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# Mémoire adaptative et effet animé : notre mémoire fonctionne-t'elle encore comme à l'âge de pierre ?

Margaux Gelin

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UNIVERSITE DE BOURGOGNE FRANCHE-COMTE

Laboratoire d'Etude de l'Apprentissage et du Développement

C.N.R.S – U.M.R. 5022

Ecole doctorale Environnements et Santé

**THÈSE**

Pour obtenir le grade de

**Docteur de l'Université de Bourgogne**

Discipline : **Psychologie**

Par **Margaux GELIN**

Le 25 octobre 2017

**Mémoire Adaptative et Effet Animé**

**Notre mémoire fonctionne-t-elle encore comme à l'âge de pierre ?**

Sous la direction de **Patrick BONIN**

Co-encadrement par **Aurélia BUGAISKA**

Soutenue publiquement devant le Jury composé de :

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*“Les espèces qui survivent ne sont pas les espèces les plus fortes, ni les plus intelligentes, mais celles qui s’adaptent le mieux aux changements.”*

*Charles Darwin, L’origine des espèces (1859).*



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## Résumé

La conception de la mémoire adaptative défend l'idée selon laquelle la mémoire humaine a évolué, pendant toute l'histoire de l'Homme, de sorte à résoudre des problèmes adaptatifs spécifiques (e.g., trouver de la nourriture, se protéger des prédateurs). De nombreuses recherches soutiennent cette conception en montrant, par exemple, que nous mémorisons mieux les informations quand nous les traitons relativement à notre propre survie (Nairne, Thompson, & Pandeirada, 2007). Récemment, un nouvel effet mnésique est venu renforcer cette approche fonctionnelle de la mémoire : l'effet animé. Il correspond à une meilleure mémorisation des entités animées (entités vivantes, capables de se déplacer de façon autonome, e.g., *bébé*, *sauterelle*) comparativement aux entités inanimées (entités non vivantes, e.g., *bouilloire*, *corde*). Cet effet serait dû à la plus grande importance des entités animées que de celle inanimées pour la survie et/ou la reproduction. Traiter ces entités de façon privilégiée a été primordiale pour la survie de nos ancêtres, et en conséquence, pour l'évolution de l'espèce humaine. Dans ce travail de thèse, nous nous sommes focalisés sur l'effet animé en mémoire épisodique afin de mieux comprendre les mécanismes proximaux qui le sous-tendent et ses conditions d'apparition. Ainsi nos principaux résultats ont-ils permis d'établir que l'effet animé en mémoire est : (1) lié au processus de remémoration (rappel conscient de détails contextuels) ; (2) indépendant des ressources cognitives disponibles ; (3) en partie sous-tendu par de l'imagerie mentale et (4) modérément modulé par le contexte d'encodage.

Mots-clefs : Mémoire adaptative ; Effet animé ; Mémoire épisodique ; Explication ultime/proximale ; Mécanismes proximaux

## Abstract

According to the adaptive memory view, human memory was shaped in the distant past to remember fitness relevant information (e.g., finding food, protecting ourselves from predators). An increasing number of studies favor this view, by showing that information related to survival is memorized better than information not related to survival (Nairne, Thompson, & Pandeirada, 2007). Recently, a new type of findings further supports this functional approach of memory: animacy effects, that is to say the observation that animates (living things able of independent movements; e.g., *baby*, *grasshopper*) are remembered better than inanimates (non-living things e.g., *teakettle*, *rope*). One account of this memory effect has been that animates are of greater importance for survival and/or reproduction. In effect, knowing how to interact with animates was crucial for the survival of our ancestors, and thus, for the evolution of our species. In this work, our main purposes were to identify some proximate mechanisms underpinning animacy effects in episodic memory as well as the contexts in which these effects are observed. Taken overall, our findings accord with the claim that animacy effects in memory are: (1) linked to recollection (conscious recall of contextual details); (2) independent of cognitive resources; (3) partially underpinned by mental imagery and (4) to some extent modulated by encoding context.

Keywords: Adaptive memory; Animacy effect; Episodic memory; Ultimate/Proximate explanation; Proximate mechanisms

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# **Introduction Générale**

## Préambule

### 1. Objectifs de la thèse

Les études entreprises dans ce travail de thèse s'inscrivent dans un cadre novateur : la mémoire adaptative. Cette conception, récemment proposée par Nairne et ses collaborateurs (Bonin & Bugaiska, 2014 ; Nairne, 2010, 2015, pour des revues de synthèse sur la mémoire adaptative), rend compte du fait que certaines informations, et plus spécifiquement celles qui sont reliées à la survie et/ou à la reproduction (eau, nourriture, animaux dangereux, partenaires sexuels...), sont mieux retenues que celles qui n'y sont pas directement reliées (Nairne, Thompson, & Pandeirada, 2007). Les travaux menés dans ce cadre s'inscrivent donc dans les conceptions fonctionnalistes de la mémoire. En effet, dans cette perspective, la mémoire opère de façon intégrée pour produire des comportements adaptés, dirigés vers un but (Versace, Nevers, & Padovan, 2002), tandis que les théories structurales considèrent plutôt que la mémoire est fractionnée en de nombreux systèmes qui sont associés à différentes régions cérébrales (Moscovitch, 1989 ; Squire, 1992 ; Tulving, 1991). Pour Nairne (2012), de la même façon que le cœur remplit la fonction d'envoyer le sang aux différents organes du corps, la mémoire serait dévolue à certaines fonctions particulières, notamment celle d'assurer notre survie. Ainsi, les travaux sur la mémoire adaptative questionnent le **pourquoi** du fonctionnement mnésique chez l'être humain et pas seulement le **comment**.

C'est dans cette perspective théorique que l'**effet animé**, qui fait l'objet de cette thèse, sera étudié. L'effet animé peut être défini comme le fait que les entités animées (entités vivantes, capables de se déplacer par leur propre source d'énergie interne) bénéficient d'un traitement privilégié par rapport aux entités inanimées (entités non vivantes, nécessitant une source d'énergie externe pour se déplacer). Une telle priorité de traitement conduit à de meilleures performances dans diverses tâches cognitives, comme nous allons le décrire. Par exemples, le temps de détection des entités animées est plus rapide que celui des entités inanimées (Abrams & Christ, 2003), leurs temps de fixation sont plus longs (Yang et al., 2012), elles sont mieux mémorisées (VanArsdall, Nairne, Pandeirada, & Blunt, 2013) etc. Dans ce travail de thèse sur l'effet animé, nous nous sommes donnés deux objectifs principaux : (1) identifier les facteurs qui modulent l'effet animé en mémoire et (2) fournir des pistes explicatives de cet effet, en tentant d'identifier les mécanismes cognitifs qui le soutiennent.

## 2. Ancrage théorique de la mémoire adaptative : La psychologie évolutionniste

La mémoire adaptative s'inscrit dans un champ disciplinaire plus vaste, la psychologie évolutionniste. Cette discipline touche des problématiques aussi diverses que le choix d'un partenaire et la coopération, elle s'intéresse également à la religion ou encore à la médecine (voir Buss, 2015 ; Workman & Reader, 2004/2007). Notre objectif n'est pas de présenter ici cette discipline de façon exhaustive, mais seulement d'en rappeler quelques principes généraux, utiles à la compréhension de notre problématique.

Par définition, « *la psychologie évolutionniste est une discipline relativement nouvelle qui applique le principe darwinien de la sélection naturelle à l'étude de l'esprit humain.* » (Workman & Reader, 2004/2007, p. 1). Darwin [1809-1882], dans deux ouvrages qu'il publie consécutivement, *La descendance de l'Homme et la sélection liée au sexe* (1871/1999) et *L'expression des émotions chez l'Homme et les animaux* (1872), aborde la question humaine et envisage l'Homme comme une espèce parmi d'autres, dont les caractéristiques ont émergé selon le principe de la sélection naturelle<sup>1</sup>. Cependant, il faut attendre la fin du 20<sup>ème</sup> siècle pour qu'apparaisse officiellement la psychologie évolutionniste dont l'ouvrage *The Adapted Mind: Evolutionary Psychology and the Generation of Culture* (Barkow, Cosmides, & Tooby, 1995) peut être considéré comme l'œuvre fondatrice. Dans *Darwin en tête ! L'Evolution et les sciences cognitives*, Van der Henst et Mercier (2009) expliquent que les psychologues évolutionnistes proposent des réponses touchant un autre niveau d'explication aux questions sur les comportements humains : ils cherchent à en expliquer le « pourquoi ».

Si le fait que l'évolution ait façonné notre corps est aisément accepté, il y a plus de réticence quant au fait qu'elle ait fait de même avec notre esprit. Ainsi, la psychologie évolutionniste fait l'objet de critiques qui sont souvent liées aux présentations caricaturales de cette discipline. On lui reproche notamment un réductionnisme génétique et la négation d'influences environnementales et culturelles. Or, considérant l'adaptation comme le concept clé de l'évolution, et la survie et la reproduction comme les buts ultimes de chaque être vivant, il semble difficile de ne pas prendre en considération les conditions environnementales et culturelles dans lesquelles les êtres vivants évoluent. En réalité, contrairement à ce qui est

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<sup>1</sup> Le principe de la sélection naturelle est que, si elles sont hérissables, les caractéristiques qui donnent aux individus un meilleur taux de reproduction vont se répandre dans la population. La sélection naturelle promeut donc les caractéristiques des individus qui l'emportent au jeu de la survie et de la reproduction (Darwin, 1859/1992).

reproché à l'approche « darwinienne » du comportement humain, les psychologues évolutionnistes adoptent une démarche qui est bien loin de négliger les conditions environnementales. Cette démarche est la suivante :

- 1. Déterminer l'EAE** (« environnement d'adaptation évolutionnaire ») ou l'environnement dans lequel nous avons évolué.<sup>2</sup>
- 2. Identifier les problèmes importants posés par cet ou ces environnements**
- 3. Imaginer des solutions possibles** pour résoudre ces problèmes sous forme de mécanismes cognitifs

L'environnement (la Culture au sens large) tient donc une place primordiale en psychologie évolutionniste. C'est pour s'adapter aux contraintes de leur environnement que les êtres vivants évoluent, et que certaines habiletés sont sélectionnées au détriment d'autres, moins efficaces. Cette vision phylogénétique, qui se veut explicative de l'état actuel des mécanismes cognitifs humains, n'est pas à opposer à une vision ontogénétique. En effet, si s'adapter aux différents environnements que l'Homme a rencontré a permis l'évolution de notre espèce au fil des générations, il est important, pour chaque individu, de s'adapter aux environnements qu'il va rencontrer tout au long de sa vie, pour pouvoir survivre et transmettre ses gènes.

### **3. Intérêt et originalité de la thèse : une double approche de l'effet animé en mémoire**

Une autre critique souvent émise à l'encontre de la psychologie évolutionniste concerne les effets qui valident ses théories. Certains auteurs estiment que ces derniers peuvent être expliqués en faisant appel à des mécanismes cognitifs généraux, qui fournissent un niveau d'explication suffisant ne nécessitant pas d'explications complémentaires.

En ce qui concerne la mémoire adaptative, par exemple, des mécanismes généraux tels que l'élaboration, l'encodage distinctif, la planification ou encore la référence à soi,

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<sup>2</sup> À l'origine, l'EAE correspondait uniquement au Pléistocène, période géologique qui s'étend de 2,6 millions d'année à environ 11000 ans (Raymond & Thomas, 2016 ; Workman & Reader, 2004/2007), mais il est aujourd'hui largement reconnu que l'adaptation humaine ne s'est pas arrêtée à cette période.

fourniraient une explication satisfaisante aux résultats obtenus avec le paradigme de survie<sup>3</sup> (Burns, Burns, & Hwang, 2011 ; Burns, Hart, Griffith, & Burns, 2013 ; Howe & Otgaar, 2013 ; Klein, Robertson, & Delton, 2011 ; Kroneisen & Erdfelder, 2011). Des explications en termes de survie et/ou de reproduction ne seraient donc pas nécessaires, voire même superflues. Cependant, il semble que cette critique provienne d'une confusion entre deux types d'explications, qui sont certes distinctes, mais néanmoins complémentaires. Il s'agit des explications dites "ultimes" et des explications dites "proximales" (Nairne, 2013). En effet, en psychologie évolutionniste, il y a deux niveaux d'explication d'un comportement. Le niveau le plus global correspond aux explications ultimes d'un phénomène. Elles portent sur la fonction d'un trait et les raisons pour lesquelles il a été sélectionné par la sélection naturelle ou sexuelle (parce qu'il a permis de survivre ou/et de se reproduire). A un autre niveau, se trouvent les explications proximales qui se focalisent sur les mécanismes (cognitifs, sociaux et/ou émotionnels) qui produisent le trait en question. Ces dernières correspondent au "comment" fonctionne le trait et quelles sont les conditions dans lesquelles il est le plus à même de s'exprimer. Ainsi, concernant la mémoire, Nairne et collaborateurs (Nairne & Pandeirada, 2010, 2016) ont proposé qu'elle aurait évolué en raison du fait qu'elle a permis de résoudre des problèmes spécifiques, relatifs à la survie et à la reproduction. Il s'agit donc d'une explication ultime. Une conséquence de cette évolution est que les informations qui sont pertinentes pour la survie, les entités animées par exemple, possèdent un statut particulier en mémoire. Comme nous allons le développer, les mécanismes proximaux qui sous-tendent de tels bénéfices mnésiques mettent en jeu un ou plusieurs des mécanismes généraux tels que l'élaboration, l'encodage distinctif, un traitement en référence à soi, l'imagerie mentale... Ces mécanismes explicatifs des effets observés en mémoire adaptative, que ce soit l'effet survie ou l'effet animé, correspondent au niveau d'explication proximale.

Les résultats obtenus dans les différentes études qui seront présentées dans ce travail, s'accordent avec une telle conception de la cognition. L'originalité de cette thèse est donc de montrer qu'inscrire l'effet animé dans une perspective évolutionniste ne conduit pas à négliger, ou à sous-estimer, l'implication de mécanismes généraux sous-tendant l'émergence de cet effet en mémoire. Ainsi, il s'agira d'étudier un effet mnésique - l'effet animé - sous

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<sup>3</sup> Le paradigme de survie est un paradigme majeur dans l'étude de la mémoire adaptative. Proposé par Nairne et al. (2007), il s'agit d'encoder des mots en référence à une situation de survie ancestrale. Cette condition d'encodage permet ensuite un accroissement des performances de mémoire comparativement à de nombreuses conditions contrôles (voir p 24)



deux angles différents, mais complémentaires, afin d'en avoir une compréhension plus globale.

Le présent document est organisé en trois chapitres. Dans un premier temps (Chapitre 1), nous allons aborder les explications ultimes de l'effet animé en mémoire. Constitué de deux articles, ce chapitre est consacré à la mise en évidence de l'effet animé en mémoire, à la détermination de son lien avec la mémoire épisodique en général (Article 1) et son extension à la mémoire de source en particulier (Article 2).

Nous envisagerons, ensuite, la question des explications proximales dans les Chapitres 2 et 3. Plus précisément, au travers de deux articles, le Chapitre 2 questionnera les mécanismes mnésiques à l'origine de l'effet animé. Un article permettra d'éclairer la question de l'indépendance ou de la dépendance de cet effet vis-à-vis des ressources cognitives et d'amorcer, comme piste explicative (proximale), l'imagerie mentale (Article 3) ; un autre article (Article 4) approfondira cette piste. Enfin, nous nous focaliserons sur un dernier élément essentiel en psychologie évolutionniste : la notion de flexibilité adaptative. Un comportement adapté l'étant forcément en fonction d'une situation donnée, le Chapitre 3 exposera des études dont l'objectif a été de déterminer si certains contextes amenaient à traiter de façon privilégiée les entités animées versus inanimées (Article 5).

Pour finir, en Discussion Générale, seront discutés deux aspects semblant faire défaut à nos travaux : le statut des végétaux et des inanimés capables de déplacement. La Discussion Générale permettra également d'aborder les différents projets expérimentaux découlant des recherches présentées dans ce travail de thèse. Ainsi, quatre axes seront développés, sur l'effet animé et l'imagerie mentale, l'effet animé et les émotions, la pertinence d'utiliser la réalité virtuelle dans les études sur l'effet animé en mémoire et la possibilité d'un effet animé en mémoire sémantique. Enfin, bien que cette thèse ait été faite dans une visée fondamentale, trois domaines dans lesquels nos données pourraient avoir des conséquences pratiques seront présentés : la pédagogie, la méthodologie expérimentale et la pratique clinique.

## **Aspects théoriques et empiriques généraux**

Comme abordé en préambule, dans cette thèse, en nous référant à des explications ultimes et proximales, nous avons adopté une perspective qui permet un éclairage complémentaire de l'effet animé en mémoire. Dans une perspective ultime, nous commencerons cette introduction par définir de façon précise ce que sont les entités animées et inanimées, et nous développerons rapidement l'importance que pouvait avoir les entités animées dans le passé ancestral. Ensuite, dans une perspective plus proximale, nous exposerons les différentes études traitant de la primauté de traitement des entités animées en psychologie cognitive, pour terminer par l'importance de cette distinction pour la mémoire à long terme.

### **1. Entités animées et entités inanimées : une différence fondamentale**

#### **1.1. Définition**

La capacité à distinguer les « objets » animés des objets inanimés est considérée comme une habileté cognitive fondamentale. En faveur de cette assertion, elle est l'une des dernières à être encore réussie par des patients Alzheimer (Hodges, Graham, & Patterson 1995 ; Saffron & Schwartz, 1994), ainsi que l'une des premières mises en place pendant le développement (Mandler & MacDonough, 1998a ; Opfer & Gelman, 2011).

Cette capacité serait acquise par l'enfant dès 7 mois environ selon Mandler (cité par Rakinson & Poulin-Dubois, 2001). En particulier, il a proposé que les bébés différencient précocement les entités animées - qui bougent seules, de façon non linéaire et qui peuvent produire des actions à distance - des entités inanimées qui ne peuvent pas bouger seules, mais seulement par contact avec un autre objet, qui se déplacent linéairement et ne peuvent pas engendrer d'action. Plus récemment, de nouvelles études sont venues renforcer ces propositions et confirmer que, dès la première année de vie, les nourrissons comprennent que les animés, contrairement aux inanimés, sont capables de mouvements auto-propulsés, c'est-à-dire provoqués par leur propre source d'énergie interne (Di Giorgio, Lunghi, Simion, & Vallortigara, 2016 ; Markson & Spelke, 2006). Ces caractéristiques constitutives de la distinction animés-inanimés ne sont pas les seules, Gelman et Spelke (1981) ont mis en évidence cinq différences fondamentales entre les entités animées et inanimés : (a) les entités

animées sont des agents, c'est-à-dire qu'elles initient l'action dans un événement causal, alors que les entités inanimées la subissent ; (b) les animés grandissent et se reproduisent ; (c) ils peuvent avoir des états mentaux comme penser, percevoir et ressentir ; (d) ils sont composés de parties directement reliées à des fonctions biologiques et (e) seuls les animés sont capables de communication et de réciprocité.

En considérant les animés comme étant seuls responsables de leurs mouvements, nous pouvons comprendre l'importance vitale qu'il y a à les traiter de façon optimale. En effet, au quotidien, les dangers sont plus souvent le fait des entités animées qu'inanimées (certains insectes ou animaux, les véhicules quand ils sont aux mains des êtres humains, ou encore, les êtres humains eux-mêmes), et ce, parce qu'elles sont capables de changer de statut souvent et par leur propre volonté : en effet, les êtres animés peuvent changer leur système de pensée, leurs comportements, leurs trajectoires... en une fraction de seconde, rendant leur surveillance aussi importante que leur détection initiale, dans une scène visuelle complexe. Toutefois, ce n'est pas seulement parce qu'elles sont sources de dangers potentiels que les entités animées sont importantes, elles le sont aussi parce qu'elles sont sources d'interactions.

## **1.2. L'importance des animés dans le passé ancestral**

Dans le passé de notre espèce, la surveillance attentive des animaux, humains inclus, était primordiale pour la survie (Orians & Heerwagen, 1992). En tant que famille, amis, partenaires sexuels ou adversaires potentiels, les êtres humains étaient la source d'opportunités sociales (positives, comme partager un repas, ou négatives, comme découvrir une trahison) et d'opportunités sexuelles indispensables à la survie et la perpétuation de l'espèce humaine. Certains animaux, non humains, étaient des prédateurs de l'Homme : ils représentaient une source de dangers dont il fallait se protéger en raison de leur venin (serpents), de leurs cornes (rhinocéros), de leurs griffes ou leurs dents (tigres à dents de sabre), de leur masse (mammouths), de leur force ou de leur propension à charger. Les animaux pouvaient également être une source d'alimentation quand ils pouvaient être chassés, ou lorsqu'ils fournissaient des informations sur d'autres animaux, plantes ou ressources pouvant se trouver à proximité.

Des données, provenant de l'observation de sociétés *actuelles* de chasseurs-cueilleurs, suggèrent que les interactions avec les animaux ont joué un rôle primordial dans la vie quotidienne de nos ancêtres, et ce, depuis le plus jeune âge, représentant une pression

sélective importante. Par exemple, même si la chasse de gros animaux ne devient réellement effective qu'à partir de l'adolescence, les jeunes enfants sont impliqués dans un large éventail d'activités en lien avec des animaux, que ce soit la pêche, la collecte d'insectes ou encore la capture de petits gibiers (Barrett, 2005 ; Hewlett & Lamb, 2005 ; Pereira & Fairbanks, 2002). L'extrapolation au passé ancestral des connaissances au sujet de ces sociétés de chasseurs-cueilleurs suggère que, bien que les rencontres indésirables avec des animaux dangereux, comme les carnivores, les serpents et les araignées, se sont produites fréquemment chez les individus de tous âges pendant les temps ancestraux, elles sont le plus souvent létales pour les enfants (Barrett, 2005 ; Hill & Hurtado, 1996 ; Volk & Atkinson, 2008). Les variations du taux de mortalité des enfants n'ayant pas encore atteint la puberté ont des conséquences dramatiques sur la démographie d'une société (Bogin, 1997 ; Jones, 2009 ; Stearns, 2006). Ainsi, les compétences qui prodiguent un avantage dans les activités qui impliquent d'interagir avec des animaux, et qui assurent leur bon déroulement, ont sans doute été retenues par la sélection naturelle. En effet, ces interactions sont capitales, tant pour la survie de l'individu et du groupe (apport de nourriture) que pour celle de l'espèce, en jouant sur le potentiel reproductif de tout ceux qui ne sont pas décédés avant leur puberté.

### *En résumé*

Les entités animées correspondent aux êtres vivants, capables de se déplacer de façon autonome, grâce à une source d'énergie interne ; il s'agit donc des animaux, êtres humains inclus. Les entités animées sont douées d'intentions, qui en font, depuis toujours, des cibles privilégiées. En effet, que ce soit à travers des interactions sociales (recherche de partenaire sexuel pour la reproduction, création d'alliance...), dans le cadre de la recherche d'alimentation (chasse, pêche...) ou parce qu'ils sont sources de dangers (prédateurs ou ennemis), les animaux, êtres humains inclus, ont très probablement exercés des pressions sélectives importantes sur l'espèce humaine. Ainsi, les caractéristiques qui prodiguent un avantage dans les activités impliquant d'interagir avec des entités animées ont sans doute été sélectionnées. Parmi les compétences susceptibles d'être issues de ce processus de sélection, il y a inévitablement des caractéristiques physiques, telles que la capacité à courir sur de longues distances ou la forme de notre mâchoire. Ce type de capacités ne fera pas l'objet de ce travail. En effet, c'est à l'influence de l'évolution sur d'autres types de compétences de l'Homme que nous nous sommes intéressés : les compétences cognitives. Dans les parties qui suivent nous nous focaliserons sur l'impact de la caractéristique animée dans différents

domaines de la psychologie cognitive et notamment, la psycholinguistique, l'attention, la perception visuelle et la mémorisation.

## **2. La distinction Animés/Inanimés en psychologie cognitive**

La dimension animée est essentielle en psychologie cognitive et a donc fait l'objet de très nombreuses études, que ce soit dans le domaine du langage (Silverstein, 1976), de l'organisation des connaissances en mémoire sémantique (Caramazza & Shelton, 1998) ou encore de la perception visuelle et de l'attention (Pratt, Radulescu, Guo, & Abrams, 2010). Dans les parties qui suivent, nous nous focalisons sur les études reliées directement à notre problématique, à savoir des études dans le domaine de l'attention et de la perception. Les études en psycholinguistique seront brièvement évoquées ci-après et nous reviendrons plus spécifiquement sur l'organisation des connaissances en mémoire sémantique, lors de la Discussion Générale.

### **2.1. Etudes en psycholinguistique**

De très nombreux travaux sont consacrés au traitement des animés dans une perspective de psycholinguistique. Ces travaux ne seront pas abordés ici de façon détaillée dans la mesure où ils sont très éloignés de notre problématique. Cependant, il nous a semblé important de mentionner ce champ de la psychologie cognitive, qui s'intéresse depuis longtemps à la distinction entre animés et inanimés.

En 1999, Laws et Neve, ont étudié l'impact du caractère animé dans une tâche de dénomination. Les participants devaient décider, pour chaque image présentée, si elle renvoyait à une entité vivante ou non-vivante. Les images n'apparaissaient à l'écran que pendant 20 ms. Ensuite, le participant avait autant de temps que nécessaire pour donner sa réponse. Les résultats ont montré que les participants étaient plus rapides pour dénommer les items renvoyant à des entités vivantes et faisaient significativement plus d'erreurs sur ceux renvoyant à des entités non-vivantes, et ce, malgré un contrôle minutieux des items sur la familiarité des concepts (jugée par les sujets eux-mêmes), la fréquence lexicale et la complexité visuelle des images. Cependant, un point faible de cette étude était que les participants avaient également dû évaluer la familiarité visuelle des items, et, en ce qui concerne cette variable, les items vivants étaient jugés plus familiers que les non-vivants. La

familiarité visuelle pourrait donc être une variable responsable du temps de dénomination plus rapide pour les items vivants. Toutefois, les chercheurs ont répliqué ces résultats, avec différents participants, différents stimuli et l'effet animé était chaque fois obtenu sur les performances en dénomination.

La majorité des autres études en psycholinguistique s'intéresse plutôt au transfert des informations du niveau conceptuel au niveau linguistique. Plus précisément, elles visent à déterminer si des contraintes ou des caractéristiques au niveau conceptuel, telles que la dimension animée, ont un impact sur des processus qui relèvent du niveau linguistique (e.g., au niveau de l'encodage syntaxique), affectant ainsi le processus de compréhension ou de production des phrases (Clifton, Traxler, Mohamed, Williams, Morris, & Rayner, 2003 ; Lowder & Gordon, 2012).

## **2.2. Etudes en perception et attention visuelles**

A l'heure actuelle, outre dans le domaine de la psycholinguistique, la primauté de traitement des entités animées sur les entités inanimées est principalement observée dans le domaine de la perception et de l'attention visuelles.

Ainsi, Kirchner et Thorpe (2006), ont montré que les personnes initiaient plus rapidement des saccades oculaires pour les photos d'animaux que pour celles d'autres objets. Leur procédure expérimentale consistait à présenter simultanément deux images (l'une dans l'hémichamp visuel droit et l'autre dans l'hémichamp visuel gauche) aux participants qui devaient alors effectuer une saccade, le plus rapidement possible, vers le côté où un animal était présenté. Leurs résultats ont montré, pour les participants les plus rapides, une initiation du mouvement oculaire avant 150 ms.

Abrams et Christ (2003) ont fait l'hypothèse que les êtres vivants captent l'attention parce que leur mouvement est le signal d'un événement biologiquement significatif. En effet, les entités capables d'initier un mouvement doivent avoir leur propre source d'énergie interne pour le faire, ce qui signifie aussi que leurs mouvements et leurs intentions sont plus difficiles à anticiper. Pour ce faire, les auteurs ont étudié les conséquences attentionnelles associées aux mouvements, en utilisant un paradigme de recherche visuelle. Ils ont comparé la capture attentionnelle pour quatre types de stimuli :

- Des stimuli qui commençaient à se déplacer (initiation du mouvement)

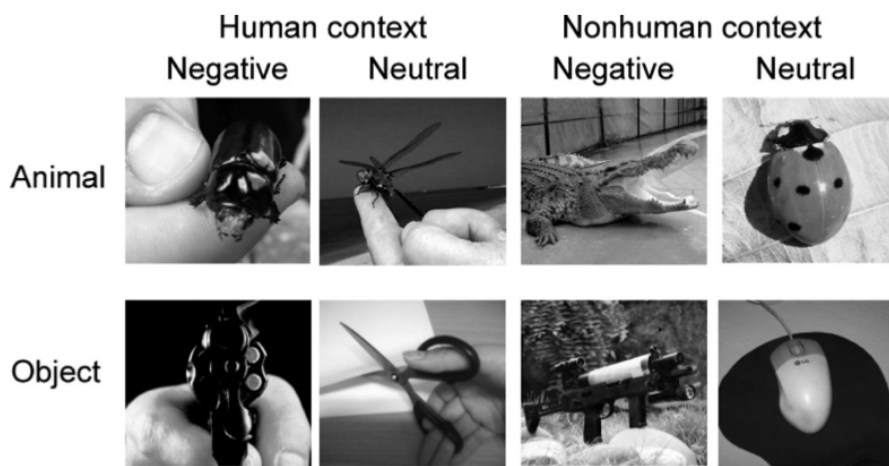
- Des stimuli qui cessaient de se déplacer (achèvement du mouvement)
- Des stimuli qui étaient continuellement en mouvement (mouvement continu)
- Et des stimuli qui ne bougeaient pas (statique)

Leurs résultats concordaient avec une seule conclusion : ce n'est pas le mouvement en tant que tel qui capte l'attention, mais son initiation. En effet, les participants, dont la tâche était d'identifier la lettre cible parmi trois lettres distractrices, étaient bien plus rapides lorsque la cible initiait un mouvement, comparativement aux trois autres conditions. De plus, quand les chercheurs avaient ajouté un délai avant l'apparition de la cible, ils observaient des temps de réaction bien plus longs en condition « initiation du mouvement ». Le fait que cette condition soit particulièrement sujette à l'inhibition est un argument supplémentaire en faveur de sa pertinence en terme de capture attentionnelle. Ainsi, tous les mouvements n'attirent pas l'attention de la même façon. D'après Abrams et Christ (2003), ceux qui jouent un rôle important dans la catégorisation des objets en termes de vivant/non-vivant sont plus enclins à la capture attentionnelle.

Des conclusions du même ordre peuvent être tirées des travaux de Pratt et al. (2010). Ces auteurs ont montré une plus grande sensibilité à des formes géométriques animées en mouvement plutôt qu'à des formes inanimées en mouvement. Ainsi, ils ont étudié l'impact d'une caractéristique particulière des entités animées : la capacité d'auto-déplacement. Leur procédure expérimentale consistait à comparer le temps de réaction pour détecter des cibles incluant des objets géométriques dont le mouvement résultait de collisions (qu'ils appelaient un « mouvement inanimé », qui ne résulte pas de l'activation d'une source d'énergie interne) et d'autres dont le mouvement n'était pas prédictible (un « mouvement animé », parce qu'il résulte d'une source d'énergie interne). Au travers de six expériences, ils ont trouvé que les cibles ayant un déplacement animé amenaient à des réponses plus rapides que celles dont le déplacement était inanimé. Pratt et al. (2010) ont conclu de l'ensemble de ces études qu'il y avait une influence profonde de l'évolution sur la façon d'extraire des informations du champ visuel. L'attraction pour les entités animées semble avoir lieu dans de nombreuses conditions et sans que les participants ne s'en rendent compte. En effet, lors des entretiens post-expérimentaux, aucun participant ne rapportait avoir remarqué qu'il y avait deux types de mouvements.

L'attraction pour les entités animées a également été mise en évidence avec un matériel plus écologique, à savoir des photographies mettant en scène différents objets,

animés et inanimés, par ailleurs jugés négatifs ou neutres (Yang et al., 2012). Dans cette étude, les scènes visuelles étaient donc constituées d'un objet focal (animé négatif, animé neutre, inanimé négatif ou inanimé neutre) dans un contexte incluant ou non un être humain. Ainsi, il y avait huit conditions expérimentales auxquelles chaque participant était soumis (cf. Figure 1) : des photos représentant un animal négatif dans un contexte humain (e.g., un cafard dans une main), des photos représentant un animal neutre dans un contexte humain (e.g., une libellule sur un doigt), des photos représentant un objet négatif dans un contexte humain (e.g., un revolver dans une main), des photos représentant un objet neutre dans un contexte humain (e.g., une paire de ciseaux dans une main), et ces quatre mêmes conditions dans un contexte non humain.



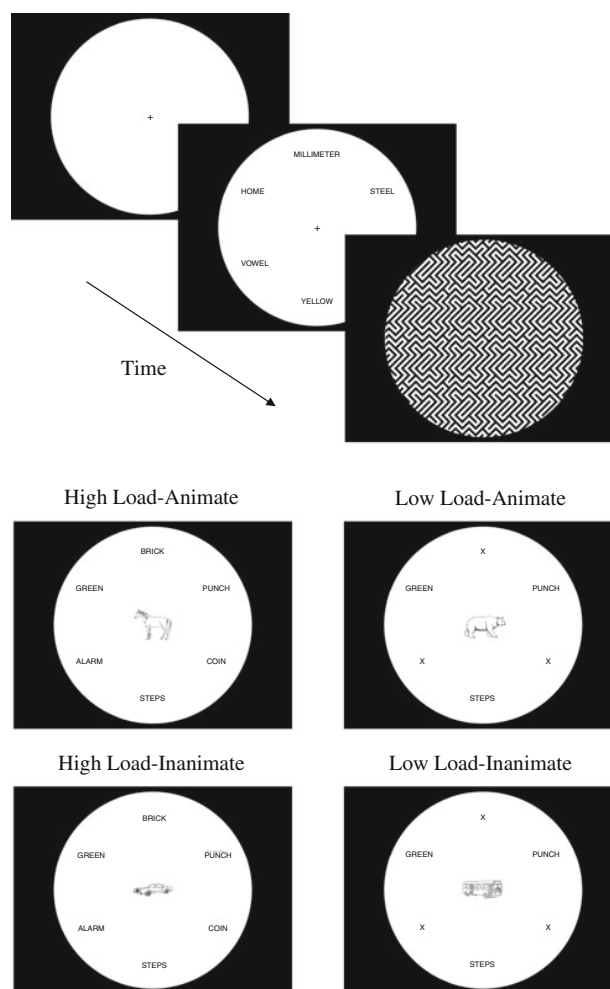
**Figure 1.** Illustration des 6 conditions expérimentales de l'étude de Yang et al., 2012. Figure issue de l'article "Distinct processing for pictures of animals and objects: Evidence from eye movements" par J. Yang, A. Wang, M. Yan, Z. Zhu, C. Chen, et Y. Wang, 2012, *Emotion*, 12(3), p. 542. © 2012 American Psychological Association.

Les participants devaient regarder chaque image, après quoi ils devaient soit (a) lire une phrase et déterminer si elle décrivait la photo (60% des cas), soit (b) regarder un écran blanc puis se concentrer pour regarder l'image suivante (40% des cas). Comme les hypothèses des auteurs portaient sur le comportement d'exploration visuelle des participants, ils ont eu recours à une méthode d'enregistrement des mouvements oculaires (en anglais : *eye-tracking*) afin de mesurer le nombre de fixations, leurs durées, ainsi que la probabilité et la durée de la première fixation sur différentes aires d'intérêt : l'objet focal, le contexte et le fond de la photo. Les chercheurs prédisaient que le caractère animé, représenté à la fois par l'objet focal quand il s'agissait d'un animal et par le contexte quand celui-ci était humain, devait attirer



davantage l'attention. Par conséquent, les auteurs s'attendaient à ce que les 6 conditions expérimentales faisant intervenir au moins l'un de ces deux éléments (objet focal animé et/ou contexte humain) soient privilégiées à celles qui ne les incluaient pas (fixations plus longues, et plus nombreuses). Leurs hypothèses portaient également sur l'interaction entre le caractère animé et la valence émotionnelle. En effet, ils s'attendaient également à ce que le caractère animé attire d'autant plus l'attention qu'il était connoté négativement. Les principaux résultats de cette étude se sont révélés parfaitement cohérents avec ces hypothèses : les participants regardaient plus souvent et plus longtemps les objets focaux quand il s'agissait d'animaux plutôt que d'artefacts, mais cette différence diminuait dans le cas d'un contexte humain et disparaissait quand l'objet focal était négatif (quand le contexte contient un être humain, le degré d'attention vis-à-vis des artefacts négatifs et des animaux négatifs était similaire). Cette étude suggère donc que le caractère animé, qu'il soit porté par l'objet focal ou par le contexte, attire l'attention et plus particulièrement s'il est assimilé à un danger. Yang et collaborateurs ont interprété ces données comme témoignant de la capacité des êtres humains à évaluer les situations menaçantes rapidement et efficacement.

Plus récemment, Calvillo et Jackson (2013) ont montré la primauté de traitement des entités animées sur les entités inanimées en s'appuyant sur un phénomène particulier : la cécité attentionnelle (ou cécité d'inattention ; en anglais : *inattention blindness*). Il s'agit de l'échec d'identification d'un stimulus, souvent inattendu, mais pourtant parfaitement visible. La cécité attentionnelle apparaît souvent lors des tâches qui demandent de l'attention, typiquement parce qu'un nombre trop important d'éléments mobilisent déjà l'attention de l'observateur. Dans l'étude de Calvillo et Jackson (2013), les participants voyaient plusieurs mots disposés en cercle sur l'écran et devaient trouver parmi eux celui qui désignait une couleur (e.g., rouge). Lors de certains essais, les essais critiques, une image apparaissait de façon inattendue au centre du cercle de mots. Elle représentait soit une entité animée soit une entité inanimée en fonction du groupe expérimental (cf. Figure 2). De plus, pour la moitié des participants, le nom de couleur était présenté parmi cinq autres mots (condition de forte charge attentionnelle) ; et pour l'autre moitié, il était présenté parmi deux autres mots (condition de faible charge attentionnelle). Ainsi, il y avait quatre conditions possibles. Pour chacune d'elles, les participants devaient écrire le nom de couleur qu'ils avaient vu et, pour l'essai où une image apparaissait, ils devaient dire s'ils avaient remarqué quelque chose de particulier. Quand ils déclaraient avoir perçu quelque chose de différent, par rapport aux premiers essais, ils devaient décrire de quoi il s'agissait.

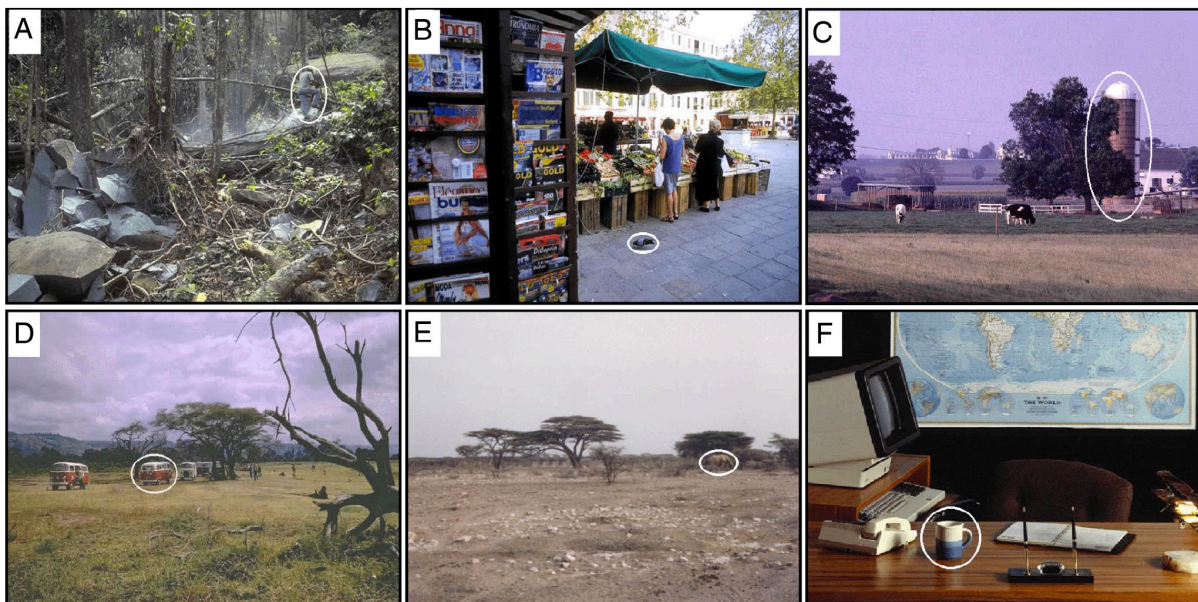


**Figure 2.** Illustration d’une séquence expérimentale (partie supérieure) et des quatre conditions d’essais critiques (partie inférieure) utilisées dans l’étude de Calvillo et Jackson (2013). Figure issue de l’article “Animacy, perceptual load, and inattention blindness” par D. P. Calvillo & R. E. Jackson, 2013, *Psychonomic Bulletin & Review*, 21(3), p. 672. © 2013 by Psychonomic Society.

Les résultats de cette étude ont montré que le pourcentage de participants ayant correctement reconnu l’image inattendue était dépendant du caractère animé et de la charge perceptive : les images étaient plus facilement reconnues quand elles renvoyaient à un objet animé et quand la charge perceptive était faible. Calvillo et Jackson ont interprété ces résultats en regard de « l’hypothèse de surveillance des animés » (en anglais: « *animate-monitoring hypothesis* », New, Cosmides, & Tooby, 2007). Selon cette hypothèse, les stimuli animés, du fait de leur importance dans les environnements ancestraux, sont traités différemment des stimuli inanimés. Ainsi, les participants manifestaient moins de cécité attentionnelle pour les images renvoyant à des entités animées, parce que ce type d’objet capte l’attention plus facilement que les objets inanimés.

### 2.3. L'hypothèse de surveillance des animés : une interprétation évolutionniste de la primauté de traitement des entités animées

Pour New et al. (2007), l'attention spécifique pour les animés, c'est-à-dire les animaux, êtres humains inclus, est le reflet de priorités ancestrales et non de l'expérience que l'on peut avoir avec ce type de stimuli. Plus précisément, ils font l'hypothèse que ce biais attentionnel n'est pas le fruit d'un apprentissage spécifique au cours de la vie des individus, mais qu'il est dû au fait que le système attentionnel humain aurait évolué de sorte à développer des critères de sélection spécifiques. Ainsi, il y aurait un recrutement d'attention spontané, plus fort pour les animaux que pour les artefacts. Pour tester leur hypothèse, ils ont eu recours à un paradigme de détection de changements. Les participants devaient trouver l'élément qui différait entre deux scènes visuelles naturelles complexes qui se succédaient. La Figure 3 présente des exemples des scènes visuelles utilisées par les auteurs, ainsi que les éléments qui différaient entre les deux scènes successives. Ces éléments appartenaient à 5 catégories distinctes, deux catégories dites « animées » (des humains et des animaux) et trois « inanimées » (des plantes, des artefacts manipulables par l'Homme et des artefacts fixes, comme une maison ou un silo à grains).



**Figure 3.** Illustration des scènes visuelles naturelles complexes utilisées dans l'étude de New et al., 2007. Figure issue de l'article "Category-specific attention for animals reflects ancestral priorities, not expertise" par J. New, L. Cosmides, et J. Tooby, 2007, *Proceedings of the National Academy of Sciences of the United States of America*, 104(42), p. 16600. © 2007 by The National Academy of Sciences of the USA.

Dans un premier temps, leurs résultats ont permis d'établir la primauté de traitement des entités animées comparativement aux entités inanimées. En effet, ils révélaient que les changements portant sur les objets animés étaient détectés plus souvent, mais aussi plus rapidement que ceux qui portaient sur les objets inanimés. De plus, il y avait de 20 à 25 % de bonnes réponses supplémentaires pour les cibles animées qu'inanimées, ce qui suggère qu'en plus de susciter un traitement plus fréquent, les objets animés captent l'attention, et ce indépendamment de l'intérêt que leur portait les participants<sup>4</sup>. En effet, l'effet du caractère animé n'était, a priori, pas un effet secondaire du fait que les animaux, ou les humains, seraient des cibles plus intéressantes.

Ensuite, dans le but de déterminer si l'attention spécifique observée pour les animés est le reflet de priorités ancestrales, New et al. (2007) ont testé une hypothèse alternative, proposant l'expérience comme critère sélectif de l'attention. Selon une telle hypothèse, les résultats précédents seraient dus à l'exposition répétée et aux connaissances développées vis-à-vis des stimuli animés au cours de la vie. New et al. (2007) ont alors comparé la détection d'artefacts mobiles (véhicules, e.g., une voiture) à celle d'animaux, d'êtres humains et d'artefacts statiques (e.g., une tasse). Les véhicules étant des éléments mobiles, potentiellement dangereux et rencontrés depuis l'enfance, ils devraient, selon cette hypothèse alternative, être détectés au même niveau que les entités animées. Or, les résultats indiquaient que les animaux et les êtres humains, restaient les catégories détectées les plus rapidement et avec les taux d'erreur les plus faibles, alors que les véhicules captaient relativement peu l'attention, comme les autres entités inanimées. Ainsi, les auteurs concluaient à un biais lié au développement de critères ancestraux et non à une sensibilité, développée depuis l'enfance, pour des objets en mouvement et présents fréquemment dans l'environnement. Chez l'Homme, certaines catégories sémantiques, les animés en l'occurrence, capteraient naturellement l'attention. Il s'agirait d'un héritage dû à la sélection naturelle ayant permis la survie de l'espèce humaine face aux dangers. L'ensemble de ces données favorisent « l'hypothèse de surveillance des animés » de New et al. (2007).

Ce type de résultats a été récemment répliqués avec un tout autre matériel : des LEGO<sup>®</sup> (LaPointe et al., 2016). L'intérêt de ce matériel est qu'il permet d'avoir des objets qui

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<sup>4</sup> Dans les études sur la détection de changement, les items jugés intéressants sont détectés plus rapidement que ceux qui sont jugés inintéressants (Kelley, Chun, & Chua, 2003; Rensink, O'Regan, & Clark, 1997). Afin de s'assurer que l'intérêt n'entre pas en jeu dans les résultats de cette étude, les auteurs ont renouvelé leurs analyses avec le score d'intérêt comme co-variable, ni les temps de réaction, ni le nombre d'erreurs n'ont été modifiés.

sont conceptuellement, mais non réellement, animés (e.g., un personnage) ou inanimé (e.g. un simple empilement de blocs). Selon l'hypothèse de surveillance des animés (New et al., 2007), l'interaction de notre espèce avec les animés, associée à leur importance pour notre survie, ont entraîné un biais attentionnel pour les animés. Les LEGO<sup>®</sup> n'étant pas intrinsèquement animés, mais pouvant l'être conceptuellement, l'observation d'une différence entre animés et inanimés établirait que le caractère animé peut être généralisé à du matériel réellement inanimé quand il présente, en surface, les traits d'une entité animée.

L'objectif de LaPointe et al. (2016) était donc d'étudier dans quelle mesure l'impact du caractère animé sur l'attention était dépendant du matériel utilisé. Leur procédure expérimentale était en tous points similaire à celle de New et al. (2007). Dans une première étude ils ont comparé les performances de détection de changement (rapidité et pourcentages d'erreurs) pour des personnages en LEGO<sup>®</sup> avec celles pour des objets en LEGO<sup>®</sup> (e.g., un arbre en LEGO<sup>®</sup>). Dans la seconde expérience, ils ont utilisé des inanimés plus homogènes, à savoir des empilements de blocs en LEGO<sup>®</sup>, dont la taille et la couleur étaient appareillées aux personnages en LEGO<sup>®</sup> (Voir Figure 4). Dans la troisième expérience, les visages des personnes en LEGO<sup>®</sup> étaient occultés pour contrôler la détection des visages. Enfin, dans les deux dernières expériences, comme New et al. (2007), ils ont cherché à perturber le traitement des personnages en inversant (Expérience 4a) et en floutant (Expérience 4b) les images.

Dans chacune de leurs études, les auteurs ont observé un avantage en faveur des LEGO<sup>®</sup> « humains » comparativement à ceux « non-humains », avec des temps de détection plus rapides et un pourcentage d'erreurs moindre. Dans l'ensemble, ces résultats mettent clairement en évidence que les participants ont traité différemment, et plus efficacement, les LEGO<sup>®</sup> lorsqu'il s'agissait de personnages. Pour expliquer cette différence de performances, les auteurs parlent d'une généralisation du caractère animé, comme cela avait déjà été observé par Johansson (1973) ou encore Pratt et al. (2010), qui avaient mis en évidence qu'il est possible d'attribuer le statut d'animé à un ensemble de points lumineux (Johansson, 1973) ou à des formes géométriques en mouvements (Pratt et al., 2010), lorsque ceux-ci possèdent des caractéristiques animées. Les personnages en LEGO<sup>®</sup>, bien que fictifs, possèdent des caractéristiques de surface typiques des entités animées, à savoir des bras, des jambes et un visage.



**Figure 4.** Illustration d'une scènes visuelles utilisées dans l'étude 2 de LaPointe et al., 2016. Figure issue de l'article "An Attentional Bias for LEGO® People Using a Change Detection Task: Are LEGO® People Animate?" par M. R. P. LaPointe, R. Cullen, B. Baltaretu, M. Campos, N. Michalski, S. Sri Satgunarajah, M. L. Cadieux, M. V. Pachai, and D. I. Shore, 2016, *Revue canadienne de psychologie expérimentale*, 70(3), p. 223. © 2016 by Canadian Psychological Association.

### *En résumé*

L'effet animé est étudié en psychologie cognitive depuis plusieurs années, que ce soit dans le domaine de la psycholinguistique (e.g., Laws & Neve, 1999) ou dans celui de l'attention (e.g., Abrams & Christ, 2003). Les principaux résultats issus de ces études témoignent d'une priorité de traitement des entités animées : elles sont dénommées plus rapidement que les inanimées (Laws & Neve, 1999), elles provoquent des saccades oculaires plus rapides (Kirchner & Thorpe, 2006), elles attirent plus rapidement l'attention (Pratt et al., 2010), elles sont fixées plus longtemps (Yang et al., 2012) et elles sont moins sensibles à la cécité attentionnelle (Calvillo & Jackson, 2013). Pour expliquer cette priorité de traitement, New et al. (2007) propose « l'hypothèse de surveillance des animés ». Plus précisément, ils font l'hypothèse que le biais attentionnel en faveur des entités animées ne relève pas d'un apprentissage au niveau ontogénétique, mais qu'il serait le résultat de l'évolution phylogénétique du système attentionnel humain. Ainsi, il y aurait un recrutement d'attention spontané plus fort pour les animaux, humains inclus, que pour les artefacts, parce que cela a permis à l'espèce humaine de perdurer à travers les âges. Dans la partie qui suit nous nous

focaliserons sur un autre domaine de la psychologie cognitive qui s'est intéressé, bien que plus tardivement, à l'effet animé : la mémoire.

### **3. L'effet animé en mémoire**

Au vu de l'ensemble des données dans le domaine de l'attention, on peut s'attendre à ce que l'effet animé soit observable dans d'autres domaines de la psychologie cognitive, et notamment dans le domaine de la mémoire.

#### **3.1. Généralités sur la mémoire**

Classiquement, en psychologie cognitive, on regroupe sous le terme de mémoire les processus d'encodage (mise en mémoire), de stockage (conservation en mémoire) et de récupération des représentations mentales (recherche en mémoire). De nombreuses recherches sur la mémoire consistent donc à identifier et à comprendre les mécanismes en jeu dans le processus de mémorisation et à décrire ses différentes composantes (Lockhart, 2000). En 1985, le modèle de mémoire de Tulving distinguait trois systèmes mnésiques, dits de mémorisation à long terme : la mémoire procédurale, la mémoire sémantique et la mémoire épisodique. La mémoire procédurale est impliquée dans l'apprentissage d'habiletés perceptivo-motrices et cognitives (e.g., savoir conduire ou faire du vélo) et dans le conditionnement. La mémoire sémantique rend possible l'acquisition, le maintien et la restitution de connaissances générales sur le monde, indépendamment de leur contexte d'apprentissage. Enfin, la mémoire épisodique permet de se souvenir d'événements personnellement vécus, dans un contexte spatial et temporel particulier. Dans son modèle de 1995, Tulving ajouta deux autres systèmes, de mémorisation à court terme : le système de représentations perceptives et la mémoire de travail. Le système de représentations perceptives permet l'acquisition et le maintien des connaissances relatives à la forme et à la structure des informations, et la mémoire de travail est impliquée dans le maintien et la manipulation temporaire de l'information sous un format facilement accessible pendant la réalisation de tâches cognitives diverses.

L'encodage et la récupération d'une information peuvent se faire de différentes façons, ainsi, il existe de nombreuses méthodes pour étudier la mémoire à long terme. En ce qui concerne l'encodage, il peut être intentionnel (volontaire et contrôlé) ou incident



(involontaire). Ces deux procédures varient quant aux stratégies susceptibles d'être mises en place. En effet, quand la consigne demande explicitement d'apprendre, nous initions des stratégies dont le but est d'optimiser les performances mnésiques. En revanche, dans le cadre d'un apprentissage incident, aucune stratégie consciente ne peut être mise en place. Bien que l'acquisition des connaissances se fasse à la fois de façon intentionnelle et incidente, dans la vie quotidienne, en dehors du contexte scolaire ou universitaire, il est plus fréquent d'assister à des événements, ou de pratiquer des activités, sans avoir d'instructions explicites de mémorisation. C'est pourquoi, dans le cadre de nos études, nous avons utilisé majoritairement des procédures d'apprentissage incident. Concernant les procédures de récupération, deux paradigmes sont généralement utilisés, le rappel (libre ou indicé) et la reconnaissance. Le rappel est l'évocation d'une représentation en l'absence de son équivalent perceptif. Dans une tâche de rappel libre, le participant doit restituer un maximum d'informations sans aucune aide : il doit, par exemple, écrire un maximum des mots, vus lors de la phase d'encodage, sur une feuille vierge en un temps limité. Au contraire, dans une tâche de rappel indicé, le participant a un indice à sa disposition (par exemple la première lettre des mots ou leur catégorie sémantique). Par opposition au rappel, la reconnaissance est l'accès à une représentation mnésique associée à une information perceptive disponible, il s'agit, par exemple, de retrouver les mots présentés pendant la phase d'encodage parmi une liste élargie. Entre la phase d'encodage et la phase de récupération, il est ensuite possible de manipuler la période de stockage, en déterminant le temps de l'intervalle de rétention et les activités qui seront effectuées pendant ce temps.

Depuis plusieurs décennies, les chercheurs s'interrogent sur l'architecture de la mémoire (Atkinson et Schiffrin, 1968 ; Baddeley, 1992 ; Lieury, 1992a ; Tulving, 1972, 1985), son développement (Kail, 1990 ; Perlmutter, 1978), son fonctionnement (Ebbinghaus, 1885 ; Nelson & Narens, 1990) et ils cherchent à identifier les facteurs susceptibles de l'influencer (contextes de mémorisation et caractéristiques du matériel notamment, e.g., Craik & Lockhart, 1972 ; Rogers, Kuiper, & Kirker, 1977). Par exemple, il est dorénavant établi que la profondeur de traitement à l'encodage a un impact majeur sur la qualité de la mémorisation (Craik & Lockhart, 1972 répliqué par Craik & Tulving, 1975). En effet, une information peut être traitée de différentes manières, allant des niveaux les plus superficiels (e.g., un traitement sensoriel des mots, focalisé sur leur casse d'écriture) aux plus profonds (e.g., un traitement sémantique, focalisé sur la catégorie d'appartenance des mots), en passant par des niveaux intermédiaires (e.g., un traitement phonétique, focalisé sur la sonorité). Pour Craik et



Lockhart (1972), traiter un item en profondeur, quant à ses caractéristiques sémantiques, augmente les chances de le récupérer dans le futur. Finalement, bien que la répétition soit importante pour encoder une information à long terme, celle-ci ne doit pas être une répétition de maintenance mais une répétition constructive (ou élaborative). Seule cette dernière permet un apprentissage durable, car elle implique la mise en oeuvre de traitements élaborés de l'information. L'élaboration correspond à la création de liens avec des connaissances antérieures. Le fait est que, plus un matériel est élaboré, c'est-à-dire plus les connaissances auxquelles il est lié sont nombreuses, plus elles pourront servir d'indices de récupération ultérieure. Ainsi, ce n'est pas parce qu'elle a passé beaucoup de temps en mémoire à court terme, ou parce qu'elle a été de nombreuses fois répétée, qu'une information sera correctement mémorisée : la profondeur de son traitement s'avère être une caractéristique plus déterminante pour l'apprentissage ( Craik & Watkins, 1973 ; Craik & Tulving, 1975). Malgré les effets robustes établissant la théorie de la profondeur du traitement, cette notion a été fortement critiquée, et des données contradictoires ont pu être observées. Par exemple, la répétition phonétique, peut parfois engendrer un apprentissage efficace et ne sert pas seulement au maintien à court terme (Mechanic, 1964) et des traitements superficiels, non sémantiques, peuvent donner lieu à des traces mnésiques durables (e.g., le maintien à long terme du timbre de la voix ou des caractéristiques d'une odeur, Jacoby, 1975). Néanmoins, cette théorie a permis d'amorcer une approche globale et fonctionnaliste de la mémoire, en soulignant l'importance des opérations d'encodage sur la rétention future des données. En conséquence, à la suite de la théorie de la profondeur de traitement, d'autres paradigmes ont été mis en place, afin d'obtenir des performances comparables à celles obtenues avec les procédures d'encodage profond utilisées par Craik et Tulving (1975). Par exemple, Jacoby et Dallas (1981) ont demandé à leur participants, soit de lire une liste de mots, soit de les reconstruire à partir d'anagrammes. Leurs résultats montraient que l'intervention active des participants (plus généralement appelée la *génération* des items cibles) amenait à de meilleures performances que des conditions d'encodage plus passives. Comme dans la théorie de la profondeur de traitement de Craik et Lockart (1972), ces données font référence à la notion d'élaboration à l'encodage.

Parmi les procédures permettant un encodage profond et élaboré des informations, la référence à soi est sans doute l'une des plus remarquables. Ainsi, Rogers et al. (1977) font partie des premiers chercheurs à avoir proposé l'hypothèse selon laquelle les informations qui nous concernent directement seraient mieux mémorisées que les autres. Dans les paradigmes

testant l'effet de la référence à soi, les performances obtenues dans une condition de traitement sémantique sont comparées avec celles obtenues dans une condition demandant au participant de juger si l'item présenté le décrit. Les performances observées dans cette dernière condition se sont révélées toujours supérieures aux conditions mobilisant un traitement sémantique plus conventionnel. Il y aurait donc une influence bénéfique du « soi » sur les processus mnésiques. Par la suite, l'effet d'un encodage en référence à soi a été répliqué de nombreuses fois (Bower & Gulligan 1979 ; Klein, Loftus & Burton, 1989 ; Conway & Dewhurst, 1995 ; Cunningham, Turk, MacDonald & Macrae, 2008).

Comme déjà dit, récemment, un nouveau champ s'est ouvert aux études sur la mémoire, champ qui est directement issu de la psychologie évolutionniste : la mémoire adaptative (Bonin & Bugaiska, 2014 ; Nairne, 2010, 2015). Contrairement aux recherches qui ont été menées jusqu'alors, les chercheurs qui s'inscrivent dans cette perspective ne souhaitent pas seulement comprendre comment fonctionne la mémoire humaine, mais ils s'interrogent aussi sur le pourquoi d'un tel fonctionnement. Les études réalisées dans le domaine de la mémoire adaptative permettent alors d'apporter un nouveau niveau d'explication aux mécanismes (généraux) de mémoire précédemment décrits, mais aussi, de découvrir de nouveaux effets.

### **3.2. La mémoire adaptative**

Comme évoqué en préambule, la mémoire adaptative défend l'idée selon laquelle la mémoire opère de façon intégrée pour produire des comportements adaptés, dirigés vers des buts spécifiques (Versace et al., 2002). Ainsi, pour ses partisans, la mémoire aurait évolué parce qu'elle a permis aux organismes de résoudre des problèmes adaptatifs spécifiques, comme la recherche de nourriture, la reconnaissance et l'évitement des prédateurs, la recherche d'un partenaire sexuel ou encore la détection de comportements sociaux spécifiques, comme la tricherie ou le mensonge. La capacité à mémoriser, au même titre que d'autres capacités humaines, aurait donc été façonnée par les pressions sélectives rencontrées au sein des environnements ancestraux, telles que décrites par Darwin (1859/1992). Nous serions tous les héritiers de comportements qui ont permis à nos ancêtres de survivre (voir Bonin & Bugaiska, 2014 et Nairne, 2010, 2015 pour des revues de synthèse sur la mémoire adaptative). Concevoir la mémoire comme une habilité façonnée par les pressions sélectives

n'implique pas de faire abstraction des mécanismes généraux de mémoire décrits précédemment. La mémoire adaptative ne remet donc pas en question l'organisation de la mémoire décrite par Tulving (1985, 1995), la théorie de la profondeur de traitement de Craik et Lockhart (1972) ou encore le fait que la référence à soi permette un encodage profond des informations (Rogers, et al., 1977). Au contraire, elle propose de s'interroger sur les raisons pour lesquelles ces mécanismes se sont développés afin de mieux les comprendre. Ainsi, trois effets permettent d'apporter des arguments en faveur de la conception de la mémoire adaptative : l'effet survie, l'effet animé et l'effet contamination<sup>5</sup>. Ces trois effets vont dans le sens de capacités mnésiques augmentées en situation de survie, ou lorsque les informations à mémoriser relèvent de problèmes ancestraux. Cependant, il ne s'agit pas d'effets « magiques », innés et inexplicables, mais de situations particulières qui déclencheraient des mécanismes généraux de mémoire efficaces et performants.

### 3.2.1. *L'effet survie*

L'« effet survie » sur la mémorisation à long terme, effet princeps de la mémoire adaptative, en est sans doute l'illustration la plus parlante. Dans le paradigme original ayant permis de montrer cet effet (Nairne et al., 2007), les participants devaient estimer la pertinence de mots vis-à-vis d'un scénario de survie sur des échelles de Likert (en 5 points). Concrètement, les consignes données aux participants en condition de survie étaient les suivantes :

*Dans cette tâche, nous voulons que vous imaginiez que vous êtes échoués dans les prairies d'une terre étrangère sans aucun matériel de base de survie. Dans les quelques mois qui viennent, vous devrez trouver un approvisionnement constant en nourriture et en eau et vous devrez vous protéger des prédateurs. Nous allons vous montrer une liste de mots et nous vous demandons d'évaluer dans quelle mesure chaque mot est pertinent dans cette situation de survie. Certains mots peuvent être pertinents ; d'autres peuvent ne pas l'être, c'est à vous de décider.*

---

<sup>5</sup> L'effet contamination est probablement l'effet le moins étudié jusqu'à présent. Il ne fera donc pas l'objet d'un développement spécifique au sein de cette partie. Il correspond à une meilleure mémorisation des informations quand celles-ci proviennent d'une source contaminée, dans le but de nous en protéger. Nairne (2015) présente les résultats novateurs d'une étude portant sur la mémorisation d'images d'objets qui étaient soit touchés par une personne malade (contaminée) soit par une personne saine. Les participants de cette étude voyaient des images associées à la description d'une personne les ayant touché, cette description permettait de leur conférer, ou non, le statut d'objet contaminé (e.g., l'image d'un ballon associé à la description « personne ayant le nez qui coule »). Après avoir vu l'ensemble des images, ils étaient soumis à un test de rappel libre. Les résultats de cette étude allaient dans le sens d'un effet contamination en mémoire, puisque les objets précédemment associés à une personne contaminée étaient significativement mieux rappelés que ceux associés à une personne saine.

*Pour émettre votre jugement, vous devrez appuyer sur les touches 1 à 5 du clavier.*

- 1 : "Pas pertinent dans cette situation de survie"*
- 2 ; 3 ; 4 : Pertinence intermédiaire*
- 5 : "Très pertinent dans cette situation de survie"*

Cette condition d'encodage était ensuite comparée à deux types de conditions contrôles : une condition "sémantique", connue pour permettre un traitement profond des items présentés (i.e., évaluer le caractère plaisant des mots sur une échelle en 5 points) et une condition mettant en œuvre un schéma d'encodage, à savoir un scénario de déménagement. La consigne utilisée dans la condition de déménagement était proche de celle utilisée en condition de survie dans sa structure, mais elle n'évoquait en aucun cas la survie :

*Dans cette tâche, nous voulons que vous imaginiez que vous envisagez de déménager dans une nouvelle maison dans un pays étranger. Dans les quelques mois qui viennent, vous aurez besoin de localiser et d'acheter une nouvelle maison et vous devrez transporter vos effets personnels (vos affaires). Nous allons vous montrer une liste de mots et nous vous demandons d'évaluer dans quelle mesure chaque mot est pertinent dans cette situation de déménagement. Certains mots peuvent être pertinents ; d'autres peuvent ne pas l'être, c'est à vous de décider.*

*Pour émettre votre jugement, vous devrez appuyer sur les touches 1 à 5 du clavier.*

- 1 : "Pas pertinent dans cette situation de déménagement"*
- 2 ; 3 ; 4 : Pertinence intermédiaire*
- 5 : "Très pertinent dans cette situation de déménagement"*

Les résultats ont montré que le nombre de mots rappelés était plus élevé lorsque les participants encodent les mots dans le cadre d'un scénario de survie comparativement aux deux autres conditions d'encodage. Les performances mnésiques à la suite d'un encodage survie allaient même au-delà de celles obtenues avec d'autres paradigmes d'encodage, pourtant connus pour accroître la mémorisation, tels que l'imageabilité, la référence à soi ou encore la génération d'items (Nairne, Pandeirada, & Thompson, 2008). L'effet survie a été interprété comme suggérant que, lorsqu'une situation ou un contexte déclenche des mécanismes mnésiques qui ont été façonnés par les pressions sélectives - c'est-à-dire des mécanismes dévolus à la survie - la mémorisation s'en trouve améliorée. Dès lors, de nombreuses recherches ont été effectuées afin de déterminer si l'effet survie pouvait s'expliquer, non pas seulement de façon ultime, mais aussi en référence à des mécanismes proximaux, à savoir des mécanismes basiques de mémoire (pour une revue détaillée des

facteurs explicatifs de l'effet survie, voir Bonin & Bugaiska, 2014 et Kazanas & Altarriba, 2015).

### 3.2.2. *L'effet animé en mémoire*

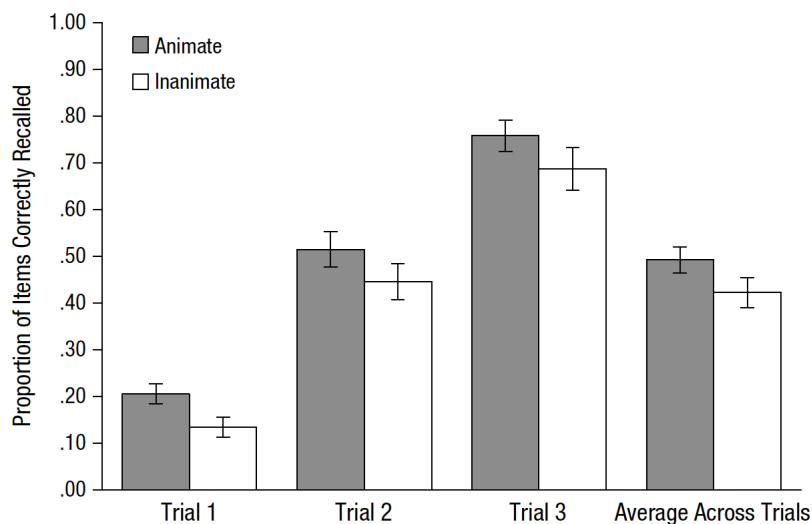
Un autre effet fournit des arguments en faveur d'une conception fonctionnelle de la mémoire humaine : l'effet animé en mémoire. Cet effet a fait l'objet des études qui seront exposées dans ce travail de thèse (Chapitres 1, 2 et 3). VanArsdall, et al. (2013) sont les premiers à avoir testé l'hypothèse d'un effet animé en mémoire. Dans une première étude, ils utilisaient 120 non-mots prononçables en anglais (e.g., *BRUGUE*, *FRAV*) dont 60 pour la phase d'apprentissage. Trente étaient associés à des propriétés animées (e.g., « *Souhaite être docteur* ») et les 30 autres à des propriétés inanimées (e.g., « *Est fabriqué en fer* »). La tâche des participants était, dans un premier temps, de déterminer si le non-mot renvoyait à quelque chose de vivant ou non, mais aussi de mémoriser ce non-mot ainsi que sa propriété. Par exemple, les participants devaient juger si « *JOTE* », sachant « *qu'il souhaite être docteur* », était plutôt représentatif d'une entité animée ou inanimée, et mémoriser le couple non-mot/propriété. Pour donner leur réponse, ils avaient à leur disposition une échelle en 6 points, allant de (1) « est très probablement un objet » à (6) « est très probablement une être vivant ». La phase expérimentale était séparée de celle de reconnaissance par deux minutes durant lesquelles les participants réalisaient une tâche distractive (ils devaient décider si des chiffres présentés à l'écran étaient pairs ou impairs). Dans la phase de reconnaissance, ils voyaient les 30 non-mots animés, les 30 non-mots inanimés ainsi que 60 nouveaux non-mots, et ils devaient déterminer, sur une échelle en 6 points, dans quelle mesure ils pensaient que les items présentés faisaient partie de la liste d'apprentissage.

Les résultats de cette étude ont révélé une meilleure reconnaissance des non-mots quand ils avaient été préalablement associés à une propriété animée. De plus, le caractère animé a impacté les temps de réponse des participants qui étaient plus rapides pour juger les items animés qu'inanimés. Le point important était que, bien que les participants jugeaient plus rapidement les non-mots associés à des propriétés animées en phase d'apprentissage, et par conséquent avaient moins de temps pour les traiter, ils les reconnaissaient mieux en phase de récupération que les inanimés. L'effet animé n'était donc pas dû au temps passé à traiter les items.

Une seconde étude avait pour objectif de répliquer l'effet du caractère animé en mémoire avec, cette fois, une tâche de rappel libre. Les 16 items (8 dans chaque catégorie) étaient toujours des non-mots associés à une propriété leur conférant soit le statut d'être vivant, soit celui d'artefact. La tâche des participants était strictement similaire à celle utilisée dans la première étude, à savoir, juger, sur une échelle en 6 points, si les non-mots renvoyaient à un objet ou au contraire à un être vivant. Après avoir effectué une tâche interférente, la même que celle utilisée dans l'Etude 1, les participants étaient soumis à une tâche de rappel libre. Ils avaient 4 minutes pour écrire le plus de non-mots possibles parmi ceux qu'ils avaient dû juger comme étant animés ou inanimés, sans rappeler la propriété qui leur était associée. Les résultats indiquaient que les non-mots associés à des propriétés vivantes étaient jugés plus rapidement que ceux associés à des propriétés non-vivantes. Les performances en rappel libre étaient relativement faibles. Cependant, le taux de rappel des items jugés « animés » était significativement supérieur à celui des items jugés comme étant des artefacts. Sur la base de ces résultats, les chercheurs ont proposé que les propriétés animées permettaient un traitement profond (ce qui expliquerait que les items animés aient entraîné une meilleure mémorisation), bien qu'en général les traitements profonds requièrent plus de temps que les traitements plus superficiels (Craik & Lockhart, 1972). Ils ont également proposé que si les animés étaient mieux retenus, cela pouvait être dû au fait que les entités animées captent l'attention. Cette explication est en accord avec la littérature sur l'effet animé observé en perception visuelle (New et al., 2007). Toutefois, nous pouvons reprocher à leur étude un certain manque de validité écologique. En effet, si l'utilisation de non-mots permet de neutraliser l'effet de toutes autres propriétés normalement associées aux mots (leur fréquence, leur âge d'acquisition, leur imageabilité...), il n'en reste pas moins qu'il ne s'agit pas d'une situation rencontrée au quotidien.

Ainsi, dans deux autres études, Nairne, VanArsdall, Pandeirada, Cogdill et LeBreton (2013) ont testé l'effet animé avec un nouveau matériel constitué de mots. Chacune de leurs études ont montré que les mots renvoyant à des entités animées (e.g., *lapin*) étaient plus susceptibles d'être rappelés que ceux renvoyant à des entités inanimées (e.g., *stylo*), même après un contrôle minutieux sur d'autres dimensions susceptibles d'affecter la mémorisation (le nombre de lettre, l'âge d'acquisition, la taille de la catégorie sémantique, la typicalité du mot dans sa catégorie sémantique, la familiarité, la fréquence d'apparition dans la langue, l'imageabilité et la concrétude).

Dans leur première expérience, ils ont repris l'étude de Rubin et Friendly (1986) afin de ré-analyser les données en incluant, comme nouvelle variable, le caractère animé des items. L'étude de Rubin et Friendly (1986) avait déjà montré que de nombreuses variables étaient prédictives du rappel (libre), notamment l'imageabilité et la valence émotionnelle. Les ré-analyses de Nairne et al. (2013) ont montré que le caractère animé était également un facteur important, plus important même que l'imageabilité qui s'avérait être le facteur expliquant la plus grande part de variance dans les taux de rappel de l'étude de Rubin et Friendly (1986). La seconde étude de Nairne et al. (2013) était une étude factorielle. Les participants devaient mémoriser 24 mots, 12 renvoyaient à des entités animées et les 12 autres à des entités inanimées. Pour cela, ils avaient 5 secondes par mot. Une fois les 24 mots appris, ils devaient effectuer une tâche distractive pendant 1 minute et enfin rappeler autant de mots que possible pendant 4 minutes. A la suite de cette première tâche de rappel libre, les participants recommençaient chacune des étapes décrites précédemment deux fois. Ils avaient donc trois essais pour mémoriser, puis rappeler, un maximum de mots. Les résultats ont montré un avantage des items animés sur le rappel, que ce soit en moyenne sur les trois essais, ou à chacun des essais comme le montre la Figure 5.



**Figure 5.** Proportion d'items correctement rappelés à chaque essai et en moyenne sur les trois essais en fonction du type d'item (animés et inanimés) dans l'étude de Nairne et al., 2013. Les barres d'erreur représentent l'erreur standard à la moyenne. Figure issue de l'article "Adaptive Memory: The Mnemonic Value of Animacy" par J. S. Nairne, J. E. VanArsdall, J. N. S. Pandeirada, M. Cogdill, and J. M. LeBreton, 2013, *Psychological Science*, 24, p. 2103. © 2013 by the Association for Psychological Science.

Depuis ces premières recherches sur l'effet animé, d'autres ont été conduites avec pour objectifs : (1) d'établir sa robustesse chez l'adulte sain (Nairne, VanArsdall, & Cogdill, 2017 pour une vue d'ensemble) ; (2) de comprendre les mécanismes qui le sous-tendent et ses conditions d'émergence (Popp & Serra, 2016 ; VanArsdall, Nairne, Pandeirada, & Cogdill, 2017 ; VanArsdall, Nairne, Pandeirada, & Cogdill, 2015) ; (3) de l'étudier sur d'autres populations comme les enfants (Aslan & John, 2016) et les personnes âgées (Bugaiska, Méot, & Bonin, 2016). Nous fournirons une présentation plus détaillée des ces différentes études au fur et à mesure des chapitres qui constituent ce travail de thèse.

### *En résumé*

La mémoire est une habilité cognitive essentielle, qui fascine les chercheurs dans des disciplines aussi diverses que la médecine et la philosophie. En psychologie cognitive, elle fait l'objet de recherche depuis plusieurs décennies. Ainsi, nous avons de plus en plus de connaissances concernant son organisation, son fonctionnement, son développement et les mécanismes qui la sous-tendent. Il y a 10 ans, un nouveau champ s'est ouvert aux études sur la mémoire : la mémoire adaptative (Bonin & Bugaiska, 2014 et Nairne, 2010, 2015 pour des revues de synthèse). Dans cette conception, la mémoire est considérée comme une fonction façonnée par la sélection naturelle, permettant l'adaptation de l'Homme à son environnement et assurant de la sorte sa survie. Récemment, en 2013, un nouvel argument est venu étayer cette conception : l'effet animé en mémoire (VanArsdall et al., 2013 ; Nairne et al., 2013). Cet effet correspond à la meilleure mémorisation des entités animées comparativement à celle inanimées.

## **4. Problématiques de recherche**

Nos propres travaux s'inscrivent dans le prolongement des études citées dans la partie précédente, sur l'effet animé en mémoire. Dans la partie qui suit (Partie Expérimentale), seront donc présentés nos différents articles, quatre sont publiés dans des revues internationales à comité de lecture et le cinquième est actuellement soumis. Dans un soucis purement esthétique, nous avons choisi de présenter tous les articles au format APA et nous



avons homogénéisé les figures et graphiques afin que les légendes et la mise en forme soient similaires d'un article à l'autre<sup>6</sup>.

La partie expérimentale est structurée en trois chapitres, répondant chacun à une problématique spécifique au sujet de l'effet animé en mémoire. Dans le **premier chapitre**, nous allons rapporter des études dont l'objectif principal était d'établir le lien entre l'effet animé et la mémoire épisodique, en répondant à ces deux questions :

- 1) L'effet animé est-il sous-tendu par le processus de remémoration, à savoir l'encodage et le rappel de détails contextuels plus riches pour les entités animées qu'inanimées ?
- 2) L'effet animé persiste-t-il en mémoire de source (ou mémoire du contexte d'encodage) ?

Dans un **deuxième chapitre**, nous nous sommes intéressés aux mécanismes proximaux qui sous-tendent l'effet animé en mémoire. Comme cela a été fait pour l'effet survie, il s'agissait de déterminer quels mécanismes généraux de mémoire permettent l'émergence de l'effet animé, ou, en d'autres termes, quels outils mnésiques permettent une meilleure mémorisation des entités animées. De nombreux mécanismes peuvent ainsi être testés, et nous avons choisi de nous focaliser sur deux problématiques:

- 1) L'effet animé est-il dépendant des ressources cognitives disponibles ?
- 2) L'imagerie mentale est-elle à l'œuvre dans l'effet animé ?

Enfin, un **troisième et dernier chapitre** s'est penché sur la notion de flexibilité. Notre objectif était de comprendre dans quelle mesure l'effet animé est dépendant ou non du contexte d'encodage et des objectifs générés par ce contexte. Notre problématique était donc la suivante :

L'effet animé est-il dépendant du contexte d'encodage ?

Afin de faciliter la lecture des différents articles, nous avons choisi de fournir une présentation brève du contexte théorique et empirique en français, ainsi qu'un résumé des objectifs et des principaux résultats, pour chacune de ces contributions.

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<sup>6</sup> Il s'agit des versions acceptées par les éditeurs des revues en question, ces versions ont donc fait l'objet de relectures sur épreuves PDF après leur transformation dans un format typographique propre à la revue.

# **Partie expérimentale**

# Chapitre 1 : Effet animé et mémoire épisodique

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## Introduction

### 1. Mémoire épisodique : intérêt en terme d'adaptation et méthodes d'évaluation

Les études qui sont présentées dans ce travail de thèse se focalisent sur la mémoire à long terme et plus précisément sur la mémoire épisodique. Comme mentionné en Introduction, la mémoire épisodique correspond à la mémoire des événements personnellement vécus, pouvant être situés dans un contexte spatial et temporel spécifique. Dans une perspective évolutionniste, la mémoire épisodique permet aux individus de maintenir une sensation de continuité de soi, d'être performants dans les interactions sociales et d'utiliser les informations issues d'évènements passés pour diriger de futurs comportements (Raby & Clayton, 2012). Ainsi, les stimuli animés, parce qu'ils sont la source potentielle de dangers ou d'interactions, pourraient davantage mobiliser notre mémoire épisodique que les entités inanimées.

Pour Tulving (1985, 1995), les tâches classiques d'évaluation de la mémoire (rappel libre, rappel indicé et reconnaissance) ne sont pas adaptées pour rendre compte des distinctions entre les différents systèmes de mémoire à long terme (sémantique, épisodique et procédurale). En effet, elles ne prennent pas en compte le contexte d'encodage et elles supposent que le souvenir est toujours conscient, alors que ce n'est pas forcément le cas. Tulving (1985) a donc proposé un type de conscience différent pour chacun des systèmes de mémoire : la conscience auto-noétique pour la mémoire épisodique, la conscience noétique pour la mémoire sémantique et la conscience anoétique pour la mémoire procédurale. La conscience auto-noétique correspond au souvenir d'un événement passé, en voyageant mentalement dans le temps afin de le revivre dans son contexte, il s'agit donc de la conscience de soi dans le passé. En revanche, la conscience noétique est la conscience du savoir, elle permet d'appréhender les connaissances générales sur notre environnement, sans pouvoir les replacer dans leur contexte d'acquisition. Le paradigme *Remember/Know* (issu de la proposition théorique de Tulving, 1985, reprise par Gardiner, 1988, 2001) permet de faire la distinction entre ces deux types de conscience. Il s'agit d'une tâche de mémoire dans laquelle le participant doit apprendre une liste d'items avant d'être soumis à une tâche de reconnaissance. L'originalité de ce paradigme réside dans cette phase de reconnaissance. En

effet, lorsque le participant reconnaît un mot, il lui est demandé de préciser son état de conscience. Pour cela, il peut répondre « je me souviens » de l'information et de son contexte, c'est la réponse « *Remember* ». Cette réponse renvoie au processus de remémoration, c'est-à-dire au rappel conscient de détails contextuels. Il peut également répondre « je sais » que l'information était présentée, sans aucun souvenir de son contexte. Il s'agit, dans ce cas, d'une réponse « *Know* » qui correspond au sentiment de familiarité ou à la sensation subjective d'avoir déjà vu le stimulus présenté.

La remémoration peut être évaluée par la collecte de réponses subjectives des participants quant à la qualité de leur récupération (e.g., le paradigme *Remember/Know*), mais également par la récupération d'informations objectives, telles que la source de l'élément. Le terme « source » désigne les circonstances temporelles, spatiales et perceptuelles de l'encodage d'une information : quand a-t-elle été délivrée ? Où est ce que c'était ? Et sous quelle forme ? (Johnson, Hashtroudi, & Lindsay, 1993). Cette définition générale équivaut donc à l'ensemble du contexte d'apprentissage. Par la suite, ces caractéristiques contextuelles peuvent servir d'indices de récupération puissants de l'information cible (Godden & Baddeley, 1975). Les paradigmes de mémoire de source manipulent donc un élément du contexte en particulier (e.g., le lieu d'apparition des mots sur l'écran : à droite versus à gauche). Pendant la phase de récupération, le participant doit alors retrouver l'information cible ainsi que l'élément du contexte qui était manipulé (sa position sur l'écran dans notre exemple).

## **2. Principaux objectifs et résultats des Articles 1 et 2**

Après avoir répliqué l'effet animé obtenu par Nairne et al. (2013) et VanArsdall et al. (2013) avec une procédure d'apprentissage incident de mots, mais également d'images, dans l'Article 1, nous avons utilisé une tâche de reconnaissance associant le paradigme *Remember/Know* (Gardiner, 1988). Notre objectif était d'évaluer non seulement la quantité d'informations mémorisées, mais aussi sa qualité, en distinguant la remémoration (en anglais « *remembering* » ou « *recollection* ») de la connaissance (en anglais : « *knowing* »). Contrairement à la remémoration, dans laquelle l'information est encodée en regard de son contexte épisodique, la connaissance renvoie davantage à la conscience abstraite et décontextualisée d'une connaissance générale. Ainsi, ce paradigme permet de différencier deux processus de mémorisation qui semblent jouer un rôle distinct dans l'effet animé. En

effet, nos résultats ont montré que l'avantage lié au caractère animé des items dépendait de la mémoire épisodique : la différence de reconnaissance entre les mots animés et inanimés était portée uniquement par les réponses « *Remember* ». Par conséquent, non seulement le caractère animé impactait la quantité d'informations mémorisées, mais également la qualité de la mémorisation.

Dans l'Article 2 nous avons voulu compléter et renforcer l'hypothèse d'un effet animé en mémoire épisodique, en utilisant un paradigme de mémoire de source. D'un point de vue adaptatif, se souvenir du contexte d'apparition des entités animées semble primordial. Ainsi, un bon « chasseur » doit inévitablement se souvenir du meilleur endroit pour capturer sa proie. C'est pourquoi nous nous attendions à ce que l'effet animé se manifeste également en mémoire de source. Les résultats obtenus dans l'Article 2 vont clairement dans ce sens.

## Article 1

### **Animates are better remembered than inanimates: further evidence from word and picture stimuli**

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Bonin, P., Gelin, M., & Bugaiska, A. (2014). Animates are better remembered than inanimates: Further evidence from word and picture stimuli. *Memory & Cognition*, 42, 370-382.

**Abstract.** In three experiments, we showed that animate entities are remembered better than inanimate entities. Experiment 1 revealed better recall for words denoting animate than inanimate items. Experiment 2 replicated this finding with the use of pictures. In Experiment 3, we found better recognition for animate than for inanimate words. Importantly, we also found a higher recall rate of “remember” than of “know” responses for animates, whereas the recall rates were similar for the two types of responses for inanimate items. This finding suggests that animacy enhances not only the quantity but also the quality of memory traces, through the recall of contextual details of previous experiences (i.e., episodic memory). Finally, in Experiment 4, we tested whether the animacy effect was due to animate items being richer in terms of sensory features than inanimate items. The findings provide further evidence for the functionalist view of memory championed by Nairne and coworkers (Nairne, 2010; Nairne & Pandeirada, *Cognitive Psychology*, 61 :1–22, 2010a, 2010b).

**Keywords.** Functionalist view of memory . Animate . Inanimate . Survival processing . Long-term Memory

Several lines of evidence suggest that animate entities have a privileged processing status over inanimate objects—in other words, that animates have priority over inanimates. The animate–inanimate distinction parallels the distinction between “living” and “nonliving” things that has been postulated to account for selective deficits in patients (for a review, see Capitani, Laiacona, Mahon, & Caramazza, 2003). Animates belong to the general category of living things. Gelman and Spelke (1981) identified the following fundamental differences between animate and inanimate objects: (1) Animates can act, whereas inanimates move only when something/someone initiates the action; (2) animates grow and reproduce; (3) animates can know, perceive, emote, learn, and think; and (4) animates are made of biological structures that maintain life and allow reproduction.

In several domains of cognitive science, a growing body of evidence supports the view that animates are given processing priority over inanimates. Animate stimuli are thought to attract more attention than inanimates because it was important for the survival of our human ancestors to identify potentially dangerous entities quickly. To illustrate this, it has been shown that animate stimuli (e.g., *animals, human faces*) attract more attention than inanimate stimuli, not only those that arouse fear (Öhman, Flykt, & Esteves, 2001; Öhman, Lundqvist, & Esteves, 2001; but see Brosch & Sharma, 2005) but also neutral stimuli (Lipp, Derakshan, Waters, & Logies, 2004). It has been shown that individuals detect changes to humans and animals more quickly and accurately than changes to inanimate objects (New, Cosmides, & Tooby, 2007; see also Kirchner & Thorpe, 2006, for evidence of faster ocular saccades in response to animals than to other objects). Recently, Yang, Wang, Yan, Zhu, Chen, and Wang (2012) tracked participants’ eye movements while they viewed pictures with animals and inanimate images as focal objects. These pictures had either negative or neutral emotional valence, and either human body parts or nonhuman parts were near the focal objects (i.e., context). The picture’s valence, arousal, position, size, and most of the low-level visual features were controlled for across categories. Their findings showed that nonhuman animals were more likely to be attended to (and to be attended to for longer) than inanimate objects. In a visual search paradigm, Abrams and Christ (2003) showed that onset of motion (i.e., an object that has just started to move), but not motion per se, was important to capture attention. According to those authors, motion onset is indicative of animacy. They postulated that the reason why motion onset captures attention is that it may signal a biologically significant event, because objects that undergo motion onset must have their own internal energy source. Since survival may depend on the rapid detection of nearby predators and prey, one can easily

imagine why a visual system in which motion onset captures attention is very useful to protect ourselves from predators. Finally, Pratt, Radulescu, Guo, and Abrams (2010) tested the hypothesis that animate motion captures visual attention by comparing the time taken to detect targets involving objects that were moving predictably as a result of collision (inanimate motion) with the time taken to detect targets involving objects that were moving unpredictably, not as a result of collision (animate motion). They found that participants responded more rapidly to targets involving objects undergoing animate than inanimate motion. They postulated that our evolutionary past, when detecting animate objects was critical for survival, has had a profound impact on the way in which we extract information from the visual field.

A novel and important finding has recently been reported in memory research, which we shall refer to as the *animacy effect* (Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, in press; VanArsdall, Nairne, Pandeirada, & Blunt, 2013). The animacy effect refers to the observation that animate stimuli are remembered better than inanimate stimuli. This finding is in line with the functionalist view of memory put forward by Nairne and coworkers (Nairne, 2010; Nairne & Pandeirada, 2008, 2010a, 2010b), whereby the human memory system has been tuned to solve critical adaptive problems (e.g., finding food and water, protection from predators, finding a mate for reproduction). This finding is particularly important since it reinforces the view that human cognitive systems are tuned to detect and remember animate things. A number of studies comparing survival encoding scenarios with various deep encoding contexts (e.g., Nairne & Pandeirada, 2008, 2010a; Nairne, Pandeirada, Gregory, & Van Arsdall, 2009; Nairne, Pandeirada, & Thompson, 2008; Nairne, Thompson, & Pandeirada, 2007) have provided evidence supporting the view that memory systems have evolved to solve fitness problems. In their seminal study, Nairne et al. (2007) demonstrated that encoding words during a survival scenario (rating whether a word denotes something that could be useful in a situation in which the participant has to find food, water, and protection against predators), as compared to several control scenarios (e.g., rating words according to pleasantness), led to better long-term retention. Many different control scenarios have been used to test the survival processing advantage (Nairne & Pandeirada, 2008). The survival effect has been found in experiments carried out in different countries (e.g., the United States, Japan, or Germany) and with different populations (mostly young adults but also older adults and children). Although the boundaries of this effect have been disputed (Klein, 2013; Otgaar et al., 2011), as have the proximate mechanisms that underpin it (e.g., Burns, Burns, &



Hwang, 2011; Nouchi, 2013), this effect has attracted considerable attention in the research community.

It is important to stress that in most studies investigating the survival processing advantage, the survival effect has mostly been obtained by varying the encoding contexts and not by directly using words more-or-less related to adaptive problems (e.g., *water, knife, fire*). Recently, however, Nairne and colleagues (Nairne et al., in press; VanArsdall et al., 2013) have used animate and inanimate stimuli that are clearly related to adaptive issues. VanArsdall et al. presented participants with nonwords together with properties that were characteristic of either living (animate) or nonliving (inanimate) things. Participants had to rate the likelihood that each nonword/property pair corresponded to either a living or a nonliving thing. They were then given a recognition memory test for the nonwords (Exp. 1) or a free-recall test (Exp. 2). In both experiments, the nonwords paired with properties of living things were remembered better than those paired with properties of nonliving things. In two other studies conducted with word stimuli (Nairne et al., in press), it was found that animate words were more likely to be recalled than inanimate words, even after the stimulus classes had been controlled for other mnemonically relevant dimensions (e.g., imageability and meaningfulness) either statistically (Study 1) or methodologically (Study 2).

The animacy effect found in memory tasks is important because it provides further empirical support for a functional view of memory. However, before any firm conclusion can be drawn from this memory effect, and in view of the novelty of this finding, we thought further evidence was required. The goal of our first experiment was to replicate in an incidental encoding task the animacy effect found in English by Nairne et al. (in press) *with words* in an intentional memory task. In Experiment 2, pictures instead of words were used, and again, the animacy effect was tested in free recall. Thus far, no studies have examined whether the advantage of animate over inanimate objects in memory also holds for picture stimuli. If memory has evolved to favor the processing of fitness-relevant information, it seems likely that the animacy effect would emerge with rich visual stimuli such as pictures. In Experiment 3, the animacy effect was tested with word stimuli in a recognition task using the remember/know paradigm (Gardiner, 1988) to evaluate not only the quantity but also the quality of recognition. In effect, the act of “remembering” involves recalling contextual episodic details of previous events and experiences, whereas “knowing” does not involve remembering as such, but is more a general sense of familiarity about more abstract knowledge. Finally, in Experiment 4, we collected sensory experience ratings (Juhász, Yap,

Dicke, Taylor, & Gullick, 2011), which are thought to reflect the extent to which a word evokes a sensory and/or perceptual experience (Juhasz & Yap, 2013). This enabled us to test whether the animacy effect could be attributable to the fact that animate items are richer in terms of sensory and/or perceptual features than inanimate items. More precise rationale of each experiment is provided below.

To sum up, although the main goal of our study was to provide further evidence for animacy effects in long-term memory, it is worth stressing that its originality lies in the fact that we investigated animacy effects (1) in recall tasks with (a) incidental learning and (b) pictures, and (2) in recollection tasks with the remember-know paradigm, and (3) we investigated whether these effects might be underpinned by different weights in terms of sensory features of animate versus inanimate items.

### **Experiment 1: Animacy effect in free recall with words**

The goal of this experiment was to replicate Nairne et al.'s (In press) finding of better free recall of words denoting animate than inanimate items. In contrast to their experiment, we used an incidental rather than an intentional encoding memory task. The participants were first presented with words and had to categorize each one as animate or inanimate. Categorization times were recorded. The categorization task was followed by two interference tasks. Finally, the participants were given an (unexpected) free-recall task. The distinction between incidental and intentional memory involves differences in self-initiated strategies while encoding episodic information (Kirchhoff, 2009). Explicitly instructing participants to encode information enables them to initiate encoding strategies (i.e., intentional encoding). Although both incidental and intentional learning occur in everyday life, the former is more prevalent, in that people generally observe events and activities without explicit instructions to remember them.

### **Method**

*Participants.* A group of 40 students (mean age 23.3 years) at the University of Bourgogne took part in the experiment in exchange for course credits. The participants were native French speakers and reported having normal or corrected-to-normal vision. None were taking medication known to affect the central nervous system.

*Stimuli.* A total of 56 nouns were selected from Snodgrass and Vanderwart’s (1980) and Bonin, Peereman, Malardier, Méot, and Chalard’s (2003) databases. Each word referred to either an animate or an inanimate object. The words were divided into two sets of 28 items matched for the *surface variables* of number of letters and bigram frequency; the *lexical variables* of book frequency, subtitle frequency, age of acquisition, number of orthographic neighbors, and orthographic uniqueness point; and the *semantic variables* of conceptual familiarity, imageability, image variability, concreteness, and emotional valence. The statistical characteristics of the controlled variables are presented in Table 1.

Since pictures corresponding to the words were used in Experiment 2, the two types of stimuli were also matched on variables pertaining to the pictures. These will be described in the Stimuli section of Experiment 2.

**Table 1.** Statistical characteristics (mean, standard deviations, min-max range, and *t* tests of the means) of the control variables in Experiments 1–3 for animate and inanimate stimuli.

|                                        | Animate |           |              | Inanimate |           |              | <i>t</i> Test      |
|----------------------------------------|---------|-----------|--------------|-----------|-----------|--------------|--------------------|
|                                        | Mean    | <i>SD</i> | Range        | Mean      | <i>SD</i> | Range        |                    |
| Number of letters *                    | 6.5     | 1.9       | 3_10         | 6.61      | 1.91      | 3_10         | $t < 1$            |
| Bigram frequency (per million words) * | 7,891   | 3,193.09  | 1,430_13,454 | 9,336     | 2,675.39  | 2,360_13,976 | $t = 1.53$ , n.s.  |
| Book frequency *                       | 16      | 36        | 0.07_186.96  | 22        | 45        | 0.07_175.2   | $t < 1$            |
| Subtitle frequency *                   | 20      | 47        | 0.15_188.41  | 13        | 30        | 0.06_154.13  | $t < 1$            |
| Age-of-acquisition (1-5) **            | 2.52    | 0.65      | 1.15_3.75    | 2.75      | 0.8       | 1.23_4.2     | $t = -1.23$ , n.s. |
| Number of orthographic neighbors *     | 2.14    | 3.4       | 0_13         | 2.5       | 3.7       | 0_11         | $t < 1$            |
| Orthographic uniqueness point *        | 4.78    | 2.27      | 0_10         | 5         | 2.74      | 0_9          | $t < 1$            |
| Conceptual familiarity **              | 2.14    | 0.79      | 1.07_3.9     | 2.49      | 0.85      | 1.18_4.97    | $t = -1.62$ , n.s. |
| Imageability ***                       | 4.42    | 0.37      | 3.64_4.96    | 4.2       | 0.49      | 3.24_4.84    | $t = 1.92$ , n.s.  |
| Image variability **                   | 2.72    | 0.67      | 1.85_4.3     | 2.5       | 0.57      | 1.6_4.07     | $t = 1.30$ , n.s.  |
| Concreteness ***                       | 4.6     | 0.31      | 3.64_4.91    | 4.67      | 0.37      | 3.05_5       | $t < 1$            |
| Emotional valence***                   | 3.29    | 0.68      | 1.32_4.56    | 2.99      | 0.64      | 1.52_4.12    | $t = 1.71$ , n.s.  |
| Name agreement **                      | 85%     | 17        | 50_100       | 82%       | 19        | 39_100       | $t < 1$            |
| Image agreement **                     | 3.68    | 0.61      | 4.7_2.35     | 3.79      | 0.58      | 2.27_4.8     | $t < 1$            |
| Visual complexity **                   | 3.38    | 0.71      | 1.95_4.97    | 3.23      | 0.87      | 1.93_4.86    | $t < 1$            |

\*Values taken from Lexique (www.lexique.org; New, Pallier, Brysbaert, & Ferrand, 2004).

\*\* All the scales are 5-point scales. The values were obtained from Bonin et al. (2003b), and from Alario and Ferrand (1999).

\*\*\* All the scales are 5-point scales. The values were obtained from Bonin et al. (2003a).

*Apparatus.* The words were presented on a Macintosh (iMac) computer running the PsyScope version 1.2.5 software (Cohen, MacWhinney, Flatt, & Provost, 1993).

*Procedure.* The participants were tested individually, seated comfortably in a quiet room. First, they carried out an animate-inanimate categorization task. They were given a brief definition of what is meant by “animate” versus “inanimate” (e.g., an animate item can move autonomously whereas an inanimate item cannot). They were told that for each presented word they should decide as quickly as possible whether it referred to an animate or inanimate item, indicating their choice by pressing a different key. Each trial began with a fixation point (+) displayed in the middle of the screen for 500ms. A word was then displayed in the middle of the screen and remained there until the participant responded. The words were presented in random order. Response times were recorded. After the categorization task, the participants performed two interference tasks commonly used to evaluate executive functions, which lasted 5 min. The first was the “X–O” letter-comparison task (Salthouse, Toth, Hancock, & Woodard, 1997), and the second was the “plus–minus” task (from Jersild, 1927, and Spector & Biederman, 1976). In the letter-comparison task, the participants had to decide, as quickly as possible, whether or not pairs of letters were identical. For the plus–minus task, the participants were told to add 3 to each number on the first board, subtract 3 from each number on the second board, and alternate between adding and subtracting 3 from the numbers on the third board. After 5 min, the participants were given a surprise free-recall task.

## **Results and discussion**

Animate words were categorized reliably faster ( $M = 960$  ms,  $SD = 219$ ) than inanimate words ( $M = 1,064$  ms,  $SD = 234$ ),  $t(39) = 5.58$ ,  $p < .001$ . More animate words were correctly recalled ( $M = 4.78$ ,  $SD = 2.08$ ) than inanimate words ( $M = 2.08$ ,  $SD = 1.40$ ), yielding a reliable main effect of the Type of Word factor,  $t(39) = 7.50$ ,  $p < .001$ . With regard to extralist intrusions, animate words ( $M = 1.05$ ,  $SD = 1.08$ ) did not yield more intrusions than inanimate ones ( $M = 1.10$ ,  $SD = 0.90$ ),  $t(39) = 0.24$ .

These findings replicate in French the animacy effect in correct free-recall initially reported by Nairne et al. (in press) in English in an intentional memory task. The effect cannot be attributable to the fact that animate words were processed for a longer time than inanimate words because we found that animate words were categorized faster than inanimate words.

It might be asked whether the animacy effect was driven by congruity. For instance, it could be that individuals relied on the animate category to make decisions about the category the item belonged to (e.g., “*is this a living thing?*”) and to cue performance during retrieval.

However, we do not think the congruency account likely because the participants were instructed to decide whether a given word referred to an animate or an inanimate thing, each decision requiring a specific response, pressing a different key. It is important to stress that the participants were given a brief explanation about what is meant by animate and inanimate before starting the categorization task. Thus, the animate category was not defined in a more positive way than the inanimate category. This was also the case in VanArsdall et al.'s (2013) study in which the participants had to use a six-point scale anchored at one end by an object and at the other by a living thing. Moreover, the animacy effect was replicated many times with intentional learning in that study, in which attention was not drawn to the animacy dimension.

It is important to stress that the animacy effect in long-term memory was found after controlling for a large number of dimensions between the two types of words. In the next experiment, we tested whether the animacy effect would be found with picture stimuli.

## **Experiment 2: Animacy effect in free recall with pictures**

The animacy effect in long-term memory has thus far been obtained with nonword (VanArsdall et al., 2013) and word (Nairne et al., in press, and Exp. 1 of the present study) stimuli. One unexplored issue is whether the animacy effect is also obtained with pictures. It is well known that information is more likely to be recollected when it is presented in pictures rather than in words (Paivio, 1971; Rajaram, 1996). Because processing pictures (i.e., imagery) preceded the processing of language (e.g., words) in the evolution of human memory (Paivio, 2007), on the basis of a functionalist view of human memory (Nairne, 2010), whereby memory has evolved to favor the processing of fitness-relevant information, we expected to find that pictures of animate items would yield better recall than pictures of inanimate items. Examining this hypothesis would provide valuable information regarding the robustness of the animacy recall advantage.

### **Method**

*Participants.* A group of 30 adults (mean age 23.63 years) taken from the same pool as in Experiment 1 and having the same characteristics took part in the experiment.

*Stimuli.* The pictures corresponding to the words used in Experiment 1 were used. They were taken from two databases (Bonin et al., 2003b; Snodgrass & Vanderwart, 1980). In addition to the controls described in Experiment 1, animate and inanimate stimuli were also matched on variables pertaining to the pictures. Thus, the name agreement, image agreement, and visual complexity of the pictures were controlled for (see Table 1). *Name agreement* is the degree to which individuals agree on a name for a particular pictured object. One widely used measure is the percentage of participants who provide the most common name. *Image agreement* is the degree to which the mental images formed by participants in response to an object name match the object's appearance; it is measured using a Likert scale. The *visual complexity* of pictures involves the number of lines and details in the drawing. Participants rate the degree of visual complexity of each picture on a 5-point scale, ranging from 1 for a *visually simple picture* to 5 for a *visually very complex picture*.

*Apparatus.* The same apparatus was used as in Experiment 1.

*Procedure.* We followed the same procedure as in Experiment 1, except that pictures were used instead of words. Although the name agreement scores were controlled for between animate and inanimate stimuli, the written words were displayed with the pictures to ensure that the participants used the intended names for the target pictures.

## **Results and discussion**

Animate pictures were categorized significantly faster ( $M = 1,156$  ms,  $SD = 377$ ) than inanimate pictures ( $M = 1,279$  ms,  $SD = 439$ ),  $t(29) = 3.28$ ,  $p < .01$ . More animate pictures were correctly recalled ( $M = 6.63$ ,  $SD = 2.63$ ) than inanimate pictures ( $M = 3.70$ ,  $SD = 2.31$ ), yielding a reliable main effect of the Type of Picture factor,  $t(29) = 3.28$ ,  $p < .01$ . With regard to extralist intrusions, animate stimuli ( $M = 0.83$ ,  $SD = 1.02$ ) did not yield more intrusions than did inanimate ones ( $M = 0.70$ ,  $SD = 1.09$ ),  $t(29) = 0.47$ .

In this experiment, we tested whether the animacy effect in memory obtained with words would also be found with pictures. Taking a functionalist view of human memory (Nairne, 2010), this effect was clearly anticipated, particularly as the processing of pictures preceded that of language in human evolution. In effect, according to the adaptive memory view, our memory systems have evolved to favor the processing of fitness-relevant information. Therefore, whatever the format of presentation of animate versus inanimate entities, we predicted that the former would be remembered better than the latter; this

prediction was clearly borne out. In line with previous studies (Paivio, 1971; Rajaram, 1996), comparison of the findings of Experiments 1 and 2 revealed better memory performance with pictures than with words. The first two experiments support previous findings (Nairne et al., in press; VanArsdall et al., 2013) of the robustness of the animacy recall advantage.

However, given that the pictures were accompanied by words, one might wonder whether the better memory performance with pictures than with words was due to the picture format itself or to the fact that the word format comprised a single stimulus whereas the picture format included an additional redundant stimulus. Thus, the issue is whether the advantage of animates over inanimates would have been found had the pictures not been labeled. As is explained above, we decided to present each picture with its corresponding written name because although the name agreement of the pictures was matched across animates and inanimates and was relatively high (>80%), it was not equal to 100 %. However, we believe that the better performance with pictures than with words observed in the present study was driven by picture processing and not by the fact that redundant stimuli were presented (the picture plus its written name), for the following reason. According to the Paivio's dual-code theory (Paivio & Csapo, 1973), the picture superiority effect in memory can be explained by the fact that during study, pictures elicit their verbal label, so that two representations or codes are stored in memory. By contrast, words do not automatically elicit a picture and have a relatively impoverished memory representation. The redundant representation for pictures favors their retrieval relative to words. Taking this view, in our experiment, the presentation of a picture would lead to both an imagery code and a verbal code, the latter being given additional activation by the accompanying written word. According to the redundancy account, the better performance for "pictures + words" in Experiment 2 than for "words only" in Experiment 1 would essentially be due to the fact that the name of the picture was effectively presented twice, and therefore, more activated. However, Paivio and Csapo showed that although pictures accompanied by words (PW) are better remembered than the same picture presented alone (P), they are not recalled as well as the word presented twice (WW). Although this issue might well be reexamined in future studies, it is likely that the superiority of recall with pictures than with words observed in the present study was driven by the contribution of imaginal memory codes more than by the redundancy of verbal memory codes.

### **Experiment 3: The animacy effect in recognition with words**

In this experiment, we tested whether the animacy effect obtained in free recall would also be found in recognition using the word stimuli of Experiment 1. Nairne et al. (in press) did not test the animacy effect obtained with words in a word recognition task. From an empirical point of view, it would thus be interesting to assess whether the animacy effect found in free recall can be observed in recognition, and more precisely, in the quality of recognition.

A number of studies in recognition memory suggest that people experience at least two quite distinct states of awareness related to the quality of recognition. The first state—remembering—involves recalling contextual details of previous events and experiences, including awareness of one’s self, usually at a particular time and in a particular place. The second state—knowing—does not involve remembering an event as such, but is a more abstract awareness of general knowledge. According to Tulving (1985), these two states of awareness reflect auto-noetic and noetic consciousness, respectively, which in turn reflect two mind/brain systems, namely episodic and semantic memory (see also Wheeler, Stuss, & Tulving, 1997). It is assumed that these two states of awareness can be measured with the remember-know paradigm (Gardiner, 1988) in which participants are given a recognition memory test and are instructed to assign their positive recognition decisions to either “remember” responses (R-responses) whenever they can consciously recollect the item’s study presentation, or “know” responses (K-responses) when they recognize the item on the basis of familiarity but are not able to consciously recollect its study presentation. Thus, remembering occurs when an individual has a sense or feeling of the self in the past (auto-noetic consciousness; Tulving, 1985). Images (often visual ones), feelings, thoughts, sensations and verbal statements directly related to the recalled episode also often come to mind during the recollective experience. The first two experiments showed that animacy enhanced the quantity of recalled information. In the third experiment, we tested the quality of the mnemonic trace by investigating whether items were recalled on the basis of remembering (R-responses) or knowing (K-responses). This would indicate whether the animacy effect on recognition involves R- and/or K-responses and would provide a better understanding of the animacy effect in long-term memory.



## Method

*Participants.* A group of 33 students (mean age 20.12 years) at the University of Bourgogne participated in the study in exchange for course credits. None were taking any medication known to affect the central nervous system.

*Stimuli.* The same word stimuli as in Experiment 1 were used here. In addition, 56 new words (half animate and half inanimate) were added for the “new” responses in the recognition task. These new words (“new”) matched the initial experimental words (“old”) on objective word frequency (“old,”  $M = 12.43$ ,  $SD = 24.22$ , min–max = 0.03–115.3; “new,”  $M = 12.73$ ,  $SD = 25.94$ , min–max = 0.03–144.3;  $t < 1$ ), age of acquisition (“old,”  $M = 2.64$ ,  $SD = 0.73$ , min–max = 1.15–4.2; “new,”  $M = 2.73$ ,  $SD = 0.83$ , min–max = 1.35–4.62;  $t < 1$ ), and number of letters (“old,”  $M = 6.55$ ,  $SD = 1.89$ , min–max = 3–10; “new,”  $M = 6.80$ ,  $SD = 2.27$ , min–max = 3–15;  $t < 1$ ).

*Apparatus.* The same apparatus was used as in the previous experiments.

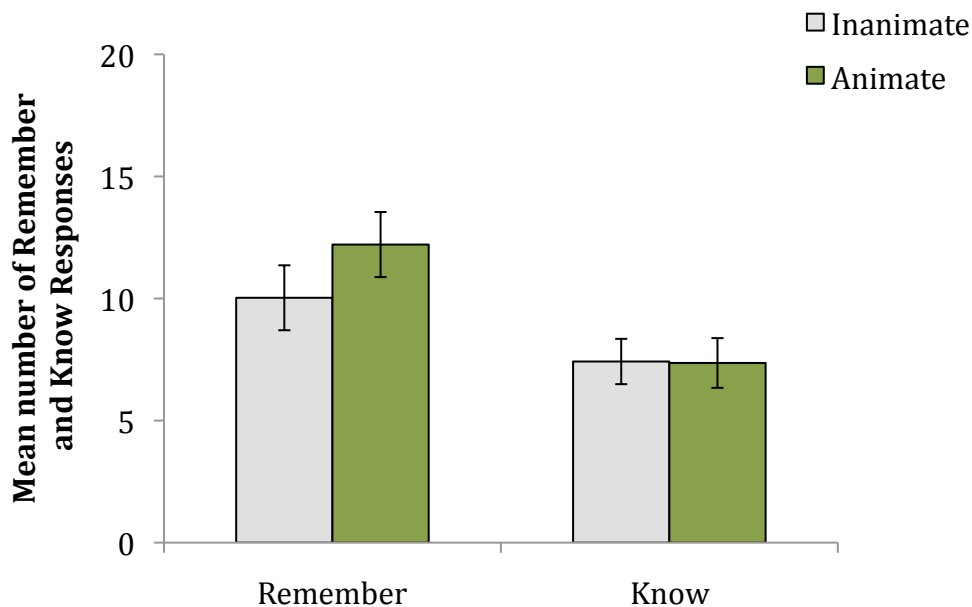
*Procedure.* The procedure was the same as in Experiment 1 except that a recognition test was performed after the distraction tasks. For this test, 112 words (56 targets and 56 fillers) were presented one at a time on the computer screen in random order and with no time limit. The participants had to say aloud if they recognized each word from the previous lists. For every word they recognized, participants had to indicate whether their recognition was based on remembering (R-response), knowing (K-response), or guessing (G-response; Gardiner, Ramponi, & Richardson-Klavehn, 1999). They were instructed to give an R-response when the word evoked a specific recollection of the learning sequence. Examples given included remembering a word because it brought to mind a particular association, image, or some other personal experience, or because something about its appearance or position could be recalled. A K-response was to be given for any words that the participants felt confident about recognizing but that did not evoke any specific conscious memory of the learning sequence. G-responses were to be used when they were not sure whether they had seen the word in the study list or not and were included to enhance the quality of K-responses. After the recognition phase, the participants had to explain at least two of their Remember and two of their know judgments to ensure that they used the two types of response correctly.

## Results and discussion

Inanimate words took longer to categorize ( $M = 1,202$  ms,  $SD = 276$ ) than animate words ( $M = 1,117$  ms,  $SD = 274$ ),  $t(32) = 3.66$ ,  $p < .001$ .

*Overall recognition.* More animate words ( $M = 22.30$ ,  $SD = 3.55$ ) were recognized than inanimate words ( $M = 20.33$ ,  $SD = 5.32$ ),  $t(32) = 2.54$ ,  $p = .016$ . Animacy did not have a significant effect on false alarms (animate words,  $M = 4.03$ ,  $SD = 3.18$ ; inanimate words,  $M = 4.06$ ,  $SD = 3.49$ ),  $t(32) = 0.06$ .

*“Remember” and “know” responses.* The means and standard errors for R- and K-responses are presented in Fig. 1. For R-responses,  $t$  test comparisons revealed a main effect of type of word,  $t(32) = 2.84$ ,  $p < .01$ , with animate words yielding higher R-responses than did inanimate words. For K-responses, we found no reliable effect of the type of word,  $t(32) = 0.07$ . The analyses revealed a significant difference between R- and K-responses for animate words,  $t(32) = 3.66$ ,  $p < .01$ , with more R- than K-responses. In contrast, no reliable difference was apparent between the two types of responses for inanimate words,  $t(32) = 1.25$ , n.s. For G-responses, no reliable difference emerged between animate ( $M = 2.72$ ,  $SD = 2.40$ ) and inanimate ( $M = 2.85$ ,  $SD = 2.12$ ) words,  $t(32) = 0.30$ .



**Figure 1.** Mean numbers and standard errors of “remember” and “know” responses as a function of animacy (animate vs. inanimate stimuli).

Finally, for false alarms, no reliable differences were observed between animate and inanimate words on R-responses (animate,  $M = 0.57$ ,  $SD = 0.97$ ; inanimate,  $M = 0.76$ ,  $SD = 1.68$ ),  $t(32) = 0.83$ , K-responses (animate,  $M = 1.36$ ,  $SD = 1.82$ ; inanimate,  $M = 1.03$ ,  $SD = 1.88$ ),  $t(32) = 1.13$ , or G-responses (animate,  $M = 2.09$ ,  $SD = 2.74$ ; inanimate,  $M = 2.27$ ,  $SD = 2.54$ ),  $t(32) = 0.57$ .

Although Experiment 1 of VanArsdall et al.'s (2013) study used recognition memory for nonwords, the animacy effect has previously only been reported *with words* in free-recall tasks (Nairne et al., in press). The aim of Experiment 3 was therefore to assess whether it would also appear in a recognition task. More importantly, we collected “remember” and “know” responses for each item judged as “recognized” since such responses are thought to reflect the kind of memory trace formed during encoding. Two important findings emerged from the analyses. First of all, the animacy property enhanced the quantity of recognized words, as more animate than inanimate words were recognized. Secondly, animate words yielded higher R-responses than inanimate words, indicating greater conscious awareness of encoding these stimuli, suggesting that animacy enhances the quality of memory traces leading to greater episodic retrieval. This finding suggests that the participants were spontaneously engaged in elaborative encoding for animate words. These findings also support the idea that the mnemonic advantage of animate words is provided by the recollection component. From an evolutionary perspective, the key uses of episodic memory are to maintain a sense of self-continuity, to ensure successful social interaction, and to direct future behavior on the basis of information about past events (Raby & Clayton, 2012). Given the functions of episodic memory and the properties of animate objects (e.g., animates can act whereas inanimates move only when something/someone acts on them; animates can know, perceive, emote, learn and think; Gelman & Spelke, 1981), it is likely that animate objects will be recollected with more episodic details than inanimate objects.

In Experiment 4, we assessed the merits of this analysis and tested whether the hypothesis that animate items have better memory traces than inanimate items could be related to the former being richer in terms of sensory (and/or perceptual) experiences (Juhasz & Yap, 2013). Images (often visual), feelings, thoughts, sensations and verbal statements directly related to the recalled episode often come to mind during the recollection process (Tulving, 1985) and could be influenced by sensorial experiences.

#### **Experiment 4: Sensory experience ratings and animacy**

In the following experiment, we assessed whether the animacy advantage in memory could be related to a specific property of animate entities, and more specifically, whether animate stimuli are richer in terms of sensory experiences than inanimate stimuli. A number of studies suggest that semantically rich stimuli are remembered better than those that are less rich (e.g., Hargreaves, Pexman, Johnson, & Zdrzilova, 2012). Hargreaves et al. found that words for concepts with a large number of semantic features were recalled better than those with few semantic features in both expected and unexpected memory tasks. In a recent study, Hoffman and Lambon Ralph (2013) used a more direct approach in which subjects rated their knowledge of objects in each sensory-motor modality separately. Compared with these ratings, feature listing overestimated the importance of visual form and functional knowledge and under-estimated the contributions of other sensory channels. An item's sensory rating was found to be a better predictor of lexical-semantic processing speed than the number of features it possessed, suggesting that such ratings better capture the overall quantity of sensory information associated with a concept. Importantly, the findings of Hoffman and Lambon Ralph also strongly suggest that animate stimuli are richer in terms of sensory knowledge than inanimate stimuli.

In the following experiment, we used sensory experience ratings (SER) to capture the richness of the animate versus inanimate items used in the previous experiments. According to Juhasz and Yap (2013), SER are thought to reflect the extent to which a word evokes a sensory and/or perceptual experience. SER are obtained by asking participants to rate on a Likert scale the degree to which any given word evokes a sensory experience. More precisely, participants are asked to judge the ability of a word to evoke an actual sensation (taste, touch, sight, sound, or smell) when they are reading the word. The sensory experience variable is therefore not limited to a single sensation and it has the potential to index the links between lexical-semantics and all sensory/perceptual modalities. If the animacy effect in memory is driven by the different weights of sensory experiences of animate versus inanimate items, we should find that SER are higher for animate than inanimate items. Therefore, in Experiment 4, we tested the hypothesis that the SER variable, which is related to semantic richness, could account for the animacy effect found in the first three experiments. We also added the French translation of the English words used by Nairne et al. (in press) since they did not use this measure in their study.

## Method

*Participants.* A group of 56 adults (mean age = 43 years) participated in the study. They were taken from a larger pool of participants (mostly university students but also people from surrounding areas) than in the previous experiments.

*Stimuli.* The word stimuli used in Experiment 1 were again used here. We also added the French translation of the words used by Nairne et al. (in press).

*Procedure.* The participants were asked to rate the sensory experience associated with words presented in a list using a 7-point scale ranging from 1 = *no sensorial experience* to 7 = *high sensorial experience*. Some examples of words with different types of ratings were given before starting the experiment. We followed closely the procedure used in Juhasz and Yap's (2013) study.

## Results and discussion

In our study, animate words were given SER ( $M = 3.00$ ,  $SD = 0.81$ ) that did not differ reliably from inanimate words ( $M = 3.08$ ,  $SD = 0.67$ ),  $t < 1$ . It was also the case in the Nairne et al. (in press) study ( $M = 3.04$ ,  $SD = 0.82$ , vs.  $M = 3.38$ ,  $SD = 0.46$ ),  $t < 1$ .

In Experiment 4, we tested whether the animacy effect in memory could be driven by the fact that animate entities are richer in terms of sensory experience than inanimate items. To do this, we collected SER for the words used in Experiments 1 and 2 plus the French translation of the words used in Nairne et al.'s (in press) Experiment 2.

Based on studies suggesting that items that are semantically rich are better remembered than items that are less rich (Hargreaves et al., 2012), and given the findings of Hoffman and Lambon Ralph (2013) suggesting greater sensory knowledge for animate than inanimate items, it was not unreasonable to hypothesize that the animacy effect could be driven by this variable. The findings were clear: No reliable difference was observed between the SER for animate and inanimate words in either the present study or the one by Nairne et al. (in press), and if anything, the difference in SER was descriptively very small for each set and ran counter to the prediction that animates are richer in sensory experience than inanimates.<sup>1</sup> Thus, the animacy effects in memory cannot be easily ascribed to differences in

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<sup>1</sup> Since it is always difficult to draw conclusions from null results, we ran an additional Bayesian analysis from the data of Experiment 4, to determine the extent to which the prediction of a reliable animacy effect on SER could be rejected. In effect, according to Masson (2011, p. 679), this kind of analysis "generates a

the richness of sensory and perceptual features. However, it could be argued that testing the hypothesis that the animacy effect was due to the richness of encoding was rather odd in that our stimuli were controlled for imageability. In effect, this variable is typically assumed to index the richness of semantic representations (Evans, Lambon Ralph, & Woollams, 2012), with the result that words that are rated high in imagery are thought to be semantically richer than those that are rated as low in imagery. However, Connell and Lynott (2012) have recently shown that imageability is visually biased at the expense of other perceptual modalities. Therefore, the findings of Experiment 4 are particularly interesting in that they clearly show that the animacy effect is not underpinned by differences at the level of sensory features.

### **General discussion**

A growing body of evidence supports the view that our memory systems have evolved to reflect specific selection pressures that belonged to our ancestral past. A core assumption of evolutionary psychologists is that the human mind is composed of cognitive modules that fulfill specific functions (Bell & Buchner, 2012). Therefore, as claimed by Nairne (2012), just as the heart serves the function of pumping the blood to the organs, and the different “apps” of our iPhones have specific functions (e.g., to indicate where we are and where to go; to provide information about train times), there is no reason why our memory systems would not have specific functions. Indeed, several studies have shown a memory advantage of processing information in terms of fitness value (Nairne et al., 2009; Nairne et al., 2008; Nairne et al., 2007). More recently, it has been found that processing items along an animacy dimension led to better retention of animate than inanimate items (Nairne et al., in press; VanArsdall et al., 2013). In the present study, we aimed to provide further evidence for the animacy effect in long-term memory. Four experiments were conducted and the findings can be easily summarized.

In Experiment 1, we found that incidental encoding led to better recall of words referring to animate than inanimate items. In Experiment 2, we found that the animacy effect found in long-term memory with words also extended to picture stimuli. This was of

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graded level of evidence regarding which model (e.g., effect absent [null hypothesis] vs. effect present [alternative hypothesis]) is more strongly supported by the data.” The analysis revealed positive evidence (Raftery, 1995) in favor of the null hypothesis.

particular interest because, according to the adaptive memory view, our memory systems have evolved to favor the processing of fitness-relevant information, whatever the format in which animate versus inanimate entities are encountered.

In Experiment 3, we used a recognition paradigm to test for the animacy effect in memory. Importantly, in order to gain a better understanding of this effect, we also investigated “remember” and “know” responses for each recognized item. We found that animate words were better recognized than inanimate words and that R-responses outnumbered K-responses for animate stimuli, whereas no difference emerged between R- and K-response for inanimate stimuli. Moreover, the findings showed that the mnemonic advantage of animate words was produced by the recollection component. This suggests that animate words benefit from more elaboration processes at encoding. It should be remembered that from an evolutionary perspective, episodic memory allows individuals to maintain a sense of self-continuity, to be successful in social interactions, and to use information from past events to direct future behavior (Raby & Clayton, 2012). This novel finding is in line with the functionalist view of memory put forward by Nairne and coworkers (Nairne, 2010; Nairne & Pandeirada, 2008, 2010a, 2010b) whereby the human memory system has been tuned to solve critical adaptive problems (e.g., finding food and water, protection from predators, finding a mate for reproduction). More particularly, the observation of more R-responses for animate than for inanimate stimuli suggests that they possess better quality and more stable traces in memory.

The advantage of animate over inanimate words and pictures was found in Experiments 1–3 in the context of an animate–inanimate categorization task. It might be asked whether the same effects would be found if the categorization task involved another dimension of the stimuli (e.g., their size). In effect, we did not design an experiment in which the orienting task was changed to draw attention to another dimension of the stimuli. However, Nairne et al. (in press) used intentional memory tasks in which no explicit mention was made of the animate–inanimate distinction in the stimuli, and the animacy effects on memory performance were still reliable. It could be argued that if the animacy effect does indeed support the functionalist view of memory, spontaneous encoding must be shown to occur along the animacy dimension. In fact there are clear empirical grounds to support this assumption, as reviewed above in the introduction.

Finally, in Experiment 4, we tested whether the hypothesis that the better quality of memory traces for animate than inanimate items might be related to the former being richer in

terms of perceptual and sensory features. However, neither the sensory experience ratings for our stimuli nor for those in Nairne et al.'s (in press) Experiment 2, yielded any reliable difference between animate and inanimate stimuli. Therefore, the animacy effect in memory is not attributable to differences in the richness of sensory/perceptual features or of semantic features in general. The functional view of memory assumes that what matters for the animacy effect is *the status in terms of fitness* of the things that we process. Because animate stimuli have a greater fitness value than inanimate stimuli, they are given processing priority. It should be noted however that the categorization times were reliably shorter for animate than inanimate stimuli in all experiments, in line with previous findings in the literature. However, there is still a possibility that animate stimuli have “something special” that renders them easier to remember than inanimate stimuli, something that has nothing to do with their animacy status. But what exactly?

*Is the animacy effect really due to “animacy” or did we miss something when investigating this effect?*

As far as the animacy effects in long-term memory are concerned, the possibility still exists that we are victims of confounding variables—namely, that we think we have shown a genuine animacy effect, when this effect is in fact driven by (an)other, uncontrolled variable(s).

First and foremost, it should be remembered that VanArsdall et al. (2013) initially found that animate items were remembered better than inanimate items using nonwords. The use of nonwords was justified by the authors by the fact that using words would require matching the stimuli on numerous dimensions and also because “demonstrating that people are more likely to remember animals than household objects might not be seen as particularly convincing by the community of memory researchers” (p. 173). Since the same nonwords were used (with different participants) with animate and inanimate properties in VanArsdall et al.'s (2013) study, it is difficult to assume that the animacy effect was due to uncontrolled properties of the stimuli. Somewhat paradoxically, in a further publication (Nairne et al., in press), the authors investigated the animacy effect in long-term memory using words (and thus contrary to their claim that finding an animacy effect with words would not be accepted by the research community).

Second, and more generally, an important and recurring issue in experimental psychology is to ensure that an effect on a behavioral outcome is genuinely attributable to the



manipulation carried out and not to another potential (but uncontrolled) variable. This concern applies here as one cannot definitively ascertain that the animacy effect in memory is not attributable to another influential variable. In other words, the animacy effect could be due to (an)other characteristic(s) of the words that is (are) correlated with the animate–inanimate distinction. This concern is particularly relevant in psycholinguistic studies in which researchers aim to establish which specific characteristics of the words play a role in lexical processing. Controlling for stimuli in psycholinguistic experiments has been said to be a difficult challenge (Cutler, 1981). To give an example, a lively debate in the literature on object and word naming has concerned whether the effect of the frequency of encountering words is actually a genuine effect of word frequency or is due to another factor such as age of acquisition (AoA). Some researchers have claimed that word frequency effects in object naming are in fact AoA effects (Bonin, Fayol, & Chalard, 2001), but subsequent studies using better word frequency measures have found effects of both variables (e.g., Bonin et al., 2003b).

Could the animacy effect be attributable to another factor, namely a by-product of other more general factors? We were careful when selecting our stimuli to control for a large number of important factors that could potentially influence word processing and long-term encoding. Since certain studies have suggested that the quality of memory traces is dependent upon the richness of the stimuli in terms of semantic or motoric features (Hargreaves et al., 2012), and given (1) the findings of our Experiment 3 that suggest that the memory traces of animate stimuli are of better quality than those of inanimate stimuli, and (2) the findings of Hoffman and Lambon Ralph (2013) suggesting that animate stimuli are richer in terms of sensory knowledge than inanimate stimuli, our Experiment 4 tested whether the animacy effect in memory might be related to differences in terms of sensory features. The outcome of this experiment was clear: Neither our stimuli nor those used by Nairne et al. (in press) differed reliably on this dimension. Of course, we cannot definitively rule out the possibility that the animacy effect is due to another potent variable rather than the status of animacy per se. But since we were able to control for a large number of potentially important variables, the weight of evidence reported in the present study, together with recent evidence on words (Nairne et al., in press) and nonwords (VanArsdall et al., 2013), strongly suggests that animacy has a strong influence on long-term memory.

*Evidence for a functional view of memory*

As we shall discuss now, we think that animacy effects in memory provide further convincing evidence for a functional view of human memory (and it should be stressed that this was the goal of the present study). Nairne and coworkers have defended the view that our memory has been sculpted by evolution as a result of problems faced by our ancestors, based essentially on findings obtained using survival processing scenarios. They found that processing stimuli (and not stimuli obviously related to adaptive problems) in terms of fitness yields better memory performance than processing them in terms of other dimensions corresponding to well-known deep encoding conditions (Nairne et al., 2008). However, the idea that the survival processing effect (e.g., Nairne et al., 2007) is due to the contribution of episodic memory to maximizing fitness in our ancestral past, that is to say that our episodic memory helped our ancestors to solve adaptive problems related to survival (Nairne & Pandeirada, 2010a, 2010b), has been challenged by a number of researchers. They maintain that the survival effect can be accounted for by appealing to more general proximate memory mechanisms such as elaboration (Howe & Derbish, in press; Kroneisen & Erdfelder, 2011), item-specific processing (Burns, Hart, Griffith, & Burns, 2013), or richness of encoding (Kroneisen, Erfelder, & Buchner, 2013). Howe and Otgaar (2013) have claimed that general memory principles provide a better explanation of the adaptive function of memory.

According to Nairne (in press), the criticisms raised against the evolutionary account of the survival memory advantage have come from a misunderstanding between ultimate and proximate explanations. Without going into the details of the line of argument, he defines ultimate explanations as “statements about the function of a trait and ‘why’ it would have been selected by nature during an evolutionary process,” whereas proximate explanations “focus on the mechanisms that produced the trait—that is, they are statements about ‘how’ the trait works and the condition under which the trait is likely to be expressed” (p. 309). Following this distinction, memory evolved because it solved specific problems related to fitness (e.g., remembering information processed for its survival value as indexed by the survival memory paradigm). One consequence of memory system evolution is that information relevant to survival would be afforded special status. However, the proximate mechanisms underpinning the retention advantages may well be elaborative, distinctive or self-related encoding.

The animacy effect in memory can clearly not be disputed on the grounds of its adaptive value. The core of the adaptive view of memory is that not all stimuli are equal when processing them in order to remember them; stimuli that are relevant to fitness are more

important than other types of stimuli. Therefore, as claimed above, animacy effects in memory provide further evidence for a functionalist view of memory.

A remaining issue that should be the focus of future studies is whether animacy effects in long-term memory are due to animates being inherently more memorable, all things being equal, or to the fact that they capture attention or lead to some kind of mental simulation that enhances memory. In other words, animacy effects in memory might be explained via attentional mechanisms rather than inherent mnemonic tunings.

In their two empirical papers on animacy effects, Nairne and colleagues (Nairne et al., in press; VanArsdall et al., 2013) envisioned such a possibility, stating that “another possibility is that the nonwords processed for animacy were remembered well because animate things are especially likely to capture attention” (VanArsdall et al., 2013, p. 176). It might be tempting from the categorization data of our experiments, consistently showing that animates were categorized faster than inanimates, to suggest that the proximate mechanism underlying animacy effects is attentional capture. However, since our study was not designed to test such an explanation, further research will be required in order to ascertain whether or not animate objects attract more attention than inanimate ones, and whether this differential attention processing results in better memory. Clearly, an avenue has been revealed for testing hypotheses regarding the proximate mechanisms of animacy effects in episodic memory—in other words, the “how” of these effects. In the meantime, the findings of the present study reinforce the claim made earlier (Nairne et al., in press; VanArsdall et al., 2013) that we remember animate things better than inanimate ones. This is a robust finding<sup>2</sup> and provides further evidence for the adaptive view of memory (Nairne, 2010; Nairne & Pandeirada, 2010a, 2010b).

It must be stressed that the primacy of processing animates over inanimates seems to be a general phenomenon as it has not only been found in perception and memory, but also in language production, showing that animate entities tend to be privileged during syntactic production processes (e.g., Branigan, Pickering, & Tanaka, 2008). In cognitive neuropsychology, the dissociation between animates and inanimates has been reported in brain-damaged patients (e.g., Bi, Han, Shu, & Caramazza, 2007). Furthermore, the brain regions underpinning the processing of animates versus inanimates have been investigated,

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<sup>2</sup> In order to determine whether animacy effects would generalize over items, we performed by-items analyses (with Animacy taken here as a between-item factor), which turned out to be reliable in both recall (Exps. 1 and 2) and recognition performance (Exp. 3).

and certain studies (e.g., Wiggett, Pritchard, & Downing, 2009) suggest that different parts of the brain are differentially involved (ventrolateral visual brain regions for animate stimuli and ventromedial for inanimate ones). Finally, the ability to distinguish between animate and inanimate items has been assumed to underlie the construction of different mental categories in the brain (Gelman & Spelke, 1981).

In conclusion, we believe that the animacy effect in memory provides another type of demonstration that clearly supports the functionalist view of memory put forward by Nairne and colleagues (Nairne, 2010; Nairne & Pandeirada, 2010a, 2010b). Indeed, the only straightforward explanation for this effect is that remembering animate entities is helpful for survival. To paraphrase a well-known saying, we could say that as far as remembering is concerned, “all stimuli are equal but some stimuli (animate ones) are more equal than others.” The next step for opponents of this view, if they want to rule out the hypothesis that the animacy effect in memory is due to our memory system being selectively tuned to processing and remembering animate items, will be to show that animate and inanimate items covary along another, uncontrolled dimension that is genuinely responsible for this effect.

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## Article 2

### Do animacy effects persist in memory for context?

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**Abstract.** The adaptive view of human memory (Nairne, 2010) assumes that animates (e.g., *rabbit*) are remembered better than inanimates (e.g., *glass*) because animates are ultimately more important for fitness than inanimates. Previous studies provided evidence for this view by showing that animates were recalled or recognized better than inanimates (e.g., Nairne, VanArtsdall, Pandeirada, Cogdill, & LeBreton, 2013), but they did not assess memory for contextual details (e.g., *where* animates vs. inanimates occurred). In this study, we tested recollection of spatial information (Study 1) and temporal information (Study 2) associated with animate versus inanimate words. The findings showed that the two types of contextual information were remembered better when they were related to animates than to inanimates. These findings provide further evidence for an ultimate explanation of animacy effects.

**Keywords.** Episodic memory, animacy, memory for context, evolutionary psychology

A growing number of studies provide evidence for the view that human memory systems were shaped to remember information relevant for fitness (i.e., items related to survival and/or reproduction) better than any other kind of information. This is known as the adaptive memory view (Bonin & Bugaiska, 2014; Nairne, 2010 for reviews). Three types of evidence support the adaptive view of memory championed by Nairne and colleagues: survival-processing effects (also referred to as the survival processing advantage, i.e., words processed with respect to an imagined survival scenario are remembered better than words processed with respect to imagined non-survival scenarios, e.g., moving to a foreign country, or with respect to standard deep processing control conditions, e.g., pleasantness ratings, see Aslan & Bäuml, 2012; Nairne, Pandeirada, & Thompson, 2008; Nairne, Thompson, & Pandeirada, 2007), contamination effects (Nairne, 2015), and animacy effects (Bonin, Gelin, & Bugaiska, 2014; Nairne et al., 2013; VanArsdall, Nairne, Pandeirada, & Blunt, 2013). It is the latter type that is addressed in the present article.

To clarify what is meant by animates, Gelman and Spelke (1981) described five fundamental differences between animate and inanimate objects: (a) animate entities are agents that can initiate action in a causal event, whereas inanimate entities are affected by it; (b) animate objects grow and reproduce; (c) they may have mental states such as thinking, perceiving and feeling; (d) they are composed of parts directly related to biological functions, and (e) only animates are capable of communication and reciprocity. In the context of the present study, animates are defined as entities that are living and that are capable of selfpropelled motion (Di Giorgio, Lunghi, Simion, & Vallortigara, in press).

Several lines of evidence suggest that animates have a processing advantage over inanimates. First of all, the ability to distinguish between animates and inanimates is a fundamental cognitive ability that emerges early in life (Mandler & McDonough, 1998). Second, a number of studies have provided evidence supporting an animate monitoring hypothesis, which postulates that humans are tuned to pay more attention to animals than to artifacts, even to modern familiar ones such as cars (New, Cosmides, & Tooby, 2007). For ancestral hunter-gatherers immersed in a rich biotic environment, animals and human beings were important categories that had to be carefully attended to (Orians & Heerwagen, 1992). For example, family members or friends could require particular protection; strangers could constitute either potential mates or enemies; many animals were predators and thus dangerous. Finally, a number of recent studies suggest that human memory systems evolved to remember animates better than inanimates (in adults: Bonin, Gelin, Laroche, Méot, &

Bugaiska, 2015; Bonin, et al., 2014; Gelin, Bugaiska, Méot, & Bonin, 2017; Nairne et al., 2013; VanArsdall, Nairne, Pandeirada, & Cogdill, 2015; VanArsdall et al., 2013; in young children: Aslan & John, 2016). Animacy effects in memory have been found with non-words associated with animate vs. inanimate properties (VanArsdall et al., 2013), with words (Nairne et al., 2013) and with pictures (Bonin et al., 2014). They are robust effects since they have been found in free recall and in recognition tasks (Bonin et al., 2014; Nairne et al., 2013), and also in cued recall (VanArsdall et al., 2015; but see Popp & Serra, 2016, who did not find animacy effects in cued-recall<sup>1</sup>).

Given the high number of semantic, lexical, and sublexical dimensions that have been controlled for in studies examining animacy effects in memory performance (e.g., Bonin et al., 2014; Nairne et al., 2013), it seems unlikely that they are due to some uncontrolled variables<sup>2</sup>. In the literature on animacy effects in memory, the evolutionary-functional account of these effects came first. However, proximate explanations are also needed and should be understood as complementary, not opposing processes (Nairne & Pandeirada, 2016). Hence, the proximate mechanisms that underpin animacy effects have begun to be explored and the available evidence suggests that: (1) the mechanisms are different from those involved in the survival processing advantage (Gelin et al., 2017), (2) imagery processes contribute to these effects (Bonin et al., 2015; Gelin et al., 2017), and (3) importantly, animacy effects in recall rates are not linked to differences in the organizational structure of animates vs. inanimates (e.g., Gelin et al., 2017; VanArsdall, Nairne, Pandeirada, & Cogdill, in press).

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<sup>1</sup> In line with previous findings (Bonin et al., 2014; VanArsall et al., 2013), Popp and Serra (2016) found that animates were remembered better than inanimates, but a reverse effect of animacy was found in cued recall (e.g., *bottle, clock* recalled better than *bear, camel*). Certain readers might well be tempted to take this finding as running counter to an evolutionary account of animacy effects in memory. As discussed in depth by Nairne and Pandeirada (2016) regarding the survival processing advantage in memory, the observation of boundary conditions of this effect --and of an animacy effect in the present case-- should not be taken as ruling out an ultimate account. For instance, while a basic reflex disappears when a relevant neurotransmitter is blocked, this does not mean that the reflex is not an adaptation. In the case of the reverse animacy effect in cued recall, as explained by Popp and Serra (2016), the same proximate mechanism --attention capture or mental arousal-- involved in animacy effects in memory can, depending on the task, alter the relationship between animacy and memory, without challenging the ultimate definitive explanation of these effects.

<sup>2</sup> In effect, it is important to stress that virtually all important psycholinguistic variables known to affect lexical processing have been investigated either methodologically or statistically in studies examining animacy effects (e.g., Bonin et al., 2014; Gelin et al., 2017).

One important aspect of the data reported by Bonin et al. (2014) relates to animacy effects on hit responses in a recognition task using the "Remember/Know" paradigm. This paradigm, developed by Gardiner (1988), distinguishes between two types of consciousness: auto-noetic consciousness, which is the memory of a past event by mentally travelling back in time to relive it in context, and noetic consciousness, which involves general knowledge about our environment without being able to put items in context (Tulving, 1985). According to Tulving (1985), these two states of awareness reflect two mind / brain systems, namely, episodic and semantic memory (see also Wheeler, Stuss, & Tulving, 1997). More precisely, Bonin et al. (2014) reported more "remember" responses for animate than for inanimate items that had been recognized, suggesting that animates benefit from a richer encoding context than inanimates, leading to better recollection of these words. Thus, the animate dimension would increase not only the amount of information stored in long-term memory, but also the quality of that information. However, more evidence is needed to substantiate the claim that animates are retained in long-term memory with more contextual details than inanimates. This was precisely the aim and the novelty of the present study. Indeed, we are not aware of any studies to date that have tested whether memory for temporal or spatial contextual information is associated with remembering animate versus inanimate items. In the two studies described below, we tested whether the better recognition of animates than inanimates found in previous studies (Bonin et al., 2014; VanArsdall et al., 2013) is accompanied by better memory of the spatial and temporal contextual aspects of animate than of inanimate items. Memory for context is generally assessed by asking participants to retrieve contextual information linked to the target, such as sensory/perceptual information, spatial and temporal information, or semantic and emotional information (Johnson, Hashtroudi, & Stephen, 1993). A few studies have examined the recall of contextual information for items encoded in survival contexts (Bröder, Krüger, & Schütte, 2011; Nairne, Pandeirada, Smith, Grimaldi, & Bauernschmidt, 2010; Nairne, VanArsdall, & Blunt, 2012; Nairne, Pandeirada, VanArsdall, & Blunt, 2015). Neither Bröder et al. (2011) nor Nairne et al. (2010) (the latter study is also described in Nairne et al., 2012) were able to find a survival processing advantage in memory for context. Both studies addressed memory for location of the items. Participants had to rate the relevance of words in two different scenarios: the original grassland scenario and a deep encoding control condition (the fancy vacation resort scenario and the moving scenario in Bröder et al., 2011, and the pleasantness rating task in Nairne et al., 2010). In Bröder et al.'s (2011) Study 1, words were presented individually in one of 16 squares that were arranged in a large 4 x 4 square on the computer screen. In their Study 2, and in Nairne et al. (2010), there

were only two screen positions (the lower or upper half of the screen, and the right or left of the screen, respectively). In Bröder et al.'s (2011) study, the participants had to decide whether any given word was “new” or “old”, whereas in Nairne et al. (2012), they had to recall them. For each recognized (“old”) word, or for each recalled word, they had to indicate where it was initially presented on the screen. Across studies, the survival processing advantage was found on item memory (but see Bröder et al.'s (2011) Study 1, in which the survival processing advantage on item memory was not found when the vacation resort scenario was used as a control non-survival scenario), but there was no reliable survival advantage in location memory. Given the adaptive significance of memory for contextual information in a survival situation, this null finding was clearly not anticipated. However, both research teams acknowledged that a lack of ecological validity pertaining to the studies addressing this issue could have explained this unexpected result (Bröder et al., 2011; Nairne et al., 2012). However, in a subsequent study, Nairne et al. (2012) provided evidence that location memory is enhanced when the collection or capturing task is critical for the survival of individuals in a group. Finally, other studies found memory for survival-related items. For example, a significant female advantage in location memory for food items has been observed (New, Krasnow, Truxaw, & Gaulin, 2007). Moreover, in a game of pelmanism, the spatial location of evolutionarily relevant stimuli (e.g., “snakes”) was memorized better than that of non-evolutionary relevant stimuli (Wilson, Darling, & Sykes, 2011). Finally, Maner, Gailliot, and DeWall (2007) found that remembering the identity of people (“who”) and their location (“where”) was enhanced when they were seen as potential mates or rivals.

### **The present study**

Recollection can be measured either by subjective reports, for example, using the Remember/Know paradigm, or by objective information such as the context of the item, e.g., where or when the item was presented. These contextual features can act as powerful retrieval cues (Godden & Baddeley, 1975). Likewise, if animacy effects are supported by recollection, they should be observed not only on item memory, as found in previous studies (Bonin et al., 2014), but also on memory for contextual information. From a fitness point of view, in the distant past, remembering having seen a hungry lion or a dangerous snake was important, but remembering exactly where and when they were seen was even more important in order to avoid encountering them again. Below, we describe two studies that were designed to determine whether animacy effects are found on memory for context. More precisely, we

explored whether the memory advantage of animates over inanimates is linked to contextual information pertaining to spatial information (Study 1) and to temporal information (Study 2).

### **Study 1: Spatial context, where?**

In addition to replicating the animacy effects on recognition (Bonin et al., 2014), the goal of Study 1 was to test whether animacy effects are also found on memory for spatial context. We used the same memory paradigm as Bröder et al. (2011) with some slight alterations to investigate the influence of the animacy dimension.

#### **Method**

*Participants.* Thirty-four students, 28 women and 6 men (mean age 20.35 years, range 17-25) from the University of Bourgogne participated in the study in exchange for course credits. None were taking medication known to affect the central nervous system and they were all native French speakers.

*Stimuli.* Sixty-four nouns were selected from the databases of Snodgrass and Vanderwart (1980) and Bonin, Peereman, Malardier, Méot, and Chalard (2003). Each word referred to either an animate or an inanimate object. The 64 nouns were initially classified into animates and inanimates by the authors. As in Bonin et al. (2015), we gauged the reliability of our classification by asking five independent adults to rate the nouns used in the two studies on a 3-point scale (1 = clearly referring to an animate, 2 = ambiguous, 3 = clearly referring to an inanimate). The agreement between the five raters was perfect [Fleiss'  $\kappa = 1$ ], fully supporting our classification. Half of the to-be-studied items represented animates and half inanimates; these two sets were matched on various linguistic variables (e.g., number of letters, word frequency, imageability) whose statistical characteristics are reported in Table 1.

In addition, 64 new words (half animates and half inanimates) were used for the “new” responses in the recognition task. These new words (“new”) matched the initial experimental words (“old”) on subtitle frequency (“old,”  $m = 20.29$ ,  $sd = 41.57$ ,  $min-max = 0.06-188.41$ ; “new,”  $m = 13.17$ ,  $sd = 20.64$ ,  $min-max = 0.11-112.43$ ;  $t = 1.22$ ), book frequency (“old,”  $m = 23.6$ ,  $sd = 52.6$ ,  $min-max = 0.07-315.74$ ; “new,”  $m = 18.02$ ,  $sd = 34.79$ ,  $min-max = 0.07-199.39$ ;  $t < 1$ ), age of acquisition (“old,”  $m = 2.57$ ,  $sd = 0.72$ ,  $min-max = 1.15-4.2$ ; “new,”  $m$



= 2.66,  $sd = 0.81$ ,  $min-max = 1.35-4.62$ ;  $t < 1$ ), and number of letters (“old,”  $m = 6.41$ ,  $sd = 1.88$ ,  $min-max = 3-10$ ; “new,”  $m = 6.73$ ,  $sd = 2.19$ ,  $min-max = 3-15$ ;  $t < 1$ ).

**Table 1.** Statistical characteristics (means, standard deviations, range, minimum-maximum, t-tests of the means) of the control variables for animate and inanimate stimuli.

|                                       | Animate |         |        |             | Inanimate |        |        |             | t-test |
|---------------------------------------|---------|---------|--------|-------------|-----------|--------|--------|-------------|--------|
|                                       | Mean    | SD      | Range  | Min-max     | Mean      | SD     | Range  | Min-max     |        |
| Number of letters*                    | 6.38    | 1.88    | 7      | 3_10        | 6.44      | 1.87   | 7      | 3_10        | .90    |
| Bigram frequency (per million words)* | 8745.56 | 3125.12 | 14120  | 2963_17083  | 9787.63   | 2570.5 | 11616  | 2360_13976  | .16    |
| Book frequency*                       | 16.12   | 33.09   | 186.89 | 0.07_186.96 | 31.07     | 65.78  | 315.67 | 0.07_315.74 | .26    |
| Subtitle frequency*                   | 20.77   | 43.16   | 188.26 | 0.15_188.41 | 19.82     | 39.9   | 176.04 | 0.06_176.1  | .93    |
| Age of acquisition (1-5)**            | 2.47    | 0.62    | 2.6    | 1.15_3.75   | 2.67      | 0.79   | 2.97   | 1.23_4.2    | .26    |
| Number of orthographic neighbors*     | 2.66    | 4.43    | 20     | 0_20        | 2.81      | 4.65   | 20     | 0_20        | .89    |
| Orthographic uniqueness point*        | 4.81    | 2.13    | 10     | 0_10        | 5.03      | 2.56   | 9      | 0_9         | .72    |
| Conceptual familiarity (1-5)**        | 2.21    | 0.85    | 3.48   | 1.07_4.55   | 2.65      | 0.98   | 3.79   | 1.18_4.97   | .07    |
| Imageability (1-5)***                 | 4.43    | 0.36    | 1.32   | 3.64_4.96   | 4.24      | 0.48   | 1.72   | 3.24_4.96   | .10    |
| Image variability (1-5)**             | 2.72    | 0.64    | 2.45   | 1.85_4.3    | 2.61      | 0.62   | 2.42   | 1.65_4.07   | .49    |
| Concreteness (1-5)***                 | 4.6     | 0.34    | 1.27   | 3.64_4.91   | 4.68      | 0.34   | 1.95   | 3.05_5      | .36    |
| Emotional valence (1-5)***            | 3.26    | 0.73    | 3.24   | 1.32_4.56   | 3.1       | 0.67   | 2.84   | 1.52_4.36   | .36    |

\* Values taken from Lexique (www.lexique.org; New, Pallier, Brysbaert, & Ferrand, 2004).

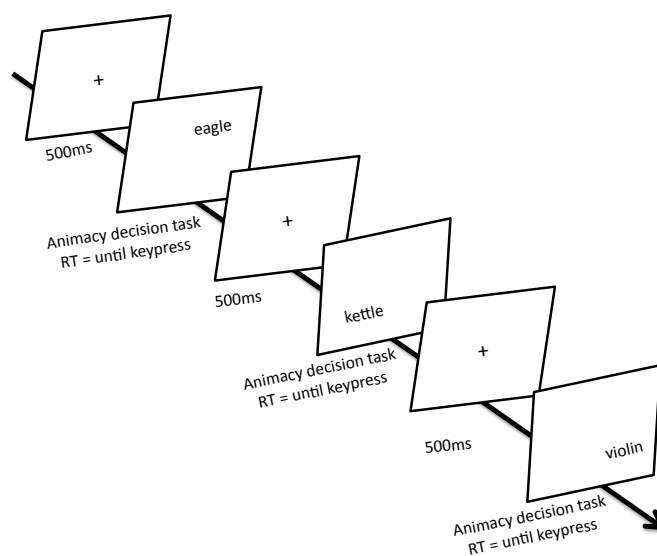
\*\* 5-point scales, with values obtained from Bonin, Peereman, Malardier, Méot, & Chalard (2003) and from Alario and Ferrand (1999).

\*\*\* 5-point scales, with values obtained from Bonin, Méot, Aubert, Malardier, Niedenthal, & Capelle-Toczec (2003).

*Procedure.* Participants were tested two at a time and were seated comfortably in a quiet room. They were not informed that the experiment involved memory but were merely told to read each word carefully. The words were presented on a Macintosh computer running the Psyscope v.1.2.5 software (Cohen, MacWhinney, Flatt, & Provost, 1993).

Figure 1 illustrates the structure of the learning phase. For each participant, the 64 words were presented randomly in a different order and in a different location on the screen. There were four possible locations corresponding to the four corners of the screen. As in Bonin et al. (2014), the participants were given a brief definition of "animate" versus "inanimate" (e.g., an animate item is capable of self-propelled motion whereas an inanimate item is not) at the beginning of the experiment. They were then told that they would see a series of words and would have to decide whether each word referred to an animate or an inanimate item. We also made sure that animate and inanimate items occurred equally often

in each screen position. However, they were not told to pay attention to where the words appeared on the screen. The learning phase was followed by two interference tasks lasting about 5 minutes: the 'X-O' letter-comparison task (Salthouse, Toth, Hancock, & Woodard, 1997) and the 'plus-minus' task (from Jersild, 1927, and Spector & Biederman, 1976). After completing these two tasks, participants performed a memory test for screen position. This consisted of a recognition test with a set of 128 words (64 targets and 64 fillers), presented randomly in the middle of the screen, with no time limit. For each word, participants had to indicate whether or not they recognized it from the set presented previously by pressing a key. For each word they recognized, they indicated where it initially appeared on the screen (top left, top right, bottom left or bottom right). The next word appeared immediately after they had given this information or indicated that they had not recognized the word. After the 128 test words had been presented, the participants were thanked and debriefed. The experiment lasted about 20 minutes.



**Figure 1.** Structure of the learning phase in Study 1.

## Results

*Encoding times.* Inanimate words took significantly longer to categorize ( $m = 1289.63$  msec,  $sd = 789.56$ ) than animate words ( $m = 1209.88$ ,  $sd = 777.44$ ),  $t(33) = 2.24$ ,  $p < .05$ ,  $d = .20$ .

*Item memory.* The hit rates, corrected hit rates, false alarm rates and A' measures (Neath & Surprenant, 2003) for both animate and inanimate words are shown in Table 2. The dependent variable of item memory was based on hits minus false alarms. We also computed a nonparametric discrimination index from signal detection theory (A', e.g., Donaldson, 1992). Below, we report the results on the A' index only. (The results for corrected hit rates, i.e., hits minus false alarms, and false alarms can be found in the Supplemental materials [Annexe 1 p. 221]).

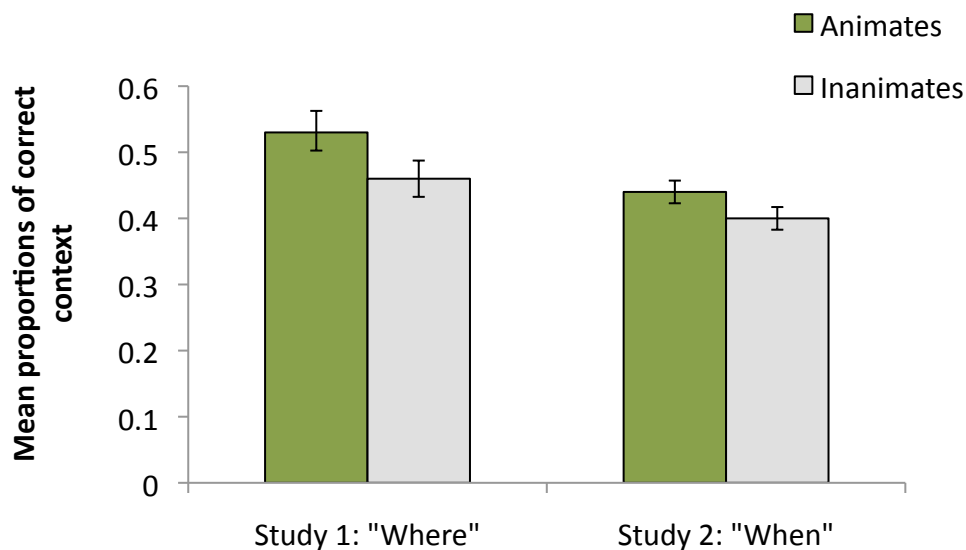
Animate words were recognized better than inanimate words,  $t(33) = 5.12$ ,  $p < .001$ ,  $d = .98$  (according to Cohen, 1988,  $d > .80$  is a large effect).

**Table 2.** Hit rates, corrected hit rates, false alarm rates and A' as a function of type of word in Studies 1 and 2. Standard deviations are provided in parentheses.

|                 | Study 1   |                     |                   |           |
|-----------------|-----------|---------------------|-------------------|-----------|
|                 | Hit rates | Corrected hit rates | False alarm rates | A'        |
| Inanimate words | .68 (.14) | .60 (.16)           | .08 (.06)         | .88 (.06) |
| Animate words   | .80 (.09) | .74 (.11)           | .06 (.07)         | .93 (.04) |
|                 | Study 2   |                     |                   |           |
|                 | Hit rates | Corrected hit rates | False alarm rates | A'        |
| Inanimate words | .69 (.16) | .60 (.16)           | .09 (.09)         | .88 (.06) |
| Animate words   | .78 (.11) | .69 (.15)           | .09 (.09)         | .91 (.05) |

*Memory for context.* To assess contextual memory performance, we used the conditional source identification measure (Murnane & Bayen, 1996), which is based on correctly recognized items only and therefore does not confuse item memory and contextual memory. For each participant, we calculated the number of animate versus inanimate words for which the contextual information was correctly identified, i.e., #context animates versus #context inanimates (for example, one participant correctly identified the location on the screen of 14 animate and 8 inanimate words). We then examined the corresponding number of hits for animates (#hits animates) and inanimates (#hits inanimates) (e.g., the participant correctly recognized 27 animate and 18 inanimate words). Finally, we computed the proportion of animates whose contextual information had been correctly identified, i.e., #context animates/#hits animates, and the proportion of inanimates whose contextual information had been correctly identified, i.e., #context inanimates/#hits inanimates.

For these correctly recognized items, the mean proportion of correct judgments for screen position made by each participant was .49 ( $sd = .15$ ). Importantly, accuracy for contextual information differed significantly from chance level (25%),  $t(33) = 9.09$ ,  $p < .001$ .



**Figure 2.** Mean proportions and standard errors of correct context as a function of Type of word (animates versus inanimates) and Type of context ("Where": Study 1 and "When": Study 2).

As can be seen in Figure 2, there was a significant difference between animates ( $m = .53$ ,  $sd = .19$ ) and inanimates ( $m = .46$ ,  $sd = .16$ ),  $t(33) = 2.58$ ,  $p < .05$ ,  $d = .42$ .

### Discussion of Study 1

The findings on encoding times are fully consistent with previous data on animacy effects. As in Bonin et al. (2014) and VanArsdall et al. (2013), animates were categorized faster than inanimates (see also Gelin et al., 2017). We also replicated the finding of better recognition for animates than inanimates. Finally, and more importantly given the purpose of the study, the findings regarding memory for context are consistent with those observed with the Remember/Know paradigm in Bonin et al. (2014). Thus, animacy effects in memory are supplemented by the recall of contextual details, here screen position. Many studies of memory for contextual information are interested in different types of contextual details. The next study thus involved memory for temporal information associated with animates versus inanimates.

## **Study 2: temporal context, when?**

To our knowledge, no study has as yet explored memory for temporal information in the context of adaptive memory. However, from an adaptive perspective, it also seems important to remember the temporal context of fitness-related information. For example, it is important for hunters to remember not only where potential prey come to drink water, but also *when* they usually come. Hence, it could be predicted that temporal information would be remembered better when it is related to animates than to inanimates.

### **Method**

*Participants.* Thirty-eight students at the University of Bourgogne took part in the study in exchange for course credits, but only 34 (30 women, 4 men, mean age 20.97 years, range 17-25) were included in the analyses (see below). None were taking medication known to affect the central nervous system and all were native French speakers.

*Stimuli.* The same word stimuli as in Study 1 were used.

*Procedure.* The procedure was the same as in Study 1 except that the words always appeared in the center of the screen, alongside a text indicating "beginning of the presentation," "middle of the presentation", or "end of the presentation". The participants were told that they would see a series of words and would have to decide whether each word referred to an animate or an inanimate item. However, they were not instructed to attend to the items' temporal position. They then completed the same two interference tasks used in Study 1, lasting approximately 5 minutes. Finally, they were tested for their memory. First, they had to indicate whether each word was "old" (i.e., they recognized it from the initial phase of the experiment) or "new". Next, in order to evaluate the temporal dimension of contextual memory, the participants were asked to indicate whether an "old" word had appeared at the beginning, in the middle or at the end of the presentation. As in the previous study, care was taken to ensure that animate and inanimate words occurred equally often in each temporal order. The next word appeared as soon as they had given this information, or indicated that they did not recognize the word. After all the test words had been presented, participants were thanked and debriefed. The whole experiment lasted about 20 minutes.

## Results and Discussion of Study 2

*Encoding times.* Participants took significantly longer to categorize inanimate ( $m = 1481.12$  msec,  $sd = 544.40$ ) than animate words ( $m = 1326.95$ ,  $sd = 466.34$ ),  $t(33) = 4.11$ ,  $p < .001$ ,  $d = .30$ .

*Item memory.* The hit rates, corrected hit rates, false alarm rates and A' measures for animate and inanimate words are shown in Table 2. Here also, animates were recognized better than inanimates,  $t(33) = 2.48$ ,  $p < .05$ ,  $d = .54$ .

*Memory for context.* Memory for context was measured as in the previous study. The mean proportion of correct context judgments made by each participant was .42 ( $sd = .07$ ). Context accuracy differed significantly from chance level, which was .33,  $t(33) = 7.68$ ,  $p < .001$ . For each participant, we computed the proportions of animate and inanimate words in memory for context. There was a significant difference between animates ( $m = .44$ ,  $sd = .10$ ) and inanimates ( $m = .40$ ,  $sd = .10$ ),  $t(33) = 2.06$ ,  $p < .05$ ,  $d = .50$  (see Figure 2).

As in Study 1, not only were animates categorized faster than inanimates, but they were also recognized better. Finally, they were also better localized in the temporal context of their presentation.

## General Discussion

According to the adaptive view of memory, evolutionary pressures encountered in the distant past sculpted our memory systems to retain fitness-related information (Nairne, 2010, 2015). Animates have greater fitness value than inanimates, and they should therefore be remembered better. This advantage of animates over inanimates has been replicated several times, by different research teams (e.g., Aslan & John, 2016; Bonin et al., 2014; VanArsdall et al., 2013). The findings of the current studies once again confirm the robustness of animacy effects. Moreover, as in previous studies (Bonin et al., 2014), animates were recognized better than inanimates when the animate items were displayed for a short time<sup>3</sup>. However, one

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<sup>3</sup> Readers may have noticed that the rating times were longer in Study 2 than in Study 1. However, a supplementary analysis run on the rating times from the two studies, with Type of context and Type of word included as factors, revealed that rating times did not reliably differ between the two studies. The only reliable effect was that of Type of word,  $F(1,66) = 20.52$ ,  $p < .001$ . In any case, as previously suggested (Bonin et al., 2014), the rating times indicate that the animacy effect in recognition cannot be due to

important aspect of animacy effects in memory that had not previously been examined was whether they would be found in memory for context; adopting an evolutionary framework suggests that they should be. We conducted two studies to assess the recollection of spatial information (i.e., screen location in Study 1) and temporal information (i.e., within-list temporal location in Study 2) related to animate versus inanimate items. We found that both types of information were remembered better when they were related to animates than to inanimates<sup>4</sup>. It is important to stress that these findings in memory for context occurred even though the words were processed quickly and that encoding was incidental, two conditions that have sometimes been shown to impede memory for context (Brewer, Marsh, Clark-Foos, & Meeks, 2010; Meiser & Sattler, 2007).

In sum, the present research increases our knowledge about animacy effects in memory by providing evidence that animacy effects persist in memory for context. Skeptical readers might think that a potential limitation of our findings lies in the fact that we chose an animacy categorization task at encoding. This task could give participants a clue about the nature of the upcoming memory test. Moreover, if participants encoded items stressing the animacy dimension, animate words could be more congruent with the encoding context and consequently remembered better, because congruency is known to improve memory (Craig & Tulving, 1975)<sup>5</sup>. However, we do not think that our findings are undermined by the choice of an animacy-inanimacy categorization task at encoding for the following reasons. First, before beginning the categorization task, the participants were given a brief definition of what is meant by animate and inanimate. Thus, animates were not given greater emphasis than inanimates. Secondly, an animacy effect has been obtained in previous studies (e.g., Bonin et al., 2015; Gelin et al., 2017; VanArsdall et al., 2013) in which intentional learning was used

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animates being processed for a longer time than inanimates. (However, the results of such a joint analysis should be interpreted with caution, as participants were not fully randomized across all conditions.)

<sup>4</sup> Interestingly, a supplementary analysis of the contextual recollection scores from the two studies with Type of context and Type of word included as factors revealed that the memory advantage of animates over inanimates was similar across both types of contextual information (the animacy factor was significant,  $F(1, 66) = 10.88$ ,  $p < .001$ , as was the Context factor,  $F(1, 66) = 6.74$ ,  $p < .05$ , whereas the interaction between Type of context and Type of word was not,  $F < 1$ ). Power analysis revealed that in order for an (interaction) effect of this size to be detected (80% chance) as significant at the 5% level, a sample of 298 participants would be required. (As mentioned in Footnote 3, the results of such a joint analysis should be interpreted with caution, as participants were not fully randomized across all conditions.)

<sup>5</sup> We thank James Nairne for bringing our attention to this interpretation of animacy effects in our studies. Supplemental Material The Supplemental Material can be found at the address (online address to be filled in)

and in which attention was not drawn to the animacy dimension. Thirdly, if, for whatever reason, the participants became aware of the future memory test during the specific encoding task used in the current studies, and if this led animates to be remembered better than inanimates, then why were there no reliable differences in false alarm rates between animate and inanimate items in the two studies (the results can be found in the Supplemental materials [Annexe 1, p. 221]). If greater attention was drawn to animate items during encoding, one would expect a bias towards false recognition of animates during the recognition phase. Fourthly, we computed  $B''D$  as an index of bias (Donaldson, 1992) in both studies. The difference between animates (Study 1:  $B''D = .59$ ; Study, 2:  $B''D = .48$ ) and inanimates (Study 1:  $B''D = .68$ ; Study, 2:  $B''D = .59$ ) was not significant in either study (Study 1:  $t(33) = -1.19$ , ns; Study 2:  $t(33) = -1.37$ , ns). Thus, the participants were not biased more towards animate than inanimate items.

It is important to stress that the present studies are the first in the field of adaptive memory to report animacy effects on context memory. Earlier studies on adaptive memory focused on survival processing and item memory. They found that processing items (words or pictures) in relation to survival issues (e.g., judging whether a *bottle* is useful for collecting food, or for protecting oneself from predators) for just a few seconds led to a memory boost compared to processing the same items in relation to non-survival issues (e.g., judging whether a *bottle* is useful when moving to a foreign country; is pleasant) (see Bonin & Bugajska, 2014; Nairne & Pandeirada, 2016 for reviews). Even though boundary conditions have been identified for survival processing effects (e.g., they are not found with stories [Seamon et al., 2012], faces [Savine, Scullin, & Roediger, 2011], or in implicit memory tasks [Tse & Altarriba, 2010]), the survival processing advantage and animacy effect appear to be robust empirical phenomena. Regarding the survival processing advantage, Nairne (2016) indicated that it has been widely replicated, since it was found reliable in 106 out of 132 published studies. Animacy effects are more recent in the memory literature, and more work is thus needed to gain an overview of their robustness. So far, only one study (Popp & Serra, 2016) has found a reverse animacy effect in cued-recall, which suggests that there are other boundary conditions for these effects that need to be identified in future studies.

What remained unclear was whether the survival processing advantage extended to context memory. As reviewed in the Introduction, some earlier studies failed to find a survival processing advantage in memory for contextual information (Bröder et al., 2011; Nairne et al., 2010). However, these studies were criticized on the grounds that they lacked ecological



validity (Nairne et al., 2012). What is striking, however, is that in our current studies we found that contextual information linked to animates was better remembered than contextual information linked to inanimates, even though we used a procedure to test context memory that was similar to those used by Bröder et al. (2011) and Nairne et al. (2010). In Bröder et al.'s (2011) Experiment 1, individual words were presented in one of 16 squares displayed on the computer screen, while in their Experiment 2 and in Nairne et al.'s (2010) study, there were only two screen locations (bottom or top in Bröder et al., 2011, and left or right in Nairne et al., 2010). Thus, our experiments could also be criticized on the grounds that they lacked ecological validity, and we acknowledge that our findings do not allow firm conclusions to be drawn, insofar as they did not test for contextual information related to dangerous animals (e.g., where was the snake) or enemies. We suggest that contextual memory may be more difficult to assess within the context of survival processing. However, other studies have found evidence for contextual information when processing items related to survival issues (Nairne et al., 2012; New et al., 2007), for example, evolutionarily dangerous animals such as snakes (Wilson et al., 2011), or in a mating context (Maner et al., 2007). Here, we found animacy effects in memory for context relating to both spatial *and* temporal information. However, as far as survival effects are concerned, it is important to note that no study to date has tested whether processing survival-related items leads to better memory of contextual temporal information. Finally, although there is evidence suggesting that animacy effects are episodic in nature (Bonin et al., 2014) and rely on proximate mechanisms related to imagery (Bonin et al., 2015; Popp & Serra, 2016), survival processing effects seem to be more difficult to define. They appear to be unique in that they are not reducible to another form of deep encoding (Nairne et al., 2015), and also, importantly, because their precise underlying proximate mechanisms have not as yet been clearly identified (Nairne, Cogdill, & Lehman, 2017).

We believe that the finding that animacy effects persist in memory for context is very important as it strengthens the ultimate explanation of animacy effects. However, even for researchers who do not adhere to the evolutionary-functional account of animacy effects, the animacy variable cannot simply be ignored, because it accounts for a significant amount of variance in memory performance and plays as important a role as imageability, which is acknowledged to be a major factor that must be controlled for when designing memory experiments (Nairne et al., 2013). Thus, at the very least, animacy is a factor that should be taken into account for methodological reasons. The influence of animacy in memory is a

relatively new discovery in the memory literature, and, even though some research work has been devoted to the proximate mechanisms underpinning animacy effects (e.g., Bonin et al., 2015; Popp & Serra, 2016; VanArsdall et al., in press), future studies are clearly needed in order to achieve a better understanding of how exactly these effects come about.

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## Chapitre 2 : Mécanismes proximaux à l'origine de l'effet animé en mémoire

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### Introduction

#### 1. Explications proximales : définition et présentation des mécanismes proximaux testés dans l'effet animé

Les premières études sur l'effet animé en mémoire (Bonin, Gelin, & Bugajska, 2014 ; Nairne et al., 2013, VanArsadall et al., 2013) avaient pour objectif d'établir la robustesse de cet effet en faisant varier le matériel utilisé ainsi que la procédure. Les résultats témoignaient d'un effet robuste, qui apparaissait quelque soit (1) le type d'apprentissage (intentionnel : Nairne et al., 2013, VanArsadall et al., 2013 ou incident : Bonin et al., 2014) ; (2) le type de matériel (des mots : Nairne et al., 2013, des non-mots : VanArsadall et al., 2013, ou des images : Bonin et al., 2014) ; (3) la tâche de récupération (du rappel libre : Nairne et al., 2013, VanArsadall et al., 2013, ou de la reconnaissance : Bonin et al., 2014).

Ces études mettaient principalement l'accent sur les explications ultimes de l'effet animé en mémoire, à savoir l'importance primordiale des entités animées pour la survie de l'espèce humaine. A ce propos, il nous semblait pertinent de rappeler que, sans ces explications ultimes, l'effet animé n'aurait peut être pas encore été découvert. En effet, c'est en adoptant une démarche de psychologues évolutionnistes que Nairne et ses collaborateurs ont mis en évidence l'effet animé en mémoire. D'après eux, si la mémoire a évolué à des fins d'adaptation, il devait en découler un avantage pour des items importants pour notre survie, les entités animées notamment.

Cependant, pour avoir une vision globale de l'effet animé en mémoire, et plus généralement pour accroître les connaissances sur le fonctionnement mnésique humain, il était nécessaire de se pencher sur les mécanismes proximaux à l'œuvre dans l'effet animé. Les mécanismes proximaux (ou explications proximales) correspondent aux soubassements cognitifs qui permettent l'apparition d'un comportement. Dans le domaine de la mémoire, différents mécanismes peuvent expliquer que certains items soient mieux mémorisés que d'autres. On peut citer l'organisation des connaissances en mémoire (Hunt & Einstein, 1981), l'élaboration à l'encodage ( Craik & Lockhart, 1972), le traitement en référence à soi (Rogers

et al., 1977), l'imagerie mentale (Brewer & Pani, 1996)... ou encore la mobilisation de plusieurs de ces mécanismes.

En ce qui concerne l'effet animé, une explication proximale pourrait être liée à la facilité de catégorisation des entités animées contrairement aux inanimées. En effet, les entités animées, telles que définie par Gelman et Spelke (1981), font toutes partie de la catégorie sémantique des animaux, alors que les inanimés renvoient à des catégories sémantiques beaucoup plus variées (e.g., les outils, les vêtements, les instruments de musiques, les meubles...). Il est donc possible que les participants organisent les items animés en catégories beaucoup plus facilement que les inanimés. Cette stratégie déployée lors de l'encodage pourrait être à l'origine d'une meilleure accessibilité en mémoire des entités animées. En effet, il est établi depuis longtemps que la structure organisationnelle des stimuli impacte significativement leur mémorisation (Hunt & Einstein, 1981). Ainsi, il est possible qu'en empêchant la mise en place de cette stratégie, l'effet animé soit éliminé voir même inversé. Dans une série d'études, VanArsdall et al. (2017) ont testé cette hypothèse en modifiant « l'environnement » d'encodage, de sorte à diminuer la probabilité qu'une stratégie catégorielle soit utilisée pendant le rappel. Aussi avaient-ils pris soin de contrôler le matériel à mémoriser sur des variables telles que la typicalité catégorielle et la taille des catégories sémantiques d'appartenance des mots. Leur procédure expérimentale consistait à demander aux participants de mémoriser 24 mots, dont 8 étaient des items cibles (4 animés et 4 inanimés). En fonction des études, les mots cibles étaient soit issus de catégories sémantiques variées, soit de deux catégories uniquement (e.g., des animaux à quatre pattes et des meubles). Les autres mots étaient des distracteurs, choisis au hasard, permettant d'atténuer la saillance catégorielle des items cibles. Les participants effectuaient trois essais, avec à chaque fois 24 mots différents, de sorte à ce qu'ils aient tous traité les 24 mots cibles, 12 animés et 12 inanimés, à la fin des trois essais. A l'issue de chaque essai, ils effectuaient une tâche interférente puis 4 minutes de rappel libre. Les résultats montraient un effet animé global significatif, ainsi qu'un effet animé pour chacun des trois essais. Ils remettaient donc en cause l'hypothèse catégorielle comme explication proximale de l'effet animé en mémoire. De plus, les scores de regroupement catégoriel (en anglais : *ARC scores*, Roenker, Thompson, & Brown, 1971), qui permettent de quantifier la tendance des participants à rappeler ensemble des items d'une même catégorie sémantique, ne différaient pas de 0 pour cette étude. Contrairement à ce que supposait l'hypothèse d'organisation catégorielle, VanArsdall et al.



(2017) ont donc observé que l'effet animé persistait bien qu'aucune stratégie de regroupement catégoriel ne soit utilisée.

D'autres mécanismes proximaux ont été invoqués pour expliquer la priorité accordée aux entités animées dans des tâches mnésiques. Popp et Serra (2016) proposent, par exemple, la capture attentionnelle et l'« éveil » (en anglais : *arousal*). Pour eux, la relation entre le caractère animé et la mémoire n'est pas directe (c'est-à-dire que le caractère animé n'est pas une propriété intrinsèque des concepts qui serait directement associée à une meilleure mémorisation), elle serait plutôt indirecte. Le caractère animé capte l'attention et produit un éveil attentionnel qui engendre un traitement cognitif permettant une meilleure mémorisation. Ceci expliquerait qu'ils obtenaient un effet facilitateur du caractère animé en rappel libre, mais inhibiteur avec une procédure de rappel indicé. Pour évaluer le rappel indicé, les auteurs ont utilisé des paires de mots (Animé-Animé ; Inanimé-Inanimé ; Animé-Inanimé ; Inanimé-Animé) et ont observé une diminution des performances de mémoire pour les 3 types de paires comportant un animé. Ils ont alors proposé que si l'attention des participants était attirée par l'un des mots de la paire (en l'occurrence un mot renvoyant à une entité animé) plutôt que sur l'association des deux mots, alors les performances de mémoire s'en trouvaient altérées.

Les pistes que nous avons choisi d'explorer, à propos des mécanismes proximaux à l'œuvre dans l'effet animé, sont de deux types. D'abord, nous voulions savoir dans quelle mesure l'effet animé était dépendant ou non des ressources cognitives. Ensuite, nous nous sommes focalisés sur l'imagerie mentale comme stratégie spontanément mise en place dans la mémorisation des entités animées. Popp et Serra (2016) ont proposé que le caractère animé capte l'attention et produit un éveil attentionnel qui engendre un traitement cognitif permettant l'augmentation des performances de mémoire. Nous proposons, dans les études qui suivent, que le traitement cognitif en question relève de l'imagerie mentale. En effet, de nombreux psychologues considèrent que l'imagerie mentale (représentation cérébrale mémorisée ou imaginée d'un objet physique, d'un concept, d'une idée, ou d'une situation) joue un rôle clé dans la mémorisation (Brewer & Pani, 1996). L'apport des neurosciences sur ce thème ne fait que renforcer cette idée, montrant que des lésions des zones connues pour sous-tendre l'imagerie visuelle peuvent avoir comme conséquence secondaire une altération des performances mnésiques (Conway & Fthenakis, 2000 ; Greenberg & Rubin, 2003).

## 2. Principaux objectifs et résultats des Articles 3 et 4

Dans l'Article 3, nous nous sommes focalisés sur le « comment » de l'effet animé au travers de 4 études. Nos objectifs étaient d'une part, d'étudier la question de la dépendance ou de l'indépendance de l'effet animé vis-à-vis des ressources cognitives, et d'autre part, de tester, comme explication proximale, l'imagerie interactive, c'est-à-dire la capacité à s'imaginer mentalement en interaction avec l'élément à mémoriser. Nos principales conclusions se sont trouvées être en cohérence avec l'hypothèse de mécanismes indépendants des ressources cognitives (l'effet animé persiste en condition de charge cognitive) et avec celle la contribution de l'imagerie interactive dans cet effet. En effet, nous avons pu constater que l'instruction d'imagerie interactive (s'imaginer mentalement en interaction avec l'objet ou l'être vivant désigné par le mot présenté) améliorerait de façon globale les performances de mémoire. Mais surtout, cette instruction augmentait significativement la mémorisation des mots renvoyant à des entités inanimées. Finalement, l'imagerie interactive ne profite pas de la même façon aux entités animées et inanimées, si bien qu'il n'y avait pas de différence significative dans les taux de rappel des items animés entre la condition contrôle (instruction de catégorisation en terme vivant/non vivant) et celle d'imagerie interactive. Pour autant, l'effet animé était présent dans les deux conditions d'encodage, ce qui signifie que l'imagerie interactive, à elle seule, ne suffit pas à expliquer l'effet animé.

Dans l'Article 4, nous avons choisi d'approfondir la piste de l'imagerie mentale comme explication proximale de l'effet animé en mémoire. Pour cela, considérant les résultats obtenus avec l'imagerie interactive, nous avons choisi d'imposer aux participants de se faire une représentation mentale, statique, des concepts désignés par les mots qui leur étaient présentés. L'imagerie interactive est inévitablement de l'imagerie mentale associée à un mouvement. Les entités animées renvoyant à tous les objets vivants capables d'auto-propulsion (Di Giorgio et al., 2016), nous pourrions penser qu'il est plus facile de générer une image mentale dynamique pour ce type d'entité, plutôt que pour des entités n'ayant pas la possibilité de bouger. On ne peut donc pas exclure que la primauté des entités animées soit liée au caractère dynamique des images mentales qu'elles engendrent. En effet, avoir une image mentale dynamique signifie aussi avoir une représentation en mémoire plus riche, car les informations liées au mouvement sont autant d'éléments venant enrichir la représentation mentale et la qualité des traces mnésiques (Hargreaves, Pexman, Johnson, & Zdrzilova, 2012). Si l'effet animé est uniquement lié au fait d'avoir une image mentale dynamique des

entités animées, alors, les statufier devrait affecter leur rappel. Or, les résultats que nous avons obtenus avec cette procédure de statufication étaient tout à fait comparables à ceux obtenus avec l'imagerie interactive. Pour finir, afin de confirmer les résultats précédents, nous avons utilisé une procédure classique d'imagerie mentale, qui n'imposait rien de particulier aux participants, si ce n'est de créer mentalement une représentation imagée des concepts désignés par les mots qui leur étaient présentés.

Aussi, nous avons vérifié le lien entre l'effet animé et des caractéristiques du matériel : la vivacité des images mentales engendrées par les mots (qui renvoie à la précision de l'image mentale) et leurs degrés d'interaction corps-objet. Les résultats de ces études vont clairement dans le sens d'une mobilisation spontanée de l'imagerie mentale pour les entités animées, et ce, indépendamment des caractéristiques du matériel.

## Article 3

### The “How” of Animacy Effects in Episodic Memory

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Bonin, P., Gelin, M., Laroche, B., Méot, A., & Bugaiska, A. (2015). The “how” of animacy effects in episodic memory. *Experimental Psychology*, 62, 371–384.

**Abstract.** Animates are better remembered than inanimates. According to the adaptive view of human memory (Nairne, 2010; Nairne & Pandeirada, 2010a, 2010b), this observation results from the fact that animates are more important for survival than inanimates. This ultimate explanation of animacy effects has to be complemented by proximate explanations. Moreover, animacy currently represents an uncontrolled word characteristic in most cognitive research (VanArsdall, Nairne, Pandeirada, & Cogdill, 2015). In four studies, we therefore investigated the “how” of animacy effects. Study 1 revealed that words denoting animates were recalled better than those referring to inanimates in an intentional memory task. Study 2 revealed that adding a concurrent memory load when processing words for the animacy dimension did not impede the animacy effect on recall rates. Study 3A was an exact replication of Study 2 and Study 3B used a higher concurrent memory load. In these two follow-up studies, animacy effects on recall performance were again not altered by a concurrent memory load. Finally, Study 4 showed that using interactive imagery to encode animate and inanimate words did not alter the recall rate of animate words but did increase the recall of inanimate words. Taken together, the findings suggest that imagery processes contribute to these effects.

**Keywords.** adaptive memory, episodic memory, animacy

Imagine that, while walking in a forest, you suddenly come across a snake. You will probably remember this event better the next time you follow the same path than a special stone perceived along the same route. Also, if when alighting at the station in an unknown city, a heterosexual man sees a woman whom he finds very attractive, he will also remember this event better than a modern building he admired along the way. In these two fictitious examples, animate things are better remembered than inanimate things. In the first example, the ultimate goal of your behavior is to save your life, whereas in the second, the man's goal might be to find a mate in order to transmit his genes. Although people are not usually aware of these (deep) ultimate goals, they are nevertheless expressed in individuals implementing a series of proximate mechanisms.

By animates, we mean living things that are capable of independent movement and can suddenly change direction without warning. Although the literature provides evidence showing that animates are better remembered than inanimates, the discovery that animacy is a potent mnemonic variable has only recently been reported (see below), but how exactly does this happen? The present article addresses this important issue.

In the present study, we endorse the view championed by Nairne and colleagues (Nairne, 2010; Nairne & Pandeirada, 2008, 2010a, 2010b) according to which our current memory functioning is the product of selective pressures that our distant ancestors faced in during the Pleistocene era, that is to say that the characteristics of episodic memory should “bear the imprints of the specific selection pressures that shaped their development” (Nairne & Pandeirada, 2010a, p. 977). According to this view, information related to survival issues is preferentially processed ahead of other types of information, with the result that the former is better remembered than the latter. This adaptive memory view is supported by two different, but related, lines of evidence: survival-processing effects and animacy effects.<sup>1</sup>

In a series of experiments, Nairne and colleagues (e.g., Nairne, Pandeirada, & Thompson, 2008; Nairne, Thompson, & Pandeirada, 2007) have shown that when participants are instructed to rate a series of unrelated words for their relevance to an imagined grassland

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<sup>1</sup> In fact, there is a third line of evidence favoring the adaptive memory view which is related to contamination, but to date, there is less work on this issue than on both survival processing and animacy. Indeed, remembering whether an item or a person has been contaminated is clearly adaptive (and avoiding things or people potentially contaminated has long been a critical issue in our deep past). Nairne (2015) recently reported a study in which his research team found that, in a free-recall test, contaminated items (touched by a sick person) were better remembered than non-contaminated items (touched by a healthy person).

survival scenario, their long-term retention (as indexed, for instance, by performance in a subsequent surprise free-recall test) is enhanced in this survival situation compared to other deep encoding control conditions (e.g., scenarios such as moving to a foreign country). This basic finding has been replicated in many studies using different participants and items (Bonin & Bugaiska, 2014; Schwartz, Howe, Toggia, & Otgaar, 2013 for reviews). Although certain boundaries to the observation of the survival-processing advantage have been identified (e.g., Kroneisen & Erdfelder, 2011; Savine, Scullin, & Roediger, 2011; Tse & Altarriba, 2010), it is a robust phenomenon which has been interpreted as evidence in support of the adaptive view of memory. According to this view, human memory systems have been selectively tuned during our ancestral past to process and retain information that is relevant for fitness.

The animacy effect in memory corresponds to the observation that animate things (e.g., *a dog, a baby*) are better remembered than inanimate things (e.g., *a lamp, a mountain*). Although reports of this effect are more recent than those of the survival-processing effect, it also seems to be a robust effect. It has been found with nonwords associated with animate versus inanimate properties (VanArsdall, Nairne, Pandeirada, & Blunt, 2013), in word paired-associate learning (VanArsdall et al., 2015), with words (Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013), and with picture stimuli (Bonin, Gelin, & Bugaiska, 2014). In the present study, we considered the question of animacy effects in episodic memory in order to shed light on the issue of how these effects arise. Thus far, the animacy effect in episodic memory has been accounted for by assuming that animates are more important in terms of fitness value than inanimates. In effect, animates can be predators, prey, or potential sexual mates. It must be stressed that such an explanation relates to the ultimate causes of this effect. However, the animacy effect is certainly underpinned by specific memory processes (i.e., proximate mechanisms) that have not as yet been identified. The aim of the present study was therefore to characterize and to identify the proximate mechanisms that give rise to animacy effects in long-term memory.

It should be noted that in cognitive science in general, there are several sources of evidence that support the idea that animates receive priority in processing. In the domain of perception, it has been shown that animate stimuli (e.g., animals, human faces) capture visual attention more quickly and hold attention longer than inanimate stimuli (Abrams & Christ, 2003; Johansson, 1973; New, Cosmides, & Tooby, 2007; Öhman, Flykt, & Esteves, 2001; Öhman, Lundqvist, & Esteves, 2001; Pratt, Radulescu, Guo, & Abrams, 2010; Van Hooff,

Crawford, & van Vugt, 2011). The distinction between animates and inanimates would be at the core of the building of conceptual representations in infancy (Opfer & Gelman, 2011) and in adults, animacy would be still a critical dimension in the organization of conceptual knowledge (Caramazza & Mahon, 2003; Caramazza & Shelton, 1998). Also, in psycholinguistics, the animacy dimension affects the process of sentence comprehension (Clifton et al., 2003; Lowder, & Gordon, 2012). Finally, in neurosciences, several substrates of animate processing have been identified (e.g., Gobbini et al., 2011).

As far as the survival effect is concerned, certain researchers have claimed that, given that it can be accounted for by proximate mechanisms (e.g., self-encoding, richness of encoding), an evolutionary account of these effects has to be dismissed. However, as explained by Nairne (2013), this assumption may be due to a failure to distinguish between proximate and ultimate causes in the explanation of the survival-processing advantage. As Nairne says (2013), ultimate explanations are “statements about the function of a trait and ‘why’ it would have been selected by nature during an evolutionary process” while proximate explanations “focus on the mechanisms that produced the trait – that is, they are statements about “how” the trait works and the condition under which the trait is likely to be expressed.” (p. 309). It should be remembered that proximate and ultimate causes are complementary, not competing, levels of explanation and that both are necessary for a complete explanation of an effect (Buss, 2010).

In sum, the aim of the present study was to investigate proximate mechanisms that may underlie the animacy effect on episodic memory, namely what we have referred to as the “how” of animacy effects. Until now, only ultimate explanations of animacy effects have been considered while proximate explanations have only been alluded to. Although animacy is a variable that is rarely, if ever, controlled in cognitive research, it nevertheless happens to be an important mnemonic variable. By applying regression techniques to the Rubin and Friendly (1986) recall rates for five word lists comprising 157 animate words plus a random selection of 157 inanimate words, Nairne et al. (2013) found that the animacy variable was a strong predictor of recall (the two other most important predictors of recall rates were imagery and concreteness). As a result, even if one completely rejects the evolutionary framework, he/she should still be concerned with animacy effects and its proximate causes.

The first study was aimed at replicating and generalizing the original finding reported by Nairne et al. (2013) that animates are better remembered than inanimates in an explicit (intentional) learning task, while using a new (and different) set of words. Little such research

on this memory effect has been conducted in the past and a replication is warranted and has even been strongly encouraged (Roediger III, 2012). We considered two candidate proximate mechanisms that have been claimed to underpin survival- processing effects and which have been assumed to be resource-dependent: elaboration and richness-of-encoding. Three other studies were therefore designed to test the hypothesis that animacy effects are sustained by resource- dependent mechanisms. In Studies 2-3A and 3B, we used a memory-load paradigm to test the hypothesis that animacy effects are due to the involvement of the process of elaboration. In Study 4, we tested the interactive imagery account of animacy effects by making use of interactive imagery. The precise rationale of Studies 2, 3, and 4 will be provided below in the introductions to each study.

### **Study 1: Animacy Effects in an Intentional Learning Task**

There have been relatively few studies of animacy effects and these effects have primarily been found in tasks where the animacy dimension was made explicit to the participants (e.g., Bonin et al., 2014, but see Nairne et al., 2013), which can be thought of as inducing a potential bias. Thus, although evidence for animacy effects in explicit memory tasks exists, it is relatively scarce. Additional evidence of animacy effects in tasks where the animacy dimension is not made explicit to the participants is therefore necessary. Our study differs from Nairne et al.'s (2013) in both the stimuli used and the procedural details (see Method below) and hence *is not an exact replication*. The observation of animacy effects in Study 1 will therefore extend the generality of the original finding.

#### **Method**

*Participants.* Thirty students (3 males, mean age 19.6 years) at the University of Bourgogne participated in the study. All participants received course credits for their participation. None were taking medication known to affect the central nervous system.

*Stimuli.* Twenty-eight nouns were selected from the Snodgrass and Vanderwart (1980) and Bonin, Peereman, Malardier, Méot, and Chalard (2003) databases. Each word referred to either an animate or an inanimate object. (The categorization of the nouns into animates and inanimates was initially done by the authors of the paper. As a further check of the reliability of our classification, we asked five independent adults to classify the nouns used in Studies 1–



3 and in Study 4 with a 3-point scale (1 = *clearly referring to an animate*, 2 = *ambiguous*, 3 = *clearly referring to an inanimate*). We found that the agreement between the five raters was perfect [Fleiss'  $\kappa = 1$ ] and in full agreement with our classification.)

The words were divided into two sets of 14 items matched for the *surface variables* of number of letters and bigram frequency; the *lexical variables* of book and subtitle frequency, age-of-acquisition, number of orthographic neighbors, orthographic uniqueness point; and the *semantic variables* of conceptual familiarity, imageability, image variability, concreteness, and emotional valence. Overall, our stimuli were controlled on a set of 12 variables, six of which were also controlled for in Nairne et al.'s (2013) original study. The statistical characteristics of the words are provided in Table 1. We did not use the translated equivalents of Nairne et al.'s items (2013), indeed only three words (two animates and one inanimate) were common to the two studies.

**Table 1.** Statistical characteristics (mean, standard deviations, range, minimum-maximum, t-tests of the means) of the control variables for animate and inanimate stimuli.

|                                       | Animate  |          |        |              | Inanimate |          |        |             | t-test |
|---------------------------------------|----------|----------|--------|--------------|-----------|----------|--------|-------------|--------|
|                                       | Mean     | SD       | Range  | Min-max      | Mean      | SD       | Range  | Min-max     |        |
| Number of letters*                    | 6.14     | 1.81     | 7      | 3_10         | 6         | 1.77     | 6      | 4_10        | .84    |
| Bigram frequency (per million words)* | 8,823.21 | 2,898.64 | 9,396  | 4,058_13,454 | 9,358.14  | 3,124.96 | 1,1616 | 2360_13976  | .65    |
| Book frequency*                       | 22.29    | 46.64    | 186.35 | 0.61_186.96  | 20.63     | 43.96    | 175.13 | 0.07_175.2  | .93    |
| Subtitle frequency*                   | 31.94    | 61.3     | 188.2  | 0.21_188.2   | 17.38     | 39.27    | 154.07 | 0.06_154.13 | .48    |
| Age-of-acquisition (1-5)**            | 2.44     | 0.75     | 2.6    | 1.15_3.75    | 2.81      | 0.91     | 2.97   | 1.23_4.2    | .26    |
| Number of orthographic neighbors*     | 3.43     | 3.92     | 13     | 0_13         | 3         | 3.93     | 10     | 0_10        | .78    |
| Orthographic uniqueness point*        | 5        | 2.2      | 10     | 0_10         | 4.07      | 2.02     | 8      | 0_8         | .27    |
| Conceptual familiarity (1-5)**        | 2.39     | 0.79     | 2.83   | 1.07_3.90    | 2.74      | 0.84     | 3.34   | 1.63_4.97   | .29    |
| Imageability (1-5)***                 | 4.28     | 0.38     | 1.28   | 3.64_4.92    | 4.05      | 0.51     | 1.56   | 3.24_4.8    | .20    |
| Image variability (1-5)**             | 2.77     | 0.72     | 2.45   | 1.85_4.3     | 2.51      | 0.61     | 2.22   | 1.85_4.07   | .33    |
| Concreteness (1-5)***                 | 4.59     | 0.28     | 0.77   | 4.09_4.86    | 4.57      | 0.46     | 1.81   | 3.05_4.86   | .93    |
| Emotional valence (1-5)***            | 3.33     | 0.55     | 1.96   | 2.48_4.44    | 3.04      | 0.6      | 1.92   | 2.2_4.12    | .21    |

\*Values taken from Lexique (<http://www.lexique.org>; New, Pallier, Brysbaert, & Ferrand, 2004).

\*\*All the scales are 5-point scales. The values were obtained from Bonin, Peereman, et al. (2003) and from Alario and Ferrand (1999).

\*\*\*All the scales are 5-point scales. The values were obtained from Bonin, Méot et al. (2003).

*Procedure.* The participants were tested individually and were seated comfortably in a quiet room. They were informed that the experiment involved memory, but they were not given information about the different types of words (i.e., animates vs. inanimates) that would be presented. During the encoding phase, the words were presented on a Macintosh computer

running the Psyscope v.1.2.5 software (Cohen, MacWhinney, Flatt, & Provost, 1993) at the rate of 3 s per word. The words were presented to each participant in a different random order. The participants were told to read the words carefully in order to remember them for a test that would be administered later. The test phase was introduced following two interference tasks: the “X-O” letter-comparison task (Salthouse, Toth, Hancock, & Woodard, 1997) and the “plus-minus” task (from Jersild, 1927, and Spector & Biederman, 1976). These two interference tasks lasted for 5 min. After these two interference tasks, the participants were asked to recall in writing as many of the words they could remember from the learning phase during a period of 5 min.

### **Results of Study 1**

Replicating the results of Nairne et al. (2013), the proportion of animate words correctly recalled ( $m = .49$ ,  $SD = 0.16$ ) was higher than that of inanimate words ( $m = .37$ ,  $SD = 0.14$ ),  $t(29) = 3.81$ ,  $p < .001$ . The raw data can be found in the Electronic Supplementary Materials 1 (ESM 1 [Annexe 2, p. 222]). The analysis on the number of intrusions showed no significant difference between animate ( $m = .33$ ,  $SD = 0.80$ ) and inanimate words ( $m = .43$ ,  $SD = 0.93$ ),  $t(29) = .55$ ,  $p > .10$ . For this and the following experiments, we used the same 3-point scale as described above in the Stimuli section on a new group of five independent raters in order to ensure that our classification of intrusive words into animates and inanimates was not biased. Across all studies, the agreement between the five raters was almost perfect (Fleiss’  $\kappa = .97$ ). However, there were three words (*pied* [foot], *fleur* [flower], *salamandre* [salamander]) for which the raters did not agree. For all studies, the analysis on the number of intrusions with these ambiguous words excluded revealed exactly the same results as those including them.

### **Discussion of Study 1**

We found a reliable animacy effect in free-recall when participants were explicitly required to learn words. As mentioned above, this outcome replicates and extends previous findings obtained in a factorial experiment and a multiple regression analysis (Nairne et al., 2013). In effect, when they reanalyzed the Rubin and Friendly (1986) data and included animacy as a predictor variable in a multiple regression analysis, Nairne et al. (2013) found that animacy accounted for a large part of the variance in predicting recall. They further found

a strong animacy effect in recall rates in a factorial experiment in which participants were asked to try to remember each presented word.

## **Study 2: Elaboration as a Proximate**

Mechanism for Animacy Effects Survival-processing effects in long-term memory have been accounted for in terms of elaboration (Erdfelder & Kroneisen, 2013). According to this hypothesis, processing items for their survival value would require more elaborative effort than when the same items are processed following other instructions related to control scenarios such as moving to a foreign land. In other words, more information would be added when processing items in survival than in non-survival encoding contexts, with the result that the retrieval cues for their recall would be more effective. Some researchers have shown that adding a cognitive load (e.g., a memory load; an auditory continuous choice reaction time task) eliminated survival effects (Kroneisen, Rummel, & Erdfelder, 2014; Nouchi, 2013, but see Stillman, Coane, Profaci, Howard, & Howard, 2014). Since elaboration is assumed to be a cognitive resource-demanding process, the observation that survival effects were no longer found following the addition of a secondary task has been interpreted as providing support for the hypothesis that these effects are underpinned by deliberative mechanisms such as elaboration (Nouchi, 2013). In the next experiment, we tested the hypothesis that elaboration could be one of the mechanisms responsible for animacy effects. It is possible that animates are better integrated in more complex frameworks than inanimates, for instance with multiple (episodic) contexts becoming more readily linked to the former than the latter. To give an illustration, when processing the animate word “zebra,” more episodic contexts may come to mind (e.g., a beautiful zebra that I saw in a zoo last year during my holidays; a zebra I recently saw while watching a TV documentary, or a picture of a zebra in a book my daughter read last month) than when processing the word “kettle” whose corresponding object can be remembered without the need for any specific details to be associated with it apart from the fact that the object is present in the kitchen. It is also possible to hypothesize that relational (or inter-item) processing is more efficient in the case of animates than inanimates because animates are easier to assign to different categories, such as “four-legged animals” or “people’s property” for example, than inanimates, which vary more across categories (this specific issue is addressed in the General Discussion). We used a secondary memory-load paradigm similar to that used by Nouchi (2013). As found for survival-processing effects, if

animacy effects are underpinned by elaboration then, since elaboration is thought to be a resource-dependent mechanism, these effects should no longer be observed (or should be drastically reduced) when a secondary task is added.

Animate entities are capable of independent movement, are able to suddenly change course without direction, and can occasionally initiate violent actions that may result in injury, or even death. Thus, the failure to detect an animate item (e.g., a snake) can be detrimental to an individual's fitness. Animates can also be friends, enemies, or potential mates who are therefore potentially of relevance for survival and reproduction. It is reasonable to hypothesize that animate items are processed by attentional processes that involve less attentional effort than inanimates. According to New et al.'s (2007) animate monitoring hypothesis, these processes are adaptively tuned in such a way that important features of the environment are captured quickly and automatically. Indeed, animacy is an important environmental dimension that seems to be processed very quickly (New et al., 2007). Thus, in our study, it is indeed possible that animate words capture more quickly attention at the time of encoding. Therefore, the performance on the secondary task should be better when inanimate words are presented.

## **Method**

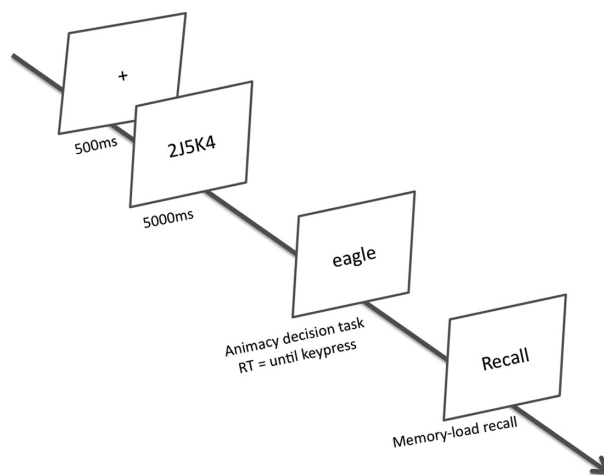
*Participants.* A group of 31 students (5 males, mean age 21.10 years) from the University of Bourgogne took part in the experiment in exchange for course credits. They were all native French speakers. Once again, none of the participants were taking medication known to affect the central nervous system.

*Stimuli.* The same word stimuli as in the previous study were used.

*Procedure.* The participants were tested individually seated comfortably in a quiet room. The animate-inanimate categorization task and the memory-load condition were within-participant factors. As in the Bonin et al. (2014) study, the participants were given a brief definition of what is meant by “animate” versus “inanimate” (e.g., an animate item can move autonomously whereas an inanimate item cannot) at the beginning of the experiment. They were further told that they would have to decide as quickly as possible whether a series of words referred to an animate or inanimate item.

The structure of an experimental trial is illustrated by Figure 1. A ready signal (+) was displayed in the middle of the screen for 500 ms. In the memory-load condition, a sequence

comprising five letters and numbers (e.g., 1B8J7) was then presented for 5,000 ms. (The same sequence of letters and numbers never appeared twice.) The participants were asked to remember this sequence of items until recall appeared on the screen. In the no-load condition, exactly the same procedure was used except that instead of a sequence of numbers and letters, the participants saw the word WHITE presented on the screen and were told that they would have to recall this word later. Then, in both conditions, a word (animate vs. inanimate) was displayed in the middle of the screen and the participants had to indicate as quickly as possible whether it referred to an animate or an inanimate item by pressing a corresponding key. (The words were presented in a random order.) The word remained on the screen until the participant responded and the time taken to respond was recorded. After each decision, the word “recall” appeared on the screen and the participants had to say aloud the sequence of letters and numbers. They then pressed the space bar to go on to the next trial. The actual oral responses to each series of trials in the memory-load condition were recorded online by the experimenter. At the end of each participant’s experimental session, the different “memory-load responses” were coded for accuracy.



**Figure 1.** Structure of an experimental trial in Studies 2, 3A, and 3B.

The two memory-load conditions were blocked with the result that half of the participants began with the memory-load condition and the other half with the no-load memory condition. Moreover, for each type of word (animate and inanimate words), half (seven words) were accompanied by a memory load whereas the other half (seven words) were not.

After all the words had been categorized (with and without a memory load), the participants performed the same two interference tasks as used in the previous studies. Then, after 5 min had elapsed, they were given a surprise free-recall task.

## Results of Study 2

Concerning performance on the secondary task, each entire sequence that was correctly recalled was coded one and otherwise zero. The results showed that the sequences comprising five letters and numbers were recalled less well when they were associated with animate words ( $m = 4.87$ ,  $SD = 1.65$ ) than inanimate words ( $m = 5.61$ ,  $SD = 1.23$ ),  $t(30) = -2.07$ ,  $p < .05$ . With regard to categorization times<sup>2</sup> in the encoding task (see Table 2), neither the main effects nor the interaction was significant, all  $F_s < 1$ .

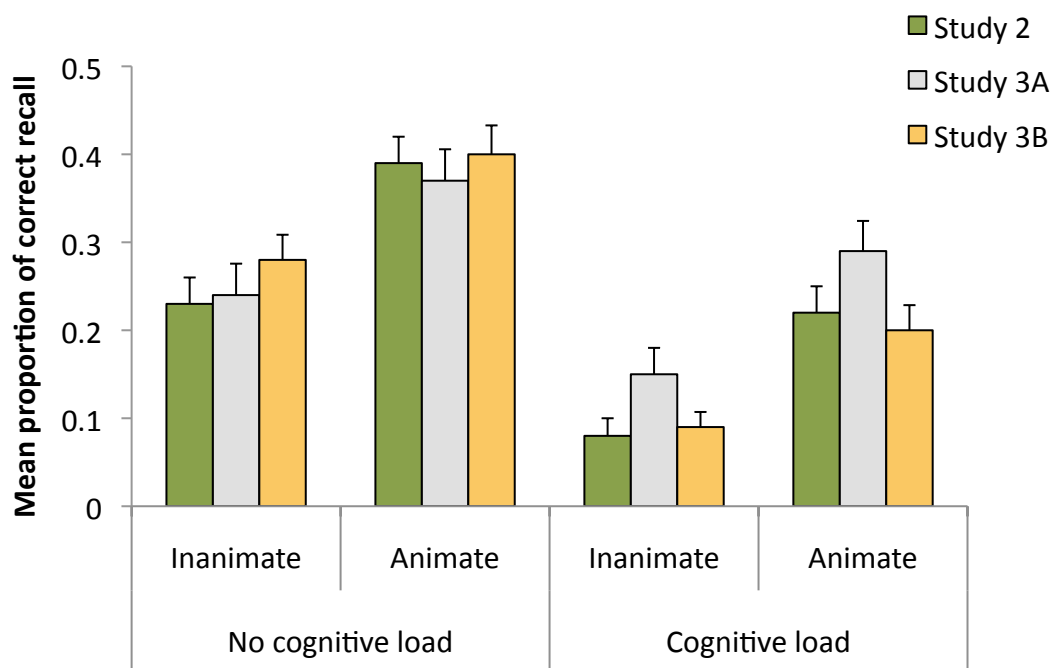
**Table 2.** Mean categorization times as a function of the different encoding conditions and type of words in Studies 2, 3, and 4. Standard deviations are provided in parentheses.

|                 | No cognitive load | Cognitive load           |
|-----------------|-------------------|--------------------------|
| <b>Study 2</b>  |                   |                          |
| Inanimate words | 1,374.29 (421.66) | 1,411.09 (376.51)        |
| Animate words   | 1,333.29 (346.36) | 1,380.44 (363.43)        |
| <b>Study 3A</b> |                   |                          |
| Inanimate words | 1,350.28 (348.81) | 1,459.57 (453.75)        |
| Animate words   | 1,277.95 (354.52) | 1,402.11 (433.73)        |
| <b>Study 3B</b> |                   |                          |
| Inanimate words | 1,282.62 (365.56) | 1,547.72 (438.94)        |
| Animate words   | 1,206.43 (294.74) | 1,474.22 (489.32)        |
|                 | Animacy task      | Interactive Imagery task |
| <b>Study 4</b>  |                   |                          |
| Inanimate words | 1,198.84 (274.15) | 3,256.78 (1,327.90)      |
| Animate words   | 1,078.32 (248.96) | 3,266.74 (1,299.18)      |

Figure 2 summarizes the results for the correct recall proportions for animates versus inanimates as a function of memory load in the current study and the two studies presented below. More words were recalled in the no-load condition than in the load condition,  $F(1, 30) = 26.04$ ,  $p < .001$ ,  $\eta_p^2 = .46$ . Also, as shown in Figure 2, more animate words than inanimate

<sup>2</sup> Given that mean RTs are sensitive to outliers, we also performed all the analyses involving categorization times using the medians. Across experiments, the results with the medians were very similar to those reported for the means.

words were recalled,  $F(1, 30) = 40.74, p < .001, \eta_p^2 = .58$ . The interaction between Encoding condition and Type of words was not significant,  $F < 1$ .<sup>3</sup> As far as the number of intrusions is concerned, there was a significant difference between animate and inanimate words,  $t(30) = 2.06, p < .05$ , with more intrusions being observed on inanimate words ( $m = .64, SD = 1.11$ ) than on animate words ( $m = .32, SD = 0.65$ ). (Even though the counterbalancing was not complete in this study, when the task completion order was introduced in the design, there was no main effect of this factor or interaction with it. Importantly, the results were exactly the same as those reported immediately above.) The raw data can be found online (see ESM 2 [Annexe 3, p. 223]).



**Figure 2.** Mean proportions and standard errors of correct recall as a function of encoding condition (no cognitive load vs. cognitive load) and Animacy (animate vs. inanimate stimuli) in Study 2, Study 3A and 3B.

### Discussion of Study 2

The findings from Study 2 show that adding a memory load during the processing of animate and inanimate words did not impede animates from being memorized better than

<sup>3</sup> We found the same pattern of results with the categorization times (z-transformed) and the scores obtained in the secondary task introduced as covariates in the analyses.

inanimates. In contrast, we found that animates were still remembered better than inanimates, even though the cognitive load manipulation was successful, as the generally deleterious effect on the overall level of recall compared to the no-load condition shows. It may be asked whether the decision to use an animacy-inanimacy categorization task at encoding had the effect of drawing attention more to animates than to inanimates. However, it is important to remember that, before the beginning of the categorization task, the participants were given a brief definition of what is meant by animate *and* inanimate. Animates were therefore not stressed more than inanimates. (Indeed, this was also the case in VanArsdall et al.'s (2013) study.) Moreover, it is important to stress that the animacy effect has been obtained in previous studies (e.g., VanArsdall et al., 2013), as well as in Study 1 which involved intentional learning and in which attention was not drawn to the animacy dimension.

Elaboration has been assumed to be a cognitive resource-demanding process (Kroneisen et al., 2014) and has been considered to be a potential candidate mechanism underlying animacy effects. Given the pattern of results obtained in Study 2, elaboration does not therefore seem to be one of the mechanisms responsible for mediating animacy effects. However, as suggested by the findings concerning performance on the secondary task, there seems to be an attentional component in the animacy effect at the time of encoding: Animates capture more attention than inanimates. Given the importance of the findings of Study 2, before discussing them further, we wanted (1) to replicate this pattern of findings, and importantly, (2) to test whether they would persist with a greater memory load. In effect, it could be argued that the load manipulation used in Study 2 was not extreme enough. We think that we would be in a better position to argue that elaboration may not be involved in animacy effects in episodic memory if we could replicate the finding that animates are recalled better than inanimates in response to a more extreme load manipulation that further reduces the likelihood of effective elaboration. In Study 3, we therefore ran two follow-up experiments: Study 3A was an exact replication of Study 2 and Study 3B was the same as Studies 2 and 3A but with a greater load manipulation.

### **Study 3: Further Tests of Elaboration as a Proximate Mechanism for Animacy Effects**

In the previous study, animacy effects were still reliable when a secondary task was added. This result (Study 2) suggests that the memory mechanisms giving rise to animacy



effects are relatively independent of cognitive resources. However, given the strong theoretical implications of this finding, we designed the following two studies. Study 3A was an exact replication of Study 2 whereas Study 3B was an extension of Studies 2 and 3A since the procedure was the same, except for the fact that the difficulty of the secondary task was increased. In effect, the use of a memory load comprising five letters and numbers as in Clarys' study (Clarys, Isingrini, & Haerty, 2000) could have been insufficient to reliably alter participants' short-term memory capacity and cognitive resources. Thus, in Study 3B, the number of items that participants had to retain was increased to seven. Because it has been assumed that elaboration requires cognitive resources (Kroneisen et al., 2014), the observation of reliable animacy effects in both Study 3A and Study 3B under memory-load conditions would reinforce the hypothesis that elaboration might not be involved in the emergence of animacy effects in memory.

### **Study 3A: Exact Replication of Study 2**

#### **Method**

*Participants.* Twenty-eight students from the University of Bourgogne took part in the experiment (7 males, mean age 19.36 years). As in the previous study, they were given course credits for their participation. They were all native French speakers and none were taking medication known to affect the central nervous system.

*Stimuli.* The same word stimuli as in the previous study were used.

*Procedure.* The procedure was strictly the same as that used in Study 2.

#### **Results of Study 3A**

Performance on the secondary task was coded in the same way as in Experiment 2. The number of sequences correctly recalled did not vary significantly between animates ( $m = 5.54$ ,  $SD = 1.35$ ) and inanimates ( $m = 5.68$ ,  $SD = 1.16$ ),  $t(27) = -.72$ ,  $p > .10$ .

As far as categorization times are concerned (see Table 2), neither the main effect of Encoding condition nor the interaction between Encoding condition and Type of words was significant,  $F(1, 27) = 3.15$ ,  $p > .05$  and  $F < 1$ . In contrast, the main effect of Type of words

was significant, with animate words being categorized faster than inanimate words,  $F(1, 27) = 4.81, p < .05, \eta^2_p = .15$ .

Turning to free-recall, as illustrated by Figure 2, more words were recalled in the no-load condition than in the load condition,  $F(1, 27) = 4.86, p < .05, \eta^2_p = .15$ . Also, more animate than inanimate words were recalled,  $F(1, 27) = 22.07, p < .001, \eta^2_p = .45$ . The interaction between Encoding condition and Type of words was not reliable,  $F < 1$ .<sup>3</sup>

Finally, the number of intrusions was not significantly different between animate ( $m = .32, SD = 0.61$ ) and inanimate words ( $m = .61, SD = 0.87$ ),  $t(27) = -1.77, p > .05$ . The raw data can be found online (see ESM 3[Annexe 4, p. 226]).

### **Study 3B: Extension of Study 2 With a Higher Memory Load**

#### **Method**

*Participants.* Thirty-two students (4 males, mean age 19.81 years) from the University of Bourgogne took part in the experiment. As in the previous experiments, they were given course credits for their participation. They were all also native French speakers and none were taking medication known to affect the central nervous system.

*Stimuli.* The same word stimuli as in the previous experiments were used.

*Procedure.* The procedure was the same as in Study 2 except for the memory load used. Here, a sequence comprising seven letters and numbers (e.g., 5K4L9I8) was presented to participants in the memory-load condition.

#### **Results of Study 3B**

Performance in the secondary task was coded in the same way as in Studies 2 and 3A. As in Study 3A, the results (i.e., correct performance) for the secondary task showed no significant difference between animate ( $m = 2.00, SD = 1.59$ ) and inanimate words ( $m = 1.78, SD = 1.54$ ),  $t(31) = .73, p > .10$ . Regarding the time taken to perform the encoding task (Table 2), the main effects of Encoding condition and Type of words were significant. Animate words were categorized faster than inanimate words,  $F(1, 31) = 8.29, p < .01, \eta^2_p = .21$ , and the participants were faster in the no-load condition than in the load condition,  $F(1, 31) =$

26.52,  $p < .001$ ,  $\eta_p^2 = .46$ . The interaction between Encoding condition and Type of words was not significant,  $F < 1$ .

The free-recall scores are presented in Figure 2. More words were significantly recalled in the no-load condition than in the load condition,  $F(1, 31) = 59.13$ ,  $p < .001$ ,  $\eta_p^2 = .59$ . Also, there was an effect of Type of words, with more animates being recalled than inanimates,  $F(1, 31) = 21.94$ ,  $p < .001$ ,  $\eta_p^2 = .51$ . The interaction between Encoding condition and Type of words was not significant,  $F < 1$ .<sup>3</sup>

The number of intrusions was significantly smaller for animate ( $m = .25$ ,  $SD = 0.44$ ) than inanimate words ( $m = .65$ ,  $SD = 0.82$ ),  $t(31) = -3.22$ ,  $p < .01$ . The raw data can be found online (see ESM 4 [Annexe 5, p. 229]).

### **Discussion of Study 3**

In Study 2, animacy effects were still reliable when a secondary task was added. This finding suggests that the memory mechanisms giving rise to animacy effects are *relatively* independent of cognitive resources. However, we wanted to gather more empirical data in order to substantiate our claim. Therefore, two additional studies were performed. Study 3A was an exact replication of Study 2 and Study 3B was an extension of Studies 2 and 3A in which the difficulty of the secondary task was increased. The findings on recall rates from both Studies 3A and 3B are clear-cut. More animate words than inanimate words were recalled in the exact replication of Study 2. More importantly, exactly the same finding was observed in Study 3B when the concurrent memory load was increased. It is important to stress that the increase in the memory load in Study 3B was successful as revealed by the secondary-task performance. In effect, the number of correctly reported sequences of letters and digits (computed over animates and inanimates) dropped to 1.89 out of 7 (which is the maximum possible number of correct responses), whereas it was 5.24 and 5.61 in Studies 2 and 3A respectively. There was therefore no indication of any modulation of animacy effects due to increased memory load in the encoding task. Contrary to the finding of Study 2 concerning performance on the secondary task, where it was observed that animates yielded a lower score than inanimates (suggesting that attention may have contributed to animacy effects), Studies 3A and 3B did not reveal any significant modulation of the secondary-task performance at the level of the animacy dimension. A direct comparison of the secondary-task performance across Studies 2, 3A, and 3B revealed a main effect of the memory-load factor,

$F(2, 88) = 95.89, p < .001, \eta^2_p = .69$ , with the impact of the memory load used in Study 3B being stronger than in Studies 3A and 2,  $t(88) = 13.83, p < .001$ , and no significant difference was observed between these latter two studies,  $t(88) = 1.19, p > .10$  (Note that, concerning the latter comparison, it would have been somewhat surprising to find a significant difference given that the memory load used in Studies 2 and 3A was exactly the same). The main effect of animacy was not significant,  $F(1, 88) = 1.18, ns$ . The interaction between “animacy” and “memory load” was nearly significant,  $F(2, 88) = 2.96, p = .056, \eta^2_p = .06$ . A close examination of this interaction confirmed that only in Study 2 was the secondary-task performance higher when it was accompanied by inanimate words than by animate words. The findings concerning the secondary-task performance as a function of animacy are therefore inconsistent across Experiments 2, 3A, and 3B. Given that the difference was in the same direction in Experiment 3B and in Experiment 2, even though it was not significant in Experiment 3B, we conducted a power analysis on the data of this latter experiment. This analysis revealed that the observed power was weak (.11 if the size of the observed difference is considered to be the true one). However, this analysis also revealed that about 330 participants would be required to obtain a power of .80 (one-tailed test).

If we now consider the categorization times, in line with Bonin et al.’s (2014) findings, animate words were categorized faster than inanimate words across studies even though the difference was not significant in Study 2. This trend is also consistent with findings in the literature showing that animates are detected faster than inanimates (New et al., 2007). Given that animates were recalled better than inanimates in spite of the fact that the participants self-exposed animates less time than inanimates, the above finding cannot therefore be attributable to animates taking more time to process than inanimates.

Taken as a whole, the findings from Studies 2 and 3 strongly suggest that the memory mechanisms giving rise to animacy effects are relatively independent of cognitive resources. However, this should not be taken to mean that evolved mechanisms, in general, are automatic. In effect, as claimed by Barrett, Frederick, Haselton, and Kurzban (2006), the use of cognitive load in experiments should not be taken as a litmus test for evolved mechanisms because “automaticity” is not a mandatory component of evolutionary accounts. We will return to this issue in the General Discussion.

## **Study 4: Richness of Encoding and Interactive Imagery as a Proximate Mechanism for Animacy Effects**

Kroneisen et al. (2014) have claimed that the survival-processing advantage in memory is due to the fact that it involves a powerful set of domain-general encoding processes, that is, elaboration and distinctive processing, which are not present at such level in control conditions. Both elaboration and distinctive processes are assumed to be resource-dependent. In one study, Kroneisen, Erdfelder, and Buchner (2013) tested the hypothesis that survival-processing effects in memory are due to the richness of encoding. According to this hypothesis, in a survival context, the survival-relevance rating task leads participants to implicitly think about different possible uses of objects.

As a result, more distinctive and unique memory representations of the items are produced during encoding in the survival scenario than in the other deep encoding control scenarios used. These memory traces provide a large number of potential retrieval cues at the time of memory tests. In line with the richness-of-encoding account of the survival-processing advantage, Kroneisen et al. (2013) found that the survival-processing effect vanished when an interactive imagery task was used compared to a classical relevance-rating task. Here we adopted the imagery-interactive task used by Kroneisen et al. (2013). However, the reasoning that led Kroneisen and colleagues to their predictions concerning the effect of interactive imagery instructions on the survival-processing effect does not transfer directly to animacy effects. In Study 4, our aim was to test the hypothesis that animate words trigger interactive imagery (of acts or the contexts in which they occur) more spontaneously and more easily than inanimates. Interactive imagery has been claimed to be a powerful mnemonic mechanism (e.g., Bower, 1970; Bower & Winzenz, 1970; Wilton, 2006). Using interactive imagery should have a beneficial influence on memory performance on both types of items. However, if interactive imagery is the mechanism that mediates animacy effects, explicit instructions to make use of interactive imagery would equate animate and inanimate words with regard to interactive imagery processing.

### **Method**

*Participants.* Fifty-six students (6 males, mean age 20.48 years) from the University of Bourgogne took part in the experiment in exchange for course credits. They were divided into

two groups according to the encoding condition (interactive imagery vs. animacy). None were taking any medication known to affect the central nervous system.

*Stimuli.* The word list was the same as that in the Bonin et al. (2014) study. Fifty-six nouns were divided into two lists of animate versus inanimate words.

*Procedure.* The participants were tested individually in a quiet room. They were randomly assigned to one of the two encoding conditions (interactive imaging vs. animacy rating). The instructions for the animacy-rating condition were the same as used in Study 2 and in the Bonin et al. (2014) study. The specific instructions used in the interactive imaging condition were very similar to those used in the Kroneisen et al. (2013, p. 497) study:

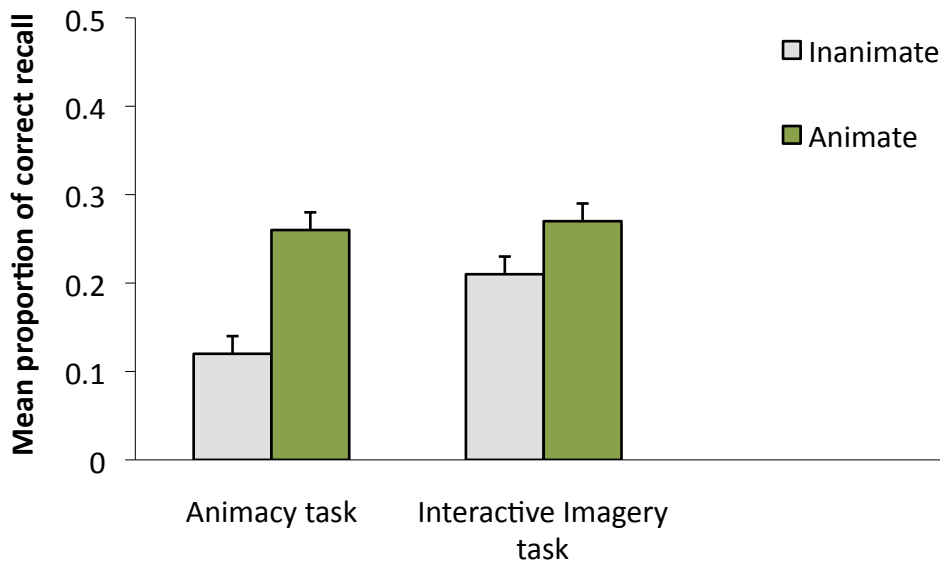
*“I am going to present you with a list of words. For each word, I am going to ask you to imagine A SITUATION in which you are interacting with the object, animal, or person to which the word refers. The situation in question can be real (refers to an object that you have already interacted with) or fictional (you have never interacted with this object, but it could happen). In addition, I want you to rate each word on a scale to indicate whether the task of imagining this interaction with the object, animal or person was easy or very difficult. In order to do this, you will have a 5 point scale, with 1 indicating “very difficult to imagine interacting with this object” and 5 indicating “very easy to imagine interacting with this object”. For example, if you see the word FORK, you could imagine yourself in your kitchen, using the fork to eat; if you see the word ZEBRA, you could imagine yourself in a zoo, feeding the zebra, etc.”*

#### **Results of Study 4**

Animate words were not reliably categorized faster than inanimate words,  $F(1, 54) = 2.46, p > .10, \eta_p^2 = .04$  (see Table 2). The words in the animacy condition were categorized significantly faster than the words in the interactive imagery condition,  $F(1, 54) = 71.74, p < .001, \eta_p^2 = .57$ . The interaction effect between the two factors failed to reach significance,  $F(1, 54) = 3.42, p > .05, \eta_p^2 = .06$ .

As far as the ratings in the interactive imagery condition are concerned, animates received lower scores ( $m = 3.42, SD = 0.66$ ) than inanimates ( $m = 3.61, SD = 0.59$ ),  $t(28) = -2.17, p < .05$ . However, the difference in the time taken to make these ratings for animates ( $m$

= 3,267,  $SD = 1,299$ ) and inanimates ( $m = 3,257$ ,  $SD = 1,328$ ) was not significant,  $t(27) = .15$ ,  $p > .10$ .



**Figure 3.** Mean proportions and standard errors of correct recall as a function of encoding condition (animacy task vs. interactive imagery task) and Type of words (animate vs. inanimate words) in Study 4.

More words were correctly recalled in the interactive imagery condition than in the animacy condition,  $F(1, 54) = 7.86$ ,  $p < .01$ ,  $\eta^2_p = .13$ . Also, more animate words were recalled correctly than inanimate words,  $F(1, 54) = 54.28$ ,  $p < .001$ ,  $\eta^2_p = .50$ . Finally, the interaction between Encoding condition and Type of words was significant,  $F(1, 54) = 7.13$ ,  $p < .01$ ,  $\eta^2_p = .11$ . As shown in Figure 3, the difference between animates and inanimates was greater in the animacy condition than in the interactive imagery condition. The recall rate of animate words was similar in the interactive imagery and animacy conditions,  $t(54) = .52$ ,  $p > .10$ , whereas more inanimate words were recalled in the interactive encoding condition than in the animacy encoding condition,  $t(54) = 3.81$ ,  $p < .001$ . Interestingly, the results showed that the difference between animate and inanimate words was still reliable in the interactive imagery condition,  $t(27) = 3.36$ ,  $p < .01$ , thus indicating that animate words were again recalled better than inanimate words in this condition.<sup>4</sup> The analysis performed on the number of intrusions revealed no significant difference between the “animacy” group and

<sup>4</sup> When the times taken to perform the animacy versus interactive imagery task (z-transformed) were introduced as covariates in the analyses, the pattern of recall rates remained the same.

“interactive imagery” group,  $F(1, 54) = 2.78, p > .10$ . A significant effect of Type of words appeared: There were more intrusions on inanimate words ( $m = 1.27, SD = 1.71$ ) than on animate words ( $m = .66, SD = 1.01$ ),  $F(1, 54) = 10.42, p < .01$ . The raw data can be found online (see ESM 5 [Annexe 6, p. 232]).

#### **Discussion of Study 4**

The findings from Study 4 have important theoretical implications. Unlike the survival-processing effects, which are no longer observed when individuals process words using interactive imagery (Kroneisen et al., 2013), Study 4 revealed that the animacy effect on free-recall, though reliable, was reliably reduced in an interactive imagery condition. More importantly, the reduction of the animacy effect was entirely due to inanimates being better recalled when an interactive imagery strategy was used compared to a condition in which the participants were not made aware of this strategy. Also interestingly, the ratings in the interactive imagery condition were higher for inanimates than animates. Given that animates did not benefit from the interactive encoding procedure, this suggests that the processing of animate items triggers more the use of interactive imagery. Thus, interactive imagery has no effect on animate items in our study but instead increased performance on inanimates. Nevertheless, because inanimate words were not recalled in the same proportion as animate words in our interactive imagery condition, we can assume that another factor must be involved in the processing of animate words. Further studies will be needed in order to identify this additional factor.

The creation of interactive images from animate words was, however, estimated to be slightly more difficult than from inanimate words, even though this was not reflected in the time taken to create these visual images. We also found no evidence suggesting that attentional resources are allocated differently to animates compared to inanimates (Studies 2 and 3). Given the findings from Study 4, which suggest that interactive imagery contributes to animacy effects, one implication is that interactive imagery is resource-free. In the Introduction, we claimed that elaboration is thought to be a resource-demanding process. Some authors have proposed the idea that interactive imagery could be a form of elaboration (e.g., Willoughby, Wood, Desmarais, Sims, & Kalra, 1997). If this idea is correct, then our findings suggest that this type of elaborative processing is not resource-demanding.



## General Discussion

The finding that animates are remembered better than inanimates is new in the literature on episodic memory. It has been accounted for within the adaptive view of memory according to which the functional characteristics of human memory are the product of selective pressures encountered during our distant past (Nairne, 2010, 2013; Nairne & Pandeirada, 2010b). Because animate things have a stronger fitness value than inanimates, they are prioritized during processing and are remembered better. However, even if we are not concerned, and/or do not subscribe to the evolutionary account of these effects, it is nevertheless worthwhile examining the proximate mechanisms of animacy effects given that these effects represent a potent new variable in the memory literature. Indeed, the aim of the present study was to investigate the “how” of animacy effects in episodic memory. The findings obtained from a series of four studies are clear-cut and help delineate certain functional characteristics of the mechanisms underlying animacy effects.

First of all, we were able to replicate the findings initially reported by Nairne et al. (2013). Animacy is therefore a very important dimension that leads to better memory traces for animates than for inanimates. The memory-load studies showed that the memory mechanisms underlying animacy effects are not resource-demanding. It is important to remember that the survival-processing advantage has been found to be reliably modified by a memory-load manipulation (e.g., Nouchi, 2013) and that this has led certain researchers to claim that elaboration, which is a resource-demanding process, is a potential proximate mechanism of this memory effect (Kroneisen et al., 2013; Nouchi, 2013). The findings of Studies 2 and 3 do not fit well with a strong elaboration account of animacy effects. In Study 4, we aimed at testing the hypothesis that animate words trigger interactive imagery more spontaneously and more easily than inanimates. Although using interactive imagery should have a beneficial influence on memory performance on both types of items, the idea was that if interactive imagery is the mechanism that mediates animacy effects, the requirement to use interactive imagery would place animate and inanimate words on an equal footing. In line with this account, a key finding from Study 4 was that the animacy effect, although significant, was reliably reduced in the interactive imagery condition because the encoding of inanimates was boosted by the use of an imagery encoding strategy. By contrast, animates did not benefit from interactive imagery. It is important to stress that the animacy advantage was found with both concreteness and imageability controlled for. This finding rules out the idea

that animates may be better remembered than inanimates because the former are easier to represent by means of mental images (and/or are more concrete) than the latter. It is already clear that the survival and animacy effects are not mediated by exactly the same set of mechanisms.

While not completely ruling out the idea that the animacy effect might be due to an inherent property, yet to be identified, that makes animates easier to remember, we believed it is unlikely given the high number of dimensions that were controlled for in our studies. In sum, one important factor that helps to explain the advantage of animate words is interactive imagery. Furthermore, the findings of the memory-load studies are indicative that interactive imagery is resource-free. The influence of interactive imagery on animacy effects is consistent with the recent findings of VanArsdall et al. (2015) in paired-associate learning. One interesting aspect of their data was the finding that the animacy advantage remains strong in cued-recall regardless of whether people are more (Experiment 1) or less (Experiment 2) likely to output animate stimuli as incorrect responses, thus suggesting, as stated by VanArsdall et al. (2015), that “(...) *the locus of the animacy advantage is in the association itself. Animate concepts are simply easier to associate with matched stimulus terms.*” (p. 662). Given that a major role has been ascribed to interactive imagery in paired-associate learning (Bower, 1970), and because strong animacy effects are found in such tasks, it makes great sense to assume that imagery processes contribute to animacy effects.

Are animacy effects dependent on the type of tests used to assess long-term retention? Indeed, the type of measure used for assessing memory is a critical issue (see Tse & Altarriba, 2010 and Schwartz & Brothers, 2013 for discussions of this issue with reference to the survival-processing advantage). If animacy effects were to be found only in recall as found in earlier studies (Bonin et al., 2014; Nairne et al., 2013; VanArsdall et al., 2013), this would certainly represent a serious limitation. However, they have also been found in recognition hits (Bonin et al., 2014) and in an associative learning task involving paired-associate learning (VanArsdall et al., 2015).

Sceptical readers might think that animacy effects are just a function of the more organized nature of the animate items relative to the inanimate items. They may object to our favored evolutionary account of these effects which is dismissed by appealing to the fact that the “animate” condition provides participants with a related category (i.e., moving animals) in which one item may cue other items at the time of recall. We do not think that such an account of animacy effects is satisfactory for the following reasons. First of all, as reviewed

above, animacy effects have been found in memory tasks (e.g., recognition, paired-associate learning) in which it is less easy to rely on category-based organizational strategies. Second, VanArsdall et al. (2015) compared animate items with pieces of furniture (a very salient category) and strong animacy effects were still found. These findings thus make it difficult to argue that animate items provide special access to some kind of categorical information. Third, in the Nairne et al. (2013) study, the regression analyses showed strong animacy advantages and the recall values for these items were taken from the Rubin and Friendly (1986) recall rates in which randomly selected lists were used. The recall rates for the animate items were not taken from lists containing a high proportion of animate items. Fourth, the analyses of extra-list intrusions in the current studies showed that there were always more intrusions for inanimates than animates (but reliably so only in Studies 2, 3B, and 4), even when the animacy dimension was made explicit. This latter result does not fit well with an organizational hypothesis of animacy effects in free-recall because such a hypothesis would predict more intrusions on animate words. It is important to stress that there were about twice as many inanimate as animate intrusions. If anything, this therefore suggests that the organizational structure of the inanimates has a detrimental impact on the animacy effect. Finally, we examined the semantic similarity of the items within the animate and inanimate categories using the Normalized Google Distance (NGD). This measure is derived from the number of hits returned by the Google search engine for a given set of words (Cilibrasi & Vitanyi, 2007; Hutson & Damian, 2014). Words that co occur in the search space take on values close to zero, whereas those words that never co-occur take on infinite values. Using Google.fr, we computed NGD values for all pairs of animates and all pairs of inanimates. The average NGD value was 0.475 for the animate category and 0.482 for the inanimate category, and the difference was not significant,  $t(180) = .174, p > .10$ . Thus, the items in the animate category were not closer to one another than the items in the inanimate category.<sup>5</sup>

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<sup>5</sup> As suggested to us by one anonymous reviewer, one interesting possibility to account for animates being recalled better than inanimates is “output interference,” that is to say inanimates were recalled less than animates because they suffered from the recall of animates. We examined the serial recall of the words in the animacy-rating condition of Study 4 (we chose this particular condition for the analyses because it has been used several times in the literature, e.g., Bonin et al., 2014). The correlation coefficient between the position of a word in the recalled sequence and the percentage of participants recalling an animate at this position was  $.50, p < .05$ , which indicates that this percentage decreases with the position in which words were recalled. Descriptive statistics showed that most of the first three recalled items were animates (89%, 64%, and 82% in positions 1, 2 and 3, respectively). Importantly, in no position in the recall sequence were inanimates recalled by the majority of the participants. We found the same result when comparing the mean percentages of animates among the first  $n/2$  recalls made by each participant with the means among the last  $n/2$  recalls, where  $n$  corresponds to the total number of recalls made by the participant (for odd values of  $n$ , we did not count the word recalled at the median position). The difference

Given that we were able to identify a potential proximate mechanism – interactive imagery – that nicely accounts (at least in part) for animacy effects in memory, and because interactive imagery belongs to a powerful set of domain-general encoding processes (Bower, 1970), it might be argued that it challenges the evolutionary account of animacy effects. However, an evolutionary (ultimate) account of animacy effects cannot be dismissed simply because these effects can also be accounted for by proximate mechanisms (e.g., self-encoding, richness of encoding). In order to explain why animates are remembered better than inanimates, we must also look at the different kinds of mechanisms – qualified as belonging to domain-general encoding processes (e.g., elaboration, self-reference) – that are able to produce such a memory boost.

Before concluding, there are two important aspects that need to be discussed.

First of all, we wish to stress here that adopting a functional perspective to investigate memory is a very fruitful strategy because it helps to reveal findings, in this case animacy effects, which would perhaps otherwise have gone unnoticed (Nairne, 2005). Surprisingly, these effects have not previously been explored as a mnemonic dimension, unlike word characteristics such as word frequency or imageability, which have been frequently investigated (Nairne et al., 2013). Second, we have identified a proximate mechanism – interactive imagery – that mediates animacy effects in episodic memory. Moreover, we have found that a memory load did not alter these effects, thus leading us to suggest that this mechanism is relatively free of cognitive resources. However, this does not mean that evolved mechanisms, in general, possess the feature of automaticity, that is, they require no cognitive effort or are automatically prioritized. The idea that evolved mechanisms are necessarily automatic in their operation has been previously put forward in the literature (DeSteno, Bartlett, Braverman, & Salovey, 2002). However, as pointed out by Barrett et al. (2006), evolutionary psychologists invoke the central concept of functional specialization (Pinker, 1997) rather than referring to a particular list of function features such as automaticity. Evolutionary psychologists have clearly emphasized the *flexible nature of evolved processes*, and thus, evolved processes are not always automatically prioritized (Gonzaga, Haselton, Smurda, Davies, & Poore, 2008).

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in means was not significant,  $t(27) = 1.46, p > .10$ , and each mean percentage was above .50 (first  $n/2$  recalls:  $t(27) = 8.02, p < .001, m = .75$ ; last  $n/2$  recalls:  $t(27) = 4.72, p < .001, m = .68$ ), indicating that animates were recalled better than inanimates at both the beginning and the end of the recall sequence.

In conclusion, our findings help constrain theoretical interpretations of animacy effects in memory and strongly reinforce the conclusion that animacy is an important dimension that needs to be carefully taken into account in memory research.

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## Article 4

### Animacy effects in episodic memory and imagery processes

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**Abstract** Animates (e.g., *tiger*) are remembered better than inanimates (e.g., *stone*) because, according to an evolutionary account, the former are ultimately more important for fitness than the latter (e.g., animates can be dangerous animals). What, however, are the proximate mechanisms underpinning this memory effect? We focused on imagery processes as one proximate explanation of animacy effects in memory. We tested whether animacy effects are related to the vividness of the generated mental images (Study 1), or to the dynamic/motoric nature of mental images corresponding to animate words (Study 2). The findings showed that: (1) Animates are not estimated to be more vivid than inanimates; (2) The potentially more dynamic/motoric nature of the representations of animates does not seem to be a factor making animates more memorable than inanimates. In Study 3, we compared a condition in which participants had to categorize animate and inanimate words with a condition in which they had to form mental images from them. The animacy effect on memory was significant after categorizing but not after forming mental imagery. Indeed, imagery improved the recall of inanimates but not that of animates. Overall, the findings provide further and strong evidence for the hypothesis that imagery processes are more readily involved when processing animates than inanimates. Imagery is thus one proximate explanation of animacy effects in episodic memory.

**Keywords:** episodic memory; animacy; mental imagery; evolutionary psychology

Rubin and Friendly (1986) were the first to investigate thoroughly the impact of various item characteristics on memory performance in adults. It is now well-known that item-based characteristics influence lexical processing and long-term encoding and, as a result, that certain important dimensions must be taken into account when selecting materials for the design of memory experiments. However, it is only recently that the investigation of a number of word features, such as number of semantic features (Hargreaves, Pexman, Johnson, & Zdrzilova, 2012), or manipulability of the objects (Madan & Singhal, 2012), has been the focus of specific studies on memory. The different word characteristics include semantic characteristics such as concreteness, imageability, or emotional valence. Importantly, recent studies have found that animacy, which is also a semantic variable, has a prominent role in episodic memory (Bonin, Gelin, & Bugaiska, 2014; Bonin, Gelin, Laroche, Méot, & Bugaiska, 2015; Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013; VanArsdall, Nairne, Pandeirada, & Blunt, 2013; see Nairne, VanArsdall, & Cogdill, 2017 for a review). The most powerful defining attribute of animates is self-propulsion (Di Giorgio, Lunghi, Simion, & Vallortigara, 2016). Thus, animates can be defined as any entity that is able to move by self-propulsion<sup>1</sup>. Broadly speaking, animates can be equated with living things and inanimates with nonliving things. VanArsdall et al. (2013) reported that nonwords associated with properties that caused them to appear as animates (e.g., *JODE is a nurse*) were remembered better in free recall or in recognition than nonwords linked to properties that made them appear to be inanimates (e.g., *JODE is made of iron*). Nairne et al. (2013) further extended this finding to real words, showing that words referring to animates (e.g., *bird, baby*) were recalled better than words referring to inanimates (e.g., *mountain, glass*). Interestingly, Nairne et al. (2013) reanalyzed the data from Rubin and Friendly (1986) and included animacy as a predictor variable. They found that animacy accounted for a large amount of variance in the recall rates. Moreover, the unique contribution of the animacy variable was nearly twice that of imageability which is also a very influential variable in long-term memory retention. Furthermore, the animacy effects in memory found by Nairne et al. (Nairne et al., 2017 for an overview) have been replicated with a different set of words and in another language (Bonin et al., 2014) and they have also been found when pictures have been used as stimuli (Bonin et al., 2014). Importantly, using the remember-know paradigm (Gardiner, 1988), Bonin et al. (2014) indicated that animates were recognized better than

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<sup>1</sup> We are aware of the fact that plants are also living things that barely move, and might therefore be included in the category of animates. However, in our studies, we considered only animals and humans as animates, setting aside the issue of the status of plants in episodic memory. We acknowledge that plants should be the focus of future studies on animacy effects in memory.

inanimates on the "remember" responses, but not on the "know" responses, suggesting that these effects are episodic in nature. Also, animacy effects do not vary across different sets of encoding instructions and they are found in both explicit and implicit learning tasks (Gelin, Bugajska, Méot, & Bonin, 2017). Thus, animacy effects in memory are robust.

It is important to stress that animacy was revealed to be an important mnemonic dimension because Nairne and colleagues adopted an evolutionary framework to study episodic memory (Nairne, 2010, 2015). According to this theoretical framework, certain functional characteristics of human memory were sculpted due to selective pressures faced by our ancestors in the distant past. Thus, animates (e.g., *tiger*) are remembered better than inanimates (e.g., *stone*) because the former items are of greater importance for survival and/or reproduction than the latter items, that is to say that they are of greater fitness value (e.g., animates can be dangerous animals). This ultimate explanation of animacy effects has to be complemented by proximate explanations. The present research focused on this latter type of explanations and addressed the issue of how animacy effects in memory emerge, i.e., what are the mechanisms underpinning these effects. More precisely, our aim was to further address the role of imagery processes in animacy effects in memory (Bonin et al., 2015).

Several hypotheses have been put forward in the literature – attentional capture or mental arousal (Popp & Serra, 2016), imagery processes (Bonin et al., 2015) – but none of these accounts is able to provide a full account of animacy effects. We shall return to the different hypotheses of animacy effects in memory that have been proposed in the General Discussion. As mentioned above, we focus here on one explanation of animacy championed by Bonin et al. (2015), namely the hypothesis that animates are remembered better than inanimates because the memory of animates relies more strongly on imagery processes than that of inanimates. In Bonin et al.'s (2015) Study 4, participants were assigned to one of the following two encoding conditions: interactive imaging versus animacy categorization. In the animacy categorization condition, they were given a brief definition of what is meant by "animates" and "inanimates" at the start of the experiment. They were then told that they would have to decide, as quickly as possible, whether any given word presented on the screen referred to an animate or to an inanimate item. In the interactive imagery condition, participants had to imagine, for each word, a situation in which they were interacting with the object, animal or person, the word referred to. They were further instructed that the situation could be real or fictional, i.e., perhaps they had never interacted with this object, but this might happen. After this study phase, there was a short distractor phase, after which the

participants were given a surprise free recall test. In the interactive imagery group, the animacy effect on recall rate was reliable but it was smaller than the animacy effect found in the categorization group. Importantly, the reduction of the animacy effect was entirely due to inanimates being recalled better when an interactive imagery strategy was used, as compared to a condition in which the participants were not explicitly told to use this type of encoding. According to Bonin et al. (2015), interactive imagery could be one proximate mechanism underpinning animacy effects in episodic memory.

In the present studies, our aim was to further explore the role of imagery processes in animacy effects in memory. In the first study, we tested whether the vividness of mental images generated from animate versus inanimate words could be a factor involved in animacy effects in memory. In a second study, we assessed the role of motoric information in the mental images generated from animate words. It is possible that animates may lead to the creation of mental images that are more dynamic and motoric in nature than the mental images generated from inanimates, the latter being possibly more static in nature. The dynamic and motoric nature of mental images of animates could render their representations richer and thus easier to retrieve at recall than those of inanimates. Finally, given the findings of Studies 1 and 2, in a third and final study, we investigated the effect of simply instructing participants to form mental images on the recall of animate versus inanimate words. The rationale of this final study will be presented later.

### **Study 1. Vividness ratings of animates and inanimates**

Episodic memories have several properties, one of which is that they are often represented in the form of visual images (Conway, 2009). These memories may come to mind with different levels of vividness. Vividness corresponds to the phenomenological experience of perceiving in one's head an object, a smell, a sound, etc., as if we were actually experiencing it with our senses. Indeed, our personal (autobiographical) memories vary as a function of the vividness of the details they comprise: Highly important personally experiences are often made up of vivid details (e.g., my first kiss was with a shy black-haired girl). What is more, autobiographical memories of significant public events that are emotionally salient and that may have important consequences for the self, the so called 'flashbulb' memories (e.g., the 09/11 twin-towers terrorist attack, the death of princess Diana),

are characterized as having a high level of vividness (e.g., Talarico & Rubin, 2003). However, vivid memories of significant public events (e.g., Attack of September 11, 2001) are not necessarily accurate (e.g., Hirst, Thompson, & Bromley, 2015; Talarico & Rubin, 2003), and are no more accurate than everyday (personal) memories (Talarico & Rubin, 2003). More generally, while certain studies suggest that vivid items are recalled better (Collins, Taylor, Wood, & Thompson, 1988; D'Angiulli, Runge, Faulkner, Zakizadeh, Chan, & Morcos, 2013; Shedler & Manis, 1986), other studies have failed to find evidence that the vividness of information increases its memorability (e.g., Frey & Eagly 1993).

One issue related to animacy effects is whether animates are inherently more vivid than inanimates, and whether this specific property could account, at least in part, for their better memorability. It is important to remember that animacy effects have been found when the imageability and concreteness factors were controlled for (e.g., Bonin et al., 2014). Thus, animacy effects are not merely due to the fact that animate items are easier to imagine (or more concrete) than inanimate items. However, the characteristics of episodic memories of animates versus inanimates – and in particular their degree of vividness – have not as yet been explored extensively. Study 2 therefore addressed this issue. Participants were given a list of words that referred to either animate concepts or to inanimate concepts and had to rate their degree of vividness using Likert scales.

## **Method**

*Participants.* Twenty-three adults (13 women, mean age: 32.57 years old) were involved. They were taken from a larger pool of participants than the one used in the previous experiment, i.e., psychology students together with employed adults.

*Stimuli.* The word stimuli (N = 116) were animate and inanimate words that had been used in our previous studies (Bonin et al., 2014; Bonin et al., 2015; Gelin et al., 2017).

*Procedure.* The questionnaire was sent by email and completed at home by the participants. The words were presented in a list and, for each word, the participants were asked to rate the vividness of the visual imagery generated from it using a 5-point scale with 1 = "no image at all", 2 = "vague and dim", 3 = "moderately clear and vivid", 4 = "clear and reasonably vivid" and 5 = "perfectly clear and as vivid as normal vision". The instructions were adapted from the French translation by Santarpia, Blanchet, Lambert, Mininni, and Thizon-Vidal (2008) of the Vividness of Visual Imagery Questionnaire (VVIQ, Marks, 1973).

## Results and Discussion of Study 1

Words referring to animate concepts (A) were not rated as more vivid than words referring to inanimate concepts (I). This was the case with: (1) The 32 words taken from Gelin et al.'s (2017) Experiment 4 ( $A = 4.24$  versus  $I = 4.29$ ,  $t < 1$ ); (2) The 28 words taken from Bonin et al.'s (2015) Experiments 1-3 ( $A = 4.01$  versus  $I = 4.11$ ,  $t < 1$ ); (3) The 56 words taken from Bonin et al.'s (2014) Experiments 1-4 ( $A = 4.09$  versus  $I = 4.10$ ,  $t < 1$ ). Thus, contrary to our hypothesis that the visual images generated from animate words are more vivid than those generated from inanimates, the current findings show that this property cannot account for animacy effects in episodic memory.

It might be argued that the fact that the vividness of the images generated for animate and inanimate items was similar when participants performed the task at their leisure at home does not necessarily mean that the vividness of the images would have been the same had they provided their ratings in a somewhat more stressful and time-constrained environment. Therefore, in order to address this concern, we decided to design another experiment which was more time-constrained, and also much more similar to the experimental settings used when evaluating animacy effects in memory. In this experiment, only a subset of the animate and inanimate words was used. More precisely, we used the words that were employed in Bonin et al.'s (2015) Studies 1-3 and a procedure similar to that used by D'Angiulli et al. (2013) to evaluate the vividness of words. The participants were 30 students from the University of Bourgogne (8 men, mean age: 21.17 years old), who were seated in a quiet room in front of a computer screen. After the experimenter gave the instructions about how to perform the task, they had to start each trial by pressing the spacebar on the keyboard. This triggered the appearance of a word at the center of the screen for 350 ms. After they had read each word as quickly as possible, the participants had to generate a mental image from it. They had to press the spacebar again as soon as they thought their image was complete. They then provided a rating of the vividness of their mental image on a 7-point scale, which was the same as that used in Mark (1973) [1: "no image", 2: "very vague/dim", 3: "vague/dim", 4: "not vivid", 5: "moderately vivid", 6: "very vivid", and 7: "perfectly vivid"]. In order to minimize imagery persistence between trials, each evaluation of vividness was followed by a fixation cross centered on the screen for four seconds. Likewise, there was a minimum inter-trial interval of five seconds (Craver-Lemley & Reeves, 1987). In order to familiarize the participants with the procedure, a practice session with six additional words (3 animates and 3 inanimates) was used. As found for the ratings made at home, words referring to animate



concepts were not evaluated as being more vivid than words referring to inanimate concepts ( $A = 5.27$  versus  $I = 5.57$  out of 7,  $t(26) = -1.55$ ,  $p = .13$ ). Thus, when words were rated in a laboratory setting, that is to say in a more time-constrained environment resembling that used to assess animacy effects in memory, animates were not rated as more vivid than inanimates.

It is important to note that, until now, studies on animacy effects in memory have controlled for the imageability dimension of the words but they have not specifically taken account of the vividness of the mental representations generated from animate and inanimate words. At a methodological level, the current finding is important since it rules out the interpretation that animacy effects in memory could be linked to this uncontrolled dimension.

### **Study 2. Are animacy effects due to the more dynamic/motoric nature of the representations of animate things?**

Bonin et al. (2015) found that when participants were instructed to encode words by generating images in which they imagined certain interactions with the items denoted by the words (e.g., *glass*: taking a glass to their mouth; *fly*: trying to catch a fly with their hand), there was a long-term memory benefit for words referring to inanimates but not for words referring to animates, as compared to a control encoding situation where both types of words were simply categorized as animate versus inanimate. This pattern of findings suggests that animates give rise to mental images that are more dynamic/motoric in nature than inanimates for which the mental images are more static in nature. Animates are entities that are capable of self-propelled motion and this is one of their core defining features (Di Giorgio et al., 2016). One hypothesis is that motion is present in the mental representations corresponding to animate words and that this property makes them more memorable than inanimates. Likewise, the memory trace of animates would be richer than that of inanimates in terms of motoric information. Indeed, this hypothesis is related to a more general account holding that animate items are remembered better because, on average, they possess richer attributes (Nairne et al., 2017). Theories of embodied cognition (e.g., Barsalou, 2008) assume that sensorimotor experience is involved in a variety of cognitive processes and that sensorimotor experience can play a role in cognition. A large body of work has provided evidence that variations in the amount of sensory-motor experience elicited by words may lead to differences in processing, and words that are rich in terms of sensory and/or motoric features enjoy processing benefits

in a variety of lexical tasks (e.g., Pexman, Hargreaves, Siakaluk, Bodner, & Pope, 2008; Yap, Tan, Pexman, & Hargreaves, 2011). In particular, it has been found that words with a greater number of semantic features are remembered better in a free recall task (Hargreaves et al., 2012). To test the 'dynamic/motoric hypothesis' of animacy effects, in contrast to Bonin et al.'s (2015) Study 4 in which participants had to imagine interacting with the referents of the items, the participants in the present Study 2A had to "freeze" their mental representations for both animates and inanimates, that is to say for any given word they had to imagine the corresponding referent as a static image, as if they were photographs of objects, animals, or people. If animates are remembered better than inanimates because their corresponding representations are in a more dynamical/motoric format (e.g., a *bird* is mentally represented as flying, a *lion* as running), then "freezing" as an encoding strategy should give rise to impoverished representations of animates. We therefore predicted that the animacy effect should be reduced in this encoding situation because animates would be less well remembered than in a control encoding situation in which the participants were not explicitly directed to process words using mental imagery. Indeed, we hypothesized that, perhaps by default, most animates are represented in a dynamic way. In contrast, most inanimates should produce mental representations that are, in general, more static in nature. The latter should therefore not be altered by the freezing encoding situation. This hypothesis was tested in Study 2A.

In line with the idea that animates elicit more dynamic/motoric mental representations than inanimates, Study 2B tested the interesting possibility that animates generally refer to items which the body can interact with more easily than is generally the case for inanimates (e.g., it is easier to interact with a *cat* than with a *mountain*). Indeed, this characteristic – referred to as body-object interaction (BOI) – has been shown to facilitate the processing of words in several lexical tasks: In visual and in auditory lexical decision tasks (Siakaluk, Pexman, Aguilera, Owen, & Sears, 2008), in semantic categorization tasks (Siakaluk, Pexman, Sears, Wilson, Locheed, & Owen, 2008) and in memory tasks (Madan & Singhal, 2012; Sidhu & Pexman, 2016). Madan and Singhal (2012) examined memory for words referring to objects that are highly manipulable (e.g., *camera*) and for words referring to objects that are less manipulable (e.g., *table*). Highly manipulable objects were remembered better than less manipulable objects. According to Madan and Singhal (2012), this memory benefit would be due to the automatic activation of motoric representations. A recent study by Sidhu and Pexman (2016) has shown that both recognition hits and recall rates were higher for verbs associated with a greater amount of bodily information. Thus, there are some

empirical grounds for the hypothesis that animates are remembered better than inanimates because the former are associated with greater amounts of bodily information. Study 2B explored this issue by collecting BOI ratings for animate and inanimate words that have been used in previous studies (Bonin et al., 2014; Bonin et al., 2015; Gelin et al., 2017). Likewise, we followed Siakaluk et al.'s (2008) procedure. In order to collect body–object interaction (BOI) ratings, we asked a group of adults to rate (animate versus inanimate) words based on the ease or difficulty with which a human body can physically interact with each word's referent.

## **Study 2A. Freezing mental représentations**

### **Method**

*Participants.* Sixty-nine students (61 women, mean: 19.63 years) from the University of Bourgogne took part in the experiment in exchange for course credits. They were divided into two groups according to the encoding condition (static imagery versus animacy categorization). None were taking any medication known to affect the central nervous system and they were all native French speakers.

*Stimuli.* The word list was the same as the one used in Gelin et al.'s (2017) Study 4. Thirty-two nouns were selected from the Snodgrass and Vanderwart (1980), the Bonin, Peereman, Malardier, Méot and Chalard (2003) and from the Bueno and Megherbi (2009) databases. Each word referred to either an animate or to an inanimate object that belonged to one of the following eight categories: insects, birds, animals with four legs and humans (determined by professions) for the animate stimuli, and furniture, tools, clothes, and musical instruments for the inanimate stimuli.

The words were divided into two sets of 16 items (animates versus inanimates) matched for the surface variables of number of letters and bigram frequency; the lexical variables of book and subtitle frequency, age-of-acquisition, number of orthographic neighbors, orthographic uniqueness point; and the semantic variables of conceptual familiarity, imageability, image variability, concreteness, emotional valence and mention frequency. The statistical characteristics of the words are provided in Gelin et al.'s (2017) Table 5 (p.13).

*Procedure.* The participants were tested two by two in a quiet room. They were randomly assigned to one of the two encoding conditions (static imaging versus animacy rating). The instructions for the animacy rating condition were the same as used in the Gelin et al (2017) and the Bonin et al. (2014) studies, and more precisely:

*"I am going to present you with a list of words. For each word, you will have to decide whether it refers to an animate or to an inanimate item. A word refers to an animate item if it refers to something that is living, something that can move on its own, as is the case of human beings and animals. For example, the words "indian" and "fish" refer to animates. Conversely, a word refers an inanimate item if it refers to something that is not living, something that cannot move on its own. For example, the words "knife" and "car" refer to inanimates. For each word, press the "A" key for animate and the "I" key for inanimate in order to provide your answer."*

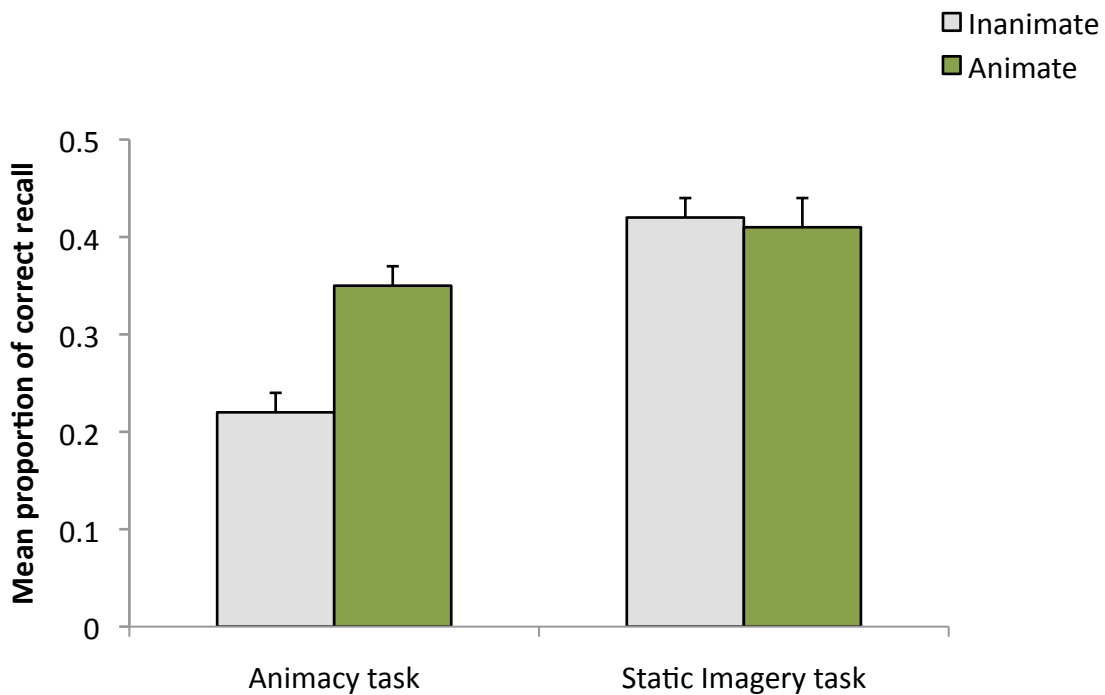
The specific instructions used in the static imaging condition were:

*"I am going to present you with a list of words. For each word, I am going to ask you to imagine a static image, like a photograph of the object, animal, or person which the word refers to. In addition, I want you to rate each word on a scale to indicate whether the task of imagining this static image of the object, animal or person was easy or very difficult. In order to do this, you will have a 5-point scale, with 1 indicating "very difficult to imagine this object, animal, or person" and 5 indicating "very easy to imagine this object, animal, or person".*

## **Results**

Animate words were not categorized or rated reliably faster ( $m = 1853$  ms,  $sd = 672$ ) than inanimate words ( $m = 1803$ ,  $sd = 650$ ),  $F(1, 67) = .55$ ,  $p = .46$ ,  $\eta^2p = .01$ . The words in the animacy decision condition were rated reliably faster ( $m = 1045$ ,  $sd = 198$ ) than the words in the static imagery condition ( $m = 2635$ ,  $sd = 1498$ ),  $F(1, 67) = 37.27$ ,  $p < .001$ ,  $\eta^2p = .36$ . The interaction between the two factors was not significant,  $F(1, 67) = 2.59$ ,  $p = .11$ ,  $\eta^2p = .04$ .

As far as the ratings in the static imagery condition are concerned, inanimates were not given lower scores ( $m = 4.35$ ,  $sd = .50$ ) than animates ( $m = 4.29$ ,  $sd = .65$ ),  $t(34) = .52$ ,  $p = .61$ .



**Figure 1.** Mean proportions and standard errors of correct recall as a function of encoding condition (Animacy task versus Static Imagery task) and Type of words (animate versus inanimate words).

More words were correctly recalled in the static imagery condition than in the animacy decision condition,  $F(1, 67) = 23.78, p < .001, \eta^2p = .26$ . Also, more animate than inanimate words were recalled correctly,  $F(1, 67) = 13.28, p < .001, \eta^2p = .17$ . Importantly, the interaction between Encoding condition and Type of words was significant,  $F(1, 67) = 15.80, p < .001, \eta^2p = .19$ . Post-hoc Tukey tests revealed a significant difference between animates and inanimates in the animacy decision condition,  $p < .001$ , but not in the static imagery condition,  $p = .99$  (see Figure 1). Also, the recall rate of animate words was not significantly different between the static imagery and the animacy decision conditions,  $p = .17$ , whereas more inanimate words were correctly recalled in the static imagery encoding condition than in the animacy decision encoding condition,  $p < .001$ .

The analysis performed on the number of intrusions revealed a significant difference between the "animacy" group and "static imagery" group,  $F(1, 67) = 33.16, p < .001, \eta^2p = .33$ . (The numbers of intrusions were  $m = 2.48, sd = 2.04$  and  $m = .35, sd = .59$  respectively.) However, the effect of Type of words failed to reach significance,  $F(1, 67) = 3.52, p = .06$ , as did the interaction between Type of words and Condition,  $F(1, 67) = 3.52, p = .06$ .

## **Study 2B. Body-Object Interaction norms for animates and inanimates**

### **Method**

*Participants.* Twenty-five students from the University of Bourgogne (24 women, mean age= 18.08 years old) participated in the study. They took part in this experiment in exchange for a course credit.

*Stimuli.* The same sets of words as described for Study 2A were used.

*Procedure.* The students received the questionnaire by email and completed it at home. They were asked to rate the body-object interaction (BOI) associated to words presented in a list using a 7-point scale with 1 = "Low BOI"; 4 = "Medium BOI" and 7 = "High BOI". The instructions given to the participants were our own French translation of the instructions used for the body-object interaction rating task by Bennett, Burnett, Siakaluk and Pexman (2011).

### **Results**

Animate words were given BOI scores reliably lower than those of inanimate words. This was the case for: (1) The 32 words taken from Gelin et al.'s (2017) Experiment 4 ( $A = 3.23$ ;  $I = 4.74$ ;  $t(30) = -4.58$ ,  $p < .001$ ); (2) The 28 words taken from Bonin et al.'s (2015) Experiment 1-3 ( $A = 3.32$  ;  $I = 4.38$ ;  $t(26) = -2.34$ ,  $p < .05$ ); (3) The 56 words taken from Bonin et al.'s (2014) Experiments 1-4 ( $A = 2.99$  versus  $I = 4.22$ ,  $t(54) = -4.1$ ,  $p < .001$ ).

### **Discussion of Studies 2A and 2B**

The findings of Studies 2A and 2B are clear-cut regarding the hypothesis that animacy effects in episodic memory are due to animates having more dynamic/motoric representations than inanimates. The findings from Study 2A showed that freezing the mental representations of both animates and inanimates had the same effects as imagining interacting with the referent of both types of words. Indeed, compared to a control condition in which participants had to categorize words on the animacy dimension, the recall rate of inanimates was increased whereas the recall rates of animates did not vary reliably. Thus, if the observation that animates were remembered better than inanimates was due to the fact that the representations

of animates are more dynamic/motoric in nature, the freezing condition should have caused animates to be recalled less well than in the control condition, whereas the recall of inanimates should have been unchanged. Bonin et al. (2015) found that interactive imagery boosted the recall of inanimates, but not that of animates, suggesting that animates more readily prompt representations that include motoric interactions. For example, when reading the word dog, people imagine themselves petting a dog. However, Study 2B indicated that animates were rated as being less easy for the body to interact with than inanimates, thus further suggesting that if animates are remembered better than inanimates, this is not because their referents are intrinsically easier for the body to interact with.

Recently, Nairne et al. (2017) reported an experiment in which participants had to read sentences describing one animate interacting with an inanimate (e.g., *the mouse is touching the sled*) or describing one inanimate interacting with another inanimate (e.g., *the lamp is touching the bottle*). Importantly, the same inanimate words were coupled either with animate or with inanimate words. The participants had to imagine the situation described by each sentence and then provide a vividness rating. A surprise memory test was given and revealed that inanimates that had been imagined touched by animates were remembered better than inanimates touched by inanimates. On the basis of this interesting finding, Nairne et al. (2017) suggested that the boost in the recall of inanimates in the interactive imagery condition in Bonin et al.'s (2015) Study 4 was due to 'yourself' (an animate thing) imagining interacting with inanimates. However, when participants were asked to freeze their mental representations, they no longer imagined themselves interacting with inanimates. Despite this, inanimates still exhibited a memory boost compared to a control condition in which participants had to categorize the items as animates or inanimates (indeed, the same control condition as used in Bonin et al.'s (2015) study). What is common to the procedure used in Bonin et al.'s (2015) Study 4 and the present study is that the participants were guided to create mental images from words. Perhaps, the single instruction to imagine the referents of the words brought about a memory boost for inanimates and not animates, because imagery processes are less strongly involved for the former than for the latter type of words. Stated differently, animates generally rely more heavily on imagery processes than inanimates and, since imagery processes can boost memory (e.g., Elliot, 1973; Lupiani, 1977; Oliver, Bays & Zabrocky, 2016; Winnick & Brody, 1984), animates are remembered better than inanimates. This hypothesis was tested in a third and final study.

### **Study 3. Creating mental images from animate and inanimate words**

Although the precise instructions varied between Bonin et al.'s (2015) Study 4 and Study 2A, the participants were required to create mental images from the words. The outcome was that inanimates were remembered better when mental images were generated than when they were categorized. This was not the case of animates whose recall rates did not vary as a function of the orienting tasks. It is therefore possible that simply encoding words by creating mental images for both types boosts the memory of inanimates, but not of animates, because animates engage imagery processes more readily than inanimates.

#### **Method**

*Participants.* Sixty native French-speaking students (52 women, mean age: 19.95 years) took part in the experiment. They were all students from the University of Bourgogne and were rewarded with course credits. They were divided into two groups according to the encoding condition groups, namely mental imagery versus animacy categorization. None were taking any medication known to affect the central nervous system.

*Stimuli.* The stimulus set was the same as that used in Gelin et al.'s (2017) Study 1. Twenty-eight French nouns were selected from the Snodgrass and Vanderwart (1980) and Bonin, Peereman, Malardier, Méot and Chalard (2003) databases. The words were divided into two sets, 14 animate objects and 14 inanimate objects, matched for the surface variables of number of letters and bigram frequency; the lexical variables of book and subtitle frequency, age-of-acquisition, number of orthographic neighbors, orthographic uniqueness point; and the semantic variables of conceptual familiarity, imageability, image variability, concreteness, and emotional valence. The statistical characteristics of the words are provided in Gelin et al.'s (2017) Table 1 (p. 4).

*Procedure.* The participants were tested individually in a quiet room. They were randomly assigned to one of the two encoding conditions: mental imaging versus animacy rating. The instructions for the animacy rating condition were the same as those used in Study 2A.

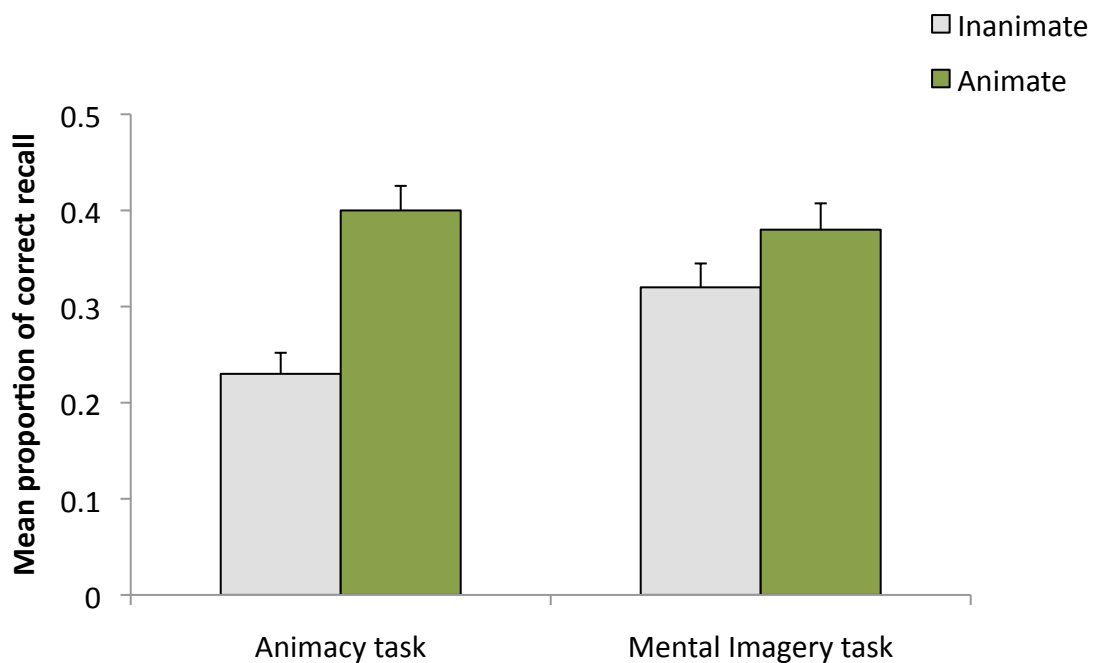
The specific instructions used in the mental imaging condition were:



"I am going to present you with a list of words. For each word, I am going to ask you to imagine a mental image of the object, animal, or person which the word refers to. In addition, I want you to rate each word on a scale to indicate whether the task of imagining this mental image of the object, animal or person was easy or very difficult. In order to do this, you will have a 5 point-scale, with 1 indicating "very difficult to imagine this object, animal, or person" and 5 indicating "very easy to imagine this object, animal, or person".

## Results

Animate words were not categorized or rated reliably faster ( $m = 1479$  ms,  $sd = 500$ ) than inanimate words ( $m = 1517$  ms,  $sd = 531$ ),  $F(1, 58) = 2.02$ ,  $p = .16$ ,  $\eta^2p = .03$ . The words in the animacy categorization condition were rated reliably faster ( $m = 1040$  ms,  $sd = 286$ ) than the words in the mental imagery condition ( $m = 1956$  ms,  $sd = 727$ ),  $F(1, 58) = 41.15$ ,  $p < .001$ ,  $\eta^2p = .42$ . The interaction between the two factors was not significant,  $F(1, 58) = .24$ ,  $p = .63$ ,  $\eta^2p = .004$ . As far as the ratings in the mental imagery condition are concerned, inanimates were not given lower scores ( $m = 3.95$ ,  $sd = .53$ ) than animates ( $m = 4.11$ ,  $sd = .66$ ),  $t(29) = 1.97$ ,  $p = .06$ .



**Figure 2.** Mean proportions and standard errors of correct recall as a function of encoding condition (Animacy task versus Mental Imagery task) and Type of words (animate versus inanimate words).

The recall rate in the mental imagery condition did not differ significantly from that in the animacy categorizing condition,  $F(1, 58) = 1.55, p = .22, \eta^2p = .03$ . More animate words than inanimate words were recalled correctly,  $F(1, 58) = 35.00, p < .001, \eta^2p = .38$ . Importantly, the interaction between Encoding condition and Type of words was significant,  $F(1, 58) = 10.09, p < .01, \eta^2p = .15$ . Post-hoc Tukey tests revealed a significant difference between animates and inanimates in the animacy categorization condition,  $p < .001$ , but not in the mental imagery condition,  $p = .22$  (see Figure 2). Also, the recall rate of animate words was not significantly different between the mental imagery and the animacy categorization conditions,  $p = .91$ , whereas more inanimate words were correctly recalled in the imagery condition than in the animacy categorizing condition,  $p < .05$ .

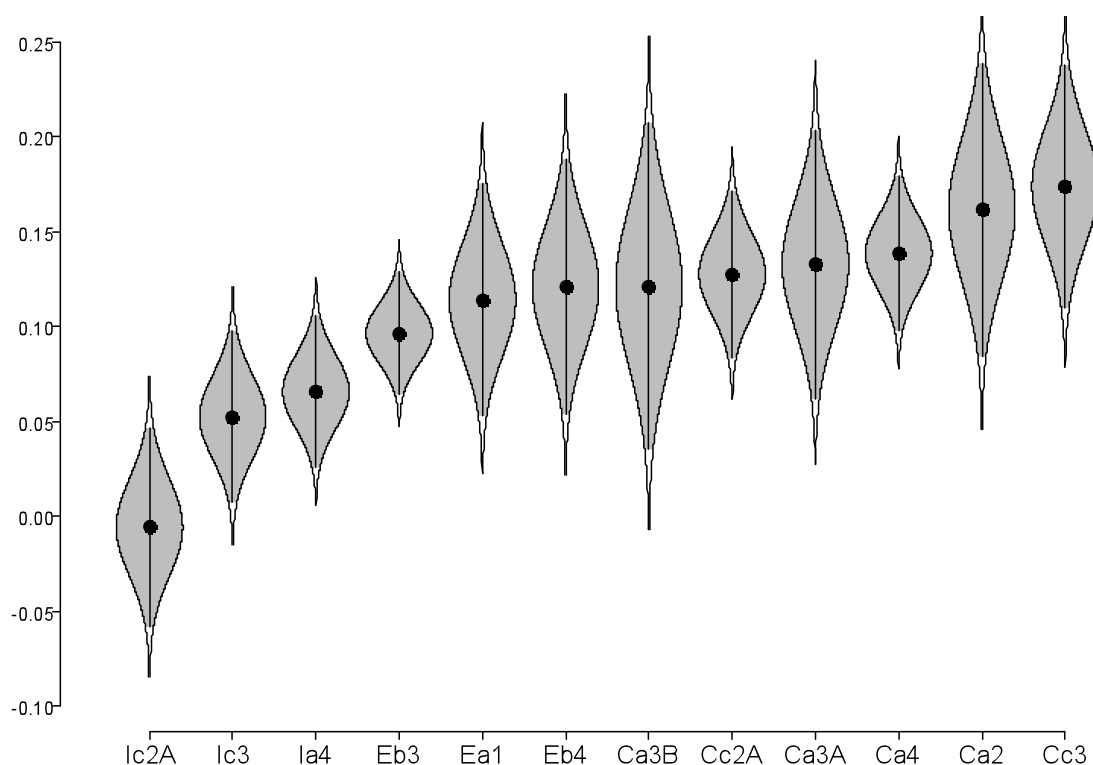
The analysis performed on the number of intrusions revealed no reliable difference between the "animacy" group and "mental imagery" group,  $F(1, 58) = 1.78, p = .18, \eta^2p = .03$ . (The numbers of intrusions were  $m = 1.1, sd = 1.49$  and  $m = .67, sd = .91$ , respectively.) Also, the effect of Type of words was not significant,  $F(1, 58) = .46, p = .50, \eta^2p = .01$ . Finally, the interaction between Type of words and Condition was also not significant,  $F(1, 58) = .46, p = .50, \eta^2p = .01$ .

### **Discussion of Study 3**

The findings of Study 3 are clear-cut. We again found that animates are remembered better than inanimates in the animacy categorization task. However, when adults had to encode words by creating mental images for both animates and inanimates, the difference in the recall rates of the two types of words was no longer reliable because of a memory boost in the recall rate of inanimates. This outcome is consistent with our reasoning that instructions directing participants to create mental images for both types of words should have the effect of placing inanimates and animates on an equal footing.

There is one potential issue concerning the findings of Study 2A and 3 that imagery reduces animacy effects compared to a situation where words are categorized on the animate-inanimate dimension. We have assumed that an animate-inanimate categorization task is a reliable control condition making it possible to evaluate animacy effects in memory relative to encoding conditions that entail the use of mental imagery. And importantly, we have also assumed that the use of mental imagery truly reduces animacy effects because inanimates, more than animates, benefit from this encoding strategy. What, therefore, is the effect of using

a categorization task to evaluate animacy effects in memory? We think that the choice of an animate-inanimate categorization task is not a serious concern for the following reasons. First of all, as described in the Procedure section of Study 2A, before performing the categorization task, a brief definition of what is meant by animate and inanimate words was given to the participants and animates were not stressed more than inanimates. Second, Gelin, Bugaiska, Méot, and Bonin (2017) have shown that animacy effects in memory are independent of encoding instructions<sup>2</sup>. Thus, it is not necessary to focus on the animacy dimension in order to obtain animacy effects in memory. Finally, to further develop the finding that animacy effects are reduced when mental imagery is used as an encoding strategy, we took into account the sizes of the animacy effects that were found in certain of our previous studies.



**Figure 3.** 95% cat's-eye confidence intervals of the by-participants differences between animates and inanimates obtained in the encoding conditions involving imagery, intentional learning and categorization (I = imagery, E = Explicit learning, C = categorization; a = Bonin et al.'s (2015) study, b = Gelin et al.'s (2017) study, c = the present study; the numbers (plus letters) (e.g., 2A, 3) correspond to the study number in the corresponding papers).

<sup>2</sup> In effect, Gelin et al. (2017) found animacy effects not only when participants were instructed to encode words for their survival value but also when they encoded words in non-survival scenarios, such as planning a trip as a tour guide, or moving to a new house. Animates are also remembered better when words are rated for their pleasantness (Gelin et al., 2017) or even when they have to be explicitly learned (Bonin et al., 2015).

Figure 3 shows the cat's-eye confidence intervals (e.g. Cumming, 2012) of the by-participants differences between animates and inanimates obtained in different studies involving imagery, intentional learning, or categorization. As shown by Figure 3, animacy effects were the lowest in the three studies involving imagery, whereas the reverse was true for the studies in which words had to be categorized. Finally, there were medium animacy effects when intentional learning was used. Contrast analyses revealed that the mean for the imagery conditions ( $m = .0349$ ) was lower than that obtained with intentional learning instructions ( $m = .1101$ ),  $t(139.7) = 3.59$ ,  $p < .001^3$ . Also, we found that the difference in the effects of animacy between categorization ( $m = .1423$ ) and intentional learning was not significant,  $t(157.9) = 1.57$ ,  $p > .1$ .

To summarize, the findings of Studies 2A and 3, together with the above supplementary analyses, fit with the hypothesis that imagery processes are more readily involved in the processing of animates than of inanimates or, conversely, that inanimates rely less on these processes.

## General Discussion

The study of the mnemonic influence of animacy is new in the episodic memory literature. To date, only a few studies have investigated the impact of this dimension (Nairne et al., 2017). However, an increasing number of findings suggest that animacy effects in memory are robust. As set out in the Introduction, memory for animates has been consistently found to be better than for inanimates in both intentional and incidental learning as well as in a variety of memory tasks: free recall (Bonin et al., 2014; Nairne et al., 2013), recognition (Bonin et al., 2014), and cued recall (VanArsdall, Nairne, Pandeirada, & Cogdill, 2015, but see Popp & Serra, 2016 and below). It is important to keep in mind that animacy effects in memory were discovered because of the adoption of an evolutionary framework championed by James Nairne and his research team (Nairne, 2010, 2015). The major assumption of evolutionary psychology is that our cognitive mechanisms evolved through natural selection because they provided benefits for fitness. Nairne assumes that our memory systems were sculpted by a range of selection pressures faced by our ancestors in the distant past (Nairne,

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<sup>3</sup> The difference was also significant ( $p < .05$ ) when the imagery study from the current Study 2A (i.e., Ic2A), for which the observed animacy effect was negative, was excluded,  $t(122.1) = 2.39$

2010, 2015; Nairne & Pandeirada, 2010, 2016) and that our memory systems evolved to solve adaptive problems. Therefore, memory processes should be tuned to encode and retrieve information related to survival and reproduction issues, including finding food and water, protecting ourselves against predators or enemies, or finding a mate. The impact of animacy in memory was therefore predicted by an evolutionary account of memory. Stated differently, this novel finding was acquired through forward engineering (Nairne, 2015), and, therefore, studies of animacy effects in memory were first focused on ultimate explanations. Exactly how animacy effects are produced and the nature of the mechanisms underpinning these effects are issues that have been investigated more recently (Bonin et al., 2015; Popp & Serra, 2016; VanArsdall, Nairne, Pandeirada, & Cogdill, 2017). However, ultimate and proximate explanations should not be thought of as rival explanations. On the contrary, they are complementary (Nairne & Pandeirada, 2016). In the present research, we focused on proximate explanations of animacy effects in episodic memory and aimed to provide further evidence for the hypothesis that imagery processes are involved in animacy effects. At the end of the discussion, we will address the link between proximate and ultimate explanations.

Let us summarize the main findings of our studies. First of all, we explored the role of the vividness of animates versus inanimates. Contrary to our expectations, vividness ratings were not found to be a relevant dimension that could partially account for animacy effects in memory. In a second study, we tested a hypothesis that derived directly from a previous work of our own (Bonin et al., 2015), namely that animates would be represented mentally in a more dynamic manner than inanimates. However, the findings of Studies 2A and 2B were not consistent with this account. Indeed, the findings from Study 2A revealed that "freezing" the mental representations of animates and inanimates had the same effects as imagining interacting with their referents. Given that freezing the mental representations makes animates more like inanimates, it should have had a detrimental effect on the memorability of animates if, indeed, their dynamic/motoric nature were the key factor underpinning animacy effects. If animates are remembered better than inanimates, this cannot be because they have referents for which it is intrinsically easier for the body to interact with since the findings of Study 2B revealed that the participants thought that the body could interact with inanimates more easily than with animates. This maybe the reason why, when participants were explicitly told to imagine themselves interacting with animates versus inanimates in Bonin et al.'s (2015) Study 4, they rated it slightly easier to imagine themselves interacting with inanimates than animates.

The present findings also rule out the idea that animacy effects in memory are due to the fact that animates give rise to representations in which one is more personally involved (by imagining touching the animate objects, e.g., touching the baby), because when the participants were oriented to freeze their mental representations, they were explicitly told to imagine the objects as if they were taking a photograph of them. Such a situation introduces a distance between oneself and the objects with no direct contact with the body except for visual contact.

Given that in both Bonin et al.'s (2015) Study 4 and the current Study 2A, the participants had to create mental images from words, we put forward the hypothesis that animates may have been remembered better than inanimates because animates more readily (or more strongly) mobilize imagery processes than inanimates. As a result, inanimates receive a memory boost when individuals are directed to encode them using imagery because this is a well-known procedure that improves memory (Elliot, 1973; Lupiani, 1977; Oliver et al., 2016; Winnick & Brody, 1984). This is precisely what our Study 3 indicated. When adults were led to encode words by creating mental images for both animate or inanimate words, rather than categorizing them as animates or inanimates, the animacy effect on memory performance vanished. This was due to the presence of a memory boost for inanimates only. As a matter of fact, animates were not recalled better when participants had to imagine them than when they had to categorize them. Overall, by providing further and stronger evidence that imagery processes contribute to animacy effects in memory, our research work makes a strong theoretical contribution by increasing our knowledge of the proximate mechanisms underpinning the memory benefit of animates compared to inanimates. It should be remembered that we started with the ultimate explanation of animacy effects in memory, namely the assumption that animates should be remembered better than inanimates because they are more important for fitness purposes. What our findings now strongly suggest is that in order to achieve this evolutionary function, imagery is co-opted as a proximate mechanism. This account of animacy effects in memory is certainly not the only one and we admit that, in order to provide a full account of animacy effects, it will be necessary to consider other proximate mechanisms in future studies.

In the literature, several hypotheses have been forward to account for animacy effects in memory. Popp and Serra (2016) identified two general accounts of the animacy memory advantage. The first account is that the relationship between the animacy status of items and memory is direct, that is to say animacy is a feature of a concept that is directly associated

with better memory. The second account is that a proximate mechanism mediates the relationship between animacy and memory: animacy captures attention or produces mental arousal. The direct account is clearly at odds with the finding of Popp and Serra (2016) that "object-object" pairs are remembered better than "animal-animal" pairs in cued recall. Indeed the hypothesis that animacy effects are in part due to attentional capture had already been proposed by Bonin et al. (2014) and VanArsdall et al. (2013). Popp and Serra assume that animates capture more attention than inanimates. In line with this hypothesis, when pairs of words are presented for learning, if attention is drawn to one word in a pair (an animate word) rather than focused on the association itself, then pairs comprising animate stimuli should be less well remembered than pairs comprising only object stimuli. However, attentional capture cannot be the sole process responsible for animacy effects in memory because even though animates are detected faster than inanimates (e.g., Altman, Khislavsky, Coverdale, & Gilger, 2016; New, Cosmides, & Tooby, 2007), once detected, they do not appear to be more attentionally demanding, as shown by Bonin et al. (2015) in a dual-task paradigm. Bonin et al. (2015) did not find that animacy effects in free recall were modulated by the addition of a concurrent memory load consisting of letters and digits. Finally, one account of animacy effects in free recall that has often been put forward is that they are due to organizational processes. The idea is that animates are easier to chunk and to retrieve (e.g., they belong to the category of animals or humans) than inanimates, which generally come from more diverse categories (e.g., *tools, furniture*). However, this hypothesis has been ruled out in recent studies (Gelin et al., 2017; VanArsdall et al., 2017).

Before concluding, one important issue to address concerns about the boundary conditions of animacy (and survival processing) effects and how these can sometimes be misinterpreted at the level of ultimate explanations. We would like to make clear that the observation that survival processing benefits or animacy effects in memory are not observed under certain conditions, or even that they can be reversed (Popp & Serra, 2016), should not be taken to argue against ultimate explanations of these memory effects. Indeed, Popp and Serra (2016) were able to provide evidence of reversed animacy effects in cued recall. More precisely, in one experiment (Experiment 1), they showed that whereas animals were recalled better than objects in cued recalled, object-object pairs were recalled better than animal-animal pairs (e.g., *bottle, clock* recalled better than *bear, camel*). In another experiment (Experiment 3), they compared adults' cued recall for different pairs of words: animal-animal, object-object but also animal-object and object-animal and found that object-object pairs were

recalled better than the other types of pairs, all of which included an animal stimulus. Thus, these reversed animacy effects are important because they provide boundary conditions for the observation of animacy effect in memory. However, these latter findings should not be interpreted as invalidating the ultimate account of animacy effects, namely that animates are remembered better than inanimates because animate entities are more important than inanimates for both survival and reproduction. On the contrary, an ultimate explanation does not imply the strong assumption that animacy effects in memory should always be reliably observed, with animates being remembered better than inanimates in all contexts and tasks. More generally, evolutionary psychologists do not assume that evolved mechanisms are rigid (Kenrick & Griskevicius, 2013). For example, as explained by Nairne and Pandeirada (2016), observing that birds cannot fly under certain conditions (e.g., because their feathers are covered with oil) does not rule out the idea that flying has an ultimate function. The reversal of animacy effects in cued recall can be easily accounted for if one assumes that animates attract more attention than inanimates (Popp & Serra, 2016): Because attention is drawn to animates in pairs of words, the memory of word pairs will be impaired by the presence of animates in the pairs.

To conclude, we propose that because imagery is a very powerful process that boosts memory, this may be the reason why it has been co-opted to help us remember important things, and more particularly, animates.

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## Chapitre 3 : Flexibilité pour mieux s'adapter

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### Introduction

#### 1. L'importance d'un système flexible pour une bonne adaptation

Ne pas observer l'effet animé en toutes circonstances (e.g., l'effet animé s'inverse dans le cadre d'une procédure de rappel indicé de paires de mots, Popp & Serra, 2016) ne signifie pas que cet effet n'a pas de valeur adaptative. Observer des conditions posant des limites à un effet ne devrait pas être surprenant puisque la plupart, sinon toutes les adaptations ont des « limites ». Comme l'argumentent Nairne et Pandeirada (2016), bloquez le système circulatoire et vous observerez que le système immunitaire cessera de fonctionner ; épuisez les neurotransmetteurs et les réflexes seront altérés ; couvrez les plumes d'un oiseau avec de l'huile et il ne pourra plus voler. Pour autant, personne ne prétendrait que ces conditions, dans lesquelles le système immunitaire, les réflexes ou le vol ne fonctionnent plus, remettent en cause le fait que ces capacités soient le fruit de l'évolution. De même, si l'effet animé tend à diminuer, disparaître ou même s'inverser dans certaines situations, cela n'implique pas d'emblée que les explications ultimes de cet effet soient à remettre en cause.

De plus, comme nous l'avons déjà évoqué en préambule, si l'adaptation à l'environnement a permis l'évolution de l'espèce humaine au fil des générations, il est également important, pour chaque individu, de s'adapter aux différents environnements rencontrés tout au long de sa vie. En ce qui concerne la mémoire, elle se serait développée de sorte à nous permettre de résoudre des problèmes adaptatifs. Conformément aux enjeux que représentent la survie et la reproduction pour l'évolution de l'espèce, nous pouvons supposer que la mémoire a évolué essentiellement pour résoudre des problèmes qui y sont directement reliés (Klein, Cosmides, Tooby, & Chance, 2002 ; Nairne, 2005 ; Sherry & Schacter, 1987). Pour autant, il est évident que la mémoire est désormais utilisée dans des environnements qui sont très différents des environnements ancestraux ; ainsi intervient-elle dans de nombreuses situations, si ce n'est dans toutes les situations du quotidien. La diversité de ces situations a peut être amené à privilégier un système flexible, dépendant des objectifs liés à la situation. Par exemple, pour préparer un déménagement, il semblerait inapproprié de négliger les entités inanimées, alors que dans le cadre d'une expédition en Afrique ou dans la jungle

amazonienne, il en va de notre survie de favoriser les entités animées. Nous avons donc pensé qu'il était aussi important d'évaluer la flexibilité de l'effet animé en mémoire: cet effet est-il indépendant du contexte ou est-il obtenu uniquement dans des conditions d'encodage spécifiques ? Nous avons abordé cette question dans l'article qui suit.

## **2. Principaux objectifs et résultats de l'Article 5**

Dans l'Article 5, nous avons testé si certains contextes, plus que d'autres, conduisaient les participants à privilégier les entités animées. Nous avons utilisé trois contextes différents : un contexte de survie, celui de Nairne et al. (2007) et deux contextes « non-survie », un contexte de déménagement dans un pays étranger (Nairne et al., 2007) et un contexte d'organisation de voyage dans un pays étranger, spécialement créé pour cette étude. Nous avons également utilisé deux situations d'encodage contrôles, à savoir, une tâche d'évaluation des mots quant à leur degrés d'agréabilité et une tâche d'apprentissage intentionnel.

Les résultats ont montré que l'effet animé s'observait aussi bien dans un scénario de survie, que dans une tâche d'évaluation des mots quant à leur agréabilité ou dans le cadre d'un apprentissage intentionnel. Concernant les contextes « non-survie », l'effet animé n'était pas significatif (ou alors seulement marginalement) dans le scénario de déménagement dans un pays étranger. Cependant, avec le nouveau scénario de planification d'un voyage, l'effet animé persistait. L'élément essentiel qui ressortait de l'ensemble des résultats sur les scénarios « non-survie » est qu'aucune situation n'a amené les entités inanimées à être significativement mieux mémorisées que les entités animées. En l'état actuel de nos connaissances, l'effet animé semble donc "flexible", bien que modérément : il apparait qu'il puisse être atténué dans des situations qui requièrent de porter plus d'attention aux entités inanimées.

## Article 5

# Are animacy effects in episodic memory independent of encoding instructions?

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**Abstract.** The adaptive view of human memory [Nairne, J. S. 2010. Adaptive memory: Evolutionary constraints on remembering. In B. H. Ross (Ed.), *The psychology of learning and motivation* (Vol. 53 pp. 1–32). Burlington: Academic Press; Nairne, J. S., & Pandeirada, J. N. S. 2010a. Adaptive memory: Ancestral priorities and the mnemonic value of survival processing. *Cognitive Psychology*, 61, 1–22, 2010b; Memory functions. In *The Corsini encyclopedia of psychology and behavioral science*, (Vol 3, 4th ed. pp. 977–979). Hoboken, NJ: John Wiley & Sons] assumes that animates (e.g., *baby*, *rabbit* presented as words or pictures) are better remembered than inanimates (e.g., *bottle*, *mountain*) because animates are more important for fitness than inanimates. In four studies, we investigated whether the animacy effect in episodic memory (i.e., the better remembering of animates over inanimates) is independent of encoding instructions. Using both a factorial (Studies 1 and 3) and a multiple regression approach (Study 2), three studies tested whether certain contexts drive people to attend to inanimate more than to animate things (or the reverse), and therefore lead to differential animacy effects. The findings showed that animacy effects on recall performance were observed in the grassland-survival scenario used by Nairne, Thompson, and Pandeirada (2007. Adaptive memory: Survival processing enhances retention. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 33, 263–273) (Studies 1–3), when words were rated for their pleasantness (Study 2), and in explicit learning (Study 3). In the non-survival scenario of moving to a foreign land (Studies 1–2), animacy effects on recall rates were not reliable in Study 1, but were significant in Study 2, whereas these effects were reliable in the non-survival scenario of planning a trip as a tour guide (Study 3). A final (control) study (Study 4) was conducted to test specifically whether animacy effects are related to the more organised nature of animates than inanimates. Overall, the findings suggest that animacy effects are robust since they do not vary across different sets of encoding instructions (e.g., encoding for survival, preparing a trip and pleasantness).

**Keywords.** Episodic Memory . Animacy . evolutionary psychology

According to evolutionary psychologists, some items are of greater importance for survival and/or reproduction than others, that is to say that these are of greater fitness value (Buss, 2014; Saad, 2011). They therefore assume that these items should be prioritised for processing. Likewise, animate things are more important for fitness than inanimate things because the former consist of animals or persons and these can be potential predators, prey, sexual partners or rivals. More specifically, by animates we mean living things that are capable of independent movement and can suddenly change direction without warning.<sup>1</sup> Indeed, several lines of evidence indicate that animates are processed differently from inanimates. In the domain of perception, there is empirical evidence showing that animates are detected faster than inanimates and delay visual disengagement (Abrams & Christ, 2003; Öhman, Flykt, & Esteves, 2001; Öhman, Lundqvist, & Esteves, 2001; New, Cosmides, & Tooby, 2007; Pratt, Radulescu, Guo, & Abrams, 2010). For example, a recent study has shown that dangerous animals capture and hold the attention of modern humans (Yorzinski, Penkunas, Platt, & Coss, 2014).

Of importance for the purposes of the present studies is the finding that animates are better remembered than inanimates. These effects have been found across different tasks: with non-words associated with animate vs. inanimate properties (VanArsdall, Nairne, Pandeirada, & Blunt, 2013), in word paired-associate learning (VanArsdall,

Nairne, Pandeirada, & Cogdill, 2015), in free recall (Bonin, Gelin, & Bugańska, 2014; Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013) and tasks measuring the number of recognition hits (Bonin et al., 2014). These effects have been found with non-words (VanArsdall et al., 2013), words (Bonin et al., 2014; Nairne et al., 2013) and pictures (Bonin et al., 2014). However, we still do not know whether animacy effects in memory vary across different sets of encoding instructions. Therefore, in the present work, we examined this issue since it should help constrain the theoretical interpretation of these effects. In the first study, we focused on animacy effects in incidental encoding tasks and addressed the issue of the ubiquity of animacy effects in episodic memory. So far, animacy effects have been found in explicit learning memory tasks (Nairne et al., 2013), as well as in incidental encoding tasks (e.g., Bonin et al., 2014; VanArsdall et al., 2013). We are not aware of any study that has

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<sup>1</sup> According to Gelman and Spelke (1981), the fundamental features that distinguish animates from inanimates are the following: (1) animates can move, whereas inanimates move only when the action is initiated by something or someone; (2) animates grow and reproduce; (3) animates are able to know, perceive, emote, learn and think; and (4) animates are made of biological structures that maintain life and allow reproduction.



examined whether animacy effects are observed in clear-cut survival situations where obviously they should be found. Nairne and colleagues' studies (e.g., Nairne & Pandeirada, 2008, 2010a, 2010b; Nairne, Pandeirada, & Thompson, 2008; Nairne, Thompson, & Pandeirada, 2007) have repeatedly shown that words rated for their relevance in an imaginary scenario in which one must survive amongst the grasslands of a foreign land (where one consequently has to find food and drinking and protect oneself against predators), are better remembered than words processed in comparable deep encoding conditions in which survival processing is not required (e.g., words are processed in non-survival scenarios, such as moving to a new country, or are rated for their pleasantness). In the grassland-survival scenario used by Nairne and colleagues (e.g., Nairne et al., 2007, 2008), the instructions, among other things, explicitly indicate to the participants that they have to imagine themselves in a situation where they have to protect themselves from predators. Predators can be either dangerous animals or other humans. Importantly, these are animate entities. In the grassland-survival situation used by Nairne et al. (2007, 2008), animates should be given processing priority over inanimates, and they should therefore be better remembered than inanimates (but see below for a different prediction). Observing that inanimate things are better remembered than animate things in such a survival situation would certainly be at odds with the evolutionary account of animacy effects. However, at the same time, we are aware that certain inanimate things (e.g., a *bottle*) can also be useful when faced with a survival situation (e.g., to store water, to be used as a weapon).

Since animacy effects are also observed in tasks that require explicit learning (Nairne et al., 2013), this suggests that the animacy dimension is an “intrinsic” property of concepts that is taken into account at encoding, and therefore that animacy effects should also be observed in certain non-survival scenarios or in incidental memory tasks such as in pleasantness rating in which no encoding schema is activated. Thus, it could be argued that animacy effects in memory are not context dependent. They are captured whatever the encoding context. However, if we consider that processing is flexible, it is possible that stimuli in the environment are not always attended to the same extent for fitness purposes: Certain contexts can possibly cause people to attend to inanimate more than to animate things, for instance when thinking about how to deal with objects, for example, when transporting one's belongings to move into a new house. In sum, it is important to assess the generality of animacy effects in episodic memory: Are these effects context-independent or are they

obtained under specific encoding conditions? We addressed this issue in three studies (Study 1–3).

From a theoretical point of view, it is also possible to anticipate a totally different outcome if it is assumed that the same mechanism (or sets of mechanisms or module) underpins both animacy and survival-processing effects. It has been hypothesised that when memory processes are redundant across different encoding tasks, there is generally no longer any retention advantage. There is evidence suggesting that the repeated use of the same mechanism (redundancy; Burns, Hart, Kramer, & Burns, 2014) does not bring about additional benefits at the level of memory performance (e.g., Hunt & Einstein, 1981). Burns et al. (2014) put forward this line of reasoning to account for the finding that the activation of death-related thoughts underpins the survival memory effect. In one experiment, the participants had to encode words according to either a survival scenario or a moving scenario. Before this encoding episode, they were required to either write about their own death (thus inducing death-related thoughts) or about dental pain. The findings showed that the survival memory benefit was no longer observed when participants had previously thought about death rather than about dental pain. According to Burns et al. (2014), since survival processing entails the activation of the concept of death, redundancy occurs when a task requires both survival and death processing, with the result that the survival advantage is no longer observed (but see also Bugajska, Mermillod, & Bonin, 2015). If this line of reasoning is applied to animacy and survival-processing effects, no animacy effect in memory should be observed in a situation in which participants have to encode both animate and inanimate words for their survival value.

### **Study 1: animacy effects in survival and nonsurvival contexts—a factorial approach**

In the first study, we used the grassland scenario taken from Nairne et al. (2007) in which participants have to imagine they are stranded in the grasslands of a foreign land and have to survive with no basic supplies. A list of unrelated words was then presented and they had to rate each word for its survival relevance. As a non-survival scenario, we used the “moving scenario”, which has often been used as a control scenario for evaluating the survival processing advantage (e.g., Nairne et al., 2007). In this situation, the participants

have to imagine that in a few months they will have to find a house, transport their belongings, etc. and then rate the relevance of each word accordingly.

## Method

*Participants.* Sixty students (52 females; mean age 19.6 years) at the University of Bourgogne participated in the study and were divided into two groups (n = 30 in each group) that differed on encoding condition. The participants, who were all native speakers of French, received course credits for their participation and none were taking medication known to affect the central nervous system.

*Stimuli.* Twenty-eight French nouns were selected from the Snodgrass and Vanderwart (1980) and Bonin, Peereman, Malardier, Méot and Chalard (2003) databases. Each word referred to either an animate or an inanimate object.

**Table 1.** Statistical characteristics (mean, standard deviation, range, minimum maximum, t-test of the means) of the control variables for animate and inanimate stimuli used in Study 1.

|                                                   | Animate |          |        |              | Inanimate |          |        |              | t-Test    |
|---------------------------------------------------|---------|----------|--------|--------------|-----------|----------|--------|--------------|-----------|
|                                                   | Mean    | SD       | Range  | Min-max      | Mean      | SD       | Range  | Min-max      |           |
| Number of letters <sup>a</sup>                    | 6.14    | 1.81     | 7      | 3_10         | 6         | 1.77     | 6      | 4_10         | $p = .84$ |
| Bigram frequency (per million words) <sup>a</sup> | 8,823.2 | 2,898.64 | 9396   | 4,058_1,3454 | 9,358.14  | 3,124.96 | 1,1616 | 2,360_13,976 | $p = .65$ |
| Book frequency <sup>a</sup>                       | 22.29   | 46.64    | 186.35 | 0.61_186.96  | 20.63     | 43.96    | 175.13 | 0.07_175.2   | $p = .93$ |
| Subtitle frequency <sup>a</sup>                   | 31.94   | 61.3     | 188.2  | 0.21_188.2   | 17.38     | 39.27    | 154.07 | 0.06_154.13  | $p = .48$ |
| Age-of-acquisition (1-5) <sup>b</sup>             | 2.44    | 0.75     | 2.6    | 1.15_3.75    | 2.81      | 0.91     | 2.97   | 1.23_4.2     | $p = .26$ |
| Number of orthographic neighbors <sup>a</sup>     | 3.43    | 3.92     | 13     | 0_13         | 3         | 3.93     | 10     | 0_10         | $p = .78$ |
| Orthographic uniqueness point <sup>a</sup>        | 5       | 2.2      | 10     | 0_10         | 4.07      | 2.02     | 8      | 0_8          | $p = .27$ |
| Conceptual familiarity (1-5) <sup>b</sup>         | 2.39    | 0.79     | 2.83   | 1.07_3.90    | 2.74      | 0.84     | 3.34   | 1.63_4.97    | $p = .29$ |
| Imageability (1-5) <sup>c</sup>                   | 4.28    | 0.38     | 1.28   | 3.64_4.92    | 4.05      | 0.51     | 1.56   | 3.24_4.8     | $p = .20$ |
| Concreteness (1-5) <sup>c</sup>                   | 4.59    | 0.28     | 0.77   | 4.09_4.86    | 4.57      | 0.46     | 1.81   | 3.05_4.86    | $p = .93$ |
| Emotional valence (1-5) <sup>c</sup>              | 3.33    | 0.55     | 1.96   | 2.48_4.44    | 3.04      | 0.6      | 1.92   | 2.2_4.12     | $p = .21$ |

<sup>a</sup>Values taken from Lexique (www.lexique.org; New, Pallier, Brysbaert, & Ferrand, 2004).

<sup>b</sup>All the scales are 5-point scales. The values were obtained from Bonin et al. (2003b), and from Alario and Ferrand (1999).

<sup>c</sup>All the scales are 5-point scales. The values were obtained from Bonin et al. (2003a).

The words were divided into two sets of 14 items matched for the *surface variables* of number of letters and bigram frequency; the *lexical variables* of book and subtitle frequency, age-of-acquisition, number of orthographic neighbours and orthographic uniqueness point;

and the *semantic variables* of conceptual familiarity, imageability, concreteness and emotional valence. The statistical characteristics of the words are provided in Table 1.

*Procedure.* The participants were assigned to one of the two encoding conditions (survival vs. moving) and were given the following instructions (taken from Nairne et al., 2007):

*Survival condition:*

In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any survival equipment. In the coming months, you will have to find stable supplies of food and water and protect yourself from predators. We will present you with a list of words and want you to rate the relevance of each word in the survival situation. Some of the words may be relevant and others not, it's up to you to decide. You must use a rating scale of 1 (totally irrelevant) to 5 (extremely relevant) (p. 264).

*Moving condition:*

In this task, we would like you to imagine that you will be moving to a foreign country. In the coming months, you will need to find and buy a new house and must transport all of your personal belongings. We are going to show you a list of words in which you must evaluate to what extent each word is relevant to this moving scenario. Certain words may be relevant and others may be irrelevant; it's up to you to decide. You must use a rating scale of 1 (totally irrelevant) to 5 (extremely relevant) (p. 264).

In each encoding condition, the words were presented in the centre of the screen until the participant's response. A different random order was used for each participant. The participants indicated their responses by pressing a key (labelled 1 through 5 on the keyboard) corresponding to their choice. The test phase was administered after a five-minute retention interval. During this period, the participants had to perform two interference tasks: the "X-O" letter-comparison task, (Salthouse, Toth, Hancock, & Woodard, 1997) and the "plus-minus" task from Jersild (1927) and Spector and Biederman (1976). At recall, the participants were told that they had five minutes to write down the previously presented words in any order they liked.

## Results

The mean encoding times and the mean ratings (together with their standard deviations) are reported in Table 2.

*Encoding times (msec).* As far as the time taken to rate the words is concerned, the analysis of variance (ANOVA) did not indicate a reliable main effect of Encoding condition,  $F < 1$ ,  $\eta^2p = .01$ , but did reveal a main effect of type of words,  $F(1, 58) = 5.75$ ,  $p = .02$ ,  $\eta^2p = .09$ , with animate words being rated faster than inanimate words. Importantly, there was a reliable interaction between Encoding condition and Type of words,  $F(1, 58) = 4.89$ ,  $p = .03$ ,  $\eta^2p = .07$ . t-Test comparisons indicated no reliable difference in reaction times (RTs) between animate and inanimate words for the Survival encoding condition,  $t(29) = -.15$ , but a significant difference for the Moving encoding condition,  $t(29) = -2.95$ ,  $p = .006$ , showing that animate words were rated faster than inanimate words (see Table 2).

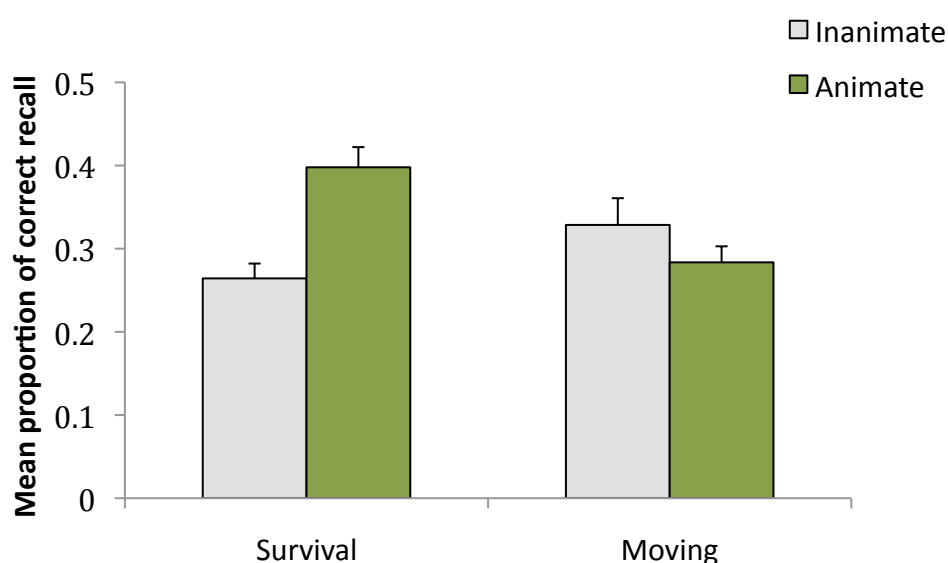
**Table 2.** Mean ratings, mean categorisation times and mean proportions of extra-list intrusions as a function of the different encoding conditions and type of words in Studies 1, 2 and 3.

| Study 1       |          |        |           |        |            |        |           |        |                   |        |           |        |
|---------------|----------|--------|-----------|--------|------------|--------|-----------|--------|-------------------|--------|-----------|--------|
|               | Survival |        |           |        | Moving     |        |           |        |                   |        |           |        |
|               | Animate  |        | Inanimate |        | Animate    |        | Inanimate |        |                   |        |           |        |
|               | Mean     | SD     | Mean      | SD     | Mean       | SD     | Mean      | SD     |                   |        |           |        |
| Reaction Time | 1,974.89 | 431.65 | 1,980.98  | 425.91 | 1,816.4    | 450.83 | 1,966.5   | 327.41 |                   |        |           |        |
| Ratings       | 2.54     | 0.46   | 2.47      | 0.58   | 1.74       | 0.77   | 2.77      | 0.6    |                   |        |           |        |
| Intrusions    | .04      | .09    | .07       | .15    | .03        | .06    | .06       | .11    |                   |        |           |        |
| Study 2       |          |        |           |        |            |        |           |        |                   |        |           |        |
|               | Survival |        |           |        | Moving     |        |           |        | Pleasantness      |        |           |        |
|               | Animate  |        | Inanimate |        | Animate    |        | Inanimate |        | Animate           |        | Inanimate |        |
|               | Mean     | SD     | Mean      | SD     | Mean       | SD     | Mean      | SD     | Mean              | SD     | Mean      | SD     |
| Reaction Time | 1,874.89 | 729.71 | 1,934.27  | 672.89 | 1,490.12   | 558.90 | 1,808.09  | 632.36 | 1,903.72          | 755.97 | 1,925.65  | 773.71 |
| Ratings       | 2.44     | 1.47   | 2.70      | 1.50   | 1.27       | 0.75   | 2.70      | 1.51   | 2.92              | 1.23   | 3.18      | 1.21   |
| Intrusions    | .03      | .08    | .13       | .22    | .04        | .07    | .12       | .19    | .03               | .07    | .11       | .21    |
| Study 3       |          |        |           |        |            |        |           |        |                   |        |           |        |
|               | Survival |        |           |        | Tour guide |        |           |        | Explicit Learning |        |           |        |
|               | Animate  |        | Inanimate |        | Animate    |        | Inanimate |        | Animate           |        | Inanimate |        |
|               | Mean     | SD     | Mean      | SD     | Mean       | SD     | Mean      | SD     | Mean              | SD     | Mean      | SD     |
| Reaction Time | 2,190.2  | 444.79 | 2,245.16  | 388.76 | 2,048.52   | 320.6  | 2,118.95  | 281.21 | –                 | –      | –         | –      |
| Ratings       | 2.23     | 0.43   | 2.46      | 0.42   | 2.43       | 0.56   | 2.05      | 0.38   | –                 | –      | –         | –      |
| Intrusions    | .03      | .05    | .03       | .04    | .03        | .04    | .06       | .08    | .04               | .13    | .09       | .15    |

Note: “–”: no encoding times and no rating were collected in the the explicit Learning condition.

*Ratings.* As far as the rating scores are concerned, a reliable main effect of Encoding condition was found,  $F(1,58) = 4.46$ ,  $p = .04$ ,  $\eta^2p = .07$ , indicating that the words were perceived as more relevant in the Survival in comparison to the Moving condition. A main effect of Type of words was found,  $F(1, 58) = 20.18$ ,  $p < .001$ ,  $\eta^2p = .26$ , showing that inanimate words were given higher scores than animate words. Finally, the interaction between Encoding condition and Type of words was significant,  $F(1, 58) = 26.31$ ,  $p < .001$ ,  $\eta^2p = .31$ . t-Test comparisons revealed no significant difference between animate and inanimate words in the Survival scenario,  $t(29) = .58$ , but a reliable difference between the two types of words in the Moving scenario,  $t(29) = -5.76$ ,  $p < .001$ , thus indicating that inanimate words were scored higher than animate words.

*Recall rates.* We did not find a significant main effect of Encoding condition on correct recall rates,  $F < 1$ ,  $\eta^2p = .01$ . Otherwise, animate words were recalled better than inanimate words,  $F(1, 58) = 4.75$ ,  $p = .03$ ,  $\eta^2p = .08$ . Importantly, as shown in Figure 1, the interaction between Encoding condition and Type of words was significant,  $F(1, 58) = 19.53$ ,  $p < .001$ ,  $\eta^2p = .25$ . T-test comparisons showed no reliable difference on recall rate between animate and inanimate words in the Moving condition,  $t(29) = -1.42$ ,  $p > .10$ , but a significant difference in the Survival condition,  $t(29) = 5.36$ ,  $p < .001$ , with more animates than inanimates being recalled ( $m = .40$  and  $m = .26$ ). Importantly, the interaction between Encoding condition and Type of words remained significant when encoding times and relevance ratings were introduced as covariates.



**Figure 1.** Mean proportions and standard errors of correct recall as a function of Encoding condition (survival vs. moving) and Animacy (animate vs. inanimate stimuli) in Study 1.

Here and in the studies reported below, for each participant, the proportion of intrusions was calculated as the number of extra-list items divided by the total number of items recalled by the participant. The extra-list items were first categorised into animates and inanimates by the authors of the paper. In order to ensure that our classification of intrusive words into animates and inanimates was not biased, we adopted a procedure that we had used in a previous study (Bonin, Gelin, Laroche, Méot, & Bugaïška, in press) and asked five independent adults to classify the intrusive words obtained in Studies 1–4 on a 3-point scale (1 = clearly referring to an animate, 2 = ambiguous and 3 = clearly referring to an inanimate). Across all studies, the agreement between the five raters was almost perfect (Fleiss'  $\kappa = .94$  for the five judges and  $.95$  with the addition of the original categorisation). (There was one word (*facteur* [meaning postman or factor], in Study 4) on which the raters did not agree and which was therefore ambiguous. When this word was excluded from the intrusion analysis of Study 4 [see below], we found exactly the same results as those that included it.)

As can be seen in Table 2, there were more inanimate (I) than animate (A) extra-list intrusions, but the difference was not significant,  $F(1, 58) = 2.51, p > .10, \eta^2 p = .04$ . Neither the main effect of Encoding condition,  $F < 1, \eta^2 p = .003$ , nor the interaction between Encoding condition and Type of words,  $F < 1, \eta^2 p = .001$ , was significant.

### **Discussion of Study 1**

We found a significant animacy effect on recall rates in a survival scenario but not in a non-survival situation, that is, moving to a new house in a foreign land. Taken together, these findings suggest that in situations where there is (a priori) a greater need to pay more attention to inanimates than to animates, the latter are no longer remembered better than the former. However, before going further in our interpretation of these findings, we thought it important to replicate and extend them. In Study 2, we once again examined the issue of whether animacy effects can be modulated by varying the encoding contexts or tasks. However, this time we used a multiple regression approach. We therefore selected concrete and imageable words from three different semantic categories and we included, as in Study 1, the survival and the moving encoding conditions. Pleasantness processing was also included in this study because it has often been used as a control task in survival-processing experiments (Nairne, Pandeirada, VanArsdall, & Blunt, 2015). As claimed by Nairne et al. (2015), the pleasantness-rating task represents a quintessential form of deep processing.

An important aspect of Study 2 is that we deliberately chose to include fewer animate than inanimate words. The proportion of animates to inanimates was 1 to 3. We think that finding a superior recall of animates over inanimates in a context where there are more inanimate than animate words in the lists would provide an even stronger argument in support of the robustness of animacy effects in episodic memory. Moreover, it would suggest that animacy effects are not just a function of the more organised nature of the animate items relative to the inanimate items, that is to say that the animate condition provides participants with a related category (i.e., moving animals) in which one item may cue other items at the time of recall. This issue will also be addressed specifically in Study 4.

### **Study 2: replicating and extending the findings from Study 1 using a multiple regression approach**

Study 2 aimed at replicating and substantiating the findings of Study 1, but using a different set of items and adopting a multiple regression approach. According to several researchers (e.g., Baayen, 2010; Balling, 2008), the factorial approach has certain disadvantages when compared to the multiple regression approach, one of which is the loss of power and influence of confounding variables. We think that the two approaches are both useful and complementary. The multiple regression approach has already been employed by Nairne et al. (2013) to investigate animacy effects in memory. In effect, Nairne et al. (2013) reanalysed Rubin and Friendly's (1986) recall data and included animacy as a predictor variable in their multiple regression analyses. They found that animacy accounted for a large part of the variance in predicting recall rates. In the present study, we explored the influence of animacy effects on recall rates by using lists that contained about one-third of animate items. This was done in order to reduce the potential saliency of the animate items and to make sure that animacy effects on recall rates are not just a function of the more organised nature of animate items.

As in Study 1, we included the grassland-survival scenario and the control moving scenario as well as a non-schematic encoding condition: pleasantness rating. In line with the findings of Study 1, we expected animacy effects to be observed in both the survival and pleasantness conditions because in neither of these two conditions is there any special emphasis on inanimate things. In contrast, and in line with the findings of Study 1, we did not predict that animates would be remembered better than inanimates in the moving encoding



condition since this situation clearly requires participants to focus more on objects than on persons or animals.

## Method

*Participants.* A total of 151 students (130 females; mean age 19.83 years) from the University of Bourgogne were involved in the study (9 participants were excluded due to atypical reaction times or ratings during the encoding phase). All the participants received course credits for their participation and, as in the previous study, all were native French speakers and none were taking medication known to affect the central nervous system.

**Table 3.** Statistical characteristics (mean, standard deviation, range, minimum-maximum, t-test of the means) of the control variables in Study 2 for list 1 and list 2.

|                                                           | List 1 |        |       |            | List 2 |       |       |            | t-Test    |
|-----------------------------------------------------------|--------|--------|-------|------------|--------|-------|-------|------------|-----------|
|                                                           | Mean   | SD     | Range | Min-max    | Mean   | SD    | Range | Min-max    |           |
| Number of letters <sup>a</sup>                            | 7.77   | 1.71   | 7     | 5_12       | 7.07   | 1.59  | 7     | 4-11       | $p = .11$ |
| Number of phonemes <sup>a</sup>                           | 5.67   | 1.46   | 5     | 4_9        | 5.07   | 1.29  | 6     | 3-9        | $p = .10$ |
| Book frequency <sup>a</sup>                               | 14.96  | 17.52  | 70.14 | 0.27_70.41 | 14.95  | 14.47 | 71.96 | 0.95-72.91 | $p = .99$ |
| Subtitle frequency <sup>a</sup>                           | 12.33  | 12.464 | 41.82 | 0.51_42.33 | 12.45  | 12.11 | 52.16 | 1.45-53.61 | $p = .97$ |
| Age-of-acquisition <sup>b</sup>                           | 2.3    | 0.59   | 2.04  | 1.23_3.27  | 2.17   | 0.51  | 2.01  | 1.35-3.36  | $p = .40$ |
| Orthographic Levenshtein distance 20 (old20) <sup>a</sup> | 2.34   | 0.75   | 3.35  | 1.5_4.85   | 2.13   | 0.59  | 2.65  | 1.4-4.05   | $p = .23$ |
| Imageability <sup>c</sup>                                 | 4.54   | 0.27   | 1.12  | 3.8_4.92   | 4.61   | 0.24  | 0.92  | 4.08-5     | $p = .32$ |
| Concreteness (1-5) <sup>c</sup>                           | 4.80   | 0.13   | 0.64  | 4.36_5.00  | 4.82   | 0.10  | 0.36  | 4.59_4.95  | $p = .53$ |
| Emotional valence (1-5) <sup>c</sup>                      | 3.36   | 0.61   | 2.56  | 1.84_4.40  | 3.16   | 0.61  | 3.04  | 1.52_4.56  | $p = .27$ |
| Sensory experience ratings (SER) <sup>d</sup>             | 3.94   | 0.96   | 3.76  | 2.36_6.12  | 3.9    | 0.73  | 2.85  | 3.03-5.88  | $p = .83$ |

<sup>a</sup>Values taken from Lexique (www.lexique.org; New, Pallier, Brysbaert, & Ferrand, 2004).

<sup>b</sup>All the scales are 5-point scales. The values were obtained from Bonin et al. (2003b), and from Alario and Ferrand (1999).

<sup>c</sup>All the scales are 5-point scales. The values were obtained from Bonin et al. (2003a)

<sup>d</sup>Sensory experience ratings (SER): Values on a seven-point scale taken from Bonin et al. (2015)

*Stimuli.* There were 2 lists of 30 words. Each list comprised three different semantic categories (animals, objects and food) and were matched on the following variables: number of letters, number of phonemes, book and subtitle frequency, age-of-acquisition, orthographic neighbourhood as measured by orthographic Levenshtein distance 20 (old20), imageability, concreteness, emotional valence and sensory experience (generally referred to as “SER”). Sensory experience for words is a recently introduced variable that corresponds to the degree to which words elicit sensory and perceptual experiences (it is measured using a Likert scale,

Bonin, Méot, Ferrand, & Bugańska, 2015; Juhasz & Yap, 2013). The statistical characteristics of the controlled variables for the two lists are presented in Table 3.

Overall, the animate (A) and inanimate (I) words were also matched on number of letters (A:  $m = 7.47$ ,  $sd = 1.62$ ; I:  $m = 7.40$ ,  $sd = 1.77$ ;  $p = .895$ ), word frequency (A:  $m = 0.86$  [log transformed],  $sd = .39$ ; I:  $m = 1.01$ ,  $sd = .39$ ;  $p = .196$ ), age-of-acquisition (A:  $m = 2.29$ ,  $sd = .53$ ; I:  $m = 2.20$ ,  $sd = .57$ ;  $p = .552$ ), old20 (A:  $m = 2.38$ ,  $sd = .87$ ; I:  $m = 2.17$ ,  $sd = .61$ ;  $p = .293$ ), imageability (A:  $m = 4.54$ ,  $sd = .27$ ; I:  $m = 4.59$ ,  $sd = .25$ ;  $p = .475$ ), concreteness (A:  $m = 4.77$ ,  $sd = .08$ ; I:  $m = 4.82$ ,  $sd = .12$ ;  $p = .083$ ), emotional valence (A:  $m = 2.99$ ,  $sd = .67$ ; I:  $m = 3.34$ ,  $sd = .60$ ;  $p = .058$ ) and SER (A:  $m = 3.96$ ,  $sd = .71$ ; I:  $m = 3.94$ ,  $sd = .91$ ;  $p = .937$ ).

*Procedure.* The participants were comfortably seated in a quiet room and were randomly assigned to one of the three encoding conditions (survival [ $n = 46$ ], moving [ $n = 49$ ] or pleasantness [ $n = 47$ ]) and to one of the two lists of words. None of them was informed that the experiment was about memory. They were only told that their task would require them to rate words along a certain dimension. The instructions for the survival and the moving scenarios were the same as in Study 1. In the pleasantness-encoding task, the participants were required to rate each word on a five-point scale in order to assess the degree to which each word evoked a positive connotation for them. More precisely, they were given the following instructions: “In this task, we would like you to rate the pleasantness of the words. Some of the words may be pleasant and others may not be—it’s up to you to decide.” In this second experiment, stimuli were presented on computers running E-prime 2.0 software (Schneider, Eschman, & Zuccolotto, 2002).

The words were presented individually for five seconds in the centre of the screen in a different random order for each participant. The participants produced their responses by pressing a key (labelled 1 through 5 on the keyboard) corresponding to their choice. After the participants had completed the encoding phase, they performed the same two distractor tasks as were used in Study 1. These two interference tasks lasted for approximately five minutes. A surprise memory test was then given to the participants. They were asked to recall as many of the previously presented words as they could by writing them down in any order they liked within a period of five minutes.

## Results

The mean encoding times and the mean rating scores (together with their standard deviations) are provided in Table 2.

By-trials RTs and ratings were analysed using linear mixed models with participants and items treated as random factors that served as the basis for intercept adjustments in accordance with the mixed model procedure set out in SPSS 21. We were interested in the effects of animate/inanimate category, scenarios and their interaction.

Number of letters, film subtitle frequency (in log), age of acquisition, orthographic neighbourhood as measured by OLD20, sensory experience ratings, concreteness, imageability and emotional valence were all included as control variables.

*Encoding times (msec).* As far as the times taken to rate the words is concerned, the main effect of animacy was significant,  $F(1, 47.96) = 31, p < .001$ , with encoding times being faster for animates than for inanimates. The main effect of Type of scenarios was also significant,  $F(2, 143.62) = 7.04, p = .001$ , with no reliable difference between the survival and pleasantness conditions,  $t < 1$ , and significantly faster rating times for the moving scenario than for the survival scenario,  $t(143.58) = -3.17, p = .002$ , and the pleasantness condition,  $t(143.64) = -3.3, p = .001$ . The interaction between Type of words and Type of scenario was significant,  $F(2, 3966.09) = 22.39, p < .001$ . Pairwise comparisons reveal that animates were rated faster than inanimates only in the moving scenario,  $t(198.04) = -8.74, p < .001$ . Finally, as far as the covariates are concerned, only SERs and emotional valence had significant facilitatory effects,  $t(47.8) = -2.82, p = .007$  and  $t(49.23) = -2.71, p = .007$ .

*Ratings.* Turning to the rating scores, both main effects were reliable, Type of words:  $F(1, 49.04) = 16.14, p < .001$ , and Type of scenario:  $F(2, 163.45) = 89.94, p < .001$ , with lower ratings for animates than for inanimates and lower ratings for the moving scenario than for the other two encoding conditions: survival:  $t(163.04) = -7.27, p < .001$  and pleasantness:  $t(163.39) = -13.38, p < .001$ . Moreover, as can be seen from Table 2, the rating scores were lower in the survival scenario than in the pleasantness condition,  $t(163.94) = -5.98, p < .001$ . The interaction between Type of words and Type of scenario was significant,  $F(2, 3964.82) = 82.74, p < .001$ , with pairwise comparisons indicating no reliable differences between animates and inanimates in the survival and pleasantness conditions (all  $ts < 1$ ), whereas animates were rated reliably lower than inanimates in the moving scenario,  $t(76.49) = -9.47, p < .001$ . Finally, concerning the covariates, there were significant positive effects of word

frequency and imageability,  $t(49.057) = 2.07, p < .05$  and  $t(50.064) = 2.28, p < .05$ , respectively.

*Recall rates.* Analyses of recall rates were performed using mixed logistic regressions with participants and items defining intercept random effects. Every item recalled within the five-minute recall interval was coded 1 and otherwise 0. A first analysis included the same fixed effects as those used in the analyses of encoding times and rating scores. In a second analysis, fixed effects of encoding times and rating scores were introduced as controlled variables.

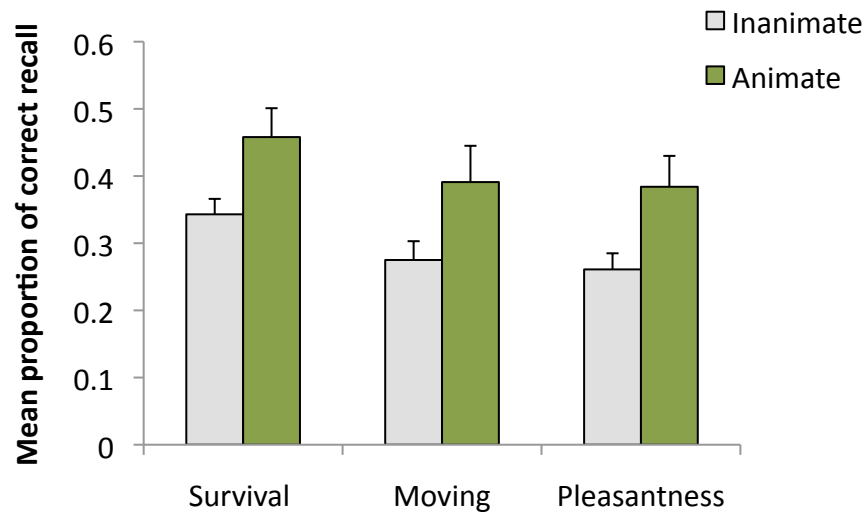
As far as the first analysis, in which encoding times and rating scores were not controlled for, is concerned, the main effect of animacy was significant,  $F(1, 4174) = 6.3, p = .012$ , with animates being better recalled than inanimates ( $m = 0.4$  and  $m = 0.3$ ). The main effect of Type of scenario was also significant,  $F(2, 4174) = 7.38, p < .001$ , with no reliable difference between the moving and pleasantness conditions,  $t < 1$  ( $m = 0.32$  in both scenarios), and significantly better recall for the survival scenario ( $m = 0.40$ ) compared to the moving scenario,  $t(4174) = 3.39, p < .001$  and to the pleasantness condition,  $t(4174) = 3.42, p < .001$ . The interaction between Type of words and Type of scenario was significant,  $F(2, 4174) = 3.81, p = .022$ . Pairwise comparisons revealed that animates were better recalled than inanimates in both the survival,  $t(4174) = 2.72, p = .007; m = 0.47$  and  $m = 0.34$ ) and pleasantness conditions,  $t(4174) = 2.87, p = .004; m = 0.39$  and  $m = 0.26$ ), but not in the moving scenario,  $t < 1$  ( $m = 0.34$  and  $m = 0.3$ ). Finally, as far as the covariates are concerned, only concreteness and imageability had significant facilitatory effects,  $t(4174) = 2.23, p = .025$  and  $t(4174) = 2.28, p = .023$ , respectively.

In the analysis in which encoding times and rating scores were introduced as covariates, the main effect of animacy was significant,  $F(1, 4130) = 9.62, p = .002$ , with animates being recalled better than inanimates ( $m = 0.42$  and  $m = 0.29$ ). The main effect of Type of scenario was also significant,  $F(2, 4130) = 8.25, p < .001$ , with all differences being significant: survival vs. moving,  $t(4130) = 1.99, p = .047, m = 0.4$  and  $m = 0.35$ ; survival vs. pleasantness,  $t(4130) = 4.07, p < .001, m = 0.4$  and  $m = 0.30$ ; moving vs. pleasantness,  $t(4130) = 2.00, p = .046, m = 0.35$  and  $m = 0.30$ . Importantly, the interaction between Type of words and Type of scenario (Figure 2) was not significant,  $F < 1$ .<sup>2</sup> In addition, both encoding times

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<sup>2</sup> It is important to note that the tests of the simple effects of the animacy factor realized at the means of the covariates were significant in all scenarios.

and rating scores had positive effects on recall,  $t(4130) = 4.6, p < .001$  and  $t(4130) = 5.52, p < .001$ , respectively. As found in the first analysis reported above, significant facilitatory effects of concreteness and imageability were also observed,  $t(4130) = 2.06, p = .039$  and  $t(4130) = 2.14, p = .032$ .



**Figure 2.** Mean proportions and standard errors of correct recall as a function of Encoding condition (survival vs. moving vs. pleasantness) and Animacy (animate vs. inanimate stimuli) in Study 2.

With regard to intrusions (see Table 2), the main effect of Encoding condition was not significant,  $F < 1, \eta^2 p = .002$ . The interaction between Encoding condition and Type of intrusions was also not significant,  $F < 1, \eta^2 p = .001$ . However, there was a significant main effect of Type of intrusions,  $F(1, 139) = 30.82, p < .001, \eta^2 p = .18$ . There were less animate (A) than inanimate (I) intrusions in the survival scenario,  $t(45) = -3.93, p < .001$ , in the moving scenario,  $t(48) = -2.91, p < .01$ , and in the pleasantness condition  $t(46) = -2.93, p < .01$ .

Given that there were food-related words in the lists of Study 2, the question arises as to whether these items were remembered better than other inanimate things. In effect, food items, though inanimate, are nevertheless relevant for survival. We therefore performed an additional analysis on recall rates in order to examine whether food items were better recalled than other inanimate items (and also how they compared to animate items) across the different encoding conditions. In this analysis, we included encoding times and rating scores as covariates together with the same fixed effects (e.g., imageability, emotional valence) as those

used in the analyses reported above. The main effect of Type of items was significant,  $F(2, 4127) = 5.49, p = .004$ , with animates being recalled better than inanimates ( $m = 0.42$  and  $m = 0.28, t(4127) = 3.26, p = .001$ ). However, animates did not significantly differ from food items ( $m = 0.33, t(4127) = 1.46, p = .14$ ), and food items also did not significantly differ from the other inanimate items,  $t(4127) = 1.01, p = .31$ . The main effect of Type of scenario was also significant,  $F(2, 4127) = 6.74, p = .001$ : Both the survival and moving scenario yielded better recall than the pleasantness condition,  $t(4127) = 3.56, p < .001$  and  $t(4127) = 2.6, p < .01$ . The interaction between Type of words and Type of scenario was not significant,  $F(4, 4127) = 1.18, p = .32$ . In addition, concreteness and imageability had a positive influence on memory performance,  $t(4127) = 4.6, p < .05$  and  $t(4127) = 3.82, p < .05$ , respectively. Finally, we also found that both encoding times and rating scores had positive effects on recall,  $t(4127) = 33.45, p < .001$  and  $t(4127) = 21.3, p < .001$ , respectively. To sum up, we did not find any advantage of food items compared to other inanimate items. It must be stressed, however, that the number of food items in Study 2 was limited (there were only 9 food items) and these findings are therefore merely a potential indication.

## **Discussion of Study 2**

The animacy effect on recall rates was replicated in the survival scenario. It is important to note that the animacy effect was obtained using lists of items that contained fewer animates than inanimates (there were about one-third of animate items). This is an important finding because it shows that animates are not recalled better than inanimates because of their more organised nature. However, we will return to this issue in Study 4. Indeed, more animates than inanimates were also recalled correctly in a non-schematic encoding task, namely the pleasantness-rating task. In this latter task, there is no special emphasis on animates or inanimates since both can potentially be judged positively or negatively. Since animacy effects have already been found in explicit learning (Nairne et al., 2013), these effects were expected in this task.

Regarding the moving condition, the results were different from those obtained in Study 1. This time the animacy effect was not reversed. It is important to stress that, even in the moving encoding scenario for which we predicted that attention might be drawn more to objects than to persons or animals, as well as in the context of lists with more inanimates than animates, animates were still better remembered than inanimates. Study 2 also revealed that in the moving scenario, animates were rated as being less relevant than inanimates and,

moreover, these ratings were made quickly. Nevertheless, animates were remembered better than inanimates. The findings from Study 1 and 2 regarding animacy effects in non-survival scenarios are somewhat ambiguous. We therefore decided to design a third study that was conceptually similar to Studies 1 and 2, except that a different non-survival scenario was used. In addition, we changed the non-schematic encoding task from a pleasantness-rating task to an explicit learning task.

Finally, we did not find any advantage of food items compared to other inanimate items. Also, the recall of food items was not significantly better than the recall of the animate items. Interestingly, a recent study by Clark and Bruno (in press) found that location memory for food items (presented as pictures) was greater when they were processed in a survival context than in a non-survival context (see also Nairne, VanArsdall, Pandeirada, & Blunt, 2012). Unfortunately, inanimate non-food items were not included in this study. It will therefore be interesting in the future to determine whether location memory for food items is better than that for inanimate non-food items.

### **Study 3: animacy effects in survival, planning a trip as tour guide and intentional learning**

In this study, we further explored animacy effects on longterm retention as a function of different encoding situations. The major changes in Study 3 were the following. First, we used another non-survival encoding scenario. More specifically, we designed a scenario “planning a trip as a tour guide” which, as yet, has not been used in the literature on adaptive memory. A variety of scenarios have been used as controls for comparison with the survival processing condition (e.g., bank robbery [Kang, McDermott, & Cohen, 2008], suicide in a space capsule [Bell, Röer, & Buchner, 2013]). However, the moving scenario has often been used in the past as a control scenario for the survival scenario (e.g., Nairne et al., 2007; Nairne & Pandeirada, 2010a; Weinstein, Bugg, & Roediger III, 2008). We thought it important to assess whether animacy effects can be obtained in a non-survival scenario different from the moving scenario, since the findings from Studies 1 and 2 were ambiguous regarding this issue. Second, the nonschematic control condition was changed to an explicit learning situation which is known to produce excellent long-term retention (Nairne & Pandeirada, 2008). Finally, as in Study 1, we used a factorial design.

## Method

*Participants.* Ninety students (78 females; mean age 19.77 years) at the University of Bourgogne participated in the study in exchange for course credits. None were taking medication known to affect the central nervous system and all were native speakers of French.

*Stimuli.* A total of 56 nouns were selected from Snodgrass and Vanderwart's (1980) and Bonin, Peereman, et al. (2003) databases. The words were divided into 2 sets of 28 items that referred to either an animate or an inanimate object. The words were matched on exactly the same set of variables as listed in Study 1. The statistical characteristics of the controlled variables can be seen in Table 4.

**Table 4.** Statistical characteristics (mean, standard deviation, range, minimum–maximum, t-test of the means) of the control variables for animate and inanimate stimuli used in Study 3.

|                                                   | Animate |         |        |             | Inanimate |         |        |             | t-Test    |
|---------------------------------------------------|---------|---------|--------|-------------|-----------|---------|--------|-------------|-----------|
|                                                   | Mean    | SD      | Range  | Min-max     | Mean      | SD      | Range  | Min-max     |           |
| Number of letters <sup>a</sup>                    | 6.50    | 1.90    | 7      | 3-10        | 6.61      | 1.91    | 7      | 3-10        | $p = .83$ |
| Bigram frequency (per million words) <sup>a</sup> | 8220.43 | 3193.09 | 12024  | 1430-13454  | 9447.93   | 2675.39 | 11616  | 2360-13976  | $p = .13$ |
| Book frequency <sup>a</sup>                       | 16      | 36      | 186.89 | 0.07-186.96 | 22        | 45      | 175.13 | 0.07-175.2  | $p = .60$ |
| Subtitle frequency <sup>a</sup>                   | 20      | 47      | 188.26 | 0.15-188.41 | 13        | 30      | 154.07 | 0.06-154.13 | $p = .48$ |
| Age-of-acquisition <sup>b</sup>                   | 2.52    | 0.65    | 2.6    | 1.15-3.75   | 2.75      | 0.80    | 2.97   | 1.23-4.2    | $p = .22$ |
| Number of orthographic neighbors <sup>a</sup>     | 2.14    | 3.40    | 13     | 0-13        | 2.50      | 3.70    | 11     | 0-11        | $p = .71$ |
| Orthographic uniqueness point <sup>a</sup>        | 4.78    | 2.27    | 10     | 0-10        | 5.00      | 2.74    | 9      | 0-9         | $p = .37$ |
| Conceptual familiarity <sup>b</sup>               | 2.14    | 0.79    | 2.83   | 1.07-3.9    | 2.49      | 0.85    | 3.79   | 1.18-4.97   | $p = .11$ |
| Imageability <sup>c</sup>                         | 4.42    | 0.37    | 1.32   | 3.64-4.96   | 4.20      | 0.49    | 1.6    | 3.24-4.84   | $p = .06$ |
| Image variability <sup>c</sup>                    | 2.72    | 0.67    | 2.45   | 1.85-4.3    | 2.50      | 0.57    | 2.42   | 1.65-4.07   | $p = .20$ |
| Concreteness <sup>c</sup>                         | 4.60    | 0.31    | 1.27   | 3.64-4.91   | 4.67      | 0.37    | 1.95   | 3.05-5      | $p = .50$ |
| Emotional valence <sup>c</sup>                    | 3.29    | 0.68    | 3.24   | 1.32-4.56   | 2.99      | 0.64    | 2.6    | 1.52-4.12   | $p = .09$ |

<sup>a</sup>Values taken from Lexique (www.lexique.org; New, Pallier, Brysbaert, & Ferrand, 2004).

<sup>b</sup>All the scales are 5-point scales. The values were obtained from Bonin et al. (2003b), and from Alario and Ferrand (1999).

<sup>c</sup>All the scales are 5-point scales. The values were obtained from Bonin et al. (2003a).

*Procedure.* The participants were tested individually and were seated comfortably in a quiet room. They were randomly assigned to one of the three encoding condition (n = 30 in each condition): survival scenario, tour guide scenario or explicit learning. The instructions given to the participants in the survival condition were exactly the same as described in the procedure section of Study 1. The instructions given to the participants in the “tour guide” condition were as follows:



*In this task, please imagine that you are working in a travel agency as tour guide. Over the next few months, you'll need to organize a trip for a group of people: find accommodation, meals and attend to administrative procedures (e.g., insurance, reservations). We would like you to rate how relevant the word would be for you in this situation. Some of the words may be relevant and others may not be—it's up to you to decide.*

In these two encoding conditions, the participants were asked to rate the words on a 5-point scale, with 1 indicating totally irrelevant in the described scenario and 5 = extremely relevant. The participants responded by pressing a key on the keyboard (1 through 5) corresponding to their choice. Each participant was told to respond within five seconds of word presentation, and no mention was made of a later retention test.

As far as the explicit learning condition is concerned, the participants were informed that the experiment involved memory but were not given any information about the different types of words (i.e., animates vs. inanimates) that would be presented. During the encoding phase, the words were presented at the rate of five seconds per word, in a different random order for each participant. The participants were told to read the words carefully in order to remember them for a test that would be administered later.

In each encoding condition, two interference tasks followed the presentation of the words. These tasks were the same as used in the previous studies. These two interference tasks lasted five minutes. After these two interference tasks, the participants were asked to recall (by writing them down) as many of the words as they could remember from the encoding phase during a period of ten minutes.

In all the encoding conditions, the stimuli were presented individually in the centre on the screen of a Macintosh computer running Psyscope v.1.2.5 software (Cohen, MacWhinney, Flatt & Provost, 1993).

## **Results**

*Encoding times.* Concerning the time taken to rate the words (see Table 2), the ANOVA did not reveal a reliable main effect of Encoding condition,  $F(1, 58) = 2.20$ ,  $\eta^2 p = .04$ , but did indicate a significant main effect of Type of words,  $F(1, 58) = 5.80$ ,  $p = .02$ ,  $\eta^2 p =$

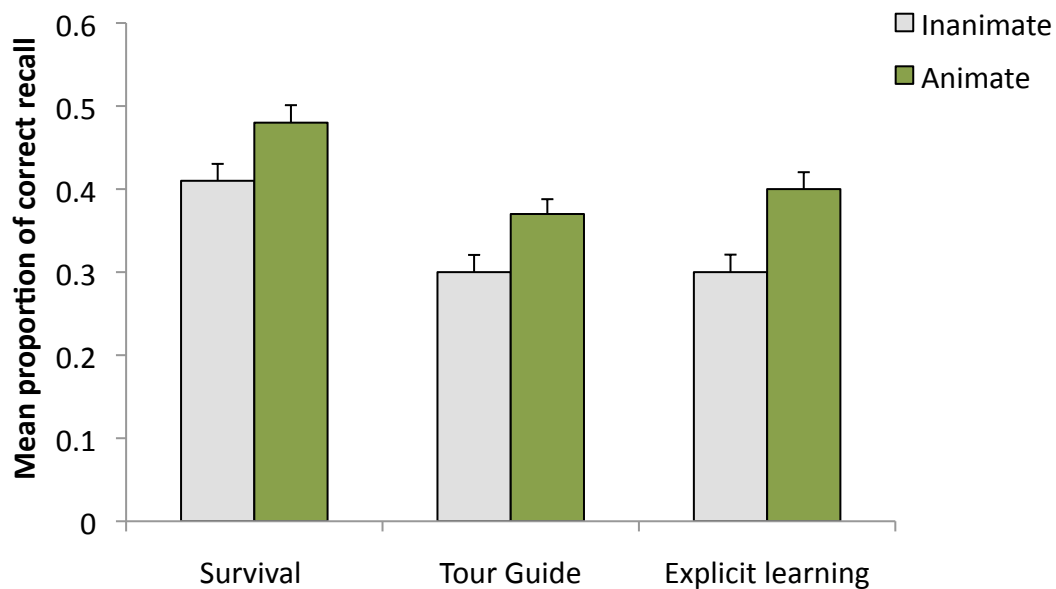
.09, with animate words being rated faster than inanimate words. The interaction between Encoding condition and Type of words was not significant,  $F < 1$ ,  $\eta^2p = .001$ .

*Ratings.* For the rating scores (see Table 2), neither the main effect of Encoding condition,  $F(1, 58) = 1.15$ ,  $\eta^2p = .02$ , nor the main effect of Type of words,  $F(1, 58) = 1.16$ ,  $\eta^2p = .02$ , was significant. However, the interaction between Encoding condition and Type of words was significant,  $F(1, 58) = 22.31$ ,  $p < .001$ ,  $\eta^2p = .28$ . *t*-Test comparisons revealed significant differences between animate and inanimate words in the Survival scenario condition,  $t(29) = -2.29$ ,  $p = .03$ , as well as in the Tour Guide scenario,  $t(29) = 4.79$ ,  $p < .001$ , with inanimate words being given higher rating scores than animate words in the Survival condition whereas the opposite was observed in the Tour Guide scenario.

*Recall rates.* As far as correct recall rates are concerned, the two main effects of Encoding condition,  $F(2, 87) = 11.99$ ,  $p < .001$ ,  $\eta^2p = .22$ , and of Type of words,  $F(1, 87) = 39.22$ ,  $p < .001$ ,  $\eta^2p = .31$ , were significant. The interaction between Encoding condition and Type of words was not significant,  $F < 1$ ,  $\eta^2p = .01$  (see Figure 3). Pairwise comparisons revealed no significant difference between the Explicit learning and Tour Guide condition,  $t < 1$ , whereas the differences between these latter two conditions and the Survival condition were both reliable: Explicit learning vs. Survival,  $t(87) = -4.52$ ,  $p < .001$ , and Tour Guide vs. Survival,  $t(87) = -3.9$ ,  $p < .001$ , thus indicating that the Survival scenario condition led to better recall performance than either the explicit learning or the Tour Guide encoding conditions. Finally, the difference between animate and inanimate words on recall rates was reliable in the three encoding conditions. More animates were recalled than inanimates in the Explicit learning condition,  $t(29) = 6.00$ ,  $p < .001$  ( $m = 0.40$  and  $m = 0.30$ ), in the Tour Guide condition,  $t(29) = 2.32$ ,  $p < .05$  ( $m = 0.37$  and  $m = 0.30$ ) and in the Survival condition  $t(29) = 3.65$ ,  $p < .01$  ( $m = 0.48$  and  $m = 0.41$ ). (In an ANOVA including only the Tour Guide and Survival conditions with ratings and encoding times introduced as covariates, animates were still significantly better recalled than inanimates in both scenarios. There was also a reliable difference between the two scenarios for animates, whereas this was only marginally significant for inanimates.)

As far as intrusions are concerned, the main effect of Encoding condition was not significant,  $F(2, 87) = 1.32$ ,  $\eta^2p = .03$ . The main effect of Type of intrusions was significant,  $F(1, 87) = 13.78$ ,  $p < .001$ ,  $\eta^2p = .14$ , as was the interaction between Encoding condition and Type of intrusions,  $F(2, 87) = 3.35$ ,  $p < .05$ ,  $\eta^2p = .07$ . As reported in Table 2, there were

more inanimate (I) than animate (A) intrusions in the three encoding conditions. The difference was significant, however, only in the explicit learning condition,  $t(29) = -3.18, p < .01$ . In the tour guide scenario, the difference was marginally significant,  $t(29) = -2.02, p = .052$ , and it was not significant in the survival scenario,  $t(29) = -.56, p > .10$ .



**Figure 3.** Mean proportions and standard errors of correct recall as a function of Encoding condition (survival vs. tour guide vs. explicit learning) and Animacy (animate vs. inanimate stimuli) in Study 3.

### Discussion of Study 3

Again, animates were better remembered than inanimates in the survival scenario. It was also the case in the explicit learning condition, as has been reported in previous studies (e.g., Nairne et al., 2013). Importantly, using a tour guide scenario as a non-survival encoding scenario resulted in reliable animacy effects on recall rates. It is worth stressing that the non-survival scenario that we used had never previously been used. We thought it appropriate to employ a scenario other than the moving scenario because, on the one hand, the latter scenario has often been used as a control scenario for the survival scenario and, on the other, because the findings concerning animacy effects in the moving condition were somewhat inconsistent across Studies 1 and 2. Also it is important to evaluate whether animacy effects can be obtained in other non-survival scenarios since it seems to be a very robust effect. It is important to stress that at no point we observe a *reliable reversal of the animacy effect* in the moving scenario where it might have been expected that more attention would be devoted to “non-living things” than to “living things”. In effect, in Study 1, the difference in recall rates

between animates and inanimates was not reliable (at a descriptive level the animacy effect was reversed), whereas in Study 2, the animacy effect reach significance. Finally, it is also worth mentioning that the survival scenario led to better recall than either the tour guide scenario or the explicit learning condition, replicating the survival processing advantage (e.g., Nairne et al., 2007; Nairne & Pandeirada, 2010a). Before going on to the

General Discussion of our findings, we thought it important to directly address the issue of the relatedness of items among the animate and inanimate categories in a fourth and final study.

#### **Study 4: animacy effects (in explicit learning): are they due to the more organised nature of animates?**

In the three studies reported above, we were careful to control for a large number of variables (e.g., number of letters, orthographic uniqueness, familiarity, imageability, concreteness and valence) across animate and inanimate stimuli. However, we did not control for relatedness and category size. As a result, it could be that animate words have a higher degree of relatedness than inanimate words, thus favouring the retrieval of the former. In Study 4, we addressed this issue in an explicit memory task. The words were controlled on the same dimensions as those used in the previous study. However, we also controlled the number of categories and the relatedness among the items across the categories (indexed by frequency of mention). VanArsdall et al. (2015) took this issue into account when investigating animacy effects in a very recent study. However, so far, this study is the only one to have addressed this issue and it is important to assess its generalizability to recall (here free recall) since the authors tested memory with cued recall. More importantly, in their experiment, they used only two different categories: the four-footed animal category for animates and the furniture category for inanimates. It is impossible to determine whether semantic knowledge interfered with memory performance since both categories were very salient. In the current study, we used eight different semantic categories and free recall as in the previous studies. Based on the findings reported by VanArsdall et al. (2015), we anticipated that animate words would be recalled better than inanimates when category size and relatedness of the items across categories are controlled for. In our view, people remember animates better than inanimates

because, ultimately, the former are more important for survival and/or reproduction than the latter and not because of the potential cohesiveness of animate items.

## Method

*Participants.* Twenty-seven adults (14 females; mean age 46.81 years) participated in this experiment as part of a presentation for a foundation called “Rotary club.” All participants included in this study were native speakers of French.

*Stimuli.* Thirty-two nouns were selected from the Snodgrass and Vanderwart (1980), Bonin, Peereman, et al. (2003) and Bueno and Megherbi (2009) databases. Each word referred to either an animate or to an inanimate object, with four categories for each type of item: insects, birds, animals with four legs and humans (identified by profession) for animate stimuli; furniture, tools, clothes and musical instruments for inanimate stimuli.

**Table 5.** Statistical characteristics (mean, standard deviation, range, minimum–maximum, t-test of the means) of the control variables in Study 4 for animate and inanimate stimuli.

|                                                   | Animate |         |        |             | Inanimate |         |        |             | t-test    |
|---------------------------------------------------|---------|---------|--------|-------------|-----------|---------|--------|-------------|-----------|
|                                                   | Mean    | SD      | Range  | Min-max     | Mean      | SD      | Range  | Min-max     |           |
| Number of letters <sup>a</sup>                    | 7       | 1.94    | 6      | 4-10        | 6.63      | 1.9     | 8      | 4-12        | $p = .60$ |
| Bigram frequency (per million words) <sup>a</sup> | 8759.69 | 2339.42 | 8345   | 4462-12807  | 8699.31   | 2274.68 | 7199   | 5151-12350  | $p = .94$ |
| Book frequency <sup>a</sup>                       | 19.38   | 27.17   | 108.92 | 1.35-110.27 | 47.78     | 79.33   | 340.61 | 0.47-341.08 | $p = .20$ |
| Subtitle frequency <sup>a</sup>                   | 18.06   | 22.17   | 84.73  | 0.69-85.42  | 23.55     | 26.48   | 110.95 | 0.49-111.44 | $p = .54$ |
| Age-of-acquisition (1-5) <sup>b</sup>             | 2.08    | 0.41    | 1.45   | 1.35-2.8    | 2.26      | 0.48    | 1.65   | 1.35-3      | $p = .26$ |
| Number of orthographic neighbors <sup>a</sup>     | 2.94    | 3.99    | 14     | 0-14        | 1.88      | 2.62    | 8      | 0-8         | $p = .40$ |
| Orthographic uniqueness point <sup>a</sup>        | 5.19    | 2.32    | 9      | 0-9         | 5.69      | 2.11    | 9      | 0-9         | $p = .54$ |
| Conceptual familiarity (1-5) <sup>b</sup>         | 2.57    | 0.72    | 3.15   | 1.4-4.55    | 3.02      | 1.12    | 3.3    | 1.53-4.83   | $p = .20$ |
| Imageability (1-5) <sup>c</sup>                   | 4.62    | 0.23    | 0.84   | 4.12-4.96   | 4.44      | 0.36    | 1.52   | 3.32-4.84   | $p = .11$ |
| Concreteness (1-5) <sup>c</sup>                   | 4.63    | 0.32    | 1.22   | 3.69-4.91   | 4.79      | 0.21    | 0.86   | 4.14-5      | $p = .14$ |
| Emotional valence (1-5) <sup>c</sup>              | 3.3     | 0.77    | 3.19   | 1.25-4.44   | 3.32      | 0.62    | 2.68   | 1.64-4.32   | $p = .95$ |
| Mention frequency <sup>d</sup>                    | 0.27    | 0.3     | 0.98   | 0-0.98      | 0.29      | 0.32    | 0.84   | 0.01-0.85   | $p = .88$ |

<sup>a</sup>Values taken from Lexique (www.lexique.org; New, Pallier, Brysbaert, & Ferrand, 2004).

<sup>b</sup>All the scales are 5-point scales. The values were obtained from Bonin et al. (2003b), and from Alario and Ferrand (1999).

<sup>c</sup>All the scales are 5-point scales. The values were obtained from Bonin et al. (2003a)

<sup>d</sup>The values were obtained from Bueno and Megherbi (2009).

The words were divided into 2 sets of 16 items matched for *the surface variables* of number of letters and bigram frequency; *the lexical variables* of book and subtitle frequency, age-of-acquisition, number of orthographic neighbours, orthographic uniqueness point; and

*the semantic variables* of conceptual familiarity, imageability, image variability, concreteness, emotional valence and mention frequency. The statistical characteristics of the words are provided in Table 5.

*Procedure.* The participants were tested collectively. They were comfortably seated facing a large screen. At the beginning of the session, they were told that they were about to participate in a cognitive psychology experiment involving memory. However, they were not informed about the different types of words that would be presented (i.e., animates vs. inanimates) and the associated categories (insects, birds, animals with 4 legs, humans, furniture, tools, clothes and musical instruments). During the encoding phase, the words were randomly presented on a large white screen via a Macintosh computer running the Psyscope v.1.2.5 software (Cohen et al., 1993) at the rate of five seconds per word. The participants were told to read the words carefully in order to remember them for a test that would be administered later. The retention test was presented following an interference task. This took the form of the digit symbol-coding task taken from the Wechsler Adult Intelligence Scale (WAIS-IV, Wechsler, 2011). This interference task lasted for two minutes. After this task, the participants were asked to recall in writing as many of the words they could remember from the learning phase during a period lasting four minutes.

## **Results**

In line with previous findings obtained in an explicit learning task (Nairne et al., 2013), the proportion of correctly recalled animate words ( $m = 0.44$ ,  $sd = .16$ ) was higher than that of inanimate words ( $m = 0.32$ ,  $sd = .17$ ),  $t(26) = 3.68$ ,  $p = .001$ . The analysis on the proportion of intrusions showed no significant difference between animate ( $m = 0.04$ ,  $sd = .07$ ) and inanimate intrusions ( $m = 0.07$ ,  $sd = .13$ ),  $t(26) = 1.26$ ,  $p = .22$ .

## **Discussion of Study 4**

In this study, we assessed whether the better memory performance for animates compared to inanimates was due to the structure of the animacy category. In line with VanArsdall et al.'s (2015) findings in cued recall, we found that animates were recalled better than inanimates when category size and cohesiveness of items across categories were controlled for. This is an important finding. A failure to observe that animacy effects persist

when the cohesiveness of animates and inanimates is controlled for would have constituted a serious challenge to our favoured evolutionary interpretation of animacy effects. It should be remembered, however, that animacy effects have also been found in recognition hits (e.g., Bonin et al., 2014) where cohesiveness of items is less important. Finally, the fact that animate did not outnumber inanimate intrusions also argues against an organisational account of animacy effects in free-recall.

## **General discussion**

In the present studies, we attempted to determine whether animacy effects in episodic memory are independent of encoding instructions. Our work was directly inspired by the adaptive memory view championed by Nairne and colleagues (Nairne, 2010; Nairne & Pandeirada, 2010a, 2010b). According to this view, certain functional characteristics of human memory were sculpted during our distant past due to selective pressures faced by our ancestors. In particular, and importantly, this view holds that learning and memory do not apply equally to all kind of items, but instead that some items—those that are relevant for fitness—are more important than others and are prioritised during processing. In other words, the brain is not a blank slate (Pinker, 2002). As reviewed in the Introduction, two types of evidence support the adaptive memory view: the survival processing advantage and animacy effects, on which we focus here. The survival processing advantage corresponds to the observation that items (words or pictures) that are rated according to a fictitious survival scenario are remembered better than items that are rated in response to a non-survival scenario (e.g., Nairne et al., 2007). Animacy effects correspond to the finding that animate things, because they have a greater fitness value than inanimates (they may be predators, prey, or potential mating partners and/or rivals), are prioritised during processing and are remembered better. At present, evidence for this memory effect is scarce but it appears to be a robust effect because it has been found in different labs with different stimuli (words and pictures) and several memory tasks (e.g., in free and cued-recall tasks, VanArsdall et al., 2013, 2015; in recognition tasks, Bonin et al., 2014; VanArsdall et al., 2013). However, thus far, the question of whether animacy effects in episodic memory vary as a function of encoding conditions has not been investigated.

In the first three studies, we found animacy effects in the grassland-survival scenario where they were clearly anticipated. In effect, in Study 1, in which a factorial design was used, we found that words referring to animate entities were better recalled than words referring to inanimate entities when participants had to rate the words for their relevance to an imaginary ancestral survival scenario. This effect was obtained with both rating scores and times taken to rate the words introduced as covariate factors. In Study 2, a multiple regression approach was used and, again, we found that animates were better remembered than inanimates in the survival scenario. It should be recalled that Nairne et al. (2013) found, using multiple regression analyses, that animacy was a reliable and strong predictor of the recall data taken from Rubin and Friendly (1986). Finally, animacy effects were again found in the survival scenario in Study 3.

As explained in the Introduction, at a theoretical level, a different pattern of outcomes was predicted based on the hypothesis that when memory processes are redundant across different encoding tasks, there is generally no longer any retention advantage (e.g., Hunt & Einstein, 1981). This hypothesis was put forward by Burns et al. (2014) to account for the finding that the activation of death-related thoughts underpins the survival memory effect (but see also Bugajska et al., 2015 and Klein (2014) for further discussion). If animacy and survival-processing effects involved the same set of mechanisms, no animacy effect in memory should have been observed in a situation in which participants have to encode both animate and inanimate words for their survival value. However, the findings from Studies 1–3 were clearly at odds with the redundancy hypothesis since reliable animacy effects were found in survival-processing conditions. Interestingly, the survival processing advantage initially discovered by Nairne et al. (2007) was replicated in Studies 2 and 3 and was additive with animacy effects. An important theoretical implication of the current studies relating to the observation that survival and animacy effects are additive is that this strongly suggests that the proximate mechanisms underpinning these effects are different. However, these mechanisms still have to be more precisely identified in future research, and especially in the case of animacy effects which have only more recently been considered in the literature on episodic memory.

Turning to the non-survival scenarios, in Studies 1–3, the findings concerning the animacy variable were somewhat mixed. In Study 1, the animacy effect was not reliable and was descriptively reversed, with inanimates being recalled better than animates. However, in Study 2, the animacy effect on recall was in the  $A > I$  direction and reached significance,



whereas in Study 3, it was significant. The most important finding across the three studies is that we never observed that inanimates were reliably recalled better than animates. Indeed, even in the moving encoding scenario, in which it might have been expected that attention would be drawn more towards objects than to persons or animals, and in particular in Study 2 that used lists comprising more inanimates than animates, inanimates were not remembered better than animates.

Taken as a whole, the findings across the three first studies show that the animacy effect in memory is a very robust effect since it is not only found in the context of a survival scenario—where it would be predicted by an evolutionary account—but also occurs in non-survival scenarios as well as in deep encoding conditions such as pleasantness (Study 2) or explicit learning (Studies 3 and 4).

In the literature, there have been claims that the survival- processing effect could potentially be explained by the perceived relevance of words (e.g., Butler, Kang, & Roediger III, 2009). A number of studies have explicitly addressed this issue but failed to find support for the congruency account of the survival processing advantage (e.g., Nairne & Pandeirada, 2011). It now seems to be generally accepted that congruency does not account for the survival processing advantage (Erdfelder & Kroneisen, 2013). However, could the superior recall of animates over inanimates be due to the fact that the former are easier to integrate within different scenarios (e.g., survival, tour guide)? In Study 1, animate words were recalled better than inanimate words in the survival scenario even though there was no reliable difference in the relevance ratings, while in Study 3, animate words were recalled better than inanimate words despite being perceived as less relevant in the survival processing task. These findings are clearly at odds with the hypothesis that animate words are better remembered because they are considered to be more relevant than inanimate words in the survival scenario. Turning to the moving condition in Study 1, we found that although inanimates were judged to be more relevant than animates, there was no reliable difference in the recall rate. Is it possible that an animacy advantage was present but was masked by a relevance effect operating in the opposite direction?<sup>3</sup> This does not seem to be the case given that in Study 2, in which the effects of encoding times, ratings and animacy on memory were considered together in a regression analysis, the better recall of animates over inanimates was still reliable. Although the observation that the rated relevance of words varies across

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<sup>3</sup> We thank an anonymous reviewer for having suggested this line of reasoning to us.

scenarios may be thought of as a limitation of the present studies, we hope that the current discussion makes clear that this does not undermine the findings of the current set of experiments. Moreover, it is worth stressing that animacy effects were found with intentional learning in Studies 3 and 4. Given that no ratings were made in these studies, the congruity argument cannot be used to explain the animacy advantage.

The survival processing advantage has been evaluated against numerous deep control encoding conditions (e.g., pleasantness, self-reference, imagery, see Nairne et al., 2008). It is therefore a strong mnemonic effect. Importantly, survival effects have been found with the use of other (non-survival related) schematic scenarios (e.g., bank robbery, in Study 3 here: tour guide). One of the most often used schematic control conditions is the moving scenario. In Study 1, but not in Study 2, the survival processing advantage was not found on recall rates when the moving scenario was considered as control encoding scenario. Why? Although it is always difficult to account for null results, we ran further analyses in order to try to find an explanation. First of all, we ran analyses at the level of individual items in order to determine whether the pattern of recall rates in Study 1 vs. Study 2 could be due to certain specific items. However, we found no indication that this might be the case. Second, we compared: (a) the rating scores and (b) encoding times across the two studies. We found that the pattern of rating scores was quite similar for animates and inanimates. This was true to a lesser extent of encoding times. Here, the most important aspect of note is that the time taken to rate animates in the moving condition was shorter in Study 2 than in Study 1. Finally, we directly examined the pattern of recall rates between Studies 1 and 2 with rating scores and encoding times introduced as covariate factors. We found that, in Study 2, animates were recalled better than inanimates in both scenarios and the same trend was observed in Study 1 in the survival condition. In the moving condition in Study 1, the recall rate for animates was similar to that for inanimates in Study 2 (the recall rates for inanimates were similar in the two studies). Thus, the failure to find a survival processing advantage in Study 1 could be rooted in the way different participants process animates in the moving condition. In sum, the moving condition certainly leads to more processing variability during encoding than the survival condition. However, we acknowledge that these supplementary analyses failed to provide a satisfactory account for the failure to find a survival processing advantage in Study 1. It is certainly the case that, probabilistically, failures to replicate most robust phenomena are expected to occur. Indeed, we are not the first to report a failure to replicate the survival processing advantage when the moving scenario was used as a control condition (Savchenko, Borges, &

Pandeirada, 2014). However, Savchenko et al. (2014) did not include a standard replication of the survival vs. moving comparison (e.g., ad hoc categories were included, an intentional learning procedure was used).

It is important to reiterate that animacy effects in memory performance were obtained with a large number of potential confounding variables controlled for. In Study 2, in particular, animacy effects were obtained when using lists of unrelated words that comprised only one-third of animate items, that is to say lists in which inanimates were more numerous and rendered potentially more salient than animates. Importantly, Study 4 showed conclusively that animacy effects are not due to the more organised nature of animate items (see also VanArsdall et al., 2015) since these effects were found in recall rates with category size and cohesiveness of the items controlled for. Also an organisational account of animacy effects in free-recall would predict more animate than inanimate extra-list intrusions, whereas just the opposite was found across our studies in which there was a consistent pattern (at least at a descriptive level): There were always more inanimate than animate intrusions (even though the difference was reliable in all encoding conditions of Study 2, and the explicit condition of Study 3 only). Thus, at a theoretical level, these latter findings place constraints on the interpretations of animacy effects in recall in that they argue against an account of animacy effects that holds that they are the result of the more organised nature of animate items. It should be remembered that the finding that animacy effects are obtained in recognition hits (e.g., Bonin et al., 2014) in itself suggests that animacy effects in memory are unlikely to be fully explained in terms of the greater cohesiveness of animates. As far as Study 2 is concerned, it might be claimed that the use of lists with less animates than inanimates resulted in the creation of an isolation effect (i.e., von Restorff effect, Hunt, 1995) which was confounded with animacy, and thus, that the comparison would be improved by using a condition containing more animate than inanimate words.<sup>4</sup> It might seem reasonable to claim that decreasing the number of animate items in the list should enhance the animacy effect. In effect, distinctiveness accounts predict that reducing the number of animate items would increase the distinctiveness of those items, thereby improving their memorability (e.g.,

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<sup>4</sup> This was suggested to us by an anonymous reviewer. It should be noted that, strictly speaking, animate items were not isolated. Furthermore, in Study 2, the learning was incidental and certain studies suggest that von Restorff effects are not obtained under conditions of incidental learning (e.g., Postman & Phillips, 1954; Saltzman & Carterette, 1959). Interestingly, and related to this issue, a recent study (Popp & Serra, in press) has shown that presenting animates (animals) and inanimates (objects) as themed-lists (all animates or all inanimates) or mixed-lists (both animates and inanimates within the lists) does not change the size of animacy effects on recall rates.

Hunt & Elliott, 1980). However, if we compare the recall rates of animate and inanimate items across studies, animates were not recalled more than inanimates in Study 2 (.39 vs. .32), in which they should have been more distinctive, than they were in Studies 1 and 3 in which there were equal numbers of items of each type (.34 vs. .30 and .42 vs. .34, respectively).

Readers who are sceptical about the evolutionary approach to episodic memory that we—following Nairne et colleagues—have championed might ask themselves whether our interpretation of animacy effects (i.e., that they are ultimately attributable to the fact that animates are more important than inanimates for fitness and are thus given processing priority, consequently leading to their better recall), is not, after all, a kind of “just-so story” (Gould, 2000; but see Kurzban, 2002). We would like to point out that had an evolutionary approach not been adopted in recent works on episodic memory, we doubt that the importance of the animacy dimension in memory would have been discovered. Animacy is one of the most important dimensions and accounts for a large amount of variance in recall rates as shown by both Nairne et al. (2013) and in our own studies. It is important to stress that the influence of concreteness, imagery or emotionality in memory has long been studied (Nairne et al., 2013), but it is only very recently that the power of the animacy dimension has been revealed. (It is worth mentioning, however, that animacy has been—and still is—a topic of much research in the fields of linguistics and psycholinguistics, e.g., Bock, Loebell, & Morey, 1992; DeDe, 2015.) Thus, adopting an evolutionary (or functionalist) approach to the study of episodic memory promises to be a fruitful endeavour. The strength of evolutionary psychology lies in its insistence on taking account of both proximate and ultimate explanations in order to achieve a comprehensive understanding of many aspects of human behaviour. Ultimate explanations are those that consider the selection pressures that have shaped the behaviour under study (in the current studies, remembering things in the long term) and which continue to do so today. However, we know that this view is not shared by certain researchers who think that it is difficult to propose ultimate explanations for a phenomenon (e.g., the survival processing advantage) if the proximate mechanisms have not yet been identified (Bell, Röer, & Buchner, 2015).

To conclude, by adopting an evolutionary perspective, that is to say by proposing that animates are of greater fitness value than inanimates, researchers have put forward the hypothesis that animates should be remembered better than inanimates (Nairne et al., 2013; VanArsdall et al., 2013), and they have therefore discovered that animacy is an important dimension. Now, there is an avenue for understanding how animacy effects come about, that

is to say an insight into the proximate mechanisms that underpin these effects. We and others have begun to explore this important issue (Bonin et al., in press; Popp & Serra, in press; VanArsdall et al., 2015).

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## **Discussion Générale**

Un large ensemble de données s'accorde avec l'idée que le système cognitif humain a évolué de sorte à résoudre des problèmes relevant des pressions de sélection dans notre passé ancestral. Nairne et ses collaborateurs, partisans de cette approche fonctionnelle de la mémoire, ont, à plusieurs reprises, mis en évidence des avantages en terme de rétention de l'information lorsque les participants sont placés en situation de survie (Nairne et al., 2007 ; Nairne et al., 2008). Dans ce cadre, la question de la distinction entre les entités animées et inanimées semblait intéressante à se poser. Les entités animées (entités vivantes, capables de se déplacer par leur propre source d'énergie) sont douées d'intentions et sont donc importantes à prendre en considération à des fins de survie. Expérimentalement, une primauté de traitement des entités animées sur les entités inanimées a été montrée dans de nombreux domaines de la psychologie cognitive (e.g., en psycholinguistique, Laws et al., 1998, et en attention visuelle, New et al., 2007 ; Pratt et al., 2010). Mais la question de l'impact du caractère animé sur la mémorisation n'avait, jusqu'à récemment, jamais été abordée. En 2013, VanArsdall et al. ont testé pour la première fois l'effet animé sur la mémorisation de non-mots. Ils ont observé un avantage, en rappel libre comme en reconnaissance, pour les non-mots préalablement associés à une propriété leur conférant le statut d'êtres vivants. Nairne et al. (2013) ont, par la suite, répliqué ces résultats avec des mots. Dès lors, d'autres recherches ont été menées sur l'effet animé en mémoire, parmi lesquelles les travaux qui ont été présentés dans ce travail de thèse.

## **1. Résumé de nos principaux résultats**

Les études que nous avons menées ont permis d'établir que l'effet animé est (1) un effet robuste ; (2) lié à la mémoire épisodique ; (3) indépendant des ressources cognitives disponibles ; (4) sous-tendu en partie par de l'imagerie mentale et (5) flexible et dépendant des objectifs liés au contexte.

### **1.1. Un effet robuste**

L'effet animé en mémoire a été répliqué avec un matériel varié, constitué de mots (e.g., Gelin, Bugajska, Méot, Vinter & Bonin, soumis à *Journal of Memory and Language*) mais aussi d'images (Bonin et al., 2014, étude 2). Il a aussi été répliqué avec différentes

procédures d'apprentissage, qu'elles soient incidentes (e.g., Gelin, Bonin, Méot, & Bugaiska, 2017) ou intentionnelles (e.g., Bonin, Gelin, Laroche, Méot, & Bugaiska, 2015, étude 1), et différentes procédures de récupération (du rappel libre, e.g., Gelin, Bugaiska, Méot, & Bonin, 2017, et de la reconnaissance, e.g., Bonin et al., 2014, étude 3). Il s'agit donc d'un effet robuste, que nous avons observé dans 15 études sur les 19 présentées dans ce travail.

## 1.2. Un effet lié à la mémoire épisodique

Dans une perspective évolutionniste, la mémoire épisodique permet aux individus de maintenir une sensation de continuité de soi, d'être performants dans les interactions sociales et d'utiliser les informations issues d'évènements passés pour diriger de futurs comportements (Raby & Clayton, 2012). Ainsi, nous supposons que les entités animées, dans le sens où elles renvoient à de potentielles sources de dangers, d'interactions ou de nourriture, mobilisent davantage notre mémoire épisodique que les entités inanimées. L'ensemble des études menées dans le but d'établir un lien entre l'effet animé et la mémoire épisodique (Bonin et al., 2014 ; Gelin, Bonin et al., 2017), ont suggéré que la primauté des entités animées sur les inanimées était portée par la remémoration, qui consiste en un rappel conscient de détails contextuels liés à l'encodage.

En effet, à l'aide d'un paradigme *Remember/Know* (Gardiner, 1988, 2001) nous avons pu observer un avantage des items animés quant à leur mémorisation. Mais surtout, en prenant en compte le type de réponse (« Je me souviens », en anglais « *Remember* », indice de remémoration et « je sais », en anglais « *Know* », indice de familiarité), nous avons observé une augmentation du nombre de réponse « *Remember* » lorsque les mots renvoyaient à des entités animées, alors qu'il y avait autant de réponses « *Remember* » que de réponses « *Know* » dans le cas des items inanimés. Aussi, en utilisant un paradigme de mémoire de source, nous avons pu confirmer que les entités animées sont non seulement mieux mémorisées que les entités inanimées, mais qu'elles sont également mieux contextualisées. En effet, quelque soit le contexte étudié, temporel ou spatial, les participants replaçaient les entités animées dans leur contexte d'encodage avec plus d'exactitude que ce n'était le cas des entités inanimées.

Les stimuli animés étaient donc encodés de façon plus profonde, avec un contexte plus riche que les inanimés. Ceci expliquerait que les mots renvoyant à des entités animées soient ensuite mieux rappelés ou reconnus. Ainsi la caractéristique animée n'augmente-t-elle pas

seulement la quantité d'informations mémorisées, mais aussi leur qualité, grâce au rappel de détails contextuels liés aux expériences passées. Cet aspect renvoie à la mémoire épisodique.

### **1.3. Un effet indépendant des ressources cognitives disponibles**

La conception de la mémoire adaptative, issue des théories évolutionnistes, a pu faire l'objet de certaines critiques. L'une d'elles concerne le fait que les effets qui la valident - l'effet survie par exemple - peuvent être expliqués en faisant appel à des mécanismes basiques de mémoire, comme l'élaboration, la référence à soi et le traitement spécifique et relationnel des items (Howe & Otgaar, 2013). Ainsi, ces auteurs estiment que l'ajout d'explications ultimes à ces explications proximales est inutile et superflu. Cependant, asseoir un effet dans une perspective évolutionniste n'implique pas de négliger l'implication de ces processus d'encodage. Au contraire, nous pensons que de tels mécanismes (l'élaboration, l'encodage distinctif, la planification...) sont autant d'outils mis à notre disposition de sorte à nous adapter à notre environnement.

Ces mécanismes psychologiques hérités de l'évolution et dévolus à la survie doivent pouvoir fonctionner même dans des situations où les ressources cognitives sont moindres, et où le temps de traitement de l'information est limité. En conséquence, si la mémoire a évolué de sorte à traiter efficacement, et à conserver durablement, les informations liées à notre survie, alors l'effet animé ne devait pas disparaître avec l'ajout d'une charge mentale. Cela, soit parce qu'il ne dépend pas des ressources cognitives, soit, s'il est sous-tendu par des mécanismes généraux ressources-dépendants, parce que le traitement des entités animées reste prioritaire sur celui des entités inanimées. Nos résultats ont permis de montrer que, quelque soit les ressources cognitives disponibles, les entités animées étaient mieux mémorisées que celles inanimées. Ainsi, bien que les performances générales de mémoire étaient diminuées par l'ajout d'une tâche secondaire, l'effet animé, lui, n'était pas affecté (Bonin et al., 2015).

### **1.4. Un effet en partie sous tendu par de l'imagerie mentale**

Dans une série d'études, nous avons comparé l'effet animé obtenu avec une tâche de catégorisation à différentes tâches d'imagerie mentale : (1) l'imagerie interactive (Bonin et al, 2015) ; (2) l'imagerie statique (Gelin et al., soumis à *Journal of Memory and Language*) et (3)

l'imagerie mentale classique (Gelin et al., soumis à *Journal of Memory and Language*). L'utilisation de l'imagerie mentale au moment de l'encodage est connue pour améliorer le rappel ultérieur des informations mémorisées (e.g., Elliot, 1973 ; Lupiani, 1977 ; Winnick & Brody, 1984). Dans nos études, nous avons en effet pu constater que toutes les instructions d'imagerie amélioreraient significativement la mémorisation des mots, mais seulement quand ils renvoyaient à des entités inanimées. En revanche, le taux de rappel des items animés n'était pas impacté. En effet, ces derniers étaient aussi bien mémorisés avec et sans instruction explicite d'imagerie. L'imagerie mentale ne profite donc pas de la même façon aux deux types de stimuli. Il semblerait que cette stratégie d'encodage soit mise en place de façon « automatique » pendant le traitement des entités animées, alors qu'elle serait utilisée uniquement lorsqu'on la sollicite de façon intentionnelle pour les entités inanimées.

D'un point de vue évolutionniste, il est plausible que nos ancêtres aient mis en place des stratégies mnésiques permettant d'accroître leurs chances de survie et leur potentiel reproductif. L'imagerie mentale pourrait être l'une de ces stratégies, elle serait alors devenue « automatique » et sous-tendrait des effets tels que l'effet animé. Evidemment, une telle hypothèse reste à mieux étayer, ce que nous envisageons dans deux projets d'étude présentés dans une prochaine partie.

### **1.5. Un effet flexible et dépendant des objectifs liés à la situation**

Nous avons enfin étudié la possibilité que l'effet animé soit flexible et qu'il témoigne d'une capacité d'adaptation à l'environnement (Gelin, Bugajska et al., 2017). Plus précisément, nous avons étudié l'effet animé dans différents contextes, à savoir, un contexte de survie (Nairne et al., 2007), un contexte de déménagement (Nairne et al., 2007), un contexte d'organisation de voyage, une situation de jugement d'agrément et une situation d'apprentissage intentionnel. Les résultats témoignent d'un effet animé flexible, plus ou moins important en fonction de la situation. Si dans un contexte de survie les entités animées tiennent une place importante (pouvant être de potentiels proies, prédateurs ou congénères) et sont donc primordiales à mémoriser, en contexte de déménagement ce sont les entités inanimées qui sont mises en avant. Lors d'un déménagement, il faut penser aux objets à déplacer d'un endroit à l'autre, il semblerait donc attendu que, pour ce type de situation, les entités inanimées soient mieux mémorisées. En réalité, il s'est avéré qu'en condition de déménagement, l'effet animé était soit non significatif (Gelin, Bugajska et al., 2017, étude 1),

soit marginal (Gelin, Bugaiska et al., 2017, étude 2), mais les entités inanimées n'ont jamais été significativement mieux mémorisées que les entités animées. De ce fait, il semblerait que les situations dans lesquelles il devient important de se focaliser sur les objets inanimés amènent à un accroissement de la mémorisation de ce type d'entités, sans que ce soit suffisant pour engendrer une primauté de traitement des entités inanimées sur les entités animées. De la même façon, quand les participants devaient organiser un voyage, juger les mots quant à leur caractère plaisant ou déplaisant, ou simplement les mémoriser intentionnellement, situations dans lesquelles, a priori, aucun des deux types de stimuli ne devrait prendre le pas sur l'autre, l'effet animé persistait. Ces résultats laissent penser qu'il est parfois nécessaire de traiter plus efficacement les entités inanimées pour s'adapter au mieux à une situation. Cependant, reléguer complètement au second plan les entités animées pourrait être dangereux et notre système cognitif a évolué de sorte à être plus sensible à ce type d'entités. C'est pourquoi, aucun des contextes testés n'a engendré d'inversion de l'effet animé, celui-ci était simplement modulé en fonction de la situation. De plus, il est possible que toutes les étapes de la mémorisation ne soient pas affectées de la même façon par les variations de situation d'encodage. Les études menées ici n'ont pas permis de déterminer si l'augmentation observée dans la mémorisation des entités inanimées, en contexte de déménagement, tenait d'une augmentation du nombre d'items inanimés correctement encodés, stockés ou récupérés. Il est donc possible que les entités animées soient toujours stockées de façon plus précise que les entités inanimées, et que la diminution de la différence observée au moment du rappel soit plutôt liée à la récupération des informations. Le contexte de déménagement pourrait rendre les items inanimés plus accessibles en mémoire par exemple.

Ainsi, il serait pertinent de renouveler ce type d'expérience avec d'autres contextes, mais aussi avec d'autres procédures qui permettraient d'explorer, plus précisément, les différents niveaux du processus de mémorisation. Par exemple, Popp et Serra (2016) ont montré qu'il était possible d'inverser l'effet animé en utilisant une procédure d'apprentissage de paires de mots. Les participants devaient mémoriser des paires de mots constituées soit de deux animés (e.g., *chien* - *alligator*) ou de deux inanimés (e.g. *trompette* - *parapluie*), soit d'un animé et d'un inanimé (e.g., *panda* - *chaussure* ; *ciseaux* - *tortue*). Ils devaient ensuite rappeler le second mot de la paire en ayant le premier mot comme indice. Les résultats montraient que, dans cette situation d'encodage – l'apprentissage de paires de mots - associée à une procédure de rappel indicé, si l'attention des participants était attirée par l'un des deux mots de la paire (en l'occurrence un mot renvoyant à une entité animée) plutôt que sur



l'association des deux mots, alors les performances de récupération en mémoire s'en trouvaient altérées. Ainsi, l'effet animé en mémoire disparaissait.

## **1.6. Conclusion intermédiaire**

L'effet animé en mémoire étaye de façon convaincante la conception générale selon laquelle le système cognitif humain a été façonné par la sélection naturelle, de sorte à détecter et à se remémorer plus efficacement des informations pertinentes pour la survie ou la reproduction. Cet effet spécifique s'accorde donc pleinement et clairement avec la conception fonctionnelle de la mémoire défendue par Nairne et collègues (Nairne, 2010 ; Nairne & Pandeirada, 2008, 2010a, 2010b), en validant une proposition théorique centrale de la mémoire adaptative : tous les stimuli ne sont pas équivalents lorsqu'il s'agit de s'en souvenir.

De plus, l'ensemble de nos résultats ouvrent de nombreuses perspectives de recherche et peuvent avoir des répercussions concrètes dans différents secteurs, tels que la pédagogie, la psychologie expérimentale, la psychologie clinique ou encore la neuropsychologie. Nous y reviendrons mais, avant cela, nous souhaitons aborder deux points importants que nous n'avons pas mentionnés dans nos travaux, à savoir : (1) à quelle catégorie rattacher les végétaux ? (2) les inanimés mobiles tels que les moyens de transport sont-ils traités comme des animés ou des inanimés ?

## **2. Animés *versus* inanimés : Quid des végétaux et des inanimés mobiles ?**

### **2.1. Les végétaux**

La définition des entités animées proposée par Gelman et Spelke (1981) peut sembler restrictive. En effet, elle inclut uniquement les entités vivantes, capables (1) de se déplacer de façon autonome, (2) de grandir et de se reproduire, (3) d'avoir des états mentaux et (4) de communiquer, ce qui exclut les végétaux. Pourtant, les plantes font partie des être vivants et leur importance en terme de survie est claire. La cueillette de fruits et de baies était une activité essentielle à l'apport de nourriture dans les sociétés ancestrales. Les plantes étaient également source de dangers, car certaines étaient toxiques alors que d'autres, au contraire, avaient des vertus médicinales. Enfin, plus tard dans le développement de l'humanité (vers - 10 000 ans avant le Présent), l'apparition de l'agriculture a permis la domestication et

l'élevage d'animaux, mais aussi la culture et le maraîchage. Comme c'est le cas pour les animés, retenir un maximum d'informations à propos des végétaux a donc probablement été important pour la survie de nos ancêtres chasseurs-cueilleurs. Ainsi, il est possible que les végétaux, jusqu'à maintenant exclus de nos études (à l'exception de Gelin, Bugajska et al., 2017, étude 2) bénéficient eux aussi d'une priorité de traitement sur les inanimés non-vivants. Dans l'étude 2 de Gelin, Bugajska et al. (2017), nous avons pris le parti d'inclure, dans les listes d'apprentissage, des items renvoyant à des aliments. Ces items, pour la majorité, renvoyaient à des fruits et des légumes et faisaient donc partie de la catégorie des végétaux. Bien que nous n'ayons trouvé aucun avantage des aliments par rapport aux autres items inanimés, leur taux de rappel n'était pas non plus significativement inférieur à celui des entités animées. De plus, Clark et Bruno (2016) ont montré que des participants mémorisaient mieux la localisation de végétaux (fruits et légumes), présentés sous forme d'images, lorsqu'ils les avaient traités dans un contexte de survie plutôt que dans un contexte de chasse au trésor (voir aussi Nairne, VanArsdall, Pandeirada, & Blunt, 2012). Cependant, dans ces différentes études, l'objectif n'était pas directement d'étudier les performances de mémorisation pour les végétaux. En effet, soit les items renvoyant à des aliments n'étaient pas comparés à un autre type de stimuli (Clark & Bruno, 2016 ; Nairne et al., 2012), soit ils étaient trop peu nombreux pour que de réelles conclusions puissent être tirées (Gelin, Bugajska et al., 2017). Il serait donc intéressant, à l'avenir, de déterminer si les items renvoyant à des végétaux bénéficient d'un avantage en terme de mémorisation, comme c'est le cas des entités animées. Ainsi, il serait possible d'élargir la définition en terme d'animé/inanimé à une définition plus globale, en terme de vivants/non vivant.

## **2.2. Les inanimés mobiles**

Afin d'élargir la distinction animés/inanimés, pour inclure le vivant au sens large dans la définition des animés, il faut non seulement s'assurer que les végétaux sont traités comme les animaux, mais aussi, que les inanimés qui bougent (e.g., les moyens de transports) sont traités de la même façon que les inanimés immobiles. En effet, il est possible de faire la distinction animé/inanimé de façon purement physique, en considérant comme animé tout objet ayant un mouvement, indépendamment du fait qu'il soit vivant ou non. Le caractère animé (au sens physique du terme) peut être à l'origine d'une meilleure mémorisation, parce qu'il est une information supplémentaire pouvant enrichir la représentation que le participant

se fait de l'objet à mémoriser ; cela d'autant plus qu'il a été montré que la qualité des traces mnésiques dépend de la richesse des stimuli en termes de traits sémantiques (Hargreaves et al., 2012).

Les résultats obtenus par Pratt et al (2010), dans une tâche de détection de cibles, ont montré une plus grande sensibilité à des formes géométriques animées (« vivantes ») en mouvement plutôt qu'à des formes inanimées (« non-vivantes ») en mouvement. Ainsi, il semblerait que tous les mouvements n'attirent pas l'attention de la même façon. Les auteurs ont justifié la primauté des mouvements animés parce que la capacité d'auto-déplacement, propre aux êtres vivants, est le signal d'un événement pertinent en terme de survie. Des données allant dans ce sens avaient déjà été rapportées par Abrams et Christ en 2003. Ces chercheurs avaient mis en évidence que les déplacements qui jouent un rôle important dans la catégorisation des objets en termes de vivant/non-vivant sont plus enclins à la capture attentionnelle. Si, dans le domaine de l'attention, il semble que la distinction animé/inanimé dans le sens vivant/non-vivant a plus de sens qu'une distinction simplement physique, aucune donnée de ce type n'a encore été trouvée dans des études sur la mémoire. Même si les résultats que nous avons obtenus avec le paradigme de « statufication » s'accordent avec une distinction fondée sur la caractère vivant plus que sur le caractère dynamique des entités animées, il nous semble essentiel de les confirmer en ayant recours à des items animés vivants (e.g., *chat*) et d'autres, non-vivants, mais sujets aux déplacements (e.g., *voiture*).

### **3. Autres pistes de recherche**

#### **3.1. L'imagerie mentale : empêcher l'imagerie mentale pourrait-il annuler l'effet animé ?**

Les mots concrets sont mieux mémorisés que les mots abstraits, c'est l'effet de concrétude en mémoire. L'imagerie mentale est souvent invoquée pour expliquer cette différence (Bevan & Steger, 1971 ; Paivio & Caspo, 1969). En effet, s'il est assez facile de se faire une image mentale des mots concrets (e.g., *bougie*), il faut faire un véritable effort pour des mots abstraits (e.g., *liberté*). Or, pouvoir encoder une information sous différents formats (e.g., verbal et imagé) augmente les chances de la récupérer efficacement en multipliant les indices de récupération disponibles. Cette théorie du double codage est également utilisée pour rendre compte de l'avantage mnésique dont profitent les images (Paivio, Rogers &

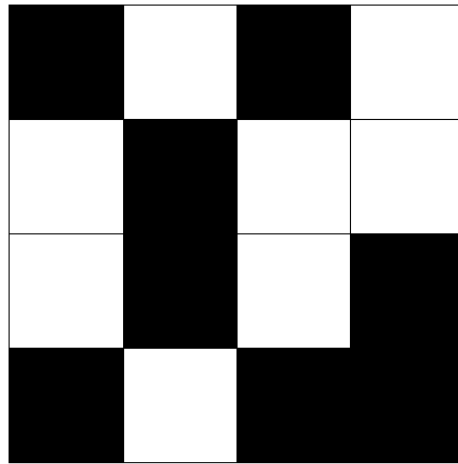
Smythe, 1968 ; Shepard, 1967). Dans leurs études de 1969, Paivio et Csapo manipulaient la disponibilité des différents codes, verbal et imagé, pour empêcher la mise en place d'un double codage et tenter d'annuler l'avantage des images et des mots concrets sur les mots abstraits. Leur hypothèse était que la réalisation d'un double codage, à savoir encoder une même information sous deux formats différents, verbal et imagé, prend du temps. De ce fait, priver les participants du temps nécessaire pour déployer une stratégie de double codage, en accélérant le rythme de présentation des items à mémoriser, devait réduire la mémorisation des items pouvant bénéficier du double codage (les mots concrets et les images dans leur étude) et l'amener au niveau des items qui n'en bénéficient pas (les mots abstraits). Pour cela, ils utilisaient différents rythmes de présentation des items, partant du principe que la construction d'une image mentale, pour un mot concret, ou l'accès au label d'une image, est un processus coûteux. Ainsi, en accord avec leur prédiction, lorsque le temps de présentation était accéléré (5,3 items par seconde) le taux de rappel des trois types de stimuli (images, mots concrets et mots abstraits) était équivalent, alors qu'en condition de présentation lente (2 items par seconde), les images étaient mieux rappelées que les mots concrets, eux même mieux rappelés que les mots abstraits.

Sur la base des données que nous avons obtenues avec les procédures d'imagerie mentale, il est possible de faire l'hypothèse que le code verbal soit directement accessible pour les items animés et inanimés mais, qu'en revanche, les animés soient plus propices à évoquer des images mentales. Si, comme nous le supposons, l'effet animé est sous tendu par de l'imagerie mentale, alors priver les participants de la possibilité d'utiliser cette stratégie devrait diminuer les performances de rappel des entités animées. Ainsi, en utilisant une procédure telle que celle de Paivio et Caspo (1969), nous pourrions peut être annuler l'avantage mnésique dont font preuve les entités animées.

Une autre possibilité, pour empêcher la création d'images mentales, serait de charger le calepin visuo-spatial de la mémoire de travail pendant l'encodage des mots. Dans le modèle de mémoire de travail de Baddeley et Hitch (1974, actualisé en 2000), l'administrateur central contrôle et coordonne deux sous-systèmes esclaves : la boucle phonologique et le calepin visuo-spatial. La boucle phonologique est impliquée dans le traitement et le maintien temporaire des informations verbales, tandis que le calepin visuo-spatial est requis lors du traitement et du maintien des informations visuelles ou spatiales. Ainsi, en mobilisant le calepin visuo-spatial, nous pourrions peut être défavoriser l'encodage des mots renvoyant à des entités animées. Concrètement, il s'agirait d'étudier l'impact d'une charge mentale visuo-

spatiale sur la mémorisation de mots animés et inanimés. Nous pourrions donc utiliser la même procédure que celle des études 2, 3a et 3b de Bonin et al. (2015).

Nous envisageons plus précisément de réaliser l'étude suivante. Pour la moitié des essais, les essais expérimentaux, les participants devront mémoriser temporairement une charge mentale visuo-spatiale (cf. Figure 6) pendant la tâche de catégorisation des mots (animés vs. inanimés). Les charges visuo-spatiales seront des carrés composés de 16 cases, dont 50% seront noircies de façon aléatoire.



**Figure 6.** Exemple de charge mentale visuo-spatiale.

Pour l'autre moitié des essais, les essais contrôles, les participants sauront qu'ils devront, en plus de catégoriser les mots, sans cesse reproduire la même matrice, une matrice simple ne surchargeant pas leur mémoire de travail, où les 8 cases de gauche seront noircies. Contrairement à ce que nous avons observé avec des charges cognitives mobilisant la boucle phonologique (e.g., *2J5K4* ; Bonin et al., 2015), l'utilisation de charges mobilisant le calepin visuo-spatial devrait affecter la mémorisation des mots renvoyant à des entités animées, en privant les participants de la possibilité de les visualiser mentalement. Notre prédiction est donc que les mots renvoyant à des entités animées devraient être moins bien rappelés dans la condition "interférence visuelle forte" que dans la condition "interférence visuelle faible". Ainsi, dans la première condition, l'effet animé devrait être annulé par réduction du taux d'items animés rappelés, alors que dans la seconde, un effet animé "classique" serait observé.

### 3.2. Effet animé et valence émotionnelle

Dans le but de mettre à l'épreuve l'hypothèse évolutionniste comme explication ultime de l'effet animé, d'autres caractéristiques des items semblent importantes à prendre en considération. L'aspect central de l'approche adaptative de la mémoire est que tous les stimuli ne sont pas égaux quant à leur traitement afin de les mémoriser. Les stimuli pertinents en terme de survie sont plus importants que d'autres types de stimuli, ce qui explique qu'ils amènent à des performances de rappel supérieures. Dans le cadre de l'effet animé, il est donc envisageable que la manipulation de certains facteurs module l'effet et conduise à une modification des performances de rétention des informations à long terme. Par exemple, la valence émotionnelle des items pourrait être un facteur modulateur de l'effet animé.

Les émotions intéressent la psychologie évolutionniste depuis longtemps. Darwin lui-même avait publié *L'expression des émotions chez l'Homme et les animaux* en 1872. Dans cet ouvrage fondateur, il affirmait qu'un certain nombre d'expressions des émotions sont innées et communes à toutes les cultures, ce sont les émotions universelles. Si Darwin considérait 4 émotions universelles (la tristesse, la colère, la surprise et la joie), près de 100 ans plus tard, Ekman et Friesen (1967 ; 1969 ; 1971) apportaient des preuves validant non pas 4, mais au moins 6 émotions universelles, en ajoutant la peur et le dégoût aux émotions mentionnées par Darwin. Ekman et Friesen ont montré que les membres d'une société isolée d'une région reculée de la Nouvelle Guinée, les Papous, étaient capables d'identifier et de reproduire plusieurs expressions faciales des Occidentaux. De plus, les étudiants américains, à qui ils avaient ensuite montré des photographies de Papous mimant diverses expressions, les avaient immédiatement identifiées également. Sur la base de ces observations, et de l'étude de vingt autres cultures, Ekman et Friesen ont permis d'apporter des preuves expérimentales aux intuitions de Darwin.

Par la suite, des psychologues évolutionnistes ont proposé des explications fonctionnelles aux états émotionnels humains fondamentaux. Par exemple, Frederickson (1998) propose que la peur est une émotion permettant de rétrécir le champ attentionnel et d'accroître la vigilance afin de préparer à la fuite : la pression sanguine est dirigée vers les muscles et l'esprit se concentre sur les issues possibles, afin de s'échapper. A l'inverse, elle suggère que la joie incite à « être enjoué » dans le sens étymologique du terme : « s'investir dans le jeu ». Le jeu permet de favoriser les aptitudes physiques et intellectuelles, mais il est aussi l'occasion de comparer ses forces et ses faiblesses avec son groupe social (Fagen, 1981).

Elle remplit donc des fonctions sociales et intellectuelles à long-terme. Ainsi, les émotions négatives, comme la peur et la colère, prépareraient à des conditions aversives, alors que les émotions positives, comme l'amour et la joie, participeraient à la construction des connaissances et des relations sociales.

Concernant l'impact des émotions sur les capacités cognitives, des études ont permis de mettre en évidence un avantage pour les stimuli émotionnels dans des tâches d'attention visuelle (e.g., Fox, Russo, Bowles, & Dotton, 2001 ; Ohman, Flykt, & Esteves, 2001). En 2010, Mermillod et collaborateurs ont montré que le caractère menaçant des items influence les performances de détection visuelle : les stimuli dangereux étaient détectés plus rapidement que des stimuli non dangereux, et ceci, même lorsque la fréquence spatiale visuelle était basse, de sorte que les stimuli soient perçus "grossièrement" (Mermillod, Droit-Volet, Devaux, Schaefer, & Vermeulen, 2010).

De même, en mémorisation, de nombreuses données empiriques témoignent d'une plus grande persistance en mémoire et d'une plus grande vivacité du souvenir pour les informations émotionnelles (Christianson, 1992). Plus récemment, le lien entre mémoire et émotion a même été renforcé par l'apport de données en neuroimagerie, montrant une interaction entre l'amygdale, structure impliquée dans les émotions, et le complexe hippocampique, impliqué dans la mémoire. En effet, l'amygdale permet de moduler l'encodage et le stockage des souvenirs dépendant de l'hippocampe, et le complexe hippocampique peut influencer la réponse de l'amygdale quand des stimuli émotionnels sont rencontrés (Phelps, 2004).

Ainsi, nous pensons qu'il serait intéressant de tester l'interaction entre l'effet animé et l'effet de la valence émotionnelle des mots sur la mémorisation. Si le traitement des caractéristiques émotionnelle et animée permet une meilleure mémorisation des mots, parce que ces deux caractéristiques ont une importance particulière en termes de survie, alors l'effet animé pourrait être diminué dans le cas de stimuli émotionnels. En effet, si dans le cas de stimuli neutres, les entités animées (e.g., *marin*) sont plus pertinentes pour la survie que les inanimées (e.g., *tasse*), il est possible que les deux types d'entités soient d'une importance équivalente quand les stimuli sont émotionnels (e.g., *araignée*, *révolver*). C'est en tous cas ce qu'il semble se passer en termes d'attention. Dans l'étude de Yang et al. (2012), les participants regardaient plus souvent, et plus longtemps, les objets focaux quand il s'agissait d'animaux plutôt que d'artefacts, mais cette différence disparaissait quand l'objet focal était négatif.

### **3.3. L'utilisation de la réalité virtuelle dans l'effet animé**

Bien que nous soutenions l'idée selon laquelle la mémoire a évolué de sorte à conférer un avantage adaptatif dans des situations de survie, il convient de noter que les études précédemment présentées ne sont pas parfaitement écologiques. En effet, dans les études faisant intervenir un scénario, de survie, de déménagement ou bien de voyage, la mise en situation se faisait par l'intermédiaire d'un petit texte, puis les stimuli, des mots, défilaient sur l'écran d'ordinateur (Gelin, Bugajska et al., 2017). De la même façon, dans les études impliquant un contexte spatio-temporel, celui-ci correspondait à la disposition des mots sur un écran ou à leur position dans une liste (Gelin, Bonin et al., 2017). Contrairement à l'effet survie, qui nécessite une mise en situation pour émerger (le participant lit un texte lui décrivant le contexte dans lequel il doit s'immerger), l'effet animé est lié à la nature des items eux-mêmes (des mots ou des images renvoyant à des entités animées ou inanimées). Le fait que l'effet animé ne nécessite pas d'immersion particulière explique peut-être qu'il apparaisse malgré les situations purement expérimentales utilisées jusqu'à présent pour l'étudier. Néanmoins, ne pas observer l'effet animé dans des conditions plus écologiques pourrait être un obstacle à l'interprétation évolutionniste. C'est pourquoi nous pensons qu'il serait intéressant d'étudier cet effet en utilisant la réalité virtuelle.

La réalité virtuelle est de plus en plus utilisée en psychologie, que ce soit en psychologie expérimentale ou en psychologie clinique ; son principal intérêt étant son potentiel pour recréer des expériences familières entièrement contrôlées. Dans le domaine de la psychologie clinique, elle permet d'une part d'exposer le patient à des stimuli 3D complexes, dynamiques et interactifs et, d'autre part, d'évaluer et de stimuler les performances cognitives, comportementales et fonctionnelles dans des tâches qui peuvent être similaires à celles de la vie quotidienne. Cette technologie permet donc de développer des environnements de diagnostic, mais aussi de thérapie et de soutien. Ainsi, les phobies, les troubles de l'alimentation, les troubles sexuels, les troubles post-traumatiques, l'autisme, les soins palliatifs et la réadaptation, sont autant d'exemples de domaines dans lesquels la réalité virtuelle a été utilisée jusqu'à présent (Klinger et al., 2005 ; Klinger, Chemin, Lebreton, & Marié, 2006 ; Klinger, Marié, & Viaud-Delmon, 2006). Mais la réalité virtuelle est également un nouvel outil prometteur dans le domaine de la psychologie expérimentale (Fuchs, Moreau, & Arnaldi, 2006). En effet, elle permet de créer des situations écologiques, sans



compromettre le contrôle expérimental. Immergés dans un environnement virtuel, les participants sont acteurs du monde dans lequel ils progressent. Ils se sentent donc personnellement impliqués et peuvent ressentir un véritable sentiment de présence, comme le montrent les résultats d'une étude sur des victimes de brûlures (Hoffman et al., 2004). Grâce à la réalité virtuelle, des patients grands brûlés ont eu l'illusion de voler dans un monde glacé et ont pu oublier la sensation de brûlure. La qualité immersive d'un environnement virtuel peut encourager un changement d'attention du monde réel vers le monde virtuel, c'est pourquoi nous pensons que ce type de procédure pourrait être très utile pour l'étude de la mémoire adaptative. Nous pourrions alors réellement immerger les participants dans un contexte de survie ancestrale, de déménagement ou de voyage afin de répliquer de façon plus écologique les résultats obtenus par Gelin, Bugajska et al. (2017) et de lever l'ambiguïté qui persiste dans les situations « non-survie ». En effet, dans les études de Gelin, Bugajska et al. (2017), l'effet animé ne s'était pas révélé significatif dans toutes les situations « non-survie » (cf., Gelin, Bugajska et al., 2017, étude 1). Concernant les données que nous avons obtenues en mémoire de source (Gelin, Bonin et al., 2017), la réalité virtuelle pourrait également être intéressante, afin d'étudier d'autres aspects du contexte et de confirmer que les entités animées sont encodées avec plus de détails contextuels. Ainsi pouvons-nous imaginer une étude dans laquelle les participants devront se déplacer dans un environnement virtuel, avec comme objectif de trouver des items cibles, animés (e.g., *poisson*) et inanimés (e.g., *corde*). Pour cela, ils traverseront une plage, une jungle et un village. Ces trois lieux différents permettraient d'avoir un contexte spatial riche, écologique et réaliste. Ensuite, il serait intéressant de manipuler le contexte temporel en reproduisant le déroulé d'une journée, du lever du soleil jusqu'à son coucher. Trois périodes pourraient alors être utilisées comme contexte temporel naturel : le matin, l'après-midi et la nuit. Mais l'utilisation de la réalité virtuelle permettrait également de tester si l'effet animé peut s'étendre à d'autres contextes que le contexte spatio-temporel. Nous pourrions, par exemple, manipuler le contexte sonore ou des informations liées aux caractéristiques physiques des items, comme leur couleur ou leur taille.

### **3.4. Effet animé et accès aux connaissances sémantiques**

A l'heure actuelle, l'effet animé est considéré comme relevant de la mémoire épisodique. Les caractéristiques fonctionnelles de la mémoire épisodique justifient d'ailleurs pleinement cette assertion. En effet, la mémoire épisodique est un système de mémoire qui permet d'avoir un comportement adapté, dans le présent et le futur immédiat, en s'appuyant

sur des expériences passées (Allen & Fortin, 2013). Cependant, à notre connaissance, aucune étude n'a encore testé explicitement si l'effet animé pouvait également être lié à la mémoire sémantique et, plus précisément, si le caractère animé pouvait influencer l'accès aux connaissances. Dans l'étude 3 de Bonin et al. (2014), qui utilisait le paradigme *Remember/Know* (Gardiner, 1988, 2001), l'absence de différence significative entre les entités animées et inanimées pour les réponses « *Know* » peut être considérée comme un premier élément de réponse. Néanmoins, dans ce paradigme, le statut des réponses « *Know* » fait débat. Si pour Tulving (1985) la réponse « *Know* », indice de familiarité, permet d'évaluer la conscience noétique indépendamment de la conscience auto-noétique, pour d'autres auteurs ce n'est pas tout à fait le cas (voir Besson, Ceccaldi, & Barbeau, 2012, pour un article de synthèse). Ainsi, la différence entre les réponses « *Know* » et « *Remember* » pourrait davantage refléter une différence de certitude dans un processus mnésique unique (Donaldson, 1996 ; Dunn, 2004). Notre objectif ici n'est pas de prendre position dans ce débat. En revanche, le simple fait de son existence conduit à la prudence en ce qui concerne les résultats obtenus par Bonin et al. (2014) sur les réponses « *Know* ». De plus, Caramazza et Shelton (1998) ont observé des déficits sémantiques spécifiques aux entités animées chez des patients cérébrolésés. Certains patients avaient perdu la capacité à dénommer les êtres vivants, tels que les animaux, en l'absence de déficit concernant les entités non-vivantes. Plus récemment, dans une revue de cas cliniques, Capitani, Laiacona, Mahon et Caramazza (2003) ont émis l'hypothèse qu'il y aurait trois catégories sémantiques spécifiquement touchées par les déficits : les entités animées, les entités inanimées biologiques (à savoir, les végétaux) et les artefacts. Sur cette base, il est possible d'anticiper une influence du caractère animé sur l'accès aux connaissances sémantiques. Il serait donc intéressant de tester l'effet animé en décision lexicale. Une tâche de décision lexicale consiste à décider, le plus rapidement et en faisant le moins d'erreur possible, si une suite de lettres présentée sur un écran d'ordinateur est un mot de la langue ou, au contraire, un non-mot. Elle permet donc de tester l'accès au lexique. Ainsi, observer un effet animé dans une tâche de décision lexicale signifierait que les mots renvoyant à des entités animées sont plus accessibles dans le lexique que ceux renvoyant à des entités inanimées, ce qui suggérerait une prégnance des entités animées en mémoire sémantique.

De plus, en fonction du type de non-mots utilisés, la tâche de décision lexicale ne requière pas le même type de traitement. Lorsque les non-mots sont difficiles, parce qu'ils respectent les règles orthographiques et phonologiques de la langue étudiée (e.g., *dandon*), ou

encore ressemblent phonologiquement mais pas orthographiquement à des mots réels (e.g., pseudo-homophones comme "lyvre", "tenque"), la prise de décision quant à la suite de lettres présentées requiert un traitement plus profond, fondé sur les caractéristiques sémantiques des mots (Balota, Ferraro, & Connor, 1991). Dans ce cas, la reconnaissance d'un mot nécessite une recherche en mémoire des informations lexicales et sémantiques pertinentes pour distinguer les mots des non-mots. En revanche, quand les non-mots sont faciles à repérer, parce qu'ils comportent des suites de lettres illégales dans la langue étudiée (e.g., *jukgtr*), la décision lexicale requiert des traitements plus superficiels, correspondant aux premières étapes de la reconnaissance visuelle des mots. Ainsi, un effet peut être plus ou moins sensible au type de traitement requis par la tâche. Tester l'effet animé à l'aide d'une tâche de décision lexicale, incluant différents niveaux de difficultés de discrimination entre mots et non-mots, pourrait donc permettre de savoir si cet effet est également lié à des mécanismes lexicaux et à la mémoire sémantique, ou si, au contraire, il relève exclusivement de la mémoire épisodique.

#### **4. Conséquences pratiques des recherches sur l'effet animé en mémoire**

##### **4.1. Psychologie expérimentale**

Les chercheurs spécialisés dans l'étude de la mémoire reconnaissent depuis longtemps la nécessité de prendre en compte des variables liées aux items dans leurs études (Jenkins, 1979). On sait notamment que des caractéristiques des mots telles que leur longueur, ou leur fréquence dans la langue, sont systématiquement contrôlées parce que ces variables influencent la mémorisation (e.g., Hall, 1954 ; Thorndike & Lorge, 1944, pour des études sur l'effet de fréquence en mémoire à long terme). En 1986, Rubin et Friendly, ont utilisé une technique de régression pour tester l'impact de nombreuses variables liées aux mots sur une tâche de mémorisation. Ils ont trouvé trois prédicteurs principaux du rappel : la facilité à former une image mentale à partir d'un mot (l'imageabilité), le nombre de fois où un item est donné en tant qu'associé verbal (e.g., "miel" est souvent fourni en réponse à "ruche", ce que Rubin et Friendly nomment la disponibilité) et la valence émotionnelle. En reprenant cette méthode d'analyse, et en y ajoutant le caractère animé comme variable, Nairne et al. (2013) ont découvert qu'il s'agissait de l'un des plus fort prédicteur de la variance du taux de rappel des mots. En effet, le caractère animé est fortement corrélé avec les performances de rappel ( $r = .42$ ), son importance étant même près de deux fois celle de sa plus proche variable

« concurrente » : l'imageabilité. Il semble donc désormais difficile de ne pas tenir compte de cette variable dans le choix d'un matériel expérimental pour des expériences testant la mémoire. De plus, l'ensemble des études réalisées sur l'effet animé en mémoire tendent à montrer sa robustesse et le fait que le caractère animé puisse impacter les performances de mémoire dans de nombreuses situations d'encodage (e.g., Gelin, Bugaiska et al., 2017). Ainsi, même si l'interprétation en termes évolutionniste de l'effet animé peut faire débat, la caractéristique animée a de toute évidence un impact sur le fonctionnement mnésique qu'il ne faut pas, ou plus, négliger.

#### **4.2. Psychologie clinique et neuropsychologie**

De la même façon que le caractère animé n'est que rarement pris en compte dans la conception du matériel en psychologie expérimentale, il ne l'est pas non plus dans la conception des tests utilisés en psychologie clinique et en neuropsychologie. Par exemple, le *California Verbal Learning Test* (CVLT ; Delis, Kramer, Kaplan, & Ober, 1987) a été élaboré pour évaluer la mémoire épisodique. Il s'agit de donner au patient une première liste de course, la liste du lundi (liste A), à apprendre en 5 essais, et d'introduire ensuite une seconde liste, la liste du mardi (liste B), qui servira de liste interférente. Ce test permet ainsi d'évaluer les rappels libres immédiats des deux listes, mais aussi le rappel à long terme de la liste A, ainsi que le rappel indicé et la reconnaissance de cette même liste. Les deux listes sont composées de 16 mots appartenant à des catégories sémantiques bien définies, des épices/herbes aromatiques, des fruits, des outils et des vêtements dans la liste A ; des épices/herbes aromatiques, des fruits, des ustensiles de cuisine et des espèces de poissons dans la liste B.

Compte tenu de l'effet animé observé en mémoire épisodique, il est possible que l'interférence engendrée par la liste B soit d'autant plus forte qu'elle contient des mots renvoyant à des entités animées, alors que la liste A n'en contient pas. Une telle possibilité pourrait être envisagée et testée.

#### **4.3. Apprentissages et pédagogie**

Nos études pourraient enfin avoir des implications dans le champ des apprentissages et de la pédagogie. En effet, les études menées sur l'effet animé témoignent de l'importance du

caractère animé pour la mémorisation, et donc potentiellement, pour l'apprentissage. Il est par exemple possible que les informations relatives aux êtres vivants soient plus facilement apprises par les enfants.

De nombreuses études ont montré que la distinction entre animés et inanimés est acquise précocement (e.g., Mandler & McDonough, 1998 ; Rakison & Poulin-Dubois, 2001 ; pour une revue récente, voir Opfer & Gelman, 2011), mais aussi, qu'elle est observée dans de très nombreuses cultures, lui conférant un statut de "dimension universelle" (Atran, 1998). Au-delà de distinguer les entités animées des entités inanimées, les êtres humains, depuis le plus jeune âge, ont une réelle affinité naturelle avec les animaux (Bloom Pickard, Soska, & DeLoache, 2012 ; DeLoache, Bloom Pickard, & LoBue, 2011, Wilson, 1984). Par exemple, des enfants de 4 à 12 mois regardent plus longtemps une vidéo présentant un animal en mouvement plutôt qu'un artefact en mouvement (Bloom Pickard et al., 2012). Si la majorité des études utilisent la préférence visuelle pour étudier l'attrait pour les animaux chez l'enfant, des chercheurs (LoBue, Bloom Pickard, Sherman, Axford, & DeLoache, 2013) ont mené une étude permettant d'explorer cet attrait dans un environnement naturel. A travers trois expériences, conduites chez des enfants âgés de 11 à 40 mois, la préférence pour les animaux, comparativement à celle des jouets, a été évaluée avec un paradigme de jeu libre. Les enfants entraient, avec l'un de leurs parents, dans une salle de jeux, ils étaient alors libres d'interagir avec tout ce qui s'y trouvait. Dans les différentes conditions testées par les auteurs (Etude 1 : poisson et hamster vs. un panel de jouets attrayants ; Etude 2 : poisson, hamster, araignée et serpent vs. quatre jouets attrayants), les enfants ont plus interagis avec les animaux réels qu'avec les jouets, et ce, même lorsque ces derniers étaient physiquement semblables aux animaux (Etude 3 : des animaux réels vs. les mêmes animaux en jouet). De plus, ils se comportaient différemment envers les animaux et les jouets, ils parlaient plus des animaux que des jouets à leur parent et lui posaient plus de questions à leur sujet. Cette curiosité accrue envers les êtres vivants soutient l'idée que les enfants ont une affinité particulière avec les animaux, lesquels attirent et maintiennent davantage leur attention, même lorsque des jouets attrayants et stimulants sont présentés. Ainsi, les enfants d'âge préscolaire peuvent facilement distinguer les êtres vivants, tels que les animaux, des objets inanimés, mais surtout, ils en extraient des connaissances plus riches (Heyman & Gelman, 2000). Ces compétences naturelles sont exploitées dans les films populaires pour enfants, qui attribuent souvent des propriétés animées à des objets inanimés (Nairne et al., 2017). Mais il semble que ces propriétés pourraient également être mises à profit dans l'apprentissage en milieu scolaire.

Comme n'importe quelle adaptation biologique, les différentes méthodes d'apprentissage ont des coûts et des bénéfices qui peuvent différer en fonction des problèmes auxquels elles permettent de faire face (Dukas, 1999 ; Gallistel & King, 2009). Les apprentissages sociaux, par exemple, sont utilisés dans des situations où l'expérience directe s'avèrerait être dangereuse ou néfaste. C'est le cas notamment avec l'apprentissage de la peur chez les macaques (Mineka & Cook, 1988). En effet, des macaques naïfs, uniquement élevés en laboratoire et jamais exposés à des serpents, acquièrent la peur de ces prédateurs en observant la réaction de leurs congénères. Cet apprentissage est rapide et efficace puisqu'une seule exposition est nécessaire, et sans aucun feedback. Ainsi, l'apprentissage social permet qu'une information soit apprise efficacement, sans que les macaques n'aient besoin d'avoir une interaction directe avec un serpent, ce qui pourrait s'avérer fatale. Le rôle de l'apprentissage social dans l'acquisition d'informations relatives à la dangerosité a également été montré chez l'Homme (Barrett & Broesch, 2012 ; mais voir aussi Štefaníková & Prokop, 2015 qui montrent que les indices visuels de dangerosité peuvent surpasser les informations sociales, quand les deux types d'information ne sont pas congruents). Barrett et Broesch (2012) ont trouvé un biais de contenu dans l'apprentissage des animaux en faveur de leur dangerosité, à la fois pour des enfants vivant en ville (des enfants de Los Angeles, âgés de 4 à 6 ans) et des enfants issus d'une tribu amazonienne, les Shuars (âgés de 4 à 11 ans). Pour cela, ils ont utilisé une procédure d'apprentissage social sans feedback. L'expérimentateur montrait aux enfants les photographies de 16 animaux rares, 8 herbivores dont la moitié étaient dangereux et 8 carnivores, parmi lesquels 4 étaient dangereux. Les enfants de la condition contrôle devaient deviner le nom, le régime alimentaire et la dangerosité de chaque animal, alors que l'expérimentateur donnait ces différentes informations aux enfants de la condition expérimentale. Ensuite, les enfants de la condition expérimentale étaient soumis à deux tests : le premier immédiatement après la phase d'apprentissage et le second une semaine plus tard. Ils devaient alors retrouver le nom, le régime alimentaire et la dangerosité de chacun des 16 animaux. Leurs principaux résultats montraient que seules les informations relatives à la dangerosité des animaux étaient réellement apprises, cela de manière équivalente dans les deux cultures et même après un délai d'une semaine. Aussi, ce type d'informations était significativement mieux mémorisé que les informations liées au régime alimentaire ou aux noms des animaux. D'après Barrett et Broesch (2012), la sélection naturelle est susceptible de mettre en place des systèmes permettant l'acquisition rapide de connaissances relatives aux dangers environnementaux, y compris celles concernant les animaux dangereux. Plus précisément, chez les espèces sociales telles que l'Homme, les informations stockées par les

congénères sur le danger pourraient favoriser l'évolution de mécanismes d'apprentissages sociaux, qui font que les enfants s'intéressent de manière préférentielle, et se souviennent mieux, des informations transmises sur le plan culturel quand elles sont liées au danger.

Il est de plus en plus clair que la psychologie évolutionniste peut avoir un intérêt pour les sciences de l'éducation (e.g., Tricot & Roussel, 2016). L'étude décrite plus haut, mais également des études récentes de Prokop et ses collaborateurs, témoignent de la possibilité d'utiliser les théories issues de la psychologie évolutionniste pour expliquer certains biais d'apprentissage. Prokop et Fančovičová (2014) ont observé que des lycéens se souvenaient de plus d'informations concernant des plantes aux fruits rouges ou noirs, comparativement à celles dont les fruits étaient verts. Dans cette même étude, les participants mémorisaient mieux les informations liées à la toxicité des fruits, comparativement à leur nom, ou encore à l'endroit où ils poussaient. Cela suggère, d'après les auteurs, que les couleurs associées à la maturation ou à la toxicité, par conséquent les informations plus importantes pour la survie, sont plus facilement apprises. De même, Prokop, Fančovičová et Fedor (2014) ont montré que les informations liées à des parasites pouvant infecter l'Homme (e.g., le ténia) étaient mieux retenues que celles concernant des hormones. Ces résultats, encore une fois, fournissent des arguments en faveur d'un « apprentissage adaptatif ». En effet, les connaissances relatives aux parasites (par rapport aux connaissances sur les hormones) peuvent aider à éviter des maladies mortelles et sont donc plus pertinentes en termes de survie. Ces résultats font directement écho aux études faites dans le domaine de la mémoire adaptative, et notamment aux effets survie et contamination.

Concernant l'effet animé, Aslan et John (2016) ont montré qu'il était présent chez des enfants âgés de 4 à 11 ans. Pour cela, ils ont repris la procédure de VanArsdall et al. (2013), à savoir la mémorisation de non-mots associés à des propriétés leur conférant le statut d'être vivant ou d'artefact (e.g., « *BULA construit des nids* »). Les enfants, répartis en trois groupes d'âge (4-6 ans, 7-8 ans et 9-11 ans), devaient préciser si les 18 non-mots qui leur étaient présentés, en fonction de la propriété qui leur était associée, renvoyaient plus probablement à quelque chose de vivant ou de non vivant. Après cette phase d'encodage incident, et trois minutes de tâches interférentes, ils étaient soumis à une tâche de reconnaissance. Non seulement les résultats témoignaient d'un effet animé sur les performances de reconnaissance, mais aussi d'un effet de même amplitude pour les différents groupes d'âge. Ces résultats laissent donc entrevoir la possibilité que les connaissances relatives aux entités animées soient préférentiellement acquises par les enfants, et ce, tout au long de leur scolarité.

Enfin les perspectives d'implication de l'effet animé dans l'apprentissage ne sont pas limitées aux disciplines scientifiques. En effet, VanArsdall et al. (2015) ont montré, chez des adultes, que l'effet animé persiste dans le cadre d'un apprentissage associatif, comme lorsqu'il s'agit d'apprendre du vocabulaire dans une langue étrangère. En effet, dans leur étude, les participants anglophones, qui devaient apprendre la traduction anglaise de mot Swahili, avaient de meilleures performances lors d'un rappel indicé (e.g., dog - \_\_\_\_\_ ? , la réponse attendue était par exemple « *rembo* ») pour les mots renvoyant à des entités animées qu'inanimées.

## 5. Conclusion

Dans ce travail de thèse, nous avons pour objectifs principaux d'identifier les facteurs qui modulent l'effet animé en mémoire, et de fournir des pistes explicatives de cet effet, en mettant à jour les mécanismes cognitifs qui le sous-tendent. Ainsi, dans une perspective évolutionniste, nous nous sommes attachés à fournir deux niveaux d'explications complémentaires à l'effet animé en mémoire : des explications ultimes et des explications proximales.

Concernant les explications ultimes, nous avons défendu la conception d'une mémoire adaptative, telle que définie par Nairne et collaborateurs (Nairne, 2010 pour une revue de synthèse). Cette vision fonctionnelle du système cognitif humain, postule que la mémoire a évolué de sorte à privilégier un encodage solide des informations pertinentes pour la survie de l'espèce. Il en découle alors des biais attentionnels et mnésiques, tel que l'effet animé. Les entités animées, parce qu'elles étaient importantes pour nos ancêtres dans le passé ancestral, ont acquis un statut privilégié et impactent, aujourd'hui encore, les performances de mémorisation. Bien qu'hérités de l'évolution, ces biais peuvent être sous-tendus par des mécanismes que l'on qualifie de "généraux" et que des recherches se doivent de dévoiler. Ainsi, l'effet animé semble être sous-tendu en partie par de l'imagerie mentale, laquelle, mise au service des entités animées, permet d'en augmenter la mémorisation, sans que cela ne soit coûteux en ressources cognitives.

Au final, à travers l'effet animé en mémoire, nous espérons avoir apporté de nouveaux arguments en faveur de l'approche évolutionniste de la mémoire, à savoir une approche



centrée à la fois sur les mécanismes proximaux et ultimes<sup>7</sup>. Ainsi, pour nous, asseoir un effet dans une perspective évolutionniste n'implique pas qu'il faille négliger ou sous-estimer les mécanismes proximaux qui le sous-tendent. Tout au contraire, nous pensons qu'adopter une telle perspective permet d'élargir le champ des connaissances. En effet, elle permet de générer de nouvelles hypothèses et, de ce fait, d'accroître les savoirs. Cette valeur heuristique explique notamment pourquoi nous pensons qu'un éclairage évolutionniste est utile en psychologie cognitive, au même titre que dans d'autres disciplines dans lesquelles il a pris une place fondamentale depuis de nombreuses années (e.g., en biologie), ou grandissante depuis plus récemment (e.g., en psychologie sociale).

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<sup>7</sup> L'étude de l'effet animé dans une perspective évolutionniste est également présentée sous la forme d'une courte bande dessinée humoristique en Annexe 7 pp. 235-237. Il s'agit d'un projet mené en collaboration avec l'Expérimentarium, la Mission Culture Scientifique et l'Université de Bourgogne., dans un souci de vulgarisation et de valorisation du patrimoine scientifique.

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# **Annexes**

## Annexe 1 : Matériel supplémentaire de l'Article 2

Supplementary material for Study 1 and 2

| Study 1               |                 |               |                          |     |
|-----------------------|-----------------|---------------|--------------------------|-----|
|                       | Inanimate words | Animate words | t-test                   | d   |
| Hit rates (corrected) | .60 (.16)       | .74 (.11)     | $t(33) = 5.43, p < .001$ | .96 |
| False alarm rates     | .08 (.06)       | .06 (.07)     | $t(33) = -1.09, ns$      |     |
| Study 2               |                 |               |                          |     |
|                       | Inanimate words | Animate words | t-test                   | d   |
| Hit rates (corrected) | .60 (.16)       | .69 (.15)     | $t(33) = 3.41, p < .01$  | .60 |
| False alarm rates     | .09 (.09)       | .09 (.09)     | $t(33) = .30, ns$        |     |

Standard deviations in parentheses



## Annexe 2 : Matériel supplémentaire de l'Article 3, étude 1

ESM 1. Recall data for Study 1.

| subjects | age | sex | recall |         |           | intrusions |         |           |
|----------|-----|-----|--------|---------|-----------|------------|---------|-----------|
|          |     |     | total  | animate | inanimate | total      | animate | inanimate |
| 1        | 21  | F   | 11     | 9       | 2         | 6          | 4       | 2         |
| 2        | 19  | M   | 7      | 5       | 2         | 1          | 1       | 0         |
| 3        | 20  | M   | 11     | 5       | 6         | 0          | 0       | 0         |
| 4        | 19  | F   | 12     | 6       | 6         | 1          | 1       | 0         |
| 5        | 21  | F   | 11     | 7       | 4         | 0          | 0       | 0         |
| 6        | 18  | F   | 12     | 7       | 5         | 0          | 0       | 0         |
| 7        | 19  | F   | 5      | 3       | 2         | 2          | 0       | 2         |
| 8        | 18  | F   | 15     | 10      | 5         | 0          | 0       | 0         |
| 9        | 19  | F   | 11     | 6       | 5         | 0          | 0       | 0         |
| 10       | 19  | F   | 13     | 8       | 5         | 0          | 0       | 0         |
| 11       | 18  | F   | 13     | 9       | 4         | 0          | 0       | 0         |
| 12       | 18  | F   | 16     | 10      | 6         | 0          | 0       | 0         |
| 13       | 18  | F   | 12     | 8       | 4         | 2          | 0       | 2         |
| 14       | 20  | F   | 11     | 5       | 6         | 1          | 1       | 0         |
| 15       | 18  | F   | 16     | 9       | 7         | 0          | 0       | 0         |
| 16       | 18  | F   | 15     | 7       | 8         | 0          | 0       | 0         |
| 17       | 18  | F   | 10     | 6       | 4         | 0          | 0       | 0         |
| 18       | 22  | F   | 7      | 4       | 3         | 1          | 0       | 1         |
| 19       | 20  | F   | 17     | 9       | 8         | 0          | 0       | 0         |
| 20       | 18  | F   | 4      | 1       | 3         | 5          | 1       | 4         |
| 21       | 25  | F   | 13     | 7       | 6         | 1          | 1       | 0         |
| 22       | 17  | F   | 14     | 8       | 6         | 0          | 0       | 0         |
| 23       | 18  | F   | 12     | 8       | 4         | 1          | 0       | 1         |
| 24       | 22  | F   | 17     | 9       | 8         | 0          | 0       | 0         |
| 25       | 29  | M   | 10     | 6       | 4         | 0          | 0       | 0         |
| 26       | 21  | F   | 6      | 2       | 4         | 0          | 0       | 0         |
| 27       | 18  | F   | 13     | 7       | 6         | 1          | 1       | 0         |
| 28       | 18  | F   | 17     | 7       | 10        | 0          | 0       | 0         |
| 29       | 19  | F   | 13     | 8       | 5         | 0          | 0       | 0         |
| 30       | 20  | F   | 18     | 9       | 9         | 1          | 0       | 1         |

### Annexe 3 : Matériel supplémentaire de l'Article 3, étude 2

ESM 2. Recall data for Study 2.

| subject | age | sex | load condition: recall data |         |           | intrusions |         |           | no-load condition: recall data |         |           |
|---------|-----|-----|-----------------------------|---------|-----------|------------|---------|-----------|--------------------------------|---------|-----------|
|         |     |     | total                       | animate | inanimate | total      | animate | inanimate | total                          | animate | inanimate |
| 1       | 23  | F   | 2                           | 1       | 1         | 0          | 0       | 0         | 4                              | 3       | 1         |
| 2       | 24  | F   | 3                           | 3       | 0         | 0          | 0       | 0         | 2                              | 1       | 1         |
| 3       | 21  | F   | 3                           | 2       | 1         | 0          | 0       | 1         | 3                              | 3       | 0         |
| 4       | 23  | F   | 1                           | 0       | 1         | 0          | 0       | 0         | 2                              | 2       | 0         |
| 5       | 21  | F   | 1                           | 0       | 1         | 0          | 0       | 0         | 7                              | 6       | 1         |
| 6       | 21  | F   | 0                           | 0       | 0         | 1          | 0       | 1         | 5                              | 2       | 3         |
| 7       | 18  | M   | 3                           | 3       | 0         | 0          | 0       | 0         | 5                              | 3       | 2         |
| 8       | 21  | F   | 0                           | 0       | 0         | 0          | 0       | 0         | 7                              | 4       | 3         |
| 9       | 20  | F   | 5                           | 3       | 2         | 1          | 0       | 1         | 6                              | 4       | 2         |
| 10      | 20  | F   | 2                           | 2       | 0         | 4          | 2       | 2         | 1                              | 1       | 0         |
| 11      | 19  | F   | 2                           | 2       | 0         | 5          | 1       | 4         | 5                              | 3       | 2         |
| 12      | 21  | F   | 4                           | 3       | 1         | 3          | 1       | 2         | 2                              | 2       | 0         |
| 13      | 18  | F   | 2                           | 1       | 1         | 2          | 0       | 2         | 4                              | 2       | 2         |
| 14      | 18  | F   | 1                           | 0       | 1         | 1          | 0       | 1         | 8                              | 4       | 4         |
| 15      | 19  | F   | 3                           | 3       | 0         | 0          | 0       | 0         | 3                              | 1       | 2         |
| 16      | 27  | M   | 1                           | 1       | 0         | 0          | 0       | 0         | 5                              | 3       | 2         |
| 17      | 17  | M   | 0                           | 0       | 0         | 1          | 0       | 1         | 7                              | 4       | 3         |
| 18      | 19  | F   | 2                           | 2       | 0         | 0          | 0       | 0         | 5                              | 4       | 1         |
| 19      | 18  | F   | 3                           | 3       | 0         | 0          | 0       | 0         | 7                              | 4       | 3         |
| 20      | 42  | F   | 1                           | 0       | 1         | 0          | 0       | 0         | 3                              | 3       | 0         |
| 21      | 18  | F   | 5                           | 4       | 1         | 1          | 1       | 0         | 3                              | 2       | 1         |
| 22      | 19  | F   | 3                           | 2       | 1         | 6          | 2       | 4         | 6                              | 3       | 3         |
| 23      | 18  | F   | 2                           | 0       | 2         | 0          | 0       | 0         | 4                              | 3       | 1         |
| 24      | 19  | F   | 3                           | 3       | 0         | 1          | 1       | 0         | 4                              | 4       | 0         |
| 25      | 24  | M   | 1                           | 1       | 0         | 0          | 0       | 0         | 4                              | 2       | 2         |
| 26      | 21  | M   | 2                           | 1       | 1         | 0          | 0       | 0         | 4                              | 2       | 2         |
| 27      | 23  | F   | 0                           | 0       | 0         | 0          | 0       | 0         | 4                              | 3       | 1         |
| 28      | 19  | F   | 4                           | 2       | 2         | 0          | 0       | 0         | 5                              | 3       | 2         |
| 29      | 19  | F   | 2                           | 2       | 0         | 3          | 2       | 1         | 5                              | 2       | 3         |
| 30      | 23  | F   | 4                           | 4       | 0         | 0          | 0       | 0         | 5                              | 2       | 3         |
| 31      | 21  | F   | 2                           | 1       | 1         | 0          | 0       | 0         | 2                              | 1       | 1         |

ESM 2. Reaction time for Study 2.

| subject | age | sex | load condition |             |             | no-load condition |             |             |
|---------|-----|-----|----------------|-------------|-------------|-------------------|-------------|-------------|
|         |     |     | total          | animate     | inanimate   | total             | animate     | inanimate   |
| 1       | 23  | F   | 1564,5         | 1505,285714 | 1623,714286 | 1228,571429       | 1069,571429 | 1387,571429 |
| 2       | 24  | F   | 895,4285714    | 885,4285714 | 905,4285714 | 1115,428571       | 1099,428571 | 1131,428571 |
| 3       | 21  | F   | 1564,5         | 1505,285714 | 1623,714286 | 2009,571429       | 1762,428571 | 2256,714286 |
| 4       | 23  | F   | 1673,5         | 1548,142857 | 1798,857143 | 1452,928571       | 1501,857143 | 1404        |
| 5       | 21  | F   | 1125,071429    | 1106,285714 | 1143,857143 | 725,7142857       | 770,7142857 | 680,7142857 |
| 6       | 21  | F   | 2121,785714    | 1652,857143 | 2590,714286 | 1502,285714       | 1481,142857 | 1523,428571 |
| 7       | 18  | M   | 1194,571429    | 1213        | 1176,142857 | 1083,142857       | 1112        | 1054,285714 |
| 8       | 21  | F   | 1214,214286    | 1213,857143 | 1214,571429 | 1525,071429       | 1497,428571 | 1552,714286 |
| 9       | 20  | F   | 1226,428571    | 1270        | 1182,857143 | 757,5             | 721,7142857 | 793,2857143 |
| 10      | 20  | F   | 816,6428571    | 807,2857143 | 826         | 1122,785714       | 1097,714286 | 1147,857143 |
| 11      | 19  | F   | 1166,928571    | 1088,714286 | 1245,142857 | 935,3571429       | 917,4285714 | 953,2857143 |
| 12      | 21  | F   | 1320,285714    | 1420,428571 | 1220,142857 | 1188,428571       | 1151,571429 | 1225,285714 |
| 13      | 18  | F   | 1454,285714    | 1403,428571 | 1505,142857 | 1387,142857       | 1385,142857 | 1389,142857 |
| 14      | 18  | F   | 1249,928571    | 1259,714286 | 1240,142857 | 1724,357143       | 1543,571429 | 1905,142857 |
| 15      | 19  | F   | 1204,214286    | 1253,714286 | 1154,714286 | 1362,285714       | 1319,285714 | 1405,285714 |
| 16      | 27  | M   | 1505,5         | 1331,142857 | 1679,857143 | 1565,142857       | 1392,285714 | 1738        |
| 17      | 17  | M   | 1564,571429    | 2041,428571 | 1087,714286 | 924,3571429       | 961,7142857 | 887         |
| 18      | 19  | F   | 1297,642857    | 1153,285714 | 1442        | 1417,785714       | 1456,285714 | 1379,285714 |
| 19      | 18  | F   | 1197,642857    | 1128,714286 | 1266,571429 | 1148              | 1226,142857 | 1069,857143 |
| 20      | 42  | F   | 1266,714286    | 1200,428571 | 1333        | 1087,928571       | 1120,857143 | 1055        |
| 21      | 18  | F   | 2038,857143    | 2221        | 1856,714286 | 1872,714286       | 1818,714286 | 1926,714286 |
| 22      | 19  | F   | 1663           | 1856,142857 | 1469,857143 | 1584,642857       | 1496,857143 | 1672,428571 |
| 23      | 18  | F   | 1189,571429    | 1271,857143 | 1107,285714 | 1135,142857       | 1210        | 1060,285714 |
| 24      | 19  | F   | 855            | 834,8571429 | 875,1428571 | 1236,142857       | 1339,428571 | 1132,857143 |
| 25      | 24  | M   | 1737,142857    | 1723,857143 | 1750,428571 | 1661,5            | 1787,714286 | 1535,285714 |
| 26      | 21  | M   | 1647,214286    | 1697,285714 | 1597,142857 | 1198,285714       | 1176,428571 | 1220,142857 |
| 27      | 23  | F   | 1741,285714    | 1674,857143 | 1807,714286 | 1775,214286       | 1864,285714 | 1686,142857 |
| 28      | 19  | F   | 1428,142857    | 1527,571429 | 1328,714286 | 2146,857143       | 1676,714286 | 2617        |
| 29      | 19  | F   | 1067,857143    | 947,1428571 | 1188,571429 | 1063              | 1124        | 1002        |
| 30      | 23  | F   | 2093,142857    | 2077,142857 | 2109,142857 | 1907,142857       | 2268,857143 | 1545,428571 |
| 31      | 21  | F   | 1183,142857    | 973,4285714 | 1392,857143 | 1123,071429       | 980,5714286 | 1265,571429 |

ESM 2. Secondary task for Study 2.

| subject | number of errors |           |
|---------|------------------|-----------|
|         | animate          | inanimate |
| 1       | 0                | 2         |
| 2       | 3                | 1         |
| 3       | 3                | 4         |
| 4       | 1                | 3         |
| 5       | 4                | 2         |
| 6       | 5                | 2         |
| 7       | 1                | 0         |
| 8       | 4                | 1         |
| 9       | 3                | 0         |
| 10      | 4                | 0         |
| 11      | 1                | 3         |
| 12      | 1                | 3         |
| 13      | 1                | 0         |
| 14      | 1                | 2         |
| 15      | 4                | 3         |
| 16      | 4                | 1         |
| 17      | 0                | 1         |
| 18      | 0                | 0         |
| 19      | 1                | 0         |
| 20      | 0                | 2         |
| 21      | 1                | 1         |
| 22      | 1                | 2         |
| 23      | 1                | 2         |
| 24      | 0                | 0         |
| 25      | 4                | 1         |
| 26      | 5                | 1         |
| 27      | 4                | 1         |
| 28      | 2                | 0         |
| 29      | 3                | 0         |
| 30      | 3                | 4         |
| 31      | 1                | 1         |

## Annexe 4 : Matériel supplémentaire de l'Article 3, étude 3A

### ESM 3. Recall data for Study 3A.

| subject | age | sex | load condition: recall data |         |           | intrusions |         |           | no-load condition: recall data |         |           |
|---------|-----|-----|-----------------------------|---------|-----------|------------|---------|-----------|--------------------------------|---------|-----------|
|         |     |     | total                       | animate | inanimate | total      | animate | inanimate | total                          | animate | inanimate |
| 1       | 20  | F   | 1                           | 1       | 0         | 0          | 0       | 0         | 1                              | 1       | 0         |
| 2       | 19  | F   | 5                           | 3       | 2         | 1          | 0       | 1         | 1                              | 1       | 0         |
| 3       | 21  | F   | 5                           | 2       | 3         | 1          | 1       | 0         | 3                              | 2       | 1         |
| 4       | 20  | F   | 1                           | 0       | 1         | 2          | 1       | 1         | 2                              | 1       | 1         |
| 5       | 20  | M   | 2                           | 1       | 1         | 0          | 0       | 0         | 3                              | 1       | 2         |
| 6       | 20  | M   | 2                           | 2       | 0         | 6          | 2       | 4         | 3                              | 2       | 1         |
| 7       | 18  | M   | 0                           | 0       | 0         | 0          | 0       | 0         | 5                              | 2       | 3         |
| 8       | 18  | M   | 3                           | 2       | 1         | 0          | 0       | 0         | 6                              | 4       | 2         |
| 9       | 18  | F   | 4                           | 3       | 1         | 0          | 0       | 0         | 6                              | 5       | 1         |
| 10      | 25  | F   | 5                           | 4       | 1         | 0          | 0       | 0         | 5                              | 4       | 1         |
| 11      | 18  | F   | 4                           | 2       | 2         | 0          | 0       | 0         | 4                              | 2       | 2         |
| 12      | 18  | F   | 2                           | 2       | 0         | 1          | 0       | 1         | 8                              | 5       | 3         |
| 13      | 18  | F   | 2                           | 2       | 0         | 1          | 0       | 1         | 1                              | 1       | 0         |
| 14      | 20  | F   | 1                           | 1       | 0         | 1          | 1       | 0         | 6                              | 4       | 2         |
| 15      | 20  | F   | 2                           | 1       | 1         | 2          | 1       | 1         | 1                              | 1       | 0         |
| 16      | 20  | F   | 2                           | 0       | 2         | 0          | 0       | 0         | 7                              | 4       | 3         |
| 17      | 21  | F   | 2                           | 1       | 1         | 2          | 0       | 2         | 3                              | 3       | 0         |
| 18      | 19  | M   | 4                           | 1       | 3         | 0          | 0       | 0         | 8                              | 4       | 4         |
| 19      | 19  | F   | 1                           | 1       | 0         | 1          | 0       | 1         | 8                              | 4       | 4         |
| 20      | 19  | F   | 5                           | 4       | 1         | 1          | 0       | 1         | 3                              | 2       | 1         |
| 21      | 18  | F   | 3                           | 3       | 0         | 0          | 0       | 0         | 3                              | 1       | 2         |
| 22      | 19  | F   | 5                           | 3       | 2         | 2          | 2       | 0         | 2                              | 2       | 0         |
| 23      | 19  | F   | 7                           | 3       | 4         | 0          | 0       | 0         | 7                              | 4       | 3         |
| 24      | 18  | M   | 1                           | 1       | 0         | 1          | 0       | 1         | 4                              | 2       | 2         |
| 25      | 20  | F   | 4                           | 4       | 0         | 1          | 0       | 1         | 8                              | 4       | 4         |
| 26      | 18  | F   | 2                           | 2       | 0         | 2          | 1       | 1         | 2                              | 2       | 0         |
| 27      | 18  | M   | 6                           | 4       | 2         | 0          | 0       | 0         | 5                              | 2       | 3         |
| 28      | 21  | F   | 6                           | 4       | 2         | 1          | 0       | 1         | 5                              | 3       | 2         |

ESM 3. Reaction time for Study 3A.

| subject | age | sex | load condition |             |             | no-load condition |             |             |
|---------|-----|-----|----------------|-------------|-------------|-------------------|-------------|-------------|
|         |     |     | total          | animate     | inanimate   | total             | animate     | inanimate   |
| 1       | 20  | F   | 1313,428571    | 1327,857143 | 1299        | 1192,214286       | 1175        | 1209,428571 |
| 2       | 19  | F   | 869,8571429    | 816,5714286 | 923,1428571 | 1127,214286       | 1121,285714 | 1133,142857 |
| 3       | 21  | F   | 1313,428571    | 1327,857143 | 1299        | 1379,615385       | 1440,666667 | 1327,285714 |
| 4       | 20  | F   | 1286,714286    | 1314,142857 | 1259,285714 | 2150,769231       | 2298        | 1979        |
| 5       | 20  | M   | 1006,357143    | 997         | 1015,714286 | 943,0714286       | 992,8571429 | 893,2857143 |
| 6       | 20  | M   | 975,6153846    | 904,4285714 | 1058,666667 | 1320,230769       | 1230,714286 | 1424,666667 |
| 7       | 18  | M   | 2104,214286    | 2297,285714 | 1911,142857 | 1851,071429       | 1830,714286 | 1871,428571 |
| 8       | 18  | M   | 1454           | 1401,333333 | 1988,5      | 1299,357143       | 1384,142857 | 1214,571429 |
| 9       | 18  | F   | 1516,538462    | 1393,333333 | 1622,142857 | 1063,357143       | 1135,857143 | 990,8571429 |
| 10      | 25  | F   | 1089,153846    | 1113,857143 | 1060,333333 | 1356,428571       | 1253,428571 | 1459,428571 |
| 11      | 18  | F   | 1485,857143    | 1601,142857 | 1370,571429 | 1368,714286       | 1195,285714 | 1542,142857 |
| 12      | 18  | F   | 845,2857143    | 834,8571429 | 855,7142857 | 1026,923077       | 1022,142857 | 1032,5      |
| 13      | 18  | F   | 927,9285714    | 1017,857143 | 838         | 850,8333333       | 701,4       | 957,5714286 |
| 14      | 20  | F   | 939,3571429    | 966,7142857 | 912         | 956,7142857       | 928,8571429 | 984,5714286 |
| 15      | 20  | F   | 1250,142857    | 1204,285714 | 1296        | 1040,857143       | 925,5714286 | 1156,142857 |
| 16      | 20  | F   | 1552,714286    | 1288,142857 | 1817,285714 | 1285,076923       | 1275,571429 | 1296,166667 |
| 17      | 21  | F   | 1691,076923    | 1672,5      | 1707        | 1446,571429       | 1595,571429 | 1297,571429 |
| 18      | 19  | M   | 1249,642857    | 1157,142857 | 1342,142857 | 1270,714286       | 1162        | 1379,428571 |
| 19      | 19  | F   | 2653           | 2742        | 2564        | 1972,214286       | 2006        | 1938,428571 |
| 20      | 19  | F   | 1593,571429    | 1628,714286 | 1558,428571 | 1573,142857       | 1395,142857 | 1751,142857 |
| 21      | 18  | F   | 1657,230769    | 1793,166667 | 1540,714286 | 1798,857143       | 1689,142857 | 1908,571429 |
| 22      | 19  | F   | 1580,571429    | 1406,857143 | 1754,285714 | 1384,214286       | 1301,142857 | 1467,285714 |
| 23      | 19  | F   | 1907,785714    | 1726,714286 | 2088,857143 | 918,7857143       | 957,8571429 | 879,7142857 |
| 24      | 18  | M   | 1038,928571    | 1131,428571 | 946,4285714 | 1072,357143       | 981,4285714 | 1163,285714 |
| 25      | 20  | F   | 1470,928571    | 1490,285714 | 1451,571429 | 1279,928571       | 1186,428571 | 1373,428571 |
| 26      | 18  | F   | 1721,846154    | 1741,666667 | 1704,857143 | 1278,142857       | 1308,428571 | 1247,857143 |
| 27      | 18  | M   | 1236,857143    | 1146,571429 | 1327,142857 | 894,9285714       | 864,5714286 | 925,2857143 |
| 28      | 21  | F   | 2085,785714    | 1815,428571 | 2356,142857 | 1713,428571       | 1423,285714 | 2003,571429 |

ESM 3. Secondary task for Study 3A.

| subject | number of errors |           |
|---------|------------------|-----------|
|         | animate          | inanimate |
| 1       | 0                | 0         |
| 2       | 0                | 0         |
| 3       | 1                | 1         |
| 4       | 0                | 1         |
| 5       | 0                | 0         |
| 6       | 3                | 2         |
| 7       | 3                | 2         |
| 8       | 0                | 0         |
| 9       | 0                | 1         |
| 10      | 3                | 1         |
| 11      | 3                | 2         |
| 12      | 1                | 1         |
| 13      | 0                | 1         |
| 14      | 3                | 3         |
| 15      | 4                | 2         |
| 16      | 2                | 2         |
| 17      | 2                | 2         |
| 18      | 0                | 0         |
| 19      | 2                | 4         |
| 20      | 3                | 4         |
| 21      | 2                | 1         |
| 22      | 0                | 0         |
| 23      | 2                | 3         |
| 24      | 0                | 0         |
| 25      | 1                | 2         |
| 26      | 2                | 2         |
| 27      | 2                | 0         |
| 28      | 1                | 1         |

## Annexe 5 : Matériel supplémentaire de l'Article 3, étude 3B

ESM 4. Recall data for Study 3B.

| subject | age | sex | load condition: recall data |         |           | intrusions |         |           | no-load condition: recall data |         |           |
|---------|-----|-----|-----------------------------|---------|-----------|------------|---------|-----------|--------------------------------|---------|-----------|
|         |     |     | total                       | animate | inanimate | total      | animate | inanimate | total                          | animate | inanimate |
| 1       | 20  | M   | 0                           | 0       | 0         | 1          | 0       | 1         | 7                              | 4       | 3         |
| 2       | 20  | F   | 2                           | 1       | 1         | 0          | 0       | 0         | 5                              | 4       | 1         |
| 3       | 22  | F   | 4                           | 3       | 1         | 0          | 0       | 0         | 7                              | 4       | 3         |
| 4       | 19  | F   | 1                           | 0       | 1         | 1          | 0       | 1         | 4                              | 3       | 1         |
| 5       | 19  | F   | 2                           | 2       | 0         | 2          | 1       | 1         | 3                              | 1       | 2         |
| 6       | 19  | F   | 1                           | 1       | 0         | 1          | 0       | 1         | 7                              | 3       | 4         |
| 7       | 20  | F   | 2                           | 1       | 1         | 0          | 0       | 0         | 6                              | 3       | 3         |
| 8       | 18  | M   | 1                           | 1       | 0         | 2          | 1       | 1         | 4                              | 3       | 1         |
| 9       | 20  | F   | 3                           | 2       | 1         | 0          | 0       | 0         | 7                              | 5       | 2         |
| 10      | 18  | F   | 4                           | 3       | 1         | 0          | 0       | 0         | 5                              | 2       | 3         |
| 11      | 20  | F   | 1                           | 1       | 0         | 4          | 1       | 3         | 4                              | 2       | 2         |
| 12      | 20  | F   | 2                           | 1       | 1         | 0          | 0       | 0         | 4                              | 2       | 2         |
| 13      | 21  | M   | 0                           | 0       | 0         | 0          | 0       | 0         | 3                              | 2       | 1         |
| 14      | 20  | F   | 2                           | 2       | 0         | 0          | 0       | 0         | 5                              | 2       | 3         |
| 15      | 20  | F   | 3                           | 1       | 2         | 1          | 0       | 1         | 4                              | 2       | 2         |
| 16      | 23  | F   | 0                           | 0       | 0         | 0          | 0       | 0         | 5                              | 4       | 1         |
| 17      | 20  | F   | 2                           | 2       | 0         | 0          | 0       | 0         | 5                              | 3       | 2         |
| 18      | 22  | F   | 0                           | 0       | 0         | 0          | 0       | 0         | 7                              | 5       | 2         |
| 19      | 18  | F   | 3                           | 1       | 2         | 0          | 0       | 0         | 4                              | 2       | 2         |
| 20      | 19  | F   | 1                           | 1       | 0         | 3          | 1       | 2         | 2                              | 2       | 0         |
| 21      | 21  | F   | 1                           | 0       | 1         | 0          | 0       | 0         | 5                              | 4       | 1         |
| 22      | 19  | F   | 4                           | 4       | 0         | 0          | 0       | 0         | 5                              | 2       | 3         |
| 23      | 20  | F   | 2                           | 1       | 1         | 0          | 0       | 0         | 6                              | 4       | 2         |
| 24      | 22  | F   | 1                           | 0       | 1         | 3          | 1       | 2         | 5                              | 4       | 1         |
| 25      | 19  | F   | 1                           | 1       | 0         | 1          | 1       | 0         | 4                              | 4       | 0         |
| 26      | 18  | F   | 3                           | 3       | 0         | 2          | 1       | 1         | 3                              | 1       | 2         |
| 27      | 18  | F   | 2                           | 2       | 0         | 1          | 0       | 1         | 9                              | 5       | 4         |
| 28      | 20  | F   | 3                           | 2       | 1         | 2          | 0       | 2         | 4                              | 1       | 3         |
| 29      | 20  | F   | 3                           | 2       | 1         | 1          | 0       | 1         | 4                              | 2       | 2         |
| 30      | 19  | M   | 4                           | 3       | 1         | 0          | 0       | 0         | 4                              | 3       | 1         |
| 31      | 19  | F   | 4                           | 2       | 2         | 2          | 1       | 1         | 6                              | 2       | 4         |
| 32      | 21  | F   | 4                           | 3       | 1         | 2          | 0       | 2         | 0                              | 0       | 0         |



ESM 4. Reaction time for Study 3B.

| subject | age | sex | load condition |             |             | no-load condition |             |             |
|---------|-----|-----|----------------|-------------|-------------|-------------------|-------------|-------------|
|         |     |     | total          | animate     | inanimate   | total             | animate     | inanimate   |
| 1       | 20  | M   | 1533,214286    | 1469,857143 | 1596,571429 | 1001,5            | 985,1428571 | 1017,857143 |
| 2       | 20  | F   | 1426,642857    | 1339        | 1514,285714 | 1207,214286       | 1177,714286 | 1236,714286 |
| 3       | 22  | F   | 2239,214286    | 2308,571429 | 2169,857143 | 1875,714286       | 1507,142857 | 2244,285714 |
| 4       | 19  | F   | 1073,214286    | 992,1428571 | 1154,285714 | 1069              | 1114,857143 | 1023,142857 |
| 5       | 19  | F   | 1507,714286    | 1473,142857 | 1542,285714 | 1197,928571       | 1188,857143 | 1207        |
| 6       | 19  | F   | 978,2142857    | 918,1428571 | 1038,285714 | 907,9285714       | 868,5714286 | 947,2857143 |
| 7       | 20  | F   | 1278,214286    | 1505,142857 | 1051,285714 | 1329,5            | 1145,857143 | 1513,142857 |
| 8       | 18  | M   | 895,9285714    | 905         | 886,8571429 | 927,2857143       | 952,1428571 | 902,4285714 |
| 9       | 20  | F   | 1246,307692    | 1250,5      | 1242,714286 | 1144,571429       | 1107,571429 | 1181,571429 |
| 10      | 18  | F   | 1964,214286    | 1718,714286 | 2209,714286 | 1486,142857       | 1472,714286 | 1499,571429 |
| 11      | 20  | F   | 2770,285714    | 2805,714286 | 2734,857143 | 1847              | 1851        | 1843        |
| 12      | 20  | F   | 1716,857143    | 1710,857143 | 1722,857143 | 1378,214286       | 1343,571429 | 1412,857143 |
| 13      | 21  | M   | 1385,214286    | 1394,857143 | 1375,571429 | 1522,5            | 1476,714286 | 1568,285714 |
| 14      | 20  | F   | 2314,214286    | 2770,857143 | 1857,571429 | 2140,230769       | 2021,285714 | 2279        |
| 15      | 20  | F   | 1005,928571    | 941         | 1070,857143 | 1165,928571       | 1051        | 1280,857143 |
| 16      | 23  | F   | 2091,538462    | 1960,333333 | 2204        | 1479,142857       | 1386,142857 | 1572,142857 |
| 17      | 20  | F   | 1372,785714    | 1525,285714 | 1220,285714 | 1056,214286       | 1109,285714 | 1003,142857 |
| 18      | 22  | F   | 982,6923077    | 1012,833333 | 956,8571429 | 924               | 1021,166667 | 840,7142857 |
| 19      | 18  | F   | 1399,615385    | 1416,142857 | 1380,333333 | 898,9230769       | 984,4285714 | 799,1666667 |
| 20      | 19  | F   | 1004           | 994,3333333 | 1012,285714 | 1153,571429       | 976,8571429 | 1330,285714 |
| 21      | 21  | F   | 1389,857143    | 1175,857143 | 1603,857143 | 1185,785714       | 1051,428571 | 1320,142857 |
| 22      | 19  | F   | 1499,928571    | 1308,142857 | 1691,714286 | 1234,5            | 1246,571429 | 1222,428571 |
| 23      | 20  | F   | 1160,846154    | 974         | 1378,833333 | 971,7142857       | 962,4285714 | 981         |
| 24      | 22  | F   | 1440,142857    | 1364,428571 | 1515,857143 | 1221,357143       | 1203,142857 | 1239,571429 |
| 25      | 19  | F   | 1341           | 1170,857143 | 1511,142857 | 1103,714286       | 1038,571429 | 1168,857143 |
| 26      | 18  | F   | 1397,333333    | 1378,166667 | 1416,5      | 1203              | 1075,571429 | 1351,666667 |
| 27      | 18  | F   | 1788,384615    | 1828,666667 | 1753,857143 | 723,3571429       | 712,2857143 | 734,4285714 |
| 28      | 20  | F   | 2015,928571    | 1962,857143 | 2069        | 1288,214286       | 1270,142857 | 1306,285714 |
| 29      | 20  | F   | 1849,428571    | 1613,857143 | 2085        | 1321,357143       | 1317,428571 | 1325,285714 |
| 30      | 19  | M   | 994,2142857    | 900,7142857 | 1087,714286 | 787,9285714       | 776,2857143 | 799,5714286 |
| 31      | 19  | F   | 1722,769231    | 1689,142857 | 1762        | 1495,5            | 1521,857143 | 1469,142857 |
| 32      | 21  | F   | 1553           | 1396        | 1710        | 1555,5            | 1687,857143 | 1423,142857 |

ESM 4. Secondary task for Study 3B.

| subject | number of errors |           |
|---------|------------------|-----------|
|         | animate          | inanimate |
| 1       | 7                | 7         |
| 2       | 7                | 6         |
| 3       | 7                | 6         |
| 4       | 4                | 4         |
| 5       | 4                | 5         |
| 6       | 2                | 6         |
| 7       | 6                | 5         |
| 8       | 3                | 2         |
| 9       | 5                | 6         |
| 10      | 7                | 6         |
| 11      | 3                | 3         |
| 12      | 4                | 6         |
| 13      | 5                | 7         |
| 14      | 4                | 7         |
| 15      | 6                | 5         |
| 16      | 7                | 6         |
| 17      | 3                | 5         |
| 18      | 2                | 2         |
| 19      | 7                | 7         |
| 20      | 5                | 3         |
| 21      | 5                | 7         |
| 22      | 3                | 7         |
| 23      | 5                | 4         |
| 24      | 6                | 7         |
| 25      | 3                | 4         |
| 26      | 5                | 5         |
| 27      | 7                | 4         |
| 28      | 6                | 6         |
| 29      | 6                | 7         |
| 30      | 7                | 6         |
| 31      | 6                | 3         |
| 32      | 4                | 5         |

## Annexe 6 : Matériel supplémentaire de l'Article 3, étude 4

ESM 5. Recall data for Study 4.

| subject | sex | age | imagery condition: recall data |         |           | imagery condition: intrusions |         |           |
|---------|-----|-----|--------------------------------|---------|-----------|-------------------------------|---------|-----------|
|         |     |     | total                          | animate | inanimate | total                         | animate | inanimate |
| 1       | F   | 19  | 15                             | 9       | 6         | 5                             | 2       | 3         |
| 2       | F   | 18  | 12                             | 8       | 4         | 1                             | 0       | 1         |
| 3       | F   | 18  | 16                             | 8       | 8         | 0                             | 0       | 0         |
| 9       | M   | 21  | 16                             | 10      | 6         | 0                             | 0       | 0         |
| 10      | F   | 19  | 6                              | 4       | 2         | 8                             | 3       | 5         |
| 11      | F   | 22  | 20                             | 10      | 10        | 0                             | 0       | 0         |
| 14      | F   | 20  | 17                             | 10      | 7         | 0                             | 0       | 0         |
| 15      | F   | 20  | 14                             | 7       | 7         | 2                             | 1       | 1         |
| 16      | F   | 18  | 7                              | 5       | 2         | 4                             | 0       | 4         |
| 18      | F   | 19  | 15                             | 8       | 7         | 0                             | 0       | 0         |
| 20      | F   | 21  | 11                             | 4       | 7         | 3                             | 2       | 1         |
| 25      | F   | 19  | 14                             | 5       | 9         | 0                             | 0       | 0         |
| 27      | F   | 18  | 14                             | 8       | 6         | 0                             | 0       | 0         |
| 28      | F   | 20  | 18                             | 11      | 7         | 1                             | 0       | 1         |
| 30      | F   | 19  | 12                             | 6       | 6         | 1                             | 1       | 0         |
| 31      | F   | 18  | 12                             | 8       | 4         | 0                             | 0       | 0         |
| 34      | F   | 19  | 21                             | 9       | 12        | 0                             | 0       | 0         |
| 35      | F   | 22  | 5                              | 3       | 2         | 1                             | 0       | 1         |
| 36      | F   | 37  | 10                             | 10      | 0         | 3                             | 1       | 2         |
| 38      | M   | 20  | 12                             | 6       | 6         | 1                             | 0       | 1         |
| 40      | M   | 25  | 17                             | 11      | 6         | 3                             | 2       | 1         |
| 44      | F   | 23  | 13                             | 7       | 6         | 1                             | 0       | 1         |
| 45      | F   | 18  | 17                             | 11      | 6         | 0                             | 0       | 0         |
| 48      | F   | 19  | 15                             | 8       | 7         | 1                             | 0       | 1         |
| 49      | F   | 19  | 13                             | 6       | 7         | 1                             | 0       | 1         |
| 50      | F   | 19  | 5                              | 4       | 1         | 7                             | 1       | 6         |
| 52      | M   | 25  | 15                             | 9       | 6         | 0                             | 0       | 0         |
| 56      | F   | 19  | 11                             | 7       | 4         | 1                             | 1       | 0         |

| subject | sex | age | animacy condition: recall data |         |           | animacy condition: intrusions |         |           |
|---------|-----|-----|--------------------------------|---------|-----------|-------------------------------|---------|-----------|
|         |     |     | total                          | animate | inanimate | total                         | animate | inanimate |
| 4       | F   | 18  | 7                              | 5       | 2         | 1                             | 0       | 1         |
| 5       | F   | 18  | 10                             | 8       | 2         | 0                             | 0       | 0         |
| 6       | F   | 21  | 9                              | 6       | 3         | 0                             | 0       | 0         |
| 8       | M   | 21  | 13                             | 8       | 5         | 1                             | 1       | 0         |
| 12      | F   | 19  | 10                             | 7       | 3         | 2                             | 0       | 2         |
| 13      | F   | 41  | 6                              | 6       | 0         | 3                             | 0       | 3         |
| 17      | F   | 21  | 10                             | 6       | 4         | 1                             | 1       | 0         |
| 19      | F   | 20  | 14                             | 6       | 8         | 1                             | 1       | 0         |
| 21      | F   | 20  | 7                              | 3       | 4         | 1                             | 1       | 0         |
| 22      | F   | 19  | 14                             | 7       | 7         | 2                             | 1       | 1         |

|    |   |    |    |    |   |    |   |   |
|----|---|----|----|----|---|----|---|---|
| 23 | F | 23 | 10 | 8  | 2 | 3  | 0 | 3 |
| 24 | F | 20 | 9  | 5  | 4 | 2  | 2 | 0 |
| 26 | F | 19 | 16 | 11 | 5 | 2  | 1 | 1 |
| 29 | F | 19 | 15 | 10 | 5 | 2  | 1 | 1 |
| 32 | F | 19 | 16 | 10 | 6 | 5  | 1 | 4 |
| 33 | F | 20 | 10 | 9  | 1 | 0  | 0 | 0 |
| 37 | F | 23 | 6  | 4  | 2 | 11 | 5 | 6 |
| 39 | F | 18 | 14 | 8  | 6 | 0  | 0 | 0 |
| 41 | M | 21 | 9  | 6  | 3 | 1  | 0 | 1 |
| 42 | F | 18 | 10 | 7  | 3 | 3  | 2 | 1 |
| 43 | F | 18 | 8  | 5  | 3 | 9  | 3 | 6 |
| 46 | F | 24 | 14 | 13 | 1 | 0  | 0 | 0 |
| 47 | F | 20 | 5  | 5  | 0 | 0  | 0 | 0 |
| 51 | F | 19 | 12 | 9  | 3 | 1  | 0 | 1 |
| 53 | F | 18 | 12 | 7  | 5 | 4  | 1 | 3 |
| 54 | F | 18 | 12 | 10 | 2 | 5  | 2 | 3 |
| 55 | F | 19 | 9  | 6  | 3 | 6  | 2 | 4 |
| 57 | F | 19 | 10 | 8  | 2 | 3  | 0 | 3 |

#### ESM 5. Reaction time for Study 4.

| subject | sex | age | imagery condition |             |             |
|---------|-----|-----|-------------------|-------------|-------------|
|         |     |     | total             | animate     | inanimate   |
| 1       | F   | 19  | 3945,071429       | 4137,428571 | 3752,714286 |
| 2       | F   | 18  | 2243,25           | 2333,571429 | 2152,928571 |
| 3       | F   | 18  | 2271,285714       | 2164,321429 | 2378,25     |
| 9       | M   | 21  | 6133,392857       | 6496,321429 | 5770,464286 |
| 10      | F   | 19  | 2013,464286       | 2133,535714 | 1893,392857 |
| 11      | F   | 22  | 2262,392857       | 2114,357143 | 2410,428571 |
| 14      | F   | 20  | 2197,392857       | 2110,857143 | 2283,928571 |
| 15      | F   | 20  | 2338,285714       | 2411,857143 | 2264,714286 |
| 16      | F   | 18  | 3736,589286       | 3895,107143 | 3578,071429 |
| 18      | F   | 19  | 3583,089286       | 3331,821429 | 3834,357143 |
| 20      | F   | 21  | 2886,232143       | 2941,75     | 2830,714286 |
| 25      | F   | 19  | 3516,267857       | 3214,107143 | 3818,428571 |
| 27      | F   | 18  | 3063,589286       | 2981,392857 | 3145,785714 |
| 28      | F   | 20  | 2649,875          | 2634,214286 | 2665,535714 |
| 30      | F   | 19  | 1602,357143       | 1730,428571 | 1474,285714 |
| 31      | F   | 18  | 2269,678571       | 2207,571429 | 2331,785714 |
| 34      | F   | 19  | 6367,928571       | 5853,178571 | 6882,678571 |
| 35      | F   | 22  | 2695,089286       | 2797,178571 | 2593        |
| 36      | F   | 37  | 3826,428571       | 3773,642857 | 3879,214286 |
| 38      | M   | 20  | 4859,875          | 4891,964286 | 4827,785714 |
| 40      | M   | 25  | 5996,982143       | 6074,857143 | 5919,107143 |
| 44      | F   | 23  | 3937,607143       | 4039,928571 | 3835,285714 |
| 45      | F   | 18  | 4563,375          | 4588,214286 | 4538,535714 |
| 48      | F   | 19  | 2295,214286       | 2331,892857 | 2258,535714 |
| 49      | F   | 19  | 2436,446429       | 2548,678571 | 2324,214286 |
| 50      | F   | 19  | 2849,571429       | 3000,285714 | 2698,857143 |
| 52      | M   | 25  | 2205,285714       | 2256,571429 | 2154        |
| 56      | F   | 19  | 2583,285714       | 2473,678571 | 2692,892857 |

| subject | sex | age | animacy condition |             |             |
|---------|-----|-----|-------------------|-------------|-------------|
|         |     |     | total             | animate     | inanimate   |
| 4       | F   | 18  | 828,5078348       | 797,5925926 | 859,4230769 |
| 5       | F   | 18  | 1070,03373        | 1070,888889 | 1069,178571 |
| 6       | F   | 21  | 960,0185185       | 866,1111111 | 1053,925926 |
| 8       | M   | 21  | 1130,222222       | 1052,62963  | 1207,814815 |
| 12      | F   | 19  | 1097,320767       | 1058,962963 | 1135,678571 |
| 13      | F   | 41  | 1179,222222       | 1080,444444 | 1278        |
| 17      | F   | 21  | 2026,875          | 1911,964286 | 2141,785714 |
| 19      | F   | 20  | 1084,107143       | 983,6071429 | 1184,607143 |
| 21      | F   | 20  | 960,885582        | 870,5925926 | 1051,178571 |
| 22      | F   | 19  | 1125,020503       | 1005,892857 | 1244,148148 |
| 23      | F   | 23  | 1108,982143       | 919,9642857 | 1298        |
| 24      | F   | 20  | 1268,428571       | 1185,464286 | 1351,392857 |
| 26      | F   | 19  | 1131,473901       | 1107,769231 | 1155,178571 |
| 29      | F   | 19  | 1205,75           | 1117,285714 | 1294,214286 |
| 32      | F   | 19  | 1152,553571       | 1008,464286 | 1296,642857 |
| 33      | F   | 20  | 1314,631614       | 1312,37037  | 1316,892857 |
| 37      | F   | 23  | 792,1771978       | 741,4615385 | 842,8928571 |
| 39      | F   | 18  | 1097,892857       | 1128,892857 | 1066,892857 |
| 41      | M   | 21  | 1341,242165       | 1074,076923 | 1608,407407 |
| 42      | F   | 18  | 779,2592593       | 775,8148148 | 782,7037037 |
| 43      | F   | 18  | 1038,607143       | 1079,892857 | 997,3214286 |
| 46      | F   | 24  | 797,9153439       | 774,2592593 | 821,5714286 |
| 47      | F   | 20  | 1181,875          | 1154,75     | 1209        |
| 51      | F   | 19  | 1132,464286       | 1157        | 1107,928571 |
| 53      | F   | 18  | 1179,142857       | 1202,25     | 1156,035714 |
| 54      | F   | 18  | 1046,678571       | 1018,5      | 1074,857143 |
| 55      | F   | 19  | 1203,172619       | 1052,678571 | 1353,666667 |
| 57      | F   | 19  | 1645,785714       | 1683,285714 | 1608,285714 |

# Et si la **SCIENCE**

## LES MOTS DE MARGAUX



était un **OBJET**

OU LA RECHERCHE EN DESSINS



**LES MOTS DE MARGAUX**  
Margaux aborde la sélection nationale d'un point de vue psychologique et non biologique...  
SAUT!

"Grot est très fort et toujours premier en EPS (Éducation Physique et Sportive)..."

"Jean-Michel lui préfère l'histoire de l'Art..."

**PRENONS DEUX HOMMES PRÉHISTORIQUES AU HASARD...**  
GRUT!  
"et Jean-Michel cocou!"

**ET POURANT, PARFOIS, LE PHYSIQUE NE FAIT PAS TOUT!**  
A priori, Grot a biologiquement plus de chance de survivre dans ce monde hostile que Jean-Michel..."

"La mémoire joue aussi un rôle fondamental. Nos ancêtres distinguaient le vivant du non-vivant pour mieux reconnaître la proie au prédateur, l'ennemi du partenaire, et le vivant d'air ce qu'ils mémorisaient le mieux..."  
COUPAIN!  
"Et pour cause..."

**ILS NE DOIVENT DIFFÉRER QUE SUR LE FAIT QU'ILS RENVOIENT A DU VIVANT OU DU NON VIVANT...**  
Et pour ça elle demande à des volontaires de mémoriser des listes de MOTS!"  
MAIS PAS N'IMPORTE LES SAUVÉS..."

**ILS DOIVENT ÊTRE DE MÊME LONGUEUR, AVOIR LE MÊME NOMBRE DE SYLLABES, LE MÊME NOMBRE DE LETTRES...**

|          |            |
|----------|------------|
| bonnet   | boillire   |
| âne      | arrose     |
| araignée | arrose     |
| abbé     | ogre       |
| amand    | conscience |
| amand    | accouche   |
| amph     | écrou      |
| amph     | habite     |
| amph     | habiteuse  |

Ce "métrier" sélectionné dépend d'autres critères comme par exemple la valence émotionnelle,  
GRUT! HE MINQUE...

SI SE VOUS DITES "HABICITEN" PAR EXEMPLE, BEAUCOUP D'IMAGES VIENNENT EN TÊTE..."

"Une fois ce long travail de sélection achevé, j'ai passé des tests à des volontaires. Tout se passe sur informatique..."

MAIS LORSQUE JE FAIS FAIRE D'AUTRES TÂCHES QUE DE LA SIMPLE MÉMORISATION, COMME CALCULER DES MOTS OU VOUS LEUR CATALETER, PLAISANT OU...

OU ATTENDRE, VOUS DEMANDENT!

MAINTENANT JE DOIS ESSAYER DE COMPRENDRE LES SYLLABES QUE L'ON MET EN PLACE DE FAÇON AUTOMATIQUE CAR ELLES SE TRAITENT VRAIMENT TRÈS EFFICACEMENT!

MAIS LORSQUE JE FAIS FAIRE D'AUTRES TÂCHES QUE DE LA SIMPLE MÉMORISATION, COMME CALCULER DES MOTS OU VOUS LEUR CATALETER, PLAISANT OU...

AVEZ-VOUS OCCULMANCE QUE JE DÉBATS POUR AUCUNEMENT...

LE SUJET ARRIVE À BIEN RESISTER LES MOTS QU'IL A TU MAIS QU'IL NE PAS CONSCIENTEMENT VOUS MÉMORISER..."

UNE TÔTE DÉFIENT ET LE SUJET DOIT LES LIRE, LES RÉMORNER PUIS EN RÉVALIVER UN MAXIMUM. PAS SI SIMPLE!  
POURQUOI VOUS ÊTES NUL!  
"DRAGON... HEIN... BAUGER... HEIN... OCCULMANCE... HEIN..."

NOTRE CERVEAU EST BIEN PLUS CAPABLE DE MÉMORISER QUAND ON NE LUI DEMANDE PAS DE LE FAIRE, CAR LES STRATÉGIES QUE L'ON MET EN PLACE CONSCIENTEMENT NE SONT PAS TOUJOURS LES BONNES...

MAMA TU VAIS SÉRIEUSEMENT!  
MAMA TU VAIS SÉRIEUSEMENT!  
MAMA TU VAIS SÉRIEUSEMENT!  
MAMA TU VAIS SÉRIEUSEMENT!

ET TOUT ÇA GRÂCE À DES MOTS!"

FIN

**« Si vous voulez savoir comment fonctionnent les scientifiques (...) n'écoutez pas ce qu'ils disent, regardez ce qu'ils font. »**

*François Jacob*

**La recherche scientifique, ce sont des découvertes, mais aussi des échanges, des instruments scientifiques, des outils et des savoir-faire.**

**C'est cette réalité méconnue que nous vous faisons découvrir. Rien de tel que les gestes du dessinateur pour faire vivre les gestes du chercheur. Thibault Roy, Marie-Laure Baudement et Jo-Ann Campion ont rencontré des doctorants de toutes disciplines afin d'échanger sur leurs pratiques. Ces dessins illustrent ces rencontres et ces échanges.**

La Mission Culture Scientifique protège et valorise les collections scientifiques et techniques.

Ces collections participent à la recherche et à sa valorisation. Ce sont des ressources irremplaçables pour la science et l'avancement des connaissances dans de nombreux domaines tels que le changement climatique, l'écologie et l'évolution des systèmes vivants, la géologie, l'archéologie, l'ethnologie, l'anthropologie, l'histoire, la médecine... Leur mise en valeur permet au plus grand nombre d'avoir une meilleure connaissance de la recherche actuelle, des savoirs académiques et de mieux en comprendre les méthodes d'apprentissage.

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