, thus prompting an "old" judgment.[4] If a word is neither recollected nor familiar, which occurs with probability $(1 - r) \cdot (1 - f)$, the word is guessed to be "old" with the conditional probability g_i or guessed to be "new" with probability $1 - g_i$.

[4] Note that the parameters r and f correspond to the parameters c and $u_{c\_}$ (referring to "conscious" and "unconscious" memory), respectively, of the extended measurement model for the process-dissociation procedure proposed by Buchner et al. (1995). The parameter labels were adapted to maintain consistency when referring to the recollection and familiarity-based processes across experiments and to use labels that are more neutral in terms of the subjective experience of the underlying processes (e.g., familiarity in the process-dissociation procedure does not necessarily imply that the process is completely unconscious).

Table 5 Mean proportions of "old" and "new" judgments for old words presented in Phase 1 and new words as a function of animacy status and test condition in Experiment 2

The old and new words' animacy status	Inclusion test				Exclusion test			
	Judgment				Judgment			
	"Old"		"New"		"Old"		"New"	
Old animate	.84	(.01)	.16	(.01)	.28	(.02)	.72	(.02)
Old inanimate	.80	(.02)	.20	(.02)	.30	(.02)	.70	(.02)
New animate	.15	(.01)	.85	(.01)	.12	(.02)	.88	(.02)
New inanimate	.16	(.01)	.84	(.01)	.13	(.02)	.87	(.02)

Values in parentheses represent standard errors

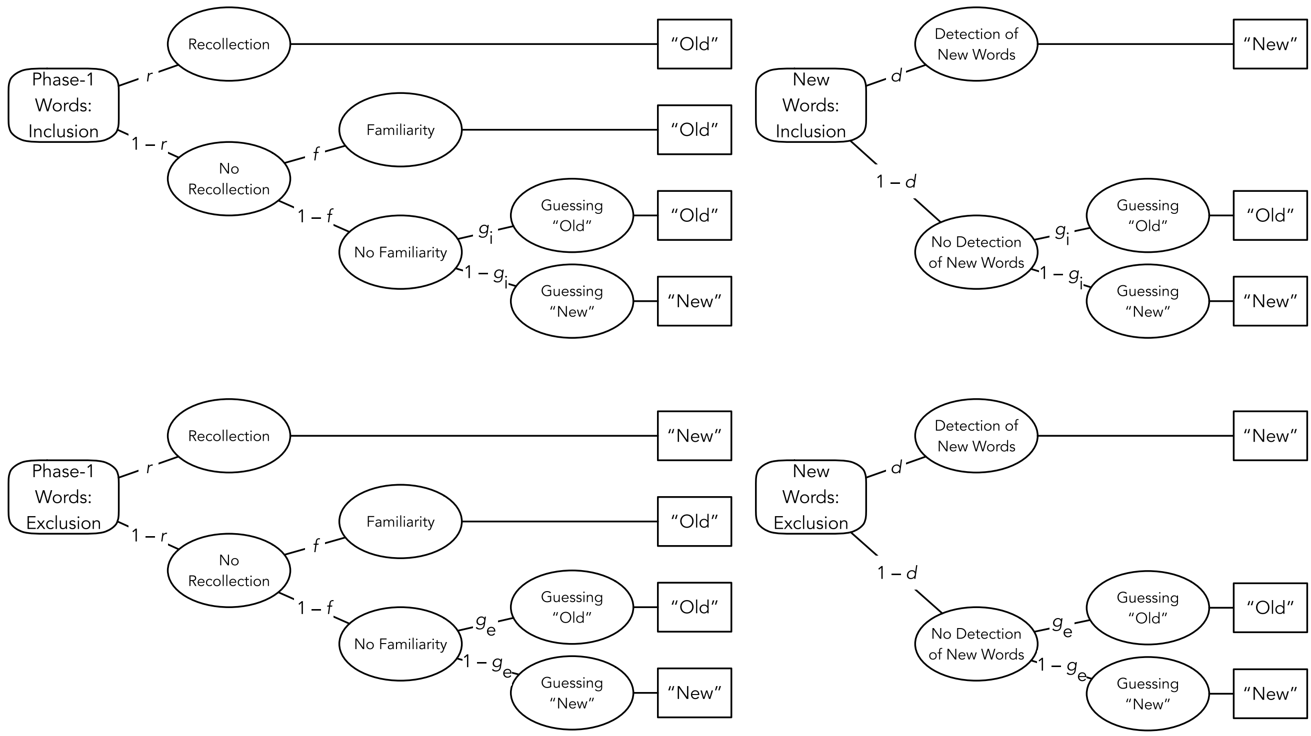

Fig. 3 The multinomial process-dissociation model by Buchner et al. (1995), adapted to the present experiment. Rounded rectangles on the left represent the presented words (old Phase-1 words or new words) of the recognition test. The upper trees refer to words presented in the inclusion test and the lower trees to words presented in the exclusion test. The parameters attached to the branches of the trees denote transition probabilities between sequences of latent cognitive states (r: probability of recollection; f: conditional probability of familiarity in case of recollection failure; g_i: conditional probability to guess "old" in an uncertainty state in the inclusion test; g_e: conditional probability to guess "old" in an uncertainty state in the exclusion test; d: probability of detecting new words as new). The rectangles on the right represent the categories of observable responses

In the exclusion test (lower left tree in Fig. 3), a Phase-1 word is assumed to be recollected with probability r. Exclusion instructions require participants to reject Phase-1 words. Therefore, recollection leads to a "new" judgment. If participants fail to recollect a Phase-1 word, which occurs with probability $1 - r$, it may still appear familiar with the conditional probability f, triggering an "old" judgment. If a word is neither recollected nor familiar, which occurs with probability $(1 - r) \cdot (1 - f)$, the word is guessed to be "old" with the conditional probability g_e or guessed to be "new" with probability $1 - g_e$.

The model depicted in Fig. 3 deviates from the original model by Buchner et al. (1995) in that it incorporates the assumption that a new word can be detected as new with probability d, prompting a "new" judgment (trees on the right side of Fig. 3). It has been shown that the model that includes this assumption provides an even better fit to the validation data by Buchner et al. than a model that denies that new words can be detected (Erdfelder & Buchner, 1995), consistent with the general pattern that two-high threshold models (including the detection of new words) perform better than one-high threshold models (denying the detection of new words) in validation studies (Bayen et al., 1996; Snodgrass & Corwin, 1988). If detection fails, which occurs with probability $1 - d$, guessing processes result in an "old" judgment with the conditional probabilities g_i and g_e in the inclusion test and the exclusion test, respectively. Alternatively, a word is guessed to be "new" with probabilities $1 - g_i$ in the inclusion test and $1 - g_e$ in the exclusion test.

To test how animacy affects the memory and guessing parameters, two sets of the processing trees displayed in Fig. 3 were needed, one for animate and one for inanimate words. Without imposing additional equality restrictions, the model is not identifiable. As suggested by Erdfelder and Buchner (1995), we adopted the assumption that the probability of recollecting an old word (r) is equal to the probability of detecting a new word as new (d), separately for animate and inanimate words, since Erdfelder and Buchner showed that the model including this restriction performed better in validation tests than alternative models.[5] This restriction resulted in a saturated model. Parallel to Experiment 1, we started our analysis by examining whether guessing differed between animate and inanimate words. The assumptions that guessing "old" in the inclusion test (g_i) does not differ between animate and inanimate words and that guessing "old" in the exclusion test (g_e) does not differ between animate and inanimate words were compatible with the data; the model incorporating these restrictions fit the data, $G^2(2) = 0.02$, $p = .990$, and was used as the base model to estimate the parameters and to test our hypotheses.

Figure 4 shows the parameter estimates of recollection (r) and familiarity-based (f) processes for animate and inanimate words. The probability of recollecting animate words was higher than that of inanimate words, $\Delta G^2(1) = 11.36$, $p < .001$, $w = 0.03$. By contrast, animate and inanimate words did not differ in familiarity, $\Delta G^2(1) = 2.64$, $p = .104$, $w = 0.01$, although, descriptively, animate words were more likely to appear familiar than inanimate words. The estimates of the guessing parameters are reported in Table 3.

[5] While the two-high threshold model does not only provide a better fit to the validation data (Erdfelder & Buchner, 1995) but also to the present data than the one-high threshold model originally proposed by Buchner et al. (1995), the assumption that the recollection of old words is equal to the detection of new words is not critical to the results reported here, since the conclusions about the animacy effects on recollection, familiarity, and guessing processes remain the same regardless of whether the two-high threshold or the original one-high threshold variant of the model is applied to the data.

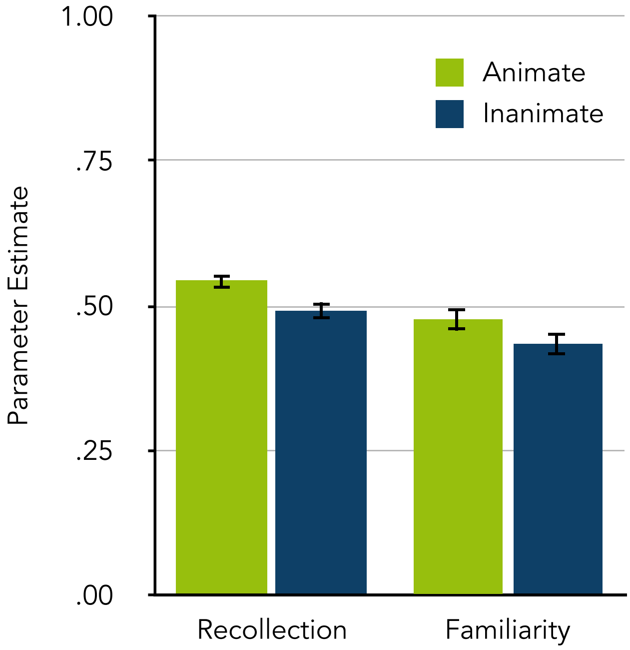

Fig. 4 The quality of recognition according to the two-high threshold variant of the multinomial process-dissociation model by Buchner et al. (1995), as estimated in Experiment 2. The parameter estimates of recollection (r) and familiarity-based (f) processes are shown separately for animate and inanimate words. The error bars represent standard errors

Discussion

The results of Experiment 2 confirm those of Experiment 1. Crucially, animate words were more likely to be recollected than inanimate words. Animacy did not significantly enhance familiarity-based processing, although animate compared to inanimate words were descriptively more likely to be judged based on familiarity. Again, guessing did not differ between animate and inanimate words. We thus conclude that animacy is associated with enhanced recollection. This conclusion is in line with the results of previous studies examining related constructs such as source memory (Gelin et al., 2018; Mieth et al., 2019).

General discussion

While the effect of animacy on free recall turned out to be a robust phenomenon (e.g., Bonin et al., 2014; Meinhardt et al., 2020; Nairne et al., 2013; Popp & Serra, 2016), data from recognition paradigms have provided only mixed support for an animacy advantage (e.g., Bonin et al., 2014; Leding, 2020; Mieth et al., 2019). Specifically, Leding (2020) reported that participants recognized more animate than inanimate words but that they also committed more false alarms on animate than on inanimate words, such that the recognition benefits were completely eliminated once guessing was taken into account. Based on these findings in isolation, it seemed possible to postulate that animacy primarily affects guessing but not memory accuracy. However, this *guessing hypothesis* contrasts with findings in the remember-know(-guess) paradigm, suggesting that animacy enhances correct recognition without affecting false-alarm rates (Bonin et al., 2014; Bugaiska et al., 2016; Rawlinson & Kelley, 2021). A possible reason for the discrepancy across studies is that animacy may not equally enhance all processes underlying recognition memory performance. Proximate mechanisms of the animacy effect such as the richness-of-encoding account (Meinhardt et al., 2020) and the attentional account (Bugaiska et al., 2019) imply the hypothesis that animacy selectively enhances recollection but not familiarity. This *recollection hypothesis* was tested in the present experiments. Both experiments provide a convergent pattern of results: Animacy enhances recollection in recognition paradigms. By contrast, familiarity and guessing are not significantly affected.

We started by examining subjectively experienced retrieval states in the remember-know-guess paradigm (Gardiner et al., 1996; Gardiner et al., 1997). Essentially, the subjective experience and associated metacognitive beliefs about remembering are supposed to be different for words that are recollected and for words that appear familiar. When examining the subjective experience of recollection and familiarity, it is important to consider guessing given that, a priori, it seemed possible that the vividness of animate beings may induce participants to guess that an animate word was recollected. Instead of comparing the raw frequencies of "remember," "know," and "guess" judgments on recognition hits and false alarms of animate and inanimate words, as was done in previous studies (Bonin et al., 2014; Bugaiska et al., 2016; Rawlinson & Kelley, 2021), we used the well-validated four-states model of memory retrieval experiences (Erdfelder et al., 2007) to obtain process-pure measures of recollection and familiarity. In line with the recollection hypothesis, animacy was selectively associated with enhanced recollection without familiarity being affected. Corresponding to the recollection advantage for old animate words, new animate words were also more likely to be detected as new than new inanimate words (see Glanzer & Adams, 1985). These findings thus suggest that the recognition advantage of animate beings is primarily driven by enhanced recollection. At the same time, we need to reject the guessing hypothesis given that the assumption that guessing does not differ between animate and inanimate words was compatible with the data.

While Experiment 1 provides further support for the recollection hypothesis of the animacy advantage, it may be problematic to solely focus on subjectively experienced recollection states to test whether animate words are better recollected than inanimate words. With the remember-know-guess paradigm, Experiment 1 necessarily relies on the participants' introspective ability to judge the quality of their retrieval states. However, it has been observed that subjective and objective measures of memory may diverge. For instance, it has been shown that emotional events may provoke flashbulb memories that are experienced as extremely vivid. This vividness, however, might reflect the arousal associated with the emotional event rather than the quality of remembering (Sharot et al., 2004; Talarico & Rubin, 2003). Accordingly, one could speculate that animate beings might elicit more vivid imagery than inanimate objects, which may boost recollection judgments. It thus should not be taken for granted that subjective and objective aspects of remembering converge without explicitly testing this assumption.

We therefore sought to conceptually replicate the effect of animacy on recollection by using a paradigm that relies on objective memory performance. In Experiment 2, participants were divided into two groups and were instructed to either include or exclude words that were previously presented in the first of two encoding phases according to the process-dissociation procedure (Jacoby, 1991). Recollection is reflected in superior performance in inclusion and exclusion tests. While both recollection and familiarity increase the probability of recognizing a word as "old" in the inclusion test, these two processes oppose each other in the exclusion test: Recollection allows participants to reject Phase-1 words, whereas familiarity prompts them to accept those words. In order to take guessing into account, parameters representing the probability of recollection and familiarity-based processes were estimated using a variant of the well-validated multinomial process-dissociation model (Buchner et al., 1995). The results suggest that, with respect to the animacy effect, the conclusions that can be drawn from subjective and objective measures of recollection and familiarity converge. Experiment 2 conceptually replicated the results of Experiment 1: Animacy was associated with enhanced recollection but not familiarity, confirming the recollection hypothesis. Furthermore, the data again forced us to reject the guessing hypothesis. The words' animacy status did not affect the guessing parameters. The present data thus confirm previous studies using the remember-know(-guess) paradigm (Bonin et al., 2014; Bugaiska et al., 2016; Rawlinson & Kelley, 2021) and extend these studies by showing that subjective and objective measures of recollection converge. Just like any measurement method, both the remember-know-guess paradigm (e.g., Umanath & Coane, 2020; Williams & Lindsay, 2019) and the process-dissociation procedure (e.g., Dodson & Johnson, 1996; Jacoby, 1998; Joordens & Merikle, 1993; for a review, see Yonelinas & Jacoby, 2012) have their limitations. The strength of the evidence presented here lies in demonstrating that methods as different as these two led to the same result with regard to the animacy effect on memory.

Due to the evolutionary-adaptive significance of living beings such as predators, prey, and mating partners, one could argue that, from an ultimate perspective, it might be adaptive that animacy enhances recollection but not familiarity. For instance, survival chances might increase if the memory trace of prey comprises a detailed recollection of the context of a previous encounter (so one knows where and when to go for hunting) rather than an acontextual memorial experience of having met a specific type of animal before. Regardless of the adaptive value of the converging evidence on how animacy affects the quality of remembering, the present findings provide insights into the proximate mechanisms underlying the animacy effect. In general, mechanistic explanations should account for the fact that animacy affects not only the quantity of remembering but also its quality. A promising explanation of the animacy effect refers to the notion that animate words are associated with a richer encoding than inanimate words (Meinhardt et al., 2020; Rawlinson & Kelley, 2021). Meinhardt et al. (2020) found that their participants spontaneously generated more ideas in response to animate than inanimate words (see also Bonin et al., 2022). Some of these associations may still be available at test and serve as effective retrieval cues in free-recall paradigms. The richness-of-encoding account thus implies that in recognition paradigms, participants should not only recognize the word but also have access to the associatively rich processing of the word that occurred during encoding, which is supposed to be experienced as enhanced recollection in the recognition test.

Another potentially related explanation of the animacy effect refers to the notion that animate words are more potent than inanimate words in capturing attention during encoding. This attentional account (Bugaiska et al., 2019) seems plausible, since animate beings and animate properties (such as animate movements) are often prioritized in perception and attention (New et al., 2007). As recollection is often assumed to be a resource-dependent process (Gardiner et al., 1996; Yonelinas, 2002), the attentional account fits the present data well. The richness-of-encoding account and the attentional account are regarded as complementary rather than competitive, since increased attention during encoding may eventually lead to richer representations (Meinhardt et al., 2020; Mieth et al., 2019). However, it seems important to mention that the more detailed recollection of animate words at retrieval is still better supported by the available data than the dependence of the animacy effect on attentional resources at encoding, for which inconsistent results have been reported (Bonin et al., 2015; Bugaiska et al., 2019; Leding, 2019; Rawlinson & Kelley, 2021). Whether the controlled allocation of attentional resources is necessary to generate and activate rich semantic representations of animate words is an open issue (Bonin et al., 2015; Rawlinson & Kelley, 2021). In the future, it will be important to disentangle these two accounts. One possibility would be to try to manipulate the postulated underlying processes – that is, attention and richness of encoding – more directly. For instance, to test the richness-of-encoding account of the animacy effect, one may rely on manipulations that have proven useful to test richness of encoding as an explanation of the survival-processing effect (Kroneisen & Erdfelder, 2011).

In summary, the present results once more confirm the hypothesis derived from the adaptive-memory framework proposed by Nairne and co-workers (Nairne et al., 2013; Nairne & Pandeirada, 2016) that animacy is associated with a memory advantage. Originally, the animacy effect refers to the quantity of remembering only: More animate than inanimate words are typically recalled in free-recall paradigms and other memory tests (Nairne et al., 2013; Nairne et al., 2017). The present results suggest that animacy affects not only the quantity of remembered information but also the subjectively experienced and objectively measurable qualitative aspects of remembering. Not only did we model the quality of recognition at the process level, but we also examined the animacy effect in two fundamentally different experimental procedures. This allowed us to tap into complementary methods to assess the quality of remembering, both subjectively with the remember-know-guess paradigm and objectively by means of the process-dissociation procedure, in order to comprehensively understand how animacy improves recognition. The results suggest that, with respect to the animacy effect, objective and subjective aspects of remembering converge: Both experiments consistently showed that animacy enhances recollection but affects neither familiarity nor guessing. Mechanistic explanations of the animacy effect thus have to account for both quantitative and qualitative changes in remembering. In this sense, the present results not only help to understand the animacy effect itself but might also promote refining the functional understanding of memory and its mechanistic underpinnings in general.

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Open practices statement The data and word materials of Experiments 1 and 2 are available at https://osf.io/knf92/. None of the experiments was preregistered.

Einzelarbeit 2

Komar, G. F., Mieth, L., Buchner, A. & Bell, R. (2024). Manipulations of richness of encoding do not modulate the animacy effect on memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *50*(4), 580–594. https://doi.org/10.1037/xlm0001249

Die Einzelarbeit 2 beinhaltet die Experimente 2.1, 2.2, 2.3 und 2.4.

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Manipulations of Richness of Encoding Do Not Modulate the Animacy Effect on Memory

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OPEN DATA

The animacy effect refers to the memory advantage of words denoting animate beings over words denoting inanimate objects. Remembering animate beings may serve important evolutionary functions, but the cognitive mechanism underlying the animacy effect has remained elusive. According to the richness-of-encoding account, animate words stimulate participants to generate more ideas than inanimate words at encoding. These ideas may later serve as retrieval cues and thus enhance recall. There is as yet only correlational evidence associating rich encoding and the animacy advantage in memory. To experimentally test the assumption that richness of encoding plays a causal role, we examined whether the animacy effect can be modulated by facilitating or suppressing rich encoding. In Experiment 1, richness of encoding was manipulated by requiring participants to write down four ideas or one idea in response to animate and inanimate words. In Experiment 2, the one-idea-generation condition was compared to an unrestricted-idea-generation condition. In Experiment 3, the unrestricted-idea-generation condition was compared to a distractor-task condition in which the idea-generation process was suppressed. In Experiment 4, richness of encoding was manipulated by asking participants to rate the relevance of the words for achieving three survival-related goals or one survival-related goal. Animate words were better remembered than inanimate words. In three of the four experiments, rich encoding led to improved recall. However, none of the manipulations of richness of encoding affected the animacy effect on memory, demonstrating its robustness irrespective of the encoding conditions. These results weaken the richness-of-encoding account of the animacy effect on memory.

Keywords: animacy advantage, adaptive memory, richness of encoding, levels of processing, elaborative encoding

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By reflecting on the adaptive function of remembered information (Nairne & Pandeirada, 2016), it is possible to derive the hypothesis that animate beings should be privileged in cognitive processing over inanimate objects. Although the distinction between animate beings and inanimate objects occurs early in development (Opfer & Gelman, 2011) and has been found to be fundamental for perception (Gao et al., 2009), attention (Altman et al., 2016; New et al., 2007), and neuronal representation (Caramazza & Shelton, 1998; Rogers et al., 2021; Thorpe et al., 1996), research has only begun to systematically investigate the effect of animacy on memory during the last decade. Nairne et al. (2013) observed that words denoting animate beings (henceforth animate words) were better remembered than words denoting inanimate objects (henceforth inanimate words). The memory advantage of animate over inanimate words is known as the *animacy effect*. The effect has been robustly observed (for a review, see Nairne et al., 2017), but the cognitive mechanism underlying the animacy effect has remained elusive. A promising candidate mechanism is a richer encoding of animate compared to inanimate words (Bonin et al., 2022; Meinhardt et al., 2020). However, the evidence in support of the richness-of-encoding account of the animacy effect is, as yet, only correlational. If there is a causal relationship between rich encoding and the memory advantage of animate over inanimate words, it should be possible to show that the animacy effect can be modulated by facilitating or suppressing rich encoding. The present series of experiments provides a stringent experimental test of this implication of the richness-of-encoding account of the animacy effect.

A large-scale study on word memorability (Madan, 2021) has recently corroborated the original finding of Nairne et al. (2013) that a word's animacy status strongly determines whether a word is recalled or not. Animate words are associated with a better memory than inanimate words even when animate and inanimate words are carefully selected to control for other mnemonically relevant word dimensions such as concreteness and meaningfulness. Since the mnemonic value of animacy has first been demonstrated (Nairne et al., 2013), the animacy advantage has been replicated

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across a wide range of experimental settings. The animacy effect on memory has been found under incidental (Bonin et al., 2014; Félix et al., 2019; Gelin et al., 2019) and intentional encoding conditions (Bonin et al., 2015; Félix et al., 2019; Nairne et al., 2013) using different encoding instructions (Gelin et al., 2017). The animacy effect is not limited to free recall (Bonin et al., 2014; DeYoung & Serra, 2021; Félix et al., 2019; Gelin et al., 2017, 2019; Leding, 2019; Meinhardt et al., 2018, 2020; Popp & Serra, 2016, 2018; VanArsdall et al., 2017) but has also been demonstrated in recognition tasks (Bonin et al., 2014; Bugaiska et al., 2016; Gelin et al., 2018; Komar et al., 2023; Rawlinson & Kelley, 2021; but see Leding, 2020) and generalizes to certain types of paired-associate recall (DeYoung & Serra, 2021; VanArsdall et al., 2015; but see Popp & Serra, 2016), serial-order recall (Daley et al., 2020) and source memory (Gelin et al., 2018; Mieth et al., 2019). Adding to its robustness, the animacy effect is not restricted to words of a certain language (it has been found in French, Bonin et al., 2014; in Portuguese, Félix et al., 2019; in German, Meinhardt et al., 2018; in English, Nairne et al., 2013; in Chinese, Xiao et al., 2016) and has also been observed when words are replaced by other to-be-remembered stimuli, such as pictures (Bonin et al., 2014) and pseudowords associated with animate or inanimate properties (Aslan & John, 2016; Mieth et al., 2019; VanArsdall et al., 2013). Animacy has been found to affect not only the number of items that are recalled but also the quality of memory (Komar et al., 2023). Using the remember-know-guess paradigm and the process-dissociation procedure, it has been demonstrated that animacy specifically improves recollection and not only familiarity (see also Bonin et al., 2014; Bugaiska et al., 2016; Rawlinson & Kelley, 2021). The animacy effect can thus be considered a robust memory phenomenon.

A central assumption of the adaptive-memory framework (for a review, see Nairne & Pandeirada, 2016) is that memory is evolutionarily tuned to information that has been essential for achieving the adaptive goals of survival and reproduction in ancestral environments (Nairne & Pandeirada, 2008). Animate beings can be predators, prey, competitors for resources, and mating partners; therefore, it has been postulated that animate beings should hold a special status in memory due to their relevance for the adaptive goals of survival and reproduction (Nairne, 2015). These functional arguments do not elucidate the cognitive mechanism underlying the animacy effect. As yet, research has not converged on what makes animate words more memorable than inanimate words. The main progress has been made in ruling out plausible candidate mechanisms. For instance, the animacy effect has been shown not to be caused by categorical recall strategies (Blunt & VanArsdall, 2021; Gelin et al., 2017; Nairne et al., 2013; Serra, 2021; VanArsdall et al., 2015, 2017), emotional arousal (Meinhardt et al., 2018; Popp & Serra, 2018), the perception of threat (Leding, 2019), or mental imagery (Blunt & VanArsdall, 2021; Gelin et al., 2019). Research on whether the animacy effect is caused by increased attentional processing of animate beings compared to inanimate objects has as yet resulted in inconclusive findings (Bonin et al., 2015; Bugaiska et al., 2019; Leding, 2019; Popp & Serra, 2016; Rawlinson & Kelley, 2021). For example, in one experiment, it was found that the animacy effect was reduced when attention was divided between the encoding of the words and a simultaneous secondary task, although animate words were significantly better recalled than inanimate words in both the divided-attention and the full-attention conditions (Leding, 2019). Other experiments did not provide evidence of a reduction of the animacy effect in dual-task paradigms (Bonin et al., 2015; Rawlinson & Kelley, 2021). A functional magnetic resonance imaging experiment (Xiao et al., 2016) showed that animate words were processed faster than inanimate words and were associated with stronger activity in the dorsal attention network, but attentional prioritization did not mediate the animacy effect on memory, suggesting that other factors must be primarily responsible for the animacy effect.

The *richness-of-encoding account* of the animacy effect is as yet among the most promising candidate cognitive accounts of the animacy effect. It is rooted in the levels-of-processing framework (Craik & Lockhart, 1972). Craik and Tulving (1975) argued that not only the depth of processing per se but rather the richness of encoded information causes deeply encoded items to be particularly memorable. A rich encoding context stimulates generating richly elaborated and distinctive associations that can serve as retrieval cues in a recall test (Moscovitch & Craik, 1976). Applying these principles to the animacy effect, Meinhardt et al. (2020) proposed that more ideas come to mind spontaneously in response to animate than in response to inanimate words. The richer encoding of animate compared to inanimate words in turn leads to a greater number of retrieval cues being available for animate compared to inanimate words, resulting in a higher recall probability of animate words (for similar ideas, see Bonin et al., 2022; Komar et al., 2023; Mieth et al., 2019).

Richness of encoding is among the most promising candidate cognitive mechanisms underlying the animacy effect (cf. Meinhardt et al., 2020) not least because the same mechanism has been helpful to understand another phenomenon that originated in the adaptive-memory framework: The survival-processing effect (Nairne et al., 2007). In a survival scenario, participants are asked to imagine being stranded in the grasslands of a foreign land without any survival materials, deprived of food and water, and threatened by predators. The participants' task is to rate how relevant a set of unrelated items, presented as to-be-read words, would be for this scenario. The survival-processing effect refers to the finding that rating the relevance of the words in the survival scenario leads to better memory for the words than rating the relevance of the words in nonsurvival control scenarios designed to support the schematic processing of the words (e.g., moving to a foreign land) and other deep encoding conditions such as a pleasantness-rating task (Nairne et al., 2007). The richness-of-encoding account of the survival-processing effect (Erdfelder & Kroneisen, 2014; Kroneisen & Erdfelder, 2011; Röer et al., 2013) implies that the survival scenario stimulates participants to generate many ideas about how the items may help them to survive in the grasslands; these ideas aid recall by serving as retrieval cues at test.

The richness-of-encoding account of the survival-processing effect is supported by two lines of evidence. Röer et al. (2013) found that participants report more ideas in the survival scenario in comparison to nonsurvival control scenarios, which confirmed an important prediction of the account. Furthermore, it has been critical for the success of the account that Kroneisen and Erdfelder (2011) provided experimental evidence that the survival-processing effect is under the control of richness of encoding. Specifically, the survival-processing effect was only present when participants were required to write down four arguments for the relevance of each word in helping them to survive and was significantly reduced when they had to write down only a single argument to support the survival relevance of each word. Moreover, the survival-processing effect was significantly reduced when participants were required to rate the relevance of the words for achieving a single survival-related goal (finding potable water), a condition that provides only limited opportunities for idea generation, in comparison to a condition in which participants rated the relevance of the words for achieving three survival-related goals (finding food, finding water, and protecting oneself from predators), which provides many opportunities for idea generation. Two other studies showed that engaging in a secondary task at encoding significantly reduced the size of the survival-processing effect, suggesting that the requirement to perform an additional task suppressed the idea-generation process and thus the rich encoding of the words that is seen as responsible for the survival-processing effect (Kroneisen et al., 2014, 2016).

Given the success of the richness-of-encoding account in illuminating the mechanism underlying the survival-processing effect (Nairne & Pandeirada, 2016), Meinhardt et al. (2020) suggested that "richness of encoding … may serve as a [cognitive] mechanism of adaptive-memory benefits in general" (p. 424). Initial support for the richness-of-encoding account of the animacy effect has already been obtained. Most importantly, Meinhardt et al. (2020) tested the crucial prediction of the richness-of-encoding account that animate words stimulate participants to generate more ideas than inanimate words. When participants were asked to write down all ideas that spontaneously came to mind when encoding the words, more ideas were indeed reported in response to animate than in response to inanimate words, a finding that was replicated by Bonin et al. (2022) with a different set of words. In both studies, the effect of animacy on free recall was partly mediated by the larger number of ideas reported in response to animate compared to inanimate words, but the direct effect of animacy on free recall remained significant even after controlling for the number of ideas that were reported at encoding. Bonin et al. (2022) added, as a limitation to these conclusions, that the number of ideas that were reported in response to the words did not reliably mediate recall of the same words when these words were encoded under other encoding conditions that did not involve idea generation. Nevertheless, they concluded that, taken as a whole, their findings support the richness-of-encoding account of the animacy effect.

However, a major limitation of the preliminary findings linking the animacy effect to richness of encoding is that "the evidence showing that richer encoding is associated with better memory is correlational" (Meinhardt et al., 2020, p. 424). Animacy may thus improve performance in both idea-generation tasks and memory tests without a direct causal relationship. A stringent test of the assumption that there is such a causal relationship requires the experimental manipulation of the causal factor of interest. Specifically, it needs to be demonstrated that a manipulation of richness of encoding modulates the animacy effect. For example, a manipulation that suppresses rich encoding should abolish or at least reduce the animacy effect. The aim of the present series of experiments was to follow up on the findings of Meinhardt et al. (2020) by providing the missing experimental test of the richness-of-encoding account of the animacy effect.

Fortunately, this test can rely on manipulations of richness of encoding that have already been proven effective in modulating the survival-processing effect (Kroneisen & Erdfelder, 2011). The present Experiment 1 was modeled after Experiment 3 of Kroneisen and Erdfelder (2011). In their experiment, the survival-processing effect was only present when participants were required to write down four ideas about how the words could be relevant to survival but was significantly reduced when participants were required to write down only one idea. Following this established approach, participants in the present Experiment 1 were asked to write down either four ideas or one idea in response to animate and inanimate words. In Experiment 2, an even stronger manipulation of richness of encoding was used by contrasting the one-idea-generation condition with an unrestricted-idea-generation condition in which participants were asked to write down as many ideas as spontaneously came to mind. In Experiment 3, the strength of the richness-of-encoding manipulation was increased once more by comparing the unrestricted-idea-generation condition to a distractor-task condition in which rich encoding was suppressed by requiring participants to solve mathematical problems during the presentation of the words (cf. Lehman et al., 2014). In the present Experiment 4 that was modeled after Kroneisen and Erdfelder's (2011) Experiment 1, participants were either required to rate the relevance of animate and inanimate words for achieving three survival-related goals or for achieving only one survival-related goal. The three-goals relevance-rating condition was designed to allow for a rich encoding of the words, whereas the one-goal relevance-rating condition provided only limited opportunities for idea generation.

We expected to replicate the finding that animate words are better remembered than inanimate words (Nairne et al., 2013). A basic implication of the richness-of-encoding account is that rich encoding should lead to enhanced memory. The critical test of the richness-of-encoding account of the animacy effect, however, is whether manipulations of richness of encoding modulate the animacy effect similar to how these manipulations have been demonstrated to modulate the survival-processing effect (Kroneisen & Erdfelder, 2011). If richness of encoding causally contributes to the animacy effect, then the animacy effect should depend on whether the encoding conditions lend themselves to rich encoding or not. Specifically, the difference in recall between animate and inanimate words should be smaller when the encoding conditions restrict or suppress a rich encoding of the words than when the encoding conditions facilitate a rich encoding of the words. In all present experiments, we consider the interaction between animacy and richness of encoding to be the critical test of the richness-of-encoding account of the animacy effect on memory.

Experiment 1

As a starting point for our series of experiments, we tested whether the animacy effect can be modulated by richness of encoding in the exact same way as the survival-processing effect by using conditions that closely mirrored those used in Experiment 3 of Kroneisen and Erdfelder (2011). In Experiment 1, richness of encoding was manipulated by requiring participants to write down either four ideas or one idea in response to animate and inanimate words. Kroneisen and Erdfelder (2011) have found a survival-processing effect in the four-ideas-generation condition but not in the one-idea-generation condition, suggesting that the restriction to think of and write down only one idea interferes with the idea-generation process that is assumed to be responsible for the survival-processing effect. Parallel to these findings, if the richness-of-encoding account of the animacy effect is valid, the animacy effect should be decreased in size in the one-idea-generation condition compared to the four-ideas-generation condition.

Method

Participants

Participants were recruited on campus at Heinrich Heine University Düsseldorf. We aimed for a sample size of at least 100 complete data sets and stopped data collection at the end of the day on which this criterion was reached. Of 101 collected data sets, three could not be included in the analysis: One data file was not saved correctly; the data of two participants were removed because these participants did not recall any of the presented words. The final sample thus consisted of 98 participants (66 female, 31 male, one nonbinary) aged between 18 and 40 ($M = 22$, $SD = 4$). Good German language skills were a requirement for participating in the experiment; 87 participants were native German speakers. A sensitivity analysis with G*Power (Faul et al., 2007) showed that, with a sample size of $N = 98$ and $\alpha = .05$, an interaction between animacy and richness of encoding on memory performance of the size $\eta_p^2 = .12$ could be detected with a statistical power of $1 - \beta = .95$. Participants were tested in groups of up to nine participants, seated separately in individual cubicles with sound-absorbing walls. Throughout the experiment, participants wore headphones with high-insulation hearing protection covers (beyerdynamic DT-150) to shield them from distraction. Participants received a small monetary reward or course credit for participating. In all experiments reported here, participants gave written informed consent prior to participation. All experiments were conducted in accordance with the Declaration of Helsinki and its amendments and were approved by the ethics committee of the Faculty of Mathematics and Natural Sciences at Heinrich Heine University Düsseldorf.

Materials, Design, and Procedure

The words were identical to those used by Meinhardt et al. (2020). The lists comprised 12 animate and 12 inanimate German words that were matched on 11 mnemonically relevant dimensions (for details, see Meinhardt et al., 2020).

Experiment 1 had a within-subjects design with animacy (animate, inanimate) and richness of encoding (four ideas, one idea) as independent variables. The words were randomly assigned to the levels of the richness-of-encoding variable, with the restriction that participants had to write down four ideas for six animate and six inanimate words and one idea for the remaining six animate and six inanimate words. The 24 words were shown in random order.

Participants were instructed that they had to perform an idea-generation task in which they were required to write down either four ideas or one idea in response to the words that they would see on the screen. Each trial started with instructions informing participants about whether they had to write down four ideas or one idea in response to the word that was about to be presented. In the four-ideas-generation condition, participants were asked "Please write down four ideas that spontaneously come to mind when reading this word." In the one-idea-generation condition, participants were asked "Please write down one idea that spontaneously comes to mind when reading this word." The instructions were shown at the top of the screen for 5 s before the word was presented at the center of the screen in 80-point Times font. Directly below the word, a text field appeared into which participants were required to type their ideas. Participants were instructed to use a separate line for each idea. Directly below the text field, a button labeled "next word" was shown that participants could use to proceed. Participants were only allowed to proceed if they had provided four ideas in the four-ideas-generation condition and one idea in the one-idea-generation condition. The idea-generation task was self-paced and the recording of the response times began when the word was presented and ended when the participant clicked on the "next word" button.

The encoding phase was followed by a distractor task in which participants judged the correctness of 20 simple mathematical equations (e.g., $3 + 6 = 9$) by clicking on either a "correct" or a "wrong" button ($M = 99\%$ correct answers). The distractor task lasted about 1 min. In the surprise memory test, participants were asked to recall the words they had been shown on the screen and to type them into a text field (each word in a separate line) in any order. Participants had 5 min to recall the words. A progress bar at the top of the screen indicated the time remaining until the test ended automatically. The median duration of the experiment was 17 min.

Transparency and Openness Statement

The data of all experiments are available on the project page of the Open Science Framework (https://osf.io/7nve4/). None of the experiments were preregistered.

Results

Idea-Generation Task

An outlier correction was applied on all response times of the present experiments by excluding response times that deviated by ± 3 *SD* or more from the individual means in all cells of the experimental designs. The mean response times in the idea-generation task are reported in Table 1.

A 2×2 repeated-measures analysis of variance (ANOVA) on the response times yielded a significant main effect of animacy, $F(1, 97) = 5.91$, $p = .017$, $\eta_p^2 = .06$, suggesting that ideas were generated faster in response to animate than in response to inanimate words. Unsurprisingly, a significant main effect of richness of encoding indicated that generating four ideas took longer than generating one idea, $F(1, 97) = 290.53$, $p < .001$, $\eta_p^2 = .75$. There was also a significant interaction between animacy and richness of encoding, $F(1, 97) = 5.49$, $p = .021$, $\eta_p^2 = .05$. Participants were faster to generate four ideas when the word was animate than when it was inanimate, $t(97) = -2.79$, $p = .006$, $d_z = -0.28$, while one idea was generated equally quickly in response to animate and inanimate words, $t(97) = -0.11$, $p = .914$, $d_z = -0.01$.

Free Recall

In the first step, recalled words that were identical to the to-be-recalled words were scored by a computer. Words that were not identical to the to-be-recalled words were manually evaluated by three human raters who were blind to the levels of the richness-of-encoding variable. Obvious misspellings and plural forms (about 3% of the recalled words) were counted as correct. Figure 1 displays the mean proportion of correctly recalled words as a function of animacy and richness of encoding. A 2×2 repeated-measures ANOVA yielded a significant main effect of animacy, $F(1, 97) = 25.69$, $p < .001$, $\eta_p^2 = .21$, indicating that animate words were better recalled than inanimate words. There was also a significant main effect of richness of encoding, $F(1, 97) = 57.82$, $p < .001$, $\eta_p^2 = .37$, indicating that generating four ideas led to better recall than generating only one idea. The critical interaction between

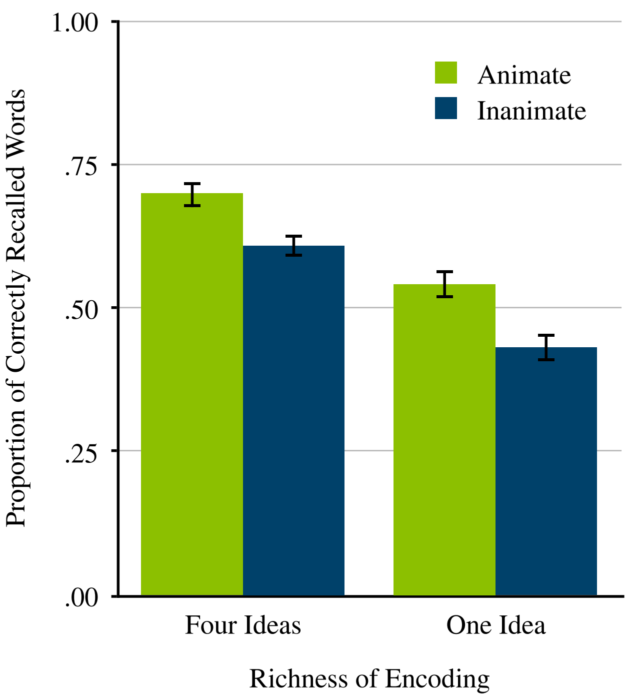
Table 1
Mean Response Times in Milliseconds in the Idea-Generation Task (Experiments 1 and 2) and the Relevance-Rating Task (Experiment 4) as a Function of Animacy and Richness of Encoding

Experiment	Animacy	Richness of encoding			
		Four ideas		One idea	
Experiment 1	Animate	26,948	(1,368)	10,517	(584)
	Inanimate	28,920	(1,475)	10,564	(544)
		Unrestricted number of ideas		One idea	
Experiment 2	Animate	35,026	(1,590)	13,365	(1,027)
	Inanimate	34,603	(1,925)	13,418	(1,252)
		Three goals		One goal	
Experiment 4	Animate	4,568	(209)	4,725	(173)
	Inanimate	4,450	(174)	4,377	(142)

Note. In Experiment 1, participants wrote down four ideas or one idea in response to animate and inanimate words. In Experiment 2, an unrestricted-idea-generation condition in which participants wrote down as many ideas as spontaneously came to mind (i.e., an unrestricted number of ideas) in response to animate and inanimate words was compared to the one-idea-generation condition. In Experiment 3 (not included in Table 1), encoding times were set to 40,000 ms under both levels of the richness-of-encoding variable. In Experiment 4, participants rated the relevance of animate and inanimate words for achieving either three survival-related goals or one survival-related goal. Values in parentheses represent standard errors.

animacy and richness of encoding was not significant, $F(1, 97) = 0.28$, $p = .595$, $\eta_p^2 < .01$, indicating that the animacy effect did not depend on whether rich encoding was discouraged by the idea-generation task. The animacy effect was of about the same size irrespective of whether participants were required to write down four ideas ($d_z = 0.34$) or one idea ($d_z = 0.36$) in response to animate and inanimate words.

Figure 1
Proportion of Correctly Recalled Words as a Function of Animacy and Richness of Encoding in Experiment 1



Note. Richness of encoding was manipulated by asking participants to write down four ideas or one idea in response to animate and inanimate words. Error bars represent standard errors. See the online article for the color version of this figure.

Intrusions (i.e., words that were not presented at encoding or synonyms of the presented words) were categorized as animate, inanimate, or noncategorizable by the same three raters who scored the misspelled and pluralized words. Inconsistencies among the raters were resolved by discussion. Participants made extremely few intrusions (fewer than one word per category), which precludes the use of inferential statistics. Descriptively, participants made about the same number of intrusions from animate and inanimate words (see Table 2).

Discussion

Experiment 1 once again replicated the animacy effect on memory (Nairne et al., 2013). Animate words were better remembered than inanimate words. Furthermore, writing down four ideas led to a better memory than writing down only one idea. This finding is consistent with the assumption that rich encoding leads to enhanced memory (Craik & Tulving, 1975), possibly because forming elaborate ideas at encoding yields cues that help to retrieve the words in the free-recall test (Moscovitch & Craik, 1976; Röer et al., 2013). The manipulation of richness of encoding was thus successful in affecting overall free-recall performance. The critical test of a causal relationship between rich encoding and the animacy advantage was whether the animacy effect could be modulated by richness of encoding. Specifically, the richness-of-encoding account of the animacy effect implies that the animacy effect should decrease when participants are required to write down only one idea in response to animate and inanimate words in comparison to when they are required to write down four ideas, parallel to what has been found for the survival-processing effect (Kroneisen & Erdfelder, 2011). This hypothesis was disconfirmed. The animacy effect did not differ as a function of whether rich encoding was discouraged by the idea-

Table 2
Mean Number of Intrusions as a Function of Animacy in Experiments 1, 2, 3, and 4

	Category					
Experiment	Animate		Inanimate		Noncategorizable	
Experiment 1	0.26	(0.09)	0.26	(0.09)	0.49	(0.29)
Experiment 2	0.07	(0.02)	0.14	(0.04)	0.11	(0.06)
Experiment 3	0.11	(0.04)	0.12	(0.03)	0.07	(0.03)
Experiment 4						
Three goals	0.11	(0.02)	0.32	(0.07)	0.10	(0.06)
One goal	0.12	(0.02)	0.27	(0.04)	0.10	(0.08)

Note. In all experiments, participants produced, on average, fewer than one intrusion per animacy category. In Experiment 4, richness of encoding was manipulated between participants by requiring them to rate the relevance of the words for achieving either three survival-related goals or one survival-related goal at encoding. Values in parentheses represent standard errors.

generation task. The results of Experiment 1 thus provide evidence against the richness-of-encoding account of the animacy effect.

Experiment 2

There are two reasons why it was necessary to follow up on the findings of Experiment 1. The first reason is that a series of experiments always provides a more solid basis for drawing theoretical conclusions than an isolated finding. Therefore, we tested whether the key findings could be replicated across different experiments.

The second reason is that Experiment 2 provides an even more stringent test of the richness-of-encoding account of the animacy effect than Experiment 1. In Experiment 1, we started by adopting the four-ideas-generation condition and the one-idea-generation condition of Kroneisen and Erdfelder's (2011) Experiment 3 to manipulate richness of encoding. Parallel to what has been observed for the survival-processing effect by Kroneisen and Erdfelder (2011), we predicted the animacy effect to be decreased in the one-idea-generation condition in comparison to the four-ideas-generation condition. However, this comparison is not the strongest conceivable test of the idea that the animacy effect is modulated by richness of encoding.

A possible problem with Experiment 1 is that participants were asked to write down a fixed number of ideas in response to both animate and inanimate words under both levels of the richness-of-encoding variable. While asking participants to write down exactly one idea in response to animate and inanimate words seems like a straightforward way of equating richness of encoding between conditions by restricting the number of ideas that have to be reported, asking participants to write down exactly four ideas might have failed to accentuate the differences in richness of encoding between animate and inanimate words. To address this issue in Experiment 2, the one-idea-generation condition was compared to an unrestricted-idea-generation condition in which participants were asked to write down as many ideas as spontaneously came to mind. The richness-of-encoding account of the animacy effect implies that participants should spontaneously generate a richer set of ideas in response to animate than in response to inanimate words. In the unrestricted-idea-generation condition, we thus expected to replicate the finding that more ideas are spontaneously written down in response to animate than in response to inanimate words (Bonin et al., 2022; Meinhardt et al., 2020). As in Experiment 1, the critical test relates to the interaction between animacy and richness of encoding. Based on the richness-of-encoding account, the animacy effect was predicted to increase in the unrestricted-idea-generation condition in which idea generation was not restricted in any way in comparison to the one-idea-generation condition in which idea generation was severely restricted by the requirement to write down exactly one idea.

Method

Participants

As in Experiment 1, participants were recruited on campus at Heinrich Heine University Düsseldorf. We aimed for a sample size of at least 100 complete data sets and stopped data collection at the end of the day on which this criterion was reached. Of 106 collected data sets, two could not be included in the analysis: One data file was not stored correctly; another participant did not recall any of the presented words. The final sample consisted of 104 participants (64 female, 40 male) aged between 18 and 39 ($M = 23$, $SD = 4$). Good German language skills were required for participation; 93 participants were native German speakers. A sensitivity analysis with G*Power (Faul et al., 2007) showed that, with a sample size of $N = 104$ and $\alpha = .05$, an interaction between animacy and richness of encoding on memory performance of the size $\eta_p^2 = .11$ could be detected with a statistical power of $1 - \beta = .95$. Participation was paid or compensated by course credit.

Materials, Design, and Procedure

Materials, design, and procedure were the same as in Experiment 1, with the exception that the four-ideas-generation condition was replaced by an unrestricted-idea-generation condition. Experiment 2 thus had a within-subjects design with animacy (animate, inanimate) and richness of encoding (unrestricted number of ideas, one idea) as independent variables. Rich encoding was induced by asking participants to write down as many ideas as spontaneously came to mind in response to the words. In this unrestricted-idea-generation condition, the idea-generation process was not restricted in any way. It was thus possible for the participants to proceed irrespective of whether they had written down no idea, one idea, or many ideas. Participants achieved a performance level of 99% correct answers in the distractor task, which separated the incidental encoding phase from the memory test. The median duration of the experiment was 18 min.

Results

Idea-Generation Task

The mean response times in the idea-generation task are reported in Table 1. A 2 × 2 repeated-measures ANOVA on the response times showed that participants required significantly more time when idea generation was unrestricted compared to when they were required to write down exactly one idea, $F(1, 103) = 253.38$, $p < .001$, $\eta_p^2 = .71$. Neither the main effect of animacy, $F(1, 103) = 0.10$, $p = .758$, $\eta_p^2 < .01$, nor the interaction between animacy and richness of encoding was significant, $F(1, 103) = 0.31$, $p = .579$, $\eta_p^2 < .01$. When participants were asked to write down as many ideas as spontaneously came to mind, they reported significantly more ideas about animate words ($M = 4.83$, $SE = 0.20$) than about inanimate words ($M = 4.42$, $SE = 0.19$), $t(103) = 4.40$, $p < .001$, $d_z = 0.43$.

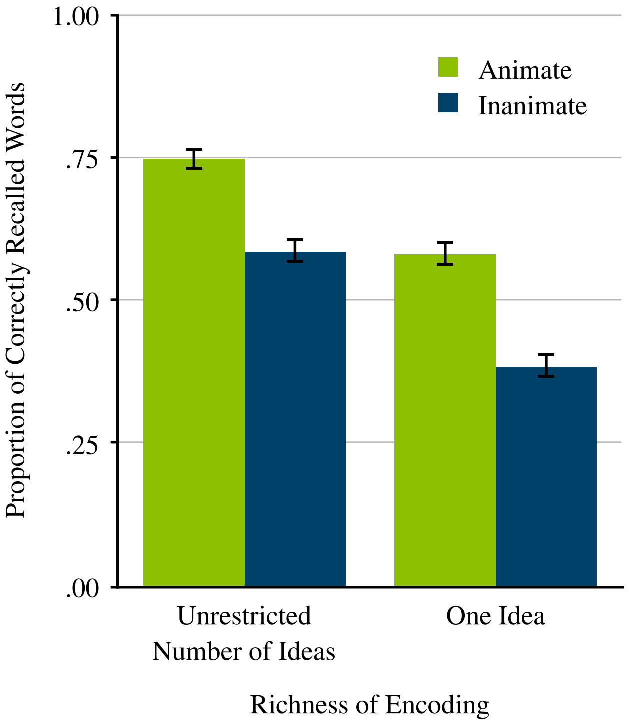
Free Recall

We used the same semi-automatized analysis protocol as in Experiment 1 to score the free-recall performance. In Experiment 2, the manually scored words comprised 2% of the correctly recalled words. Figure 2 displays the free-recall performance as a function of animacy and richness of encoding. A significant main effect of animacy, $F(1, 103) = 97.91$, $p < .001$, $\eta_p^2 = .49$, indicated that animate words were better remembered than inanimate words. A significant main effect of richness of encoding, $F(1, 103) = 67.55$, $p < .001$, $\eta_p^2 = .40$, indicated that recall was better in the unrestricted-idea-generation condition than in the one-idea-generation condition. Critically, however, there was no interaction between animacy and richness of encoding, $F(1, 103) = 0.91$, $p = .344$, $\eta_p^2 = .01$. The animacy effect was of about the same size irrespective of whether idea generation was unrestricted ($d_z = 0.66$) or restricted by the requirement to write down exactly one idea ($d_z = 0.70$) in response to animate and inanimate words.

As in Experiment 1, participants made very few intrusions. Descriptively, animate intrusions occurred less frequently than inanimate intrusions (see Table 2).

Figure 2

Proportion of Correctly Recalled Words as a Function of Animacy and Richness of Encoding in Experiment 2



Note. Richness of encoding was manipulated by asking participants to write down as many ideas as spontaneously came to mind (i.e., an unrestricted number of ideas) or exactly one idea in response to animate and inanimate words. Error bars represent standard errors. See the online article for the color version of this figure.

Discussion

As in Experiment 1, the memory advantage of animate over inanimate words was replicated. Moreover, asking participants to write down as many ideas as spontaneously came to mind led to better memory than asking participants to write down exactly one idea in response to each word, which indicates that rich encoding is beneficial for memory. Furthermore, we corroborated the finding that animate words lend themselves better to rich encoding than inanimate words (Bonin et al., 2022; Meinhardt et al., 2020): In the unrestricted-idea-generation condition, more ideas were reported in response to animate than in response to inanimate words. However, the critical prediction of the richness-of-encoding account of the animacy effect on memory was that the animacy effect should be larger when participants were allowed to write down more ideas in response to animate than in response to inanimate words and should be smaller when they were required to write down exactly one idea. Inconsistent with this prediction, the animacy effect was not modulated by richness of encoding.

Experiment 3

Experiment 3 was designed to provide an even more powerful manipulation of richness of encoding. In Experiments 1 and 2, the four-ideas-generation condition and the unrestricted-idea-generation condition, respectively, were compared to a condition in which participants were asked to write down only one idea in response to animate and inanimate words. Even though this condition has been proven effective in eliminating the survival-processing effect by Kroneisen and Erdfelder (2011), it seems possible that participants spontaneously thought of more than one idea even when the idea-generation task required them to write down only a single idea. It thus seems interesting to test whether an interaction between animacy and richness of encoding emerges when the unrestricted-idea-generation condition is compared to a condition in which the idea-generation process is suppressed.

Kroneisen et al. (2014, 2016) showed that rich encoding can be suppressed by requiring participants to focus on a secondary task. In Experiment 3, the unrestricted-idea-generation condition was compared to a distractor-task condition in which participants were engaged in solving mathematical problems to bind their attention, thus preventing them from generating ideas (see Lehman et al., 2014). In the unrestricted-idea-generation condition, participants had exactly 40 s to write down as many ideas as spontaneously came to mind in response to the animate and inanimate words. In the distractor-task condition, participants were given the same amount of time to perform a distractor task (solving math problems) for which the words were irrelevant and which should suppress forming ideas about the words. The richness-of-encoding account implies that the animacy effect should vanish or at least decrease in the condition in which rich encoding is suppressed by the distractor task in comparison to the unrestricted-idea-generation condition in which rich encoding is facilitated by the idea-generation task.

Method

Participants

Experiment 3 was implemented online using SoSci Survey (Leiner, 2021) and made available through https://www.soscisurvey.de. The experiment was advertised on social media and via email. Given that Experiment 3 was conducted online, we increased the target sample size to at least 150 complete data sets and stopped data collection at the end of the day on which this criterion was reached. Of 198 participants who had started the idea-generation task, 48 participants had to be excluded because they either did not complete the experiment ($n = 45$) or did not recall any of the presented words ($n = 3$). The final sample consisted of 150 participants (120 female, 30 male) aged between 18 and 42 ($M = 22$, $SD = 4$). Good German language skills were required for participation. A sensitivity analysis with G*Power (Faul et al., 2007) showed that, with a sample size of $N = 150$ and $\alpha = .05$, an interaction between animacy and richness of encoding on memory performance of the size $\eta_p^2 = .08$ could be detected with a statistical power of $1 - \beta = .95$. Participation was compensated by course credit or the chance to win a € 20 voucher for an online store.

Materials, Design, and Procedure

Following the procedure of our previous online experiments on the animacy effect (Komar et al., 2023), we instructed participants at the beginning of the experiment to perform the experiment alone in a quiet room without any interruptions. If they were not able to do so, they were asked to stop participating by closing the browser window. Participants were allowed to use a desktop or laptop computer, not a tablet or smartphone. At the end of the experiment, participants were asked to report whether they had followed the instructions and whether all stimuli had been accurately displayed.[1] These control questions indicated that the overwhelming majority of the participants followed the instructions and that there were no crucial technical problems with the display of the stimuli.

The same words were used as in Experiments 1 and 2. Experiment 3 had a within-subjects design with animacy (animate, inanimate) and richness of encoding (unrestricted number of ideas, distractor task) as independent variables. The words were randomly assigned to the levels of the richness-of-encoding variable with the restriction that six animate and six inanimate words were presented in the unrestricted-idea-generation condition and the remaining six animate and six inanimate words were presented in the distractor-task condition. The 24 words were shown in random order. In each trial of the encoding phase, one of the words was shown at the top of the browser window in 36-point blue-colored bold Arial font.

In the unrestricted-idea-generation condition, participants were asked to write down as many ideas as spontaneously came to mind. In each trial, 12 text fields were provided below the critical word. Participants were asked to write down each idea in a separate text field. To ensure that participants did not lose track of the critical word displayed at the top of the browser window after scrolling down, the word was repeated in 12-point blue-colored Arial font to the left of each text field.

In the distractor-task condition, participants were instructed to solve math problems. In each trial, 12 math problems (e.g., 23 + 28 = ?) were displayed below the critical word. The math problems were automatically generated and comprised addition, subtraction, and multiplication problems (four of each type). Participants were asked to type the correct solution into a text field that was displayed to the right of each math problem. To ensure that the critical word was still visible after scrolling down, the word was repeated in 12-point blue-colored Arial font to the left of each math problem. Participants were instructed to just solve the math problems. The words were thus irrelevant to the task.

In each trial, participants had 40 s to write down the ideas or to solve the math problems. This implies that, unlike in Experiments 1 and 2, the encoding task was no longer self-paced. The 40 s were chosen because the upper limit of the 95% confidence interval of the mean response time in the unrestricted-idea-generation condition of Experiment 2 was 38 s. The time remaining was displayed in the upper right corner of the browser window. When the 40 s had passed, participants were automatically redirected to a page from which they could proceed by clicking on a "next" button.

The encoding phase was followed by a filled retention interval. In a city-comparison task that lasted about 1 min, participants were asked to select the city with the larger number of inhabitants from each of 12 pairs of cities ($M = 80\%$ correct answers). In the surprise memory test, participants were asked to recall, in any order, all blue words that had been shown on the screen. Participants were explicitly instructed that they had to recall both the words in response to which they had generated ideas and the words they had seen in the math-problem trials. Each recalled word had to be written down in a separate text field. Participants had 3 min to recall the words. The time remaining was displayed in the upper right corner of the browser window until the test ended automatically. The median duration of the experiment was 26 min.

Results

Idea-Generation Task and Math Distractor Task

As in Experiment 2, participants reported significantly more ideas about animate words ($M = 7.71$, $SE = 0.18$) than about inanimate words ($M = 7.15$, $SE = 0.17$) when they were asked to write down as many ideas as spontaneously came to mind, $t(149) = 7.60$, $p < .001$, $d_z = 0.62$. The number of math problems that were correctly solved did not differ depending on the animacy status of the presented words (animate: $M = 10.00$, $SE = 0.14$; inanimate: $M = 9.97$, $SE = 0.15$, of 12 math problems that were displayed), $t(149) = 0.46$, $p = .647$, $d_z = 0.04$.

Free Recall

The same semi-automatized analysis protocol was used as in Experiments 1 and 2. The manually scored words comprised 1%

[1] Based on the responses, it would have been possible to exclude 11 more data sets. However, this would not have changed any statistical conclusions, so we decided to include these data sets into the final analysis, following a recommendation of Elliott et al. (2022).

of the correctly recalled words. Figure 3 displays the free-recall performance as a function of animacy and richness of encoding. A 2 × 2 repeated-measures ANOVA showed a significant memory advantage of animate over inanimate words, $F(1, 149) = 53.46$, $p < .001$, $\eta_p^2 = .26$. The richness-of-encoding manipulation had a significant effect on free recall, $F(1, 149) = 799.37$, $p < .001$, $\eta_p^2 = .84$. Unsurprisingly, recall was much better when participants had written down the ideas that spontaneously came to mind in response to the words than when they had performed the math distractor task at encoding. In spite of this strong manipulation of richness of encoding, the critical interaction between animacy and richness of encoding was not significant, $F(1, 149) = 0.68$, $p = .410$, $\eta_p^2 < .01$. The animacy effect was of about the same size irrespective of whether participants had generated ideas ($d_z = 0.39$) or had been engaged in the distractor task ($d_z = 0.49$).

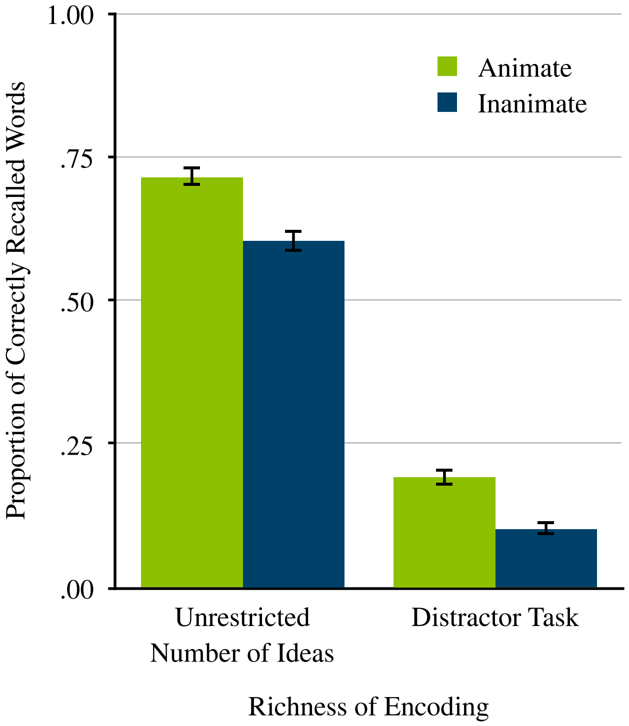
As in Experiments 1 and 2, participants made very few intrusions. Descriptively, animate intrusions occurred less often than inanimate intrusions (see Table 2).

Discussion

As in Experiments 1 and 2, animate words were better remembered than inanimate words. In the idea-generation task, we replicated the finding that participants report more ideas in response to animate than in response to inanimate words (Bonin et al., 2022; Meinhardt et al., 2020). Nevertheless, the animacy effect was robustly found even in the condition that was designed to suppress rich encoding. When participants had been engaged in the math distractor task that was used to prevent them from generating ideas, the proportion of correctly recalled words was dramatically reduced compared to when participants had been engaged in the idea-generation task (the effect size of the main effect of richness of encoding was more than twice as large as in Experiments 1 and 2), but the animacy effect did not differ in size between the distractor-task condition and the unrestricted-idea-generation condition. These results provide evidence against the richness-of-encoding account of the animacy effect.

Figure 3

Proportion of Correctly Recalled Words as a Function of Animacy and Richness of Encoding in Experiment 3



Note. Richness of encoding was manipulated by asking participants to write down as many ideas as spontaneously came to mind (i.e., an unrestricted number of ideas) in response to animate and inanimate words or by letting them perform a distractor task for which the words were irrelevant. Error bars represent standard errors. See the online article for the color version of this figure.

Experiment 4

We thought it worthwhile to test the richness-of-encoding account of the animacy effect using yet another approach. Experiment 4 was designed in analogy to Kroneisen and Erdfelder's (2011) Experiment 1 in which richness of encoding was manipulated by varying whether the encoding scenario facilitates rich encoding or not. In the three-goals relevance-rating condition, participants rated the relevance of words for achieving three survival-related goals (finding food, finding water, and protecting oneself from predators), just as in the relevance-rating task used by Nairne et al. (2007), which should allow for a rich encoding of the animate and inanimate words by providing the opportunity to generate many useful ideas. In the one-goal relevance-rating condition, participants rated the relevance of the words for achieving one survival-related goal (finding potable water), which should limit the number of useful ideas that can be generated. Parallel to what Kroneisen and Erdfelder (2011) had confirmed for the survival-processing effect, the richness-of-encoding account of the animacy effect implies that the animacy effect should be smaller when participants rate the relevance of the words for achieving one goal, which should restrict idea generation, than when participants rate the relevance of the words for achieving three goals, which should provide many opportunities for idea generation. As in Kroneisen and Erdfelder's (2011) Experiment 1, richness of encoding was manipulated between subjects to avoid disrupting the participants' immersion in the presented scenario.

Method

Participants

Experiment 4 was conducted using the online tool SoSci Survey (Leiner, 2021). Participants were recruited from the research panels of the ISO-20252:2019-certified online-access-panel provider respondi AG (https://www.respondi.com). Given that we used a between-subjects manipulation of richness of encoding in Experiment 4, we increased the target sample size to at least 500 (+ ∼10%) complete data sets and stopped data collection once this criterion was reached. Of 587 participants who had started the relevance-rating task, 107 participants had to be excluded because they either did not complete the experiment ($n = 42$) or did not recall any of the presented words ($n = 65$). The final sample, characterized by diversified levels of education and good German language skills, consisted of 480 participants (247 female, 232 male, one nonbinary) aged between 18 and 82 ($M = 37$, $SD = 17$). They were randomly assigned to either the three-goals relevance-rating condition ($n = 239$) or the one-goal relevance-rating condition ($n = 241$). A sensitivity analysis with G*Power (Faul et al., 2007) showed that, with a sample size of $N = 480$ and $\alpha = .05$, an interaction between animacy and richness of encoding on memory performance of the size $\eta_p^2 = .03$ could be detected with a statistical power of $1 - \beta = .95$. The participants received a small monetary compensation for participating.

Materials, Design, and Procedure

As in Experiment 3, we instructed participants at the beginning of the experiment to perform the experiment alone in a quiet room without any interruptions. Participants were allowed to use a desktop or laptop computer, not a tablet or smartphone. At the end of the experiment, participants were asked to report whether they had followed the instructions and whether all stimuli had been accurately presented.[2]

The same words were used as in Experiments 1–3. The experiment had a mixed design with the independent within-subjects variable animacy (animate, inanimate) and the between-subjects variable richness of encoding (three goals, one goal). Depending on the richness-of-encoding condition, participants were presented with a German version of one of the two survival scenarios taken from Kroneisen and Erdfelder's (2011) Experiment 1. In the three-goals relevance-rating condition, participants were asked to imagine being stranded in the grasslands of a foreign land without basic means of survival. Over the next months, they would have to find stable supplies of food and water and protect themselves from predators. In the one-goal relevance-rating condition, participants were asked to imagine being stranded in the grasslands of a foreign land. After searching along the surroundings and the debris flushed to the shore along with them, they would realize that they have one major problem of survival: They have no potable water. Participants rated the relevance of each animate and inanimate word for the presented scenario. The words were presented in random order. In each trial, the scenario was visible at the top of the browser window. Below the scenario, the question "How relevant is the following word for you in this survival situation?" was displayed. Below the question, the word was presented at the center of the screen in 24-point black-colored bold Arial font. The relevance of the word was rated on a five-point scale ranging from *totally irrelevant* (1) to *extremely relevant* (5). The relevance-rating task was self-paced. Participants clicked on a "next" button to proceed.

The encoding phase was followed by the city-comparison task used in Experiment 3 ($M = 79\%$ correct answers). In the surprise memory test, participants were asked to recall all words they had judged for survival relevance. The memory test was identical to that used in Experiment 3. The median duration of the experiment was 7 min.

Results

Relevance-Rating Task

The mean response times in the relevance-rating task are reported in Table 1. A 2×2 mixed ANOVA on the response times showed that the rating times were significantly longer for animate than for inanimate words, $F(1, 478) = 4.67$, $p = .031$, $\eta_p^2 = .01$. Neither the main effect of richness of encoding, $F(1, 478) = 0.04$, $p = .850$, $\eta_p^2 < .01$, nor the interaction between animacy and richness of encoding was significant, $F(1, 478) = 1.14$, $p = .285$, $\eta_p^2 < .01$.

A 2×2 mixed ANOVA on the relevance ratings showed that the words were rated to be significantly more relevant in the three-goals relevance-rating condition in comparison to the one-goal relevance-rating condition, $F(1, 478) = 8.22$, $p = .004$, $\eta_p^2 = .02$. The main effect of animacy was not significant, $F(1, 478) = 2.52$, $p = .113$, $\eta_p^2 = .01$. There was a significant interaction between animacy and richness of encoding, $F(1, 478) = 98.51$, $p < .001$, $\eta_p^2 = .17$. Inanimate words ($M = 2.77$, $SE = 0.04$) were rated to be more relevant than animate words ($M = 2.32$, $SE = 0.05$) in the three-goals relevance-rating condition, $t(238) = -9.16$, $p < .001$, $d_z = -0.59$, whereas animate words ($M = 2.56$, $SE = 0.05$) were rated to be more relevant than inanimate words ($M = 2.23$, $SE = 0.04$) in the one-goal relevance-rating condition, $t(240) = 5.37$, $p < .001$, $d_z = 0.35$.

Free Recall

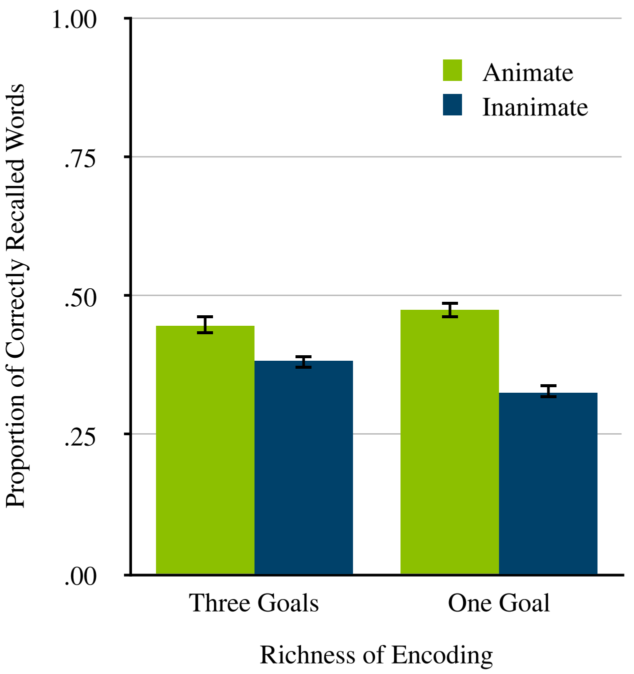
As in Experiments 1–3, a semi-automatized analysis protocol was used to score the free-recall performance. The manually scored words comprised 2% of the correctly recalled words. Figure 4 displays the free-recall performance as a function of animacy and richness of encoding. A 2×2 mixed ANOVA showed a significant memory advantage of animate over inanimate words, $F(1, 478) = 137.00$, $p < .001$, $\eta_p^2 = .22$. The main effect of richness of encoding was not significant, $F(1, 478) = 0.68$, $p = .411$, $\eta_p^2 < .01$. Parallel to what Kroneisen and Erdfelder (2011) had observed for the survival-processing effect, the richness-of-encoding account of the animacy effect implies that the animacy effect should be reduced in the one-goal relevance-rating condition compared to the three-goals relevance-rating condition, as the former puts more restrictions on the number of meaningful ideas that can be generated in response to the words. In direct opposition to this hypothesis, the animacy effect was larger in the one-goal relevance-rating condition ($d_z = 0.79$) than in the three-goals relevance-rating condition ($d_z = 0.31$). Based on these findings, the hypothesis that the animacy effect is caused by richness of encoding is incompatible with the data already at the level of the descriptive results. For completeness, the interaction between animacy and richness of encoding was statistically significant, $F(1, 478) = 21.00$, $p < .001$, $\eta_p^2 = .04$.

Following the lead of Kroneisen and Erdfelder (2011), a supplementary analysis was run in which the perceived relevance was taken into account when examining the recall of the animate and inanimate words as a function of richness of encoding. Figure 5 displays the free-recall performance as a function of animacy (animate, inanimate) and richness of encoding (three goals, one goal) separately for words that had received low (1–3, labeled "irrelevant") or high (4–5, labeled "relevant") relevance ratings. Excluding participants with missing data in one or more cells of the design leaves the data of $n = 193$ participants in the three-goals relevance-rating condition and $n = 199$ participants in the one-goal

[2] Based on the responses, it would have been possible to exclude six more data sets. In addition, there was one participant who reported problems with the on-screen readability of the text. However, the exclusion of these seven data sets would not have changed any statistical conclusions, so we decided to include them into the final analysis, following a recommendation of Elliott et al. (2022).

Figure 4

Proportion of Correctly Recalled Words as a Function of Animacy and Richness of Encoding in Experiment 4



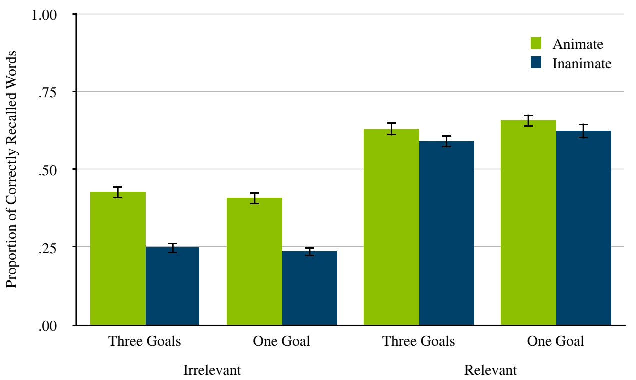
Note. Richness of encoding was manipulated by asking participants to rate the relevance of each animate and inanimate word for achieving either three survival-related goals or one survival-related goal. Error bars represent standard errors. See the online article for the color version of this figure.

relevance-rating condition. A 2 × 2 × 2 mixed ANOVA replicated the significant main effect of animacy, $F(1, 390) = 102.25$, $p < .001$, $\eta_p^2 = .21$. The main effect of richness of encoding was not significant, $F(1, 390) = 0.16$, $p = .687$, $\eta_p^2 < .01$. The significant main effect of relevance, $F(1, 390) = 457.49$, $p < .001$, $\eta_p^2 = .54$, indicated that words that were perceived to be relevant to the presented scenario were better recalled than words that were perceived to be irrelevant to the presented scenario. Relevance did not interact with richness of encoding, $F(1, 390) = 2.91$, $p = .089$, $\eta_p^2 = .01$. There was a significant interaction between animacy and relevance, $F(1, 390) = 32.36$, $p < .001$, $\eta_p^2 = .08$, indicating that the animacy effect was smaller for words that were perceived to be relevant than for words that were perceived to be irrelevant. The most important finding is that, when the perceived relevance of the words was taken into account, the interaction between animacy and richness of encoding was no longer significant, $F(1, 390) = 0.11$, $p = .746$, $\eta_p^2 < .01$. The three-way interaction between animacy, relevance, and richness of encoding was not significant either, $F(1, 390) < 0.01$, $p = .980$, $\eta_p^2 < .01$. The fact that there was no interaction between animacy and richness of encoding implies that the main conclusion that can be drawn from the data remains the same when relevance is taken into account: The hypothesis that richness of encoding causally contributes to the animacy effect is incompatible with the data.

As in Experiments 1–3, participants made very few intrusions. In both richness-of-encoding conditions, participants produced fewer animate than inanimate intrusions (see Table 2).

Figure 5

Proportion of Correctly Recalled Words as a Function of Animacy, Richness of Encoding, and Relevance in Experiment 4



Note. Richness of encoding was manipulated by asking participants to rate the relevance of each animate and inanimate word for achieving either three survival-related goals or one survival-related goal. Error bars represent standard errors. See the online article for the color version of this figure.

Discussion

From the richness-of-encoding account of the animacy effect, the hypothesis was derived that the animacy effect should be reduced in the one-goal relevance-rating condition that severely restricts idea generation in comparison to the three-goals relevance-rating condition that provides many opportunities for idea generation, parallel to what has been found for the survival-processing effect (Kroneisen & Erdfelder, 2011). This hypothesis is incompatible with the data at the level of the descriptive results because the effect was in the opposite direction of what has been predicted based on the richness-of-encoding account of the animacy effect. As a side note, Kroneisen and Erdfelder's (2011) findings of a reduction in recall of words rated with respect to one survival-related goal in comparison to words rated with respect to three survival-related goals could not be replicated in Experiment 4, suggesting that, other than the manipulations of richness of encoding used in Experiments 1–3, this particular manipulation of richness of encoding was not powerful enough to affect recall overall, even though the relevance ratings were significantly affected by the manipulation. Another complication was that inanimate words were rated to be more relevant than animate words in the three-goals relevance-rating condition, while animate words were rated to be more relevant than inanimate words in the one-goal relevance-rating condition. Given that a higher perceived relevance could be associated with better free-recall performance (Butler et al., 2009), we included the perceived relevance in a supplementary analysis (cf. Kroneisen & Erdfelder, 2011). With relevance taken into account, the animacy effect on memory was no longer modulated by richness of encoding. The animacy effect was as pronounced in the three-goals relevance-rating condition as in the one-goal relevance-rating condition. In line with Experiments 1–3, the hypothesis that richness of encoding causally contributes to the animacy effect is thus incompatible with the data.

General Discussion

The animacy effect on memory (Nairne et al., 2013) has proven to be a robust phenomenon (for a review, see Nairne et al., 2017), but the cognitive mechanism underlying the effect has remained elusive. The present results once again support the conclusion that the animacy effect is very robust. In all present experiments, the animacy effect was replicated. As richness of encoding has been demonstrated to be causally involved in the survival-processing effect (Kroneisen & Erdfelder, 2011), it has been suggested that richness of encoding may serve as a cognitive mechanism of adaptive-memory effects in general (cf. Meinhardt et al., 2020). Specifically, several previous studies have identified richness of encoding as a promising cognitive mechanism of the animacy effect (e.g., Bonin et al., 2022; Komar et al., 2023; Meinhardt et al., 2020; Mieth et al., 2019). The most important piece of evidence in support of the richness-of-encoding account of the animacy effect is that Meinhardt et al. (2020) have demonstrated that participants report more ideas in response to animate than in response to inanimate words when asked to write down as many ideas as spontaneously come to mind, a finding that has recently been replicated by Bonin et al. (2022). The present findings are consistent with the idea that animate words lend themselves better to elaborate idea generation. In Experiment 1, participants were equally fast in generating one idea in response to animate and inanimate words, but four ideas were generated more quickly in response to animate than in response to inanimate words. In Experiments 2 and 3, we replicated Meinhardt et al.'s (2020) finding that participants spontaneously report more ideas in response to animate than in response to inanimate words when idea generation is unrestricted. According to the richness-of-encoding account, rich encoding leads to enhanced free recall because the ideas generated at encoding serve as retrieval cues in the memory test. Three of the four experiments reported here support the assumption that rich encoding leads to better memory. Specifically, recall was better in those conditions in which participants had written down more ideas at encoding irrespective of whether the idea-generation task was self-paced (Experiments 1 and 2) or encoding time was held constant (Experiment 3). Restricting the number of survival-related goals from three to one had no effects on recall (Experiment 4), suggesting that this manipulation of richness of encoding may have been less effective in comparison to the manipulations used in Experiments 1–3. Nevertheless, the findings are overall in line with the mnemonic benefits of rich encoding (see Craik & Tulving, 1975; Hargreaves et al., 2012; Moscovitch & Craik, 1976).

However, even though important prerequisites for the possible validity of the richness-of-encoding account are met, a stringent test of the causal contribution of richness of encoding to the animacy effect on memory cannot be based on this evidence because it is only correlational (Meinhardt et al., 2020, p. 424). For instance, animacy may simultaneously increase both the motivation for idea generation and memory performance. With respect to the survival-processing effect, it has been crucial for the acceptance of the richness-of-encoding account that Kroneisen and Erdfelder (2011) have provided experimental evidence demonstrating that the survival-processing effect was modulated by manipulations of richness of encoding (see also Kroneisen et al., 2014, 2016), supporting the assumption of a causal relationship between richness of encoding and the survival-processing effect. The present series of experiments provides a parallel experimental test of the richness-of-encoding account of the animacy effect. Specifically, we used the richness-of-encoding manipulations established by Kroneisen and Erdfelder (2011) in conjunction with an animacy manipulation. The richness-of-encoding account of the animacy effect implies that the difference in recall between animate and inanimate words should be smaller when the encoding conditions restrict or suppress a rich encoding of the words than when the encoding conditions facilitate a rich encoding of the words.

In Experiment 1, we adapted the idea-generation task of Kroneisen and Erdfelder's (2011) Experiment 3. Participants were instructed to write down either four ideas in response to animate and inanimate words in order to facilitate a rich encoding of the words or only one idea to restrict a rich encoding of the words. The animacy effect was not modulated by richness of encoding. In Experiment 2, we used a stronger manipulation of richness of encoding by comparing the one-idea-generation condition to an unrestricted-idea-generation condition in which the idea-generation process was not restricted at all. Even though the results confirmed previous findings showing that more ideas are reported in response to animate than in response to inanimate words (Bonin et al., 2022; Meinhardt et al., 2020), the animacy effect on memory did not differ between the one-idea-generation condition and the unrestricted-idea-generation condition. In Experiment 3, the strength of the richness-of-encoding manipulation was increased once more. In an unrestricted-idea-generation condition, participants were asked to write down as many ideas as spontaneously came to mind in response to the words. In a distractor-task condition, rich encoding of the words was suppressed by requiring participants to solve math problems. The animacy effect was not modulated by richness of encoding. In Experiment 4, we used yet another approach to test the richness-of-encoding account of the animacy effect. As in Kroneisen and Erdfelder's (2011) Experiment 1, two different encoding scenarios were used to manipulate richness of encoding. Participants were asked to rate the relevance of animate and inanimate words with respect to achieving either three survival-related goals or one survival-related goal. The three goals should provide many opportunities for idea generation, while the reduction to only one goal should restrict idea generation. When the perceived relevance of the words for the respective scenario was taken into account, we replicated the pattern of results obtained in Experiments 1–3. The animacy effect was independent of the richness-of-encoding manipulation.

With respect to the critical interaction between animacy and richness of encoding, the four experiments thus provide consistent results: Although the animacy advantage in memory was associated with rich encoding in that participants reported more ideas in response to animate than in response to inanimate words (Experiments 2 and 3), the memory advantage of animate over inanimate words was independent of the richness-of-encoding manipulations in all four experiments. Not only did the interactions between animacy and richness of encoding fail to reach statistical significance in all experiments, the effect sizes associated with the interactions were also extremely small ($\eta_p^2 \leq .01$ in Experiments 1–3; the same was true for Experiment 4 once relevance was taken into account), which strengthens the conclusions based on the statistical significance tests. The richness-of-encoding manipulations failed to modulate the animacy effect on free recall, even though the manipulations were closely aligned to, or even stronger than, those that have been proven effective in modulating the survival-processing effect (Kroneisen & Erdfelder, 2011; Kroneisen et al., 2014, 2016). In other words, we found evidence for additive effects of animacy and richness of encoding, suggesting that richness of encoding is not causally involved in the effect of animacy on memory.

The mechanism underlying the animacy effect thus seems to be different from that underlying the survival-processing effect, which has been shown to be sensitive to manipulations of richness of encoding (Kroneisen & Erdfelder, 2011) and attention (Kroneisen et al., 2014, 2016). This conclusion is consistent with Gelin et al.'s (2017) finding of an animacy effect on memory regardless of whether the encoding task involved survival processing or not (see also Leding, 2018), which provides further evidence suggesting that the cognitive mechanisms underlying these two effects published under the umbrella of the adaptive-memory framework may be independent of each other.

The hypothesis we tested here was based on the richness-of-encoding account as proposed by Meinhardt et al. (2020) according to which "richer encoding (i.e., the higher number of ideas that are associated with an item) provides a greater number of retrieval cues that in turn increase the probability of a successful recall at test" (p. 423). This account has been supported by correlational evidence (Bonin et al., 2022; Meinhardt et al., 2020) and has been favorably discussed in several publications on the animacy effect (e.g., Bonin et al., 2022; Komar et al., 2023; Mieth et al., 2019). The richness-of-encoding account was based on the idea that different adaptive-memory effects—namely the survival-processing effect and the animacy effect—may be based on the same underlying cognitive mechanism. However, the survival-processing effect refers to an encoding manipulation that affects retention of the exact same material that is also used in the control conditions—random lists of words. The animacy effect refers to the differential retention of two different classes of words—animate versus inanimate words. The general idea that animate words are associated with richer memory representations thus does not necessarily imply that the richer representations of animate words must improve recall in the exact same way as the rich encoding of the words in the survival scenario. However, whereas the present findings rule out the richness-of-encoding account as proposed in Meinhardt et al. (2020) that focuses on encoding processes, the results are not necessarily inconsistent with the general idea that animate words are associated with greater representational richness than inanimate words (Nairne et al., 2017; Rawlinson & Kelley, 2021) from which hypotheses may be derived that differ from the hypotheses derived here. Nevertheless, the present findings provide important restrictions on the development of future accounts of the cognitive mechanism underlying the animacy effect.

A further limitation refers to the manipulation of richness of encoding by means of idea-generation tasks in which the number of generated ideas could only be inferred by counting how many ideas participants wrote down. For instance, we cannot be sure whether idea generation stopped when exactly one idea was written down in the one-idea-generation condition. However, it is likely that participants generated more ideas in the four-ideas-generation condition and unrestricted-idea-generation condition than in the one-idea-generation condition because more words were remembered when rich encoding was facilitated compared to when it was restricted. Moreover, the findings of Experiment 3 make it unlikely that the absence of an interaction between animacy and richness of encoding was only due to the fact that idea generation was not effectively restricted in the one-idea-generation conditions of Experiments 1 and 2. In Experiment 3, the animacy effect on memory was not modulated by whether rich encoding was facilitated in the unrestricted-idea-generation condition or suppressed by the math distractor task for which the words were completely irrelevant so that elaborate idea generation was unlikely.

Given that there is no evidence that richness of encoding is causally involved in the animacy effect, rich encoding may just be an epiphenomenon stimulated by animate words. This interpretation implies that the search for the cognitive mechanism of the animacy effect has to continue. The present results may stimulate future hypothesis tests. In Experiment 4, the animacy effect was modulated by the perceived survival relevance of the words. This may indicate that the animacy effect is driven by the perceived relevance of animate beings compared to inanimate objects. However, when interpreting this finding, it is important to keep in mind that the modulation of the animacy effect by the perceived survival relevance was the result of a supplementary post hoc analysis and has not been predicted a priori. Therefore, this finding should not be seen as a stringent confirmation of a hypothesis. Instead, it may be used to generate new hypotheses. Moreover, considering the fact that the involvement of attentional processes in the animacy effect has as yet only received mixed support (e.g., Bonin et al., 2015; Bugaiska et al., 2019; Komar et al., 2023; Leding, 2019; Popp & Serra, 2016; Rawlinson & Kelley, 2021), the attentional or automatic nature of the processes underlying the prioritization of animate beings remains to be identified in future studies. It also seems possible that the animacy effect involves a multitude of mechanisms rather than a single mechanism. Furthermore, there is some evidence for a neuronal specialization for the processing of special characteristics of animate beings (e.g., Caramazza & Shelton, 1998; Gobbini et al., 2011; Hillebrandt et al., 2014; Rogers et al., 2021). It thus cannot be excluded that the search for a domain-general mechanism might remain unsuccessful because natural selection has equipped the human mind with a specialized cognitive machinery for remembering animate beings.

The answers to these questions have to be obtained in future studies. The goal of the present series of experiments was to confirm, or to disconfirm, richness of encoding as the cognitive mechanism underlying the concrete observation that animacy enhances memory, following Nairne et al.'s (2013) observation that animacy is one of the most important determinants of free recall (see also Madan, 2021). While cognitive psychologists are well equipped with tools to confirm, or to disconfirm, hypotheses about cognitive mechanisms underlying well-defined behavioral effects such as the animacy effect on memory, a comprehensive understanding of adaptive-memory effects also requires a functional analysis of *why* these mechanisms are initiated (see Nairne & Pandeirada, 2016). For instance, had we identified richness of encoding as the cognitive mechanism underlying the animacy effect on memory, a functional analysis would still have to answer the question why a richer encoding of animate beings compared to inanimate objects is adaptive for goal pursuit when evading predators, chasing prey, competing for resources, or finding mating partners (for functional arguments, see Nairne et al., 2013, 2017). Given that the present series of experiments provides evidence against richness of encoding as the cognitive mechanism of the animacy effect, further research is required to determine both the specific cognitive mechanism underlying the animacy effect and its integration into a functional analysis of memory.

The goal of the present series of experiments was to provide a stringent test of the promising richness-of-encoding account of the animacy effect that had garnered support in previous studies (Bonin et al., 2022; Meinhardt et al., 2020). In four experiments, using manipulations of richness of encoding that had been established to modulate the survival-processing effect, no modulation of the animacy effect on memory was observed. Even though more ideas were reported in response to animate than in response to inanimate words and rich encoding led to enhanced recall (except in Experiment 4), animacy and richness of encoding did not interact, implying that the animacy effect was not modulated by whether rich encoding was facilitated or suppressed. These findings weaken the hypothesis that richness of encoding causally contributes to the animacy effect on memory. The search for the cognitive mechanism of the animacy effect thus has to continue.

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Einzelarbeit 3

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Die Einzelarbeit 3 beinhaltet die Experimente 3.1, 3.2 und 3.3.

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The animacy effect on free recall is equally large in mixed and pure word lists or pairs

Gesa Fee Komar, Laura Mieth, Axel Buchner & Raoul Bell

The cognitive mechanisms underlying the animacy effect on free recall have as yet to be identified. According to the attentional-prioritization account, animate words are better recalled because they recruit more attention at encoding than inanimate words. The account implies that the animacy effect should be larger when animate words are presented together with inanimate words in mixed lists or pairs than when animate and inanimate words are presented separately in pure lists or pairs. The present series of experiments served to systematically test whether list composition or pair composition modulate the animacy effect. In Experiment 1, the animacy effect was compared between mixed and pure lists. In Experiments 2 and 3, the words were presented in mixed or pure pairs to manipulate the direct competition for attention between animate and inanimate words at encoding. While encoding was intentional in Experiments 1 and 2, it was incidental in Experiment 3. In each experiment, a significant animacy effect was obtained, but the effect was equally large in mixed and pure lists or pairs of animate and inanimate words despite considerable sensitivity of the statistical test of the critical interaction. These findings provide evidence against the attentional-prioritization account of the animacy effect.

Other than inanimate objects, animate beings can initiate motion by themselves, grow and reproduce, are capable of mental processes and consist of biological structures that enable biological functions[1]. Based on their evolutionary relevance, it has been postulated that animate beings should have a special status in human cognition[2]. For instance, the animacy effect on free recall (henceforth animacy effect) refers to the finding that words denoting animate beings (henceforth animate words) are better recalled than words denoting inanimate objects (henceforth inanimate words). The animacy effect is robustly found even when animate words have been equated with inanimate words on many other mnemonically relevant word dimensions such as imagery or concreteness (for a review, see[3]). A potential cognitive account of the animacy effect is that animate words recruit more attention at encoding than inanimate words. As will be explicated in more detail below, this *attentional-prioritization account* implies that the difference in recall between animate and inanimate words should be more accentuated when the words are presented in mixed lists composed of both animate and inanimate words than when the words are presented in pure lists composed of either only animate or only inanimate words. As yet, there seems to be only one study[4] in which the question of whether the animacy effect differs between mixed and pure lists has been addressed. The experiments reported here build on this study and provide a stringent and sensitive test of the attentional-prioritization account of the animacy effect by comparing the animacy effect on free recall between mixed and pure lists (Experiment 1) and between mixed and pure pairs (Experiments 2 and 3) of animate and inanimate words.

The animacy effect on free recall is typically examined by asking participants to learn mixed lists of animate and inanimate words (e.g.,[2,5–7]). Since Nairne et al.'s[2] discovery, the animacy effect has been robustly replicated in many languages, including English (e.g.,[8,9]), French (e.g.,[10,11]), German (e.g.,[12,13]), Chinese[14] and Portuguese[5], using intentional (e.g.,[5,15,16]) and incidental encoding tasks (e.g.,[5,6,17]). The animacy effect was discovered as the result of a functional analysis of memory within the adaptive-memory framework (for a review, see[18]). Memory has been postulated to be tuned to preferably retain animate beings based on the idea that animate beings, as predators, prey or sexual partners, are relevant to the organism's ultimate goals of survival and reproduction[19]. This functional argument elucidates the potential evolutionary background of the animacy effect, but it does not shed light on the cognitive underpinning of the effect. The functional argument thus should be complemented with an analysis of the cognitive mechanisms underlying the animacy effect (cf.[20]). As yet, progress has mainly

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been made by ruling out potential cognitive mechanisms. Based on the empirical evidence to date, neither emotional nor mental arousal[12,21], nor perceived threat ([8], but see[22]), nor mental imagery[9,23], nor categorical organization[2,7,9,24] nor richness of encoding ([13], but see[15]) provide satisfactory cognitive accounts of the animacy effect.

A potential mechanism that may underlie the animacy effect is that animate words recruit more attention at encoding than inanimate words. A priori, the attentional-prioritization account offers a plausible cognitive mechanism because the allocation of attention at encoding is an important determinant of memory (e.g.,[25]). The idea that the animacy effect is caused by the attentional prioritization of animate relative to inanimate words at encoding has been widely discussed in the literature. For example, Nairne et al.[3] have proposed, as a potential cognitive account of the animacy effect, "that animate items naturally recruit more attention … which simply maps onto a more accessible memory trace" (p. 26). There is indeed some evidence that animate words recruit more attention than inanimate words: In a Stroop-like task, the processing of the font color of words took longer for animate than for inanimate words, suggesting that animacy recruits attentional resources at the expense of the color-naming task[26]. However, while the findings of Bugaiska et al.[26] provide evidence for an increased Stroop-like interference by animate words, the study did not include a memory test and thus cannot provide direct evidence on the question of whether the attentional prioritization of animate words is causally related to the animacy effect, that is, the better *memory* for animate than for inanimate words. To demonstrate such a causal relationship, it is necessary to show that manipulations that are expected to enable or disable the attentional prioritization of animate words affect the animacy effect. To illustrate the importance of experimental manipulations of variables affecting the construct in question, consider, for instance, the richness-of-encoding account of the animacy effect. Initial correlational findings have shown that animate words are associated with a richer idea formation than inanimate words in idea-generation tasks[6,11] and that animate words are more richly represented in memory[10,15,27–29]. However, correlation does not imply causation. Therefore, experimental manipulations of richness of encoding were necessary to test whether different levels of richness of encoding would affect the animacy effect. The fact that the animacy effect remained unaffected by experimental manipulations of richness of encoding has considerably weakened richness of encoding as the primary cognitive mechanism underlying the animacy effect[13]. Analogously, the finding that animate words interfere more with color naming than inanimate words in a Stroop-like task[26] is an intriguing phenomenon in itself, but experimental manipulations of attention are necessary to test the causal contribution of attentional prioritization to the animacy effect.

Studies in which a dual-task paradigm (see[25]) was used to test whether the animacy effect is modulated by attentional load provided mixed evidence regarding the role of attention in the animacy effect: In two studies, the animacy effect remained unaffected by whether or not attention at encoding was divided between the encoding task and a secondary task[15,30]. By contrast, Leding[8] observed that the animacy effect was significantly decreased—but not completely eliminated—when a secondary task had to be performed compared to when no secondary task had to be performed. Furthermore, in one of the three dual-task experiments of Bonin et al.[30], performance in the secondary task decreased when the task had to be performed while animate words were presented, indicating that animate words recruited more attentional resources at the expense of the secondary task than inanimate words. The mixed evidence available so far thus does not allow for a firm rejection or confirmation of the attentional-prioritization account. Therefore, further empirical tests of the account are necessary.

Another way to test the attentional-prioritization account is to examine whether the animacy effect differs between mixed lists composed of both animate and inanimate words and pure lists composed of either only animate or only inanimate words. Just as in the Stroop-like task and the dual-task paradigm, this test rests on the assumption that attention is a limited resource. The attentional-prioritization account implies that there is an asymmetry in the allocation of these limited attentional resources between animate and inanimate words such that the animate words are prioritized at the expense of the inanimate words. Many other mnemonic effects have been demonstrated to differ as a function of whether mixed or pure lists are used[31]. For instance, robust list-composition effects have been obtained when examining the effects of emotional arousal on the recognition and the free recall of words and pictures. Emotionally arousing stimuli are better remembered than neutral stimuli when emotionally arousing stimuli are presented together with neutral stimuli in mixed lists, but the effect of emotional arousal on memory is often severely reduced or even completely eliminated when emotionally arousing and neutral stimuli are presented separately in pure lists[32–34]. A possible explanation of these list-composition effects is that attentional resources are allocated asymmetrically between emotionally arousing and neutral stimuli in mixed lists[35,36]: The emotionally arousing stimuli are prioritized at the expense of the neutral stimuli in the same list so that the emotionally arousing stimuli are better remembered at the expense of the neutral stimuli. This attentional prioritization results in an accentuation of the effect of emotional arousal on memory when using mixed versus pure lists.

Parallel to the reasoning above, the attentional-prioritization account of the animacy effect implies that the animacy effect should be larger in mixed lists than in pure lists. The use of a pure-list design has been offered as a reason for the absence of an animacy effect on visual statistical learning[37], but due to the predominance of the mixed-list design when examining the animacy effect on free recall, there is only sparse evidence on whether the animacy effect differs between mixed and pure lists. Initial evidence was provided by Popp and Serra[4]. Their experiment included, among other conditions, a comparison of the animacy effect on free recall between mixed and pure lists. Their results were, however, somewhat ambiguous. At the level of statistical inference, there was no significant interaction between animacy and list composition, but at the descriptive level, the animacy effect was about twice as large in the mixed lists compared to the pure lists. This data pattern raises the question of whether the sample size of $N = 64$ participants might have been too small to detect the critical interaction between animacy and list composition. Moreover, the complexity of the experimental design might have induced interference because participants were required to perform free-recall and cued-recall tests in a repeated-measures design.

The present Experiment 1 was designed as a replication of Popp and Serra's[4] comparison of the animacy effect between mixed and pure lists with increased sensitivity in a less complex experimental design that focused only on the critical interaction between animacy and list composition on free recall. In the present Experiments 2 and 3, the words were presented simultaneously in mixed pairs composed of one animate and one inanimate word or in pure pairs composed of either two animate or two inanimate words to manipulate the competition for attention at the time of presentation. Whereas intentional encoding tasks were used in Experiments 1 and 2, Experiment 3 served to test whether animate words may receive a stronger attentional priority relative to inanimate words in an incidental encoding task. The attentional-prioritization account of the animacy effect implies that the animacy effect should be larger when animate words are presented together with inanimate words in mixed lists or pairs than when animate and inanimate words are presented separately in pure lists or pairs.

Experiment 1

Method.

Participants. The experiment was conducted online using SoSci Survey[38]. Participants were allowed to use a desktop or laptop computer, not a tablet or smartphone. To make use of the original English word material made openly available by Popp and Serra[4], participants were recruited in the United Kingdom from the research panels of the ISO-20252:2019-certified online-access-panel provider respondi AG (https://www.respondi.com).

We aimed to collect 500 complete data sets (and up to 50 additional complete data sets to compensate for exclusions) and stopped data collection once this criterion was reached. Of 637 participants who had started the intentional encoding task, 94 participants had to be excluded because they either did not complete the experiment or withdrew their consent to the use of their data. The data of 27 participants were excluded because these participants did not recall any of the presented words. Eighteen participants indicated issues with understanding English, reading the text on the screen, complying with instructions or with the display of the stimuli. Following a recommendation of Elliott et al.[39], the data of these participants were included in the final analysis; their exclusion would not have changed any statistical conclusions. The final sample of Experiment 1, characterized by diversified levels of education and good English language proficiency, consisted of 516 participants (241 female, 274 male, 1 nonbinary) aged between 18 and 85 ($M = 45$, $SD = 16$) years. The participants were randomly assigned to either the mixed-lists group ($n = 260$) or the pure-lists group ($n = 256$). A sensitivity analysis with G*Power[40] showed that, with a sample size of $N = 516$ and $\alpha = 0.05$, an interaction between animacy and list composition (that is, a variation of the animacy effect as a function of whether free recall was measured in the mixed-lists group or in the pure-lists group) on free recall as small as $\eta_p^2 = 0.02$ could be detected with a statistical power of $1 - \beta = 0.95$. Participants received a small monetary compensation for participating.

Ethics statement. In all experiments reported here, participants gave written informed consent prior to participation. The experiments were conducted in line with the Declaration of Helsinki and belonged to a series of experiments for which approval was obtained from the ethics committee of the Faculty of Mathematics and Natural Sciences at Heinrich Heine University Düsseldorf.

Materials, design and procedure. We used the English word material of Popp and Serra[4]. The pool consists of 84 animate words and 84 inanimate words that were matched on imagery, concreteness, word frequency and the number of letters (for details, see[4]).

The experiment had a mixed design with the within-subjects factor animacy (animate, inanimate) and the between-subjects factor list composition (mixed, pure). For each participant, two lists were created by randomly selecting words (without replacement) from the word pool. For participants in the pure-lists group, one list was composed of 16 randomly-ordered animate words and the other list was composed of 16 randomly-ordered inanimate words. The order of list presentation was counterbalanced across participants. For participants in the mixed-lists group, each of the two lists was composed of 8 animate and 8 inanimate words in a random order.

The procedure was similar to that of Experiment 1 of Popp and Serra[4] with the exception that free recall served as the only memory test. In the intentional encoding task, participants were informed that their task was to study two lists of nouns. Participants knew that every noun would be presented for 5 s and that it would not be possible to pause or to repeat the presentation. Thus, words were presented one after another as is typical for experiments in which the effect of animacy on free recall is examined (e.g.,[2,5–7,12,13,16]). Participants were informed that after each list, they would be asked to recall the nouns of that list in any order. Words of each list were shown in black bold 36-point Arial font at the center of the browser window. After all words of the first list had been presented, participants were instructed to recall as many of the presented nouns as possible. They were reminded that the order of the nouns was not important. Participants were asked to type each noun into a separate text field. There were 16 text fields, matching the number of words presented at encoding. When participants were sure that they could not recall any more of the nouns, they clicked a “finish memory test” button which was possible regardless of the number of words that had been recalled. The same procedure was then repeated for the second list, starting with the presentation of the list and followed by the free recall of the nouns. Before the presentation of the second list and before the second memory test, it was emphasized that the nouns of the first list were not supposed to be recalled in the second memory test.

At the end of the experiment, participants were thanked for their participation. After being instructed to provide honest answers so that reliable conclusions could be drawn from the results and being told that their answers would not have any consequences for them (cf.[41]), participants were asked whether they had complied with the instructions and whether all information had been displayed correctly. Directly after these control questions, participants were asked whether we would be allowed to use their data in an anonymized form for the data analysis, thereby giving participants the opportunity to revoke their consent, given prior to participation, by clicking on a "No, I withdraw the consent to the use of my data" option. The median duration of the experiment was 7 min.

Results. Free recall was measured by calculating the proportion of list words that were correctly recalled. A word was scored as correctly recalled only if it belonged to the immediately preceding word list. The semi-automated scoring of the free-recall data followed a two-step procedure. First, a computer program scored the exact matches between the recalled words and the list words. The remaining words were manually evaluated by three human raters. Obvious spelling mistakes or the use of the plural forms of the words were scored as correct. The manually evaluated words comprised about 5 % of the correctly recalled words.

Figure 1 displays the mean proportion of correctly recalled words as a function of animacy and list composition. The α level was set to 0.05 for all statistical tests. A 2 × 2 mixed analysis of variance (ANOVA) showed a significant recall advantage of animate over inanimate words, $F(1, 514) = 68.27$, $p < 0.001$, $\eta_p^2 = 0.12$. Words presented in pure lists were recalled significantly better than words presented in mixed lists, $F(1, 514) = 4.79$, $p = 0.029$, $\eta_p^2 = 0.01$. The critical interaction between animacy and list composition was not significant, $F(1, 514) = 1.65$, $p = 0.199$, $\eta_p^2 < 0.01$, supporting the conclusion that the animacy effect does not differ between mixed and pure lists.

The mean number of intrusions is reported in Table 1. Intrusions from the first to the second list were distinguished from extra-experimental intrusions. The extra-experimental intrusions were categorized as animate, inanimate or uncategorizable by the three raters; inconsistencies among the raters were resolved by discussion. Intrusions occurred extremely rarely which precludes the use of inferential statistics for all experiments reported here.

Discussion. Despite a large sample size of $N = 516$ that ensured a high sensitivity to detect an interaction between animacy and list composition given $\alpha = \beta = 0.05$, the animacy effect was found to be equally large in mixed and pure lists; the sample effect size associated with the critical interaction was $\eta_p^2 < 0.01$. The results thus allow us to confirm, with a higher sensitivity of the statistical test, the conclusion of Popp and Serra[4] that there is no interaction between animacy and list composition on free recall. The data pattern provides evidence against the attentional-prioritization account according to which the animacy effect is caused by animate words recruiting attention at the expense of inanimate words.

Experiment 2

In Experiment 1, all words were presented sequentially. This implies that the animate and inanimate words in mixed lists did not directly compete for resource-constraint processes at the time they were presented but only for resource-constraint processes that extended beyond the immediate presentation of the words. This raises

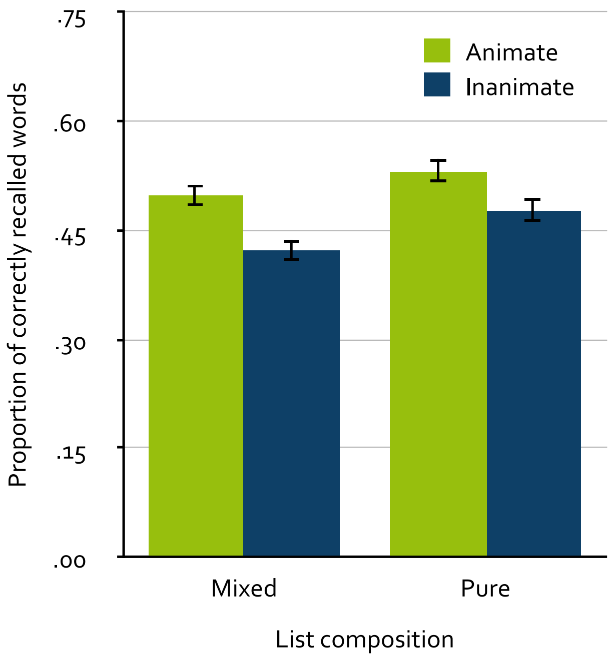

Figure 1. Mean proportion of correctly recalled words as a function of animacy and list composition in Experiment 1. Participants intentionally encoded either two mixed lists composed of both animate and inanimate words or one pure list composed of only animate words and one pure list composed of only inanimate words. The proportion of correctly recalled words refers to words recalled within the two memory tests combined. The error bars represent the standard errors of the means.

	Intrusion type		Category					
			Animate		Inanimate		Uncategorizable	
Experiment 1	First-to-second list	Mixed lists	0.08	(0.02)	0.05	(0.02)	–	–
		Pure lists	< 0.01	(< 0.01)	0.00	(0.00)	–	–
	Extra-experimental	Mixed lists	0.14	(0.03)	0.25	(0.04)	0.12	(0.07)
		Pure lists	0.21	(0.04)	0.27	(0.05)	0.23	(0.11)
Experiment 2	Extra-experimental		0.22	(0.02)	0.26	(0.03)	0.05	(0.01)
Experiment 3	Extra-experimental		0.10	(0.02)	0.24	(0.03)	0.08	(0.02)

Table 1. Mean number of intrusions as a function of animacy in Experiments 1, 2 and 3. In Experiment 1, we distinguished between intrusions from the first to the second list and extra-experimental intrusions, calculated separately for the levels of the list-composition factor. In Experiments 1, 2 and 3, extra-experimental intrusions refer to falsely reported words that were not presented at encoding. The values in parentheses represent the standard errors of the means.

the question of whether animate words would recruit attentional resources at the expense of the encoding of inanimate words when animate and inanimate words were presented simultaneously so that they could compete for resource-constraint processes at the time of presentation (cf.[42–44]). To test this hypothesis in Experiment 2, the words were presented simultaneously in mixed pairs composed of one animate and one inanimate word or in pure pairs composed of either two animate or two inanimate words. If the encoding of the animate words benefits from attentional prioritization in mixed pairs, the free recall of animate words should improve at the expense of the free recall of inanimate words. In pure pairs, competition for resource-constraint processes at the time of presentation could occur only between words of the same animacy status with the result that the encoding of the animate words could not be prioritized at the expense of the encoding of the inanimate words. The critical test was whether there is an interaction between animacy and pair composition on free recall. According to the attentional-prioritization account, the animacy effect should be larger when animate words are presented together with inanimate words in mixed pairs than when animate and inanimate words are presented separately in pure pairs.

Method. *Participants.* Participants who had not participated in Experiment 1 were recruited in the same way as in Experiment 1. Of 645 participants who had started the intentional encoding task, 101 participants had to be excluded because they either did not complete the experiment or withdrew their consent to the use of their data. The data of 36 participants were excluded because these participants did not recall any of the presented words. Eleven participants indicated issues with understanding English, reading the text on the screen, complying with instructions or with the display of the stimuli. Following a recommendation of Elliott et al.[39], the data of these participants were included in the final analysis; their exclusion would not have changed any statistical conclusions. The final sample consisted of 508 participants (318 female, 187 male, 3 nonbinary) aged between 18 and 72 ($M = 49$, $SD = 13$) years. A sensitivity analysis with G*Power[40] showed that, with a sample size of $N = 508$ and $\alpha = 0.05$, an interaction between animacy and pair composition (that is, a variation of the animacy effect as a function of whether the word pairs were mixed or pure) on free recall as small as $\eta_p^2 = 0.03$ could be detected with a statistical power of $1 - \beta = 0.95$.

Materials, design and procedure. As in Experiment 1, a random selection of 16 animate and 16 inanimate words was drawn from the word pool of Popp and Serra[4] for each participant. Other than in Experiment 1, the words were presented simultaneously in mixed pairs composed of one animate and one inanimate word or in pure pairs composed of either two animate or two inanimate words. The experiment had a within-subjects design with the factors animacy (animate, inanimate) and pair composition (mixed, pure). For each participant, the 16 animate and 16 inanimate words were randomly assigned to 8 mixed pairs and 8 pure pairs (4 pairs of animate words and 4 pairs of inanimate words) that were presented in a random order. The position (left or right) of animate and inanimate words in mixed pairs was counterbalanced.

In the intentional encoding task, participants were instructed to study several nouns. Participants knew that two nouns would be presented together for 5 s each and that it would not be possible to pause or to repeat the presentation. Participants were informed that, later on, they would be asked to recall all individual nouns in any order. Word pairs were shown in black bold 36-point Arial font at the center of the browser window. After all words had been presented, participants were instructed to recall as many of the presented nouns as possible. They were reminded that the order of the nouns was not important and that it would not be necessary to group nouns which had been presented together. There were 32 text fields, matching the number of words presented at encoding. Participants were asked to type each noun into a separate text field. When they were sure that they could not recall any more of the nouns, they clicked a "finish memory test" button. This was possible regardless of the number of words that had been recalled. The median duration of the experiment was 4 min.

Results. The free-recall data were scored with the same semi-automated procedure as in Experiment 1. The manually evaluated words comprised about 6 % of the correctly recalled words. Figure 2 displays the mean proportion of correctly recalled words as a function of animacy and pair composition. A 2×2 repeated-measures

ANOVA showed that animate words were recalled significantly better than inanimate words, $F(1, 507) = 233.78$, $p < 0.001$, $\eta_p^2 = 0.32$. Furthermore, words presented in pure pairs were recalled significantly better than words presented in mixed pairs, $F(1, 507) = 4.30$, $p = 0.039$, $\eta_p^2 = 0.01$. However, the critical interaction between animacy and pair composition was not significant, $F(1, 507) = 0.28$, $p = 0.598$, $\eta_p^2 < 0.01$, leading to the conclusion that the animacy effect does not differ between mixed and pure pairs.

The mean number of extra-experimental intrusions is reported in Table 1. Intrusions were again extremely rare.

Discussion. Despite the large sample size of $N = 508$ that ensured a high sensitivity to detect an interaction between animacy and pair composition given $\alpha = \beta = 0.05$, the animacy effect was equally large in mixed and pure pairs; the sample effect size associated with the critical interaction was $\eta_p^2 < 0.01$. This held true even though the animate and inanimate words were shown simultaneously in mixed pairs which should have caused competition for attention at the time of presentation. The data pattern thus provides evidence against the attentional-prioritization account according to which the animacy effect is caused by animate words recruiting attention at the expense of inanimate words at encoding.

Experiment 3

Parallel to Popp and Serra[4], intentional encoding tasks were used in Experiments 1 and 2. However, it seems possible that an asymmetry in the allocation of attentional resources between animate and inanimate words may play a greater role in incidental encoding tasks than in intentional encoding tasks. In intentional encoding tasks, participants are required to attend to all words that have to be recalled later, regardless of their animacy status. In incidental encoding tasks in which the participants do not know that all words have to be recalled later, intrinsic properties of the words such as the animacy status of the words may be more likely to have an impact on the allocation of attentional resources at encoding. Consistent with this hypothesis, Félix et al.[5] reported that the animacy effect was larger after incidental encoding than after intentional encoding. Félix et al.[5] discussed, as a potential explanation of this pattern, that animate words may receive a stronger attentional priority relative to inanimate words in an incidental encoding task than in an intentional encoding task. To test this possibility, an incidental encoding task was used in Experiment 3. The predictions derived from the attentional-prioritization account of the animacy effect were the same as those in Experiment 2: The critical test was whether there is an interaction between animacy and pair composition on free recall. If the animacy effect is caused by animate words recruiting attention at the expense of inanimate words at the time of presentation, the animacy effect should be larger in mixed pairs composed of one animate and one inanimate word than in pure pairs composed of either two animate or two inanimate words.

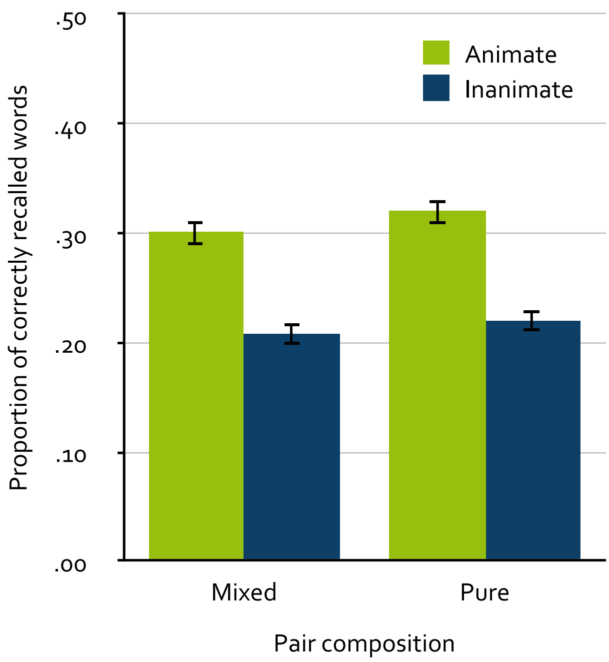

Figure 2. Mean proportion of correctly recalled words as a function of animacy and pair composition in Experiment 2. Participants intentionally encoded words presented in pairs of the configurations animate–inanimate (mixed), inanimate–animate (mixed), animate–animate (pure) and inanimate–inanimate (pure). The proportion of correctly recalled words refers to single words recalled within a single memory test. The error bars represent the standard errors of the means.

Method. *Participants.* Participants who had not participated in either Experiment 1 or Experiment 2 were recruited as before. Of 635 participants who had started the incidental encoding task, 88 participants had to be excluded because they either did not complete the experiment or withdrew their consent to the use of their data. The data of 109 participants were excluded because these participants did not recall any of the presented words. The data of one participant's repeated participation were excluded as well. Fourteen participants indicated issues with understanding English, reading the text on the screen, complying with instructions or with the display of the stimuli. Following a recommendation of Elliott et al.[39], the data of these participants were included in the final analysis; their exclusion would not have changed any statistical conclusions. The final sample consisted of 437 participants (157 female, 277 male, 3 nonbinary) aged between 18 and 85 ($M = 44$, $SD = 16$) years. A sensitivity analysis with G*Power[40] showed that, with a sample size of $N = 437$ and $\alpha = 0.05$, an interaction between animacy and pair composition (that is, a variation of the animacy effect as a function of whether the word pairs were mixed or pure) on free recall as small as $\eta_p^2 = 0.03$ could be detected with a statistical power of $1 - \beta = 0.95$.

Materials, design and procedure. For each participant, animate and inanimate words were selected from the word pool of Popp and Serra[4] and assigned to word pairs as in Experiment 2. Parallel to Experiment 2, the experiment had a within-subjects design with the factors animacy (animate, inanimate) and pair composition (mixed, pure). Other than in Experiment 2, an incidental encoding task was used. Participants were asked to count the number of letters of both nouns together and to type the total number of letters into a single text field. Participants were asked to complete this task as accurately as possible. The pools of animate and inanimate words from which a random selection of 16 animate and 16 inanimate words was drawn for each participant were equated in the number of letters[4]. The proportion of correct responses in the letter-counting task did not significantly differ among the mixed pairs of one animate and one inanimate word ($M = 0.93$, $SE = 0.01$), the pure pairs of two animate words ($M = 0.94$, $SE = 0.01$) and the pure pairs of two inanimate words ($M = 0.94$, $SE = 0.01$), $F(2, 435) = 1.98$, $p = 0.140$, $\eta_p^2 = 0.01$. Recording of the response times began when the word pair was presented and ended when the participant clicked on a "next" button to proceed. The mean response time did not significantly differ among the mixed pairs of one animate and one inanimate word ($M = 13.58$ s, $SE = 1.72$), the pure pairs of two animate words ($M = 10.95$ s, $SE = 0.42$) and the pure pairs of two inanimate words ($M = 12.00$ s, $SE = 0.86$), $F(2, 435) = 1.82$, $p = 0.164$, $\eta_p^2 = 0.01$. With the exception of being unannounced, the free-recall test was identical to that used in Experiment 2. The median duration of the experiment was 5 min.

Results. The free-recall data were scored with the same semi-automated procedure as in Experiments 1 and 2. The manually evaluated words comprised about 4 % of the correctly recalled words. Figure 3 displays the mean proportion of correctly recalled words as a function of animacy and pair composition. Due to the incidental encoding task, participants recalled fewer words overall than in Experiment 2 at the descriptive level. A 2×2 repeated-measures ANOVA showed that animate words were recalled significantly better than inanimate words, $F(1, 436) = 183.03$, $p < 0.001$, $\eta_p^2 = 0.30$. Free recall did not significantly differ between words presented in mixed pairs and words presented in pure pairs, $F(1, 436) = 1.80$, $p = 0.181$, $\eta_p^2 < 0.01$. Importantly, the critical interaction between animacy and pair composition was not significant, $F(1, 436) = 0.12$, $p = 0.730$, $\eta_p^2 < 0.01$.

The mean number of extra-experimental intrusions is reported in Table 1. Intrusions were again extremely rare.

Discussion. Despite the large sample size of $N = 437$ that ensured a high sensitivity to detect an interaction between animacy and pair composition given $\alpha = \beta = 0.05$, the animacy effect was equally large in mixed and pure pairs; the sample effect size associated with the critical interaction was $\eta_p^2 < 0.01$. This held true even though encoding was incidental in Experiment 3. It thus can be concluded that the animacy effect is not affected by the presence or absence of direct competition for attention between animate and inanimate words at encoding, irrespective of whether encoding is intentional or incidental. This rules out the possibility that an asymmetry in the allocation of attentional resources between animate and inanimate words in mixed pairs was overshadowed by the participants' intentional memorization strategies and instead further strengthens the general conclusion that the animacy effect is not caused by the attentional prioritization of animate words at encoding.

General discussion

While the adaptive-memory framework[18,19] provides a potential account of the evolutionary background of the animacy effect on free recall, the cognitive mechanisms underlying the animacy effect have as yet to be identified. The present series of experiments served to test the attentional-prioritization account according to which there is an asymmetry in the allocation of attentional resources between animate and inanimate words such that animate words are prioritized at the expense of inanimate words. A straightforward implication of this account is that the animacy effect should be larger in mixed lists in which animate words compete with inanimate words for processing resources than in pure lists in which there is no direct competition between animate and inanimate words. Given that almost all previous studies have used mixed lists (e.g.,[2,5–7,10,12,13]), it was unclear whether the animacy effect would indeed turn out to be smaller in pure lists. The starting point of the present investigation was the observation that in one previous study in which the animacy effect was compared between mixed and pure lists[4], the results appeared to be ambiguous: At the descriptive level, the animacy effect was about twice as large in the mixed lists compared to the pure lists, but the critical interaction between animacy and list composition was not statistically significant. This observation raised the question of whether the interaction between animacy and list composition would turn out to be statistically significant when the sensitivity of the statistical test was enhanced by increasing the sample size. Therefore, we conducted an experiment in which the sample size was increased from $N = 64$ in the original experiment of Popp and Serra[4] to $N = 516$ in the present Experiment 1. The results of Experiment 1 confirm that the animacy effect is equally large in mixed and pure word lists.

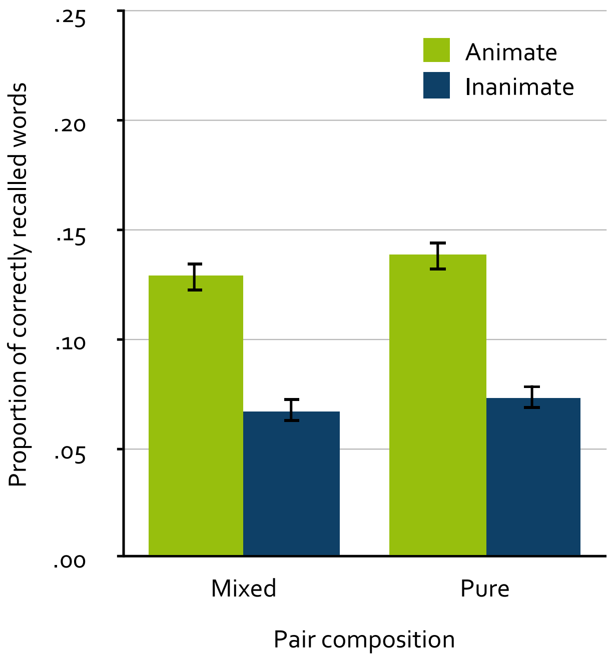

Figure 3. Mean proportion of correctly recalled words as a function of animacy and pair composition in Experiment 3. Participants incidentally encoded words presented in pairs of the configurations animate–inanimate (mixed), inanimate–animate (mixed), animate–animate (pure) and inanimate–inanimate (pure). The proportion of correctly recalled words refers to single words recalled within a single memory test. The error bars represent the standard errors of the means.

The substantial increase in sample size relative to the original experiment of Popp and Serra[4] greatly reduces the risk that the interaction between animacy and list composition was not detected due to a lack of sensitivity of the statistical test of this interaction. The results of Experiment 1 thus weaken the attentional-prioritization account of the animacy effect.

A possible limitation of the experimental test adopted in Experiment 1 was that the words were presented sequentially which implies that, in mixed lists, animate and inanimate words could compete only for resource-constraint processes that extended beyond their immediate presentation. In Experiments 2 and 3, the words were presented in mixed pairs composed of one animate and one inanimate word or in pure pairs composed of either two animate or two inanimate words. Simultaneously presenting animate and inanimate words in mixed pairs should have accentuated the direct competition for attention between animate and inanimate words at encoding compared to the sequential presentation that was used in Experiment 1 (cf.[42–44]). Nevertheless, no interaction between animacy and pair composition was found. In Experiments 1 and 2, intentional encoding tasks were used. It could have been argued that requiring participants to memorize and thus to attend to all words regardless of their animacy status may have reduced the effect of animacy on attentional prioritization (cf.[5]). Therefore, Experiment 3 was designed to test whether animate words recruit attention at the expense of inanimate words when an incidental encoding task is used. Indeed, intentional and incidental encoding led to somewhat different outcomes with regard to the effects of list and pair composition on free recall. In Experiments 1 and 2 in which intentional encoding tasks were used, list composition and pair composition, respectively, had a main effect on free recall, suggesting that pure lists and pairs lend themselves somewhat better to intentional memorization strategies than mixed lists and pairs. The main effect of pair composition was absent in Experiment 3. However, despite using a letter-counting task, the animacy effect was equally large in mixed and pure pairs. The sample effect size η_p^2 associated with the critical interaction between animacy and list composition or pair composition was smaller than 0.01 in each of the three experiments which further supports the conclusion that the present findings provide consistent evidence against the attentional-prioritization account.

The present series of experiments extends findings that have already weakened the attentional-prioritization account of the animacy effect. In three studies in which a dual-task paradigm was used, the animacy effect did not depend on attentional load[15,30] or was only decreased but not completely eliminated when a secondary task had to be performed compared to when no secondary task had to be performed[8]. These findings were interpreted as providing evidence against a strong role of attentional prioritization in the animacy effect. For instance, Bonin et al.[30] concluded that their results provide "no evidence suggesting that attentional resources are allocated differently to animates compared to inanimates" (p. 380). The strongest evidence in favor of the attentional-prioritization account has been offered by the study of Bugaiska et al.[26] who found that naming the font color of animate words took longer than naming the font color of inanimate words in a Stroop-like task. However, the study did not include a memory test and thus could not provide direct evidence on the relationship between impaired color naming of animate words and the robustly found recall advantage of animate over inanimate words. To advance our understanding of the cognitive mechanisms underlying the animacy effect, the necessity of experimental manipulations targeting the causal factor of interest has previously been emphasized[13]. This point is readily illustrated using the richness-of-encoding account. It has been counted as initial support for this account that animate words, compared to inanimate words, stimulate a richer idea formation in idea-generation tasks[6,11] and have richer representations in memory[10,15,27–29]. However, the fact that experimental manipulations targeting richness of encoding did not modulate the recall advantage of animate over inanimate words challenged the theory that richness of encoding is the primary cognitive mechanism underlying the animacy effect[13]. In a similar vein, the results of the present experimental manipulations challenge the theory that attentional prioritization is the primary cognitive mechanism underlying the animacy effect.

In the present series of experiments, we relied on the original English word material of Popp and Serra[4] because Experiment 1 was designed as a replication of Popp and Serra's[4] results obtained in free recall with increased sensitivity of the statistical test. Systematically varying one particular aspect of the procedure such as the sample size while holding other aspects such as the word material constant has the advantage of providing a contribution to the cumulative understanding of the subject matter by facilitating the interpretation of the results. It remains up to future studies to test whether the present finding that the animacy effect is equally large in mixed and pure word lists or pairs generalizes across different word materials (cf.[16,45]).

Encoding conditions under which animacy effects have been observed are diverse and range from intentional encoding tasks (e.g.,[2,5,7,8,15,16,30]) to various incidental encoding tasks that stimulate shallow levels of processing[13,46] or deep levels of processing, including tasks demanding animacy categorization (e.g.,[10,23,30]), pleasantness rating[5,9,17,46], idea generation[6,11,13] and survival processing[13,17,46]. The present series of experiments further underlines the robustness of the animacy effect in showing that the animacy effect is not limited to mixed lists but generalizes to pure lists and is equally large in mixed pairs composed of one animate and one inanimate word and pure pairs composed of either two animate or two inanimate words presented together at encoding. At the theoretical level, progress in understanding the animacy effect has as yet primarily been made by ruling out potential cognitive accounts of the effect. For example, theories attributing the animacy effect to emotional or mental arousal[12,21], perceived threat ([8], but see[22]), mental imagery[9,23], categorical organization[24] or richness of encoding[13] have been disconfirmed by the available empirical evidence. The present series of experiments lines up well with these previous studies in that its main contribution is to provide evidence against the widely discussed attentional-prioritization account of the animacy effect. It is thus up to future studies to identify the cognitive mechanism or combinations of cognitive mechanisms that underlie the animacy effect.

Data availability

The data of all experiments reported here and supplementary Bayesian analyses of the results are available at the project page of the Open Science Framework, https://osf.io/x4am5/.

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Author contributions

G.F.K., L.M., A.B. and R.B. contributed to the idea and the conception of the experiments. G.F.K. collected and analyzed the data and wrote the first draft of the manuscript with subsequent input from all co-authors. All authors gave final approval for publication.

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Competing interests

The authors declare no competing interests.

Additional information

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Erklärung über den Eigenanteil an den in der Dissertation enthaltenen Einzelarbeiten

Meine Dissertation umfasst drei Einzelarbeiten mit insgesamt neun Experimenten, die in drei verschiedenen wissenschaftlichen Fachzeitschriften publiziert wurden. Im Folgenden werde ich meinen eigenen Anteil sowie den Anteil der Koautor:innen an jeder Einzelarbeit darlegen.

Eigenanteil an Einzelarbeit 1

Publikation:

Komar, G. F., Mieth, L., Buchner, A. & Bell, R. (2023). Animacy enhances recollection but not familiarity: Convergent evidence from the remember-know-guess paradigm and the process-dissociation procedure. *Memory & Cognition*, *51*(1), 143–159. https://doi.org/10.3758/s13421-022-01339-6

Planung: Das experimentelle Design erstellte ich mit der Unterstützung von Laura Mieth, Axel Buchner und Raoul Bell.

Umsetzung: Die Experimente und die Auswertungsprogramme programmierte ich eigenständig. Laura Mieth, Axel Buchner und Raoul Bell überprüften die Korrektheit und machten konstruktive Verbesserungsvorschläge. Die Datenerhebung führte ich eigenständig durch.

Auswertung: Die statistischen Analysen führte ich eigenständig durch. Laura Mieth, Axel Buchner und Raoul Bell überprüften die Korrektheit.

Manuskript: Das Manuskript verfasste ich eigenständig, was sämtliche Schritte von der umfassenden Literaturrecherche bis zur abschließenden Formulierung beinhaltete. Die Abbildungen erstellte ich eigenständig. Laura Mieth, Axel Buchner und Raoul Bell machten konstruktive Verbesserungsvorschläge, die ich nach sorgfältiger Prüfung gegebenenfalls in das Manuskript einarbeitete. Den Begutachtungsprozess bei der wissenschaftlichen Fachzeitschrift koordinierte ich eigenständig. Im Rahmen dieses Prozesses nahm ich mit der Unterstützung von Laura Mieth, Axel Buchner und Raoul Bell Revisionen vor. Die finale Version des Manuskripts erstellte ich eigenständig.

Eigenanteil an Einzelarbeit 2

Publikation:

Komar, G. F., Mieth, L., Buchner, A. & Bell, R. (2024). Manipulations of richness of encoding do not modulate the animacy effect on memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *50*(4), 580–594. https://doi.org/10.1037/xlm0001249

Planung: Das experimentelle Design erstellte ich mit der Unterstützung von Laura Mieth, Axel Buchner und Raoul Bell.

Umsetzung: Die Experimente und die Auswertungsprogramme programmierte ich eigenständig. Laura Mieth, Axel Buchner und Raoul Bell überprüften die Korrektheit und machten konstruktive Verbesserungsvorschläge. Die Datenerhebung führte ich eigenständig durch.

Auswertung: Die statistischen Analysen führte ich eigenständig durch. Laura Mieth, Axel Buchner und Raoul Bell überprüften die Korrektheit.

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Eigenanteil an Einzelarbeit 3

Publikation:

Komar, G. F., Mieth, L., Buchner, A. & Bell, R. (2023). The animacy effect on free recall is equally large in mixed and pure word lists or pairs. *Scientific Reports*, *13*, Artikel 11499. https://doi.org/10.1038/s41598-023-38342-z

Planung: Das experimentelle Design erstellte ich mit der Unterstützung von Laura Mieth, Axel Buchner und Raoul Bell.

Umsetzung: Die Experimente und die Auswertungsprogramme programmierte ich eigenständig. Laura Mieth, Axel Buchner und Raoul Bell überprüften die Korrektheit und machten konstruktive Verbesserungsvorschläge. Die Datenerhebung führte ich eigenständig durch.

Auswertung: Die statistischen Analysen führte ich eigenständig durch. Laura Mieth, Axel Buchner und Raoul Bell überprüften die Korrektheit.

Manuskript: Das Manuskript verfasste ich eigenständig, was sämtliche Schritte von der umfassenden Literaturrecherche bis zur abschließenden Formulierung beinhaltete. Die Abbildungen erstellte ich eigenständig. Laura Mieth, Axel Buchner und Raoul Bell machten konstruktive Verbesserungsvorschläge, die ich nach sorgfältiger Prüfung gegebenenfalls in das Manuskript einarbeitete. Den Begutachtungsprozess bei der wissenschaftlichen Fachzeitschrift koordinierte ich eigenständig. Im Rahmen dieses Prozesses nahm ich mit der Unterstützung von Laura Mieth, Axel Buchner und Raoul Bell Revisionen vor. Die finale Version des Manuskripts erstellte ich eigenständig.

Erklärung an Eides statt

Ich versichere an Eides statt, dass die Dissertation von mir selbständig und ohne unzulässige fremde Hilfe unter Beachtung der „Grundsätze zur Sicherung guter wissenschaftlicher Praxis an der Heinrich-Heine-Universität Düsseldorf“ erstellt worden ist.

Ich versichere insbesondere:

(1) Ich habe keine anderen als die angegebenen Quellen und Hilfsmittel benutzt.

(2) Alle wörtlich oder dem Sinn nach aus anderen Texten entnommenen Stellen habe ich als solche kenntlich gemacht; dies gilt für gedruckte Texte ebenso wie für elektronische Ressourcen.

(3) Die Arbeit habe ich in der vorliegenden oder einer modifizierten Form noch nicht als Dissertation vorgelegt – sei es an der Heinrich-Heine-Universität Düsseldorf oder an einer anderen Universität.

Düsseldorf, 2. Mai 2024

Gesa Fee Komar