ANIMACY EFFECTS IN SPANISH VISUAL WORD RECOGNITION:

A CORPUS STUDY

by

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This thesis was prepared under the direction of the candidate's thesis advisor, Dr. Viktor Kharlamov, Department of Languages, Linguistics, and Comparative Literature, and has been approved by all members of the supervisory committee. It was submitted to the faculty of the Dorothy F. Schmidt College of Arts and Letters and was accepted in partial fulfillment of the requirements for the degree of Master of Arts.

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ABSTRACT

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This thesis analyzes if animacy facilitates the visual recognition of words in Spanish. I compared native-speaker reaction times to Spanish words with animate and inanimate referents in a word-nonword identification task, also known as the lexical decision task. Responses were collected from a database and coded for animacy as well as six lexical and semantic variables known to affect reading times. Linear mixed effects modeling suggested that participants responded to animate words significantly more quickly, independently of factors such as frequency and familiarity. The findings are interpreted from the perspective of parallel distributed processing model of word recognition in Seidenberg and McClelland (1989). The present study highlights the importance of animacy to language processing and presents one avenue through which we can understand which dimensions of the referential world are relevant to the processing and organization of language.

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LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Animacy can be defined most broadly as the contrast between living and nonliving things (Bonin et al., 2019). Speakers of most languages are constantly attending to animacy because many grammatical structures and lexical items change depending on referent animacy, such as gender, noun classes, referential form, case marking, word order, and agreement (Vihman & Nelson, 2019). Due to its linguistic prevalence, Dahl and Fraurud (1996) proposed that animacy has “deep cognitive roots” (p. 63) around which language is organized. Bonin et al. (2019) found that French speakers responded faster and more accurately to animate items on a lexical decision task, where participants are asked to identify real words and nonwords. This type of task helps researchers tap into lexical access processes to verify the kinds of information activated during word recognition (Izura & Hernandez-Munoz, 2017). If speakers produce different response times to animate and inanimate words, this suggests that semantic knowledge about animacy is activated during lexical access. This finding entails that even at the most fundamental levels of language processing (word recognition and the mental lexicon), animacy is already exerting an influence.

This thesis is a partial replication of Bonin et al. (2019). I use a large-scale database to investigate differences in lexical decision times to over 3,200 animate and inanimate words. My aim is to expand our current understanding about the role of animacy in language processing among speakers of different languages.

1.1 Roadmap for thesis

This thesis is organized into five chapters. Chapter 1 provides a brief introduction into the research project. Chapter 2 presents a literature review on animacy research in theoretical linguistics and psycholinguistics. Chapter 3 reports on the methodology and results. Chapter 4 discusses the study results and how they may fit within the predictions of a particular model of lexical access. Chapter 5 offers the conclusions.

2. LITERATURE REVIEW

This literature review introduces the field of animacy research from the context of theoretical linguistics and psycholinguistics. First, I discuss the various ways that animacy has been defined and quantified in both fields. Then, I describe linguistic approaches to animacy and provide examples of the role of animacy in grammar. Subsequently, I report on several experimental studies on animacy in language processing research and psychology. The concept of the mental lexicon and how animacy might be present therein is briefly assessed. Because the present study is interested in animacy effects as manifested specifically in visual word recognition, I additionally delve into theories of visual word recognition. Finally, I propose a theoretical framework that will be used to interpret the results of the present study.

2.1 What is animacy?

There is not a universally accepted definition of animacy within or across the diverse disciplines that have contributed to animacy research. Experimental psychology has traditionally viewed animacy from the biological point of view, centering the selection of study materials around referents' capacity to perform biological functions such as eating, breathing, reproducing, moving, and some level of sentience (Radanovic et al., 2016). This definition includes humans and animals under the animate domain (together with microscopic organisms like bacteria and amoeba). Under this view, inanimates refer to inert objects such as tools, furniture, and clothing. A biological basis for defining animacy is thought to produce a universal and fixed account of animacy effects. This approach entails that speakers of virtually any language can agree on what is alive and what is not, and the animacy status of nominal referents is a stable component of word meaning.

Yamamoto (1999) offered a different approach in making the animate/inanimate distinction. The proposal uses a hierarchical scale based on anthropocentricity, which dispenses with an animate/inanimate or human/nonhuman dichotomy and replaces it with a scale where humans are the most centrally animate beings. An entity's reduced similarity to humans places it farther away on the anthropocentric hierarchy. Langacker (1991) believed that empathy was the basis of this anthropocentric, or perhaps more appropriately, egocentric hierarchy. Speakers feel most empathy for themselves, and less empathy with entities who are less like oneself. Consider how much we identify with other people (centrally animate beings) in comparison to animals. Among animals, we feel closer to anthropomorphized animals like dogs than 'lesser' organisms like insects and bacteria (only peripherally animate and very biologically distant from us). Identifying with objects or abstract ideas is most difficult, due to the little resemblance they hold to us as speakers and humans.

Lakoff's (1987) prototype theory can help us understand the way that humans constitute prototypically animate beings. The animacy hierarchy accommodates humans on one end as the most prototypically animate entity and the least prototypically human concepts, like abstract ideas, on the other end. Identifying something of ourselves or something human in an entity favors a more animate perception of things. Computers, with their ability to perform complicated tasks, are often named by their owners, and cars' face-like grills give rise to their anthropomorphization. Volitional movement and actions also provoke more animate interpretations. The animacy or "aliveness" of supernatural entities like ghosts is ambiguous, but speakers more readily conceptualize a spirit or a witch as animate than an amoeba. This is because of the prototypically human agentivity we can assign to ghosts but not microscopic organisms (Yamamoto, 1999). One historical example of this account is the *Scala Naturae*, or "Great Chain of Being," first proposed by Aristotle but subsequently elaborated on by later scholars (Hodos & Campbell, 1969). Animals were positioned on this chain or ladder according to their grade of perfection or complexity, with humans at the top. The Scala Naturae came to have a theological connotation in medieval times. God was seen to dominate the chain as the most perfect (or prototypical) entity, of whom angels were slightly less perfect copies. Humans were still less perfect copies. Then came the 'higher' animals like primates and mammals, before finally the 'lowest' animals, such as sponges, which were the simplest and most formless beings.

An animacy hierarchy or gradience is manifest in the way that entities can be construed as highly animate in one criterion but not in the other. This generates difficulties in categorizing something as strictly animate or inanimate. Radanovic et al.'s (2016) semantic categorization task study found that Serbian and English speakers took longer to classify borderline cases like supernatural beings and microscopic organisms as animate or inanimate than prototypical exemplars like "mother" and "lamp". This finding reveals that speakers do not think of animacy as a strict dichotomy, nor a fixed set of features that entities either meet as a whole or not. Much like prototype theory predicts, there do not appear to be necessary and sufficient conditions that can definitively define animates (Geeaerts, 2006). Likewise, Trompenaars et al. (2021) showed that speakers of

Japanese and Persian both followed a similar pattern to Serbian and English speakers when asked to rank a variety of prototypical and problematic nouns as animate or inanimate. The most representative items were placed on the ends of a most/least animate spectrum, and the ambiguous cases were assigned to the middle.

Speakers can concede a greater level of animacy for certain referents than others, such as birds compared to insects or coral, to the point where their use in an animacy-mismatched grammatical paradigm is not found universally unacceptable. In a second experiment by Trompenaars et al. (2021), speakers rated the acceptability of sentences featuring inanimate referents in animate constructions. Persian speakers were presented with plural-marked inanimates (plural marking is reserved for animate referents), while Japanese speakers saw the existential verb "iru" paired with inanimate predicates ("iru" is used for animates, "aru" for inanimates). Both sets of speakers rated the sentences more acceptable when referents had been rated higher on the animacy scale. For example, a sentence containing a plural-marked "pigeon" in Persian was deemed more grammatical than a sentence with a plural-marked "worm", which in turn was deemed more acceptable than sentences with a plural-marked river and table.

A dichotomous account of animacy would predict that animacy-sensitive structures like plural-marking in Persian would lead to firm positive or negative reactions from speakers. However, Persian and Japanese speakers in this study were open to perceiving some referents as more animate than others, as indicated by their midway ratings on an animacy scale, and their acceptability ratings for animacy mismatched constructions. Trompenaars and colleagues concluded that when inanimates are seen to possess some animate behavior or attribute, such as a ship at sea expressing locomotion, speakers identify animate features that permit these referents to "enter linguistically animate constructions" (p. 13).

In considering animacy status, there is also an intersection between cultural embeddedness and personal beliefs or experiences. Many Romance languages have semantic or *natural gender* for humans and some animals, where some nouns are assigned gender according to the referent's biological sex (e.g., a male "doctor" but a female "doctora," and a male "gato" but a female "gata"), and an abstract *grammatical gender* for inanimates and most animals (e.g., a female "mesa" or table, a masculine "zapato" or shoe, and "castor" a male or female beaver; Sa-Leite, 2021). In describing a similar system for Russian, Corbett and Fraser (2000) reported that nouns whose gender is assigned semantically seem to be those where the "sex of the denotatum matters to humans" (p. 298), such as humans, domesticated animals, and cases where there is a visual difference (such as lions). Corbett and Fraser also mentioned the Zande language, where some nouns that would be considered inanimate by English speakers in North America (e.g., rainbow, moon, wheel, sweet potato) are actually of animate gender (i.e., pattern like animates in the grammar). The authors refer to Zande mythology as a possible source of these exceptions. These examples illustrate how animacy can be conceptualized based on sociocultural frameworks like religion and daily life.

Another characteristic of animacy is that its construal is potentially contextual. The animacy status of entities might not be fixed but dependent on speakers' perception within a specific context. Nieuwland and Van Berkum (2006) presented Spanish speakers with a canonically inanimate referent (e.g., a peanut) as an animate character in a fictional context. They found no neurological signatures of anomalous semantic processing for reading sentences with a verb requiring animate agents (e.g., "the peanut is in love"). In fact, when the predicate indicated inanimacy (e.g., "was salted"), participants exhibited strong neurological activity that indicates difficulty relating the sentence to discourse context. This suggests that word meaning can change depending on the circumstances developed by the discourse. Animacy may not be inherent and fixed to word meaning, but shift depending on the communicative intention, such as an entity's depiction within a fictional story.

The notion of contextually ascribed animacy is also evident in how language allows speakers to indicate shifts in animate and inanimate categories. De Swart and de Hoop (2018) described how violating grammatical constraints sensitive to animacy, such as selectional restrictions on verbs that require animate arguments, often does not lead to ungrammaticality but to a different reading of the argument's animacy. Citing contact verbs in Dutch, the authors mention that use of the differential object marker (that is reserved for inanimates) on an animate object leads to hearers interpreting the animate referent as a statue or corpse. Conversely, skipping the object marker on an inanimate object generates a meaning shift to animate status (e.g., a cup that comes alive in a fairytale). Conceptual shifting suggests that animacy may not be an intrinsic lexical property, but a flexible construct influenced by pragmatics.

The studies reviewed in this section show that animacy is a multidimensional topic with many proposed definitions and approaches. Similarly, animacy research in theoretical linguistics has produced a body of literature that purports to explain how grammar and animacy interact. The next section reviews some of the descriptions put forward by different theorists to account for the effects of animacy on morphology and syntax across languages.

2.2 Animacy in theoretical linguistics

Virtually all languages are touched by animacy in some element of their morphosyntax (Vihman & Nelson, 2019). Santazilia (2020) and Gardelle and Sorlin (2018) provided general descriptions of how animacy constrains the grammar of languages, each proposing a unique system for explaining the manifestation of animacy in morphological and syntactic phenomena.

Santazilia (2020) provided examples from Tepehua, Russian, Afar, Me'phaa, Bemba, and several Trans-New Guinean languages to suggest two major ways that animacy modifies linguistic structures: as a feature and as a condition. In the former, the overt realization of a feature or its value depends on the stem's animacy. For example, the plural affix in Breton manifests as "-oú" or "-ed" depending on whether the noun is inanimate or animate, respectively. As a condition, animacy indirectly constrains "the realization of other features" (p. 1). For instance, person in Bunak (Trans-New Guinea) is only expressed on verbs when the object is animate. Inanimate objects do not enforce person marking. Therefore, animacy only "conditions" the appearance of a feature whose value has already been set according to some other distinction, such as person or number. Santazilia specified how widespread the changes initiated by animacy can be in the grammar of disparate languages.

Gardelle and Sorlin (2018) surveyed how animacy hierarchies have been used to describe the interactions between animacy and grammar. These hierarchies are employed to outline how referents at one end of the scale tend to differ in their grammatical realization to those on the opposite end. For example, Siewierska (2004) used the following hierarchy to express the crosslinguistic likelihood of person agreement manifesting grammatically: “human > animate > inanimate > abstract” (p. 149). Person agreement is more likely to be expressed when nouns reside on the left (animate) end of the scale, regardless of the specific ways that any one language manifests number. Each pole is occupied by the most prototypically animate entities on the left pole and the most prototypically inanimate on the right pole. What referents constitute each category depends on the language, cultural beliefs, and the personal opinions of the speaker. The cut-off for person agreement in a language can occur at any point between the categorical labels. All referents to the left of the cut-off point show person agreement, while those on the right will not, although oftentimes the grammatical structure can be optional for referents in the middle categories (e.g., optional for nonhuman animals but required for humans and unacceptable for inanimates).

Animacy hierarchies can explain how the probability of expressing case marking, agreement, ergativity splits, and other morphosyntactic phenomena increases with animate versus inanimate referents. According to Gardelle and Sorlin (2018), animates behave differently because the distinction between animates in terms of number, semantic role, etc., is more salient than that between two inanimates. For example, in discourse it is typically more important or relevant to communicate the quantity of people under discussion than the quantity of feathers or strawberries, leading to a grammaticalized increase in the likelihood of number marking.

Vihman and Nelson (2019) reported that, while it is widely accepted that human cognition is sensitive to some definition of animacy, there is little agreement on the optimal way to subsume animacy under linguistic theory. Generative traditions propose that animacy is "external to the narrow grammar" (p. 262) and limit the presence of animacy to binary feature specifications under operations related to lexical semantics and compositionality (e.g., [+animate]; Chomsky, 1965). According to this theory, linguistic organization is mostly untouched by meaning and communicative goals, and so semantic properties like animacy do not exert effects on the computational mechanisms of language. But in recent decades, functionalists and cognitive linguists have argued that linguistic structures can be traced to the more general features of cognitive mechanisms like perception, memory, and attention (Harris, 2006). This approach emphasizes the importance of integrating properties of human cognition, such as the formation of mental categories, into our understanding of how language is arranged. These trends in linguistic theory welcome the notion that cognitively significant distinctions like animacy are a part of linguistic structure.

While both schools of linguistics concur that animacy effects are present in a variety of linguistic phenomena, they offer different explanations as to how those effects manifest. In the following section, I present a number of experimental studies that support functionalist and cognitivist perspectives on animacy effects in grammar.

2.3 Animacy effects in language processing

Theoretical linguistics focuses on the interactions between animacy and morphology and syntax in a structural or formal context, whereas psycholinguistics explores the role of animacy in real-time language processes such as sentence production and word recognition. Experimental research on animacy effects has revealed that, overall, animate referents possess a processing advantage (e.g., Bonin et al., 2014, Rawlinson & Kelley, 2021).

A variety of animacy effects during language comprehension and production seem to indicate that animate words figure more prominently in speakers' minds. Bonin et al. (2014) showed that French speakers remembered animate words and pictures depicting animates with greater accuracy in free-recall tasks. In VanArsdall et al. (2013), English speakers recognized novel words assigned an animate meaning faster than those given an inanimate denotation. Zanini et al. (2020) found that Italian speakers inflected animate nouns for number faster than inanimate words. Several theories have been put forward to describe how animacy may intervene in online language processing. McDonald et al. (1993) showed that animates were named first as agents or patients in an English event recall task in active and passive transitive sentences, respectively. Words whose semantic representation is accessed more easily are retrieved first and are more likely to occupy the subject position in a sentence. Prat-Sala (1997) described the influence of animate entities on word order and syntactic frames as a consequence of conceptual accessibility, defined as "[T]he ease with which the mental representation of some potential referent can be activated in or retrieved from memory" (p. 80). This account supports the notion of animates possessing processing privileges in relation to attention and memory.

Branigan et al. (2008) further discussed language production and animacy, especially in terms of syntactic structure. Referring to Levelt's (1989) theory of incremental processing, the authors suggested that language is produced as information becomes available, instead of formulated once the entire utterance has been planned and all elements retrieved. This entails that elements accessed first take precedence in processing and they are inserted first into the sentence frame. Branigan and colleagues hypothesized that animate entities are understood to be more accessible for two reasons. First, words capable of entering a greater number of conceptual relations are easier to retrieve, partly because they are more prototypical and concrete, known as the *pathway hypothesis*. For example, "human" is easier to access than "cloud" because of the many predicates that "human" can be argument to compared to "cloud" (e.g., humans can eat, see, move, and talk, but clouds can only move). Second, referents can become more salient within a particular discourse context due to givenness and semantic priming. Animate referents are more likely to be the topic of a conversation as a result of their ability to enter a greater amount of conceptual relations, termed *derived accessibility*.

The studies by Bonin et al. (2014), VanArsdall et al., (2013), Zanini et al. (2020), McDonald et al., (2003), Prat-Sala (1997), and Branigan et al. (2008) point to a prominent role for animacy in online language production and comprehension. What enables animate entities to have a processing advantage? Because animacy is a semantic component of words, it is necessary to study this question in the context of the mental lexicon This is the topic of the following section.

2.3.1 The mental lexicon and semantic representation

Lexical representation is a vast research topic in linguistics. Jarema and Libben (2007) defined the *mental lexicon* as "the cognitive system that constitutes the capacity for conscious and unconscious lexical activity" (p. 2). It is considered to be the focus of lexical storage, and is most simply conceptualized as a dictionary made up of entries containing information about each known word's meaning, sound, and grammatical information (e.g., plural forms). In an overview of mental-lexicon theories, Doczi (2019) wrote that while the existence of a dictionary-like lexicon is an oversimplified analogy, it is still helpful to imagine that word knowledge is logical and structured in some way, due to the immense magnitude of information we possess about words, and the speed and efficiency with which we can search for words despite this immensity.

Doczi (2019) provided a historical and contemporary overview of mental-lexicon models within which we can examine how animacy has been understood as a component of word meaning. Theories can be based on hierarchies, with words nested within bigger categories (e.g., “animate” -> “mammal” -> “dog” -> “collie”). Research from neuropsychology suggests that animate and inanimate words may indeed comprise distinct conceptual categories. Capitani et al. (2003) reviewed evidence from multiple case studies of patients with semantic category-specific deficits. They found that patients can show deficits in knowledge and other cognitive skills for entities in the animate domain (i.e., living beings) without showing deficits in other kinds of domains (e.g., manmade objects, fruits and vegetables, and other inanimate referents). That is, processing of each semantic category “can be damaged/spared independently of each other” (p. 227). This suggests that speakers organize their conceptual knowledge according to animate and inanimate categories, and, more generally, that categories are a feature of human cognition.

Mental-lexicon models can also be feature-oriented, where a word’s meaning arises as a unique collection of *semantic features*. This entails that the smallest unit of meaning is not the word but the features it is made up of. Smith et al.’s (1974) *feature comparison model* submitted that concepts are stored as sets of attributes. Some contemporary research supports this claim. McRae et al.’s (2005) feature norm study asked English speakers to list attributes or features for living and nonliving concepts. The authors found that speakers usually converged on the characteristics attributed to each concept, and that animate and inanimate words patterned differently on several dimensions. For example, animate words had more overlapping feature profiles compared to inanimate words. Most animals share some aspect of their appearance and behavior with one another (e.g., possessing eyes, legs, fur, capable of moving and eating), but inanimate things, designed to be functional, have very different appearances (compare a knife to a chair). Accordingly, the processing advantage for animate words may be due to a heavily correlated feature structure that leads to similar processing effects across entities within that correlated structure (Ilic et al., 2013).

Returning to Doczi (2019), the author stated that feature-based models lack a satisfactory account of how to connect word meaning to phonetic, syntactic, and morphological information about that word, since those models seem to be more focused on *concepts* rather than the language units known as “words,” which possess many different dimensions of linguistic information besides semantic. Levelt’s (1989) model of speech production consolidated the idea that there exists a discrete unit of combined semantic, syntactic, and phonetic information corresponding to what is generally understood as a “word.” That model proposed that *lemma* be used for this basic lexical unit, and *lexeme* for its sound representation. Animacy might be mapped to words as a [±animate] feature in the lemma, which helps speakers produce grammatically acceptable sentences when a morphosyntactic operation checks for animacy in the noun (see Wiltschko and Ritter, 2015, for a discussion of animacy as a phi-feature).

Lastly, Doczi (2019) analyzed the important question, how stable is word meaning, regardless of how it is represented in the lexicon? De Bot and Lowie (2010) argued that word representation should be seen as "dynamic, episodic and therefore inherently unstable" (p. 117), just like all other aspects of language processing. They alluded to the significance of context especially when considering the many factors that might impact how speakers store and organize words. This echoes some of the studies we have covered earlier in this literature review. For example, Nieuwland and Van Berkum's (2006) study on readers' reactions to an animate peanut character undergoing inanimate actions seems to exemplify the importance of discourse development to word meaning.

This subsection summarized some theories and considerations pertaining to the mental lexicon, and assessed a number of possible ways that animacy can fit into processes relating to lexical storage, structure, and representation. In the next section, I touch on the topic of animacy and lexical retrieval, and whether it is possible to test for the involvement of animacy in the lexicon.

2.4 Word recognition

Despite the myriad interpretations of how word semantics might be represented in the lexicon, we cannot deny that the meanings of words "represent some core set of information" (Balota, 1990, p. 26), although the exact nature of that information (e.g., featural, prototypical, perceptual) is still contentiously debated. Nonetheless, by tapping into word processing mechanisms, we can discover clues about the nature of the semantic representations within the mind, and whether animacy is a component of word meaning.

When speakers recognize a word, they have retrieved the representation of that word in their mental lexicon (Balota, 1990). But what types of information are used to reach that representation? What types of information make up that representation? The *lexical decision task* (LDT) is a popular paradigm for exploring these questions. The LDT is an experimental paradigm where participants engage in a word/nonword identification activity (Izura & Hernandez-Munoz, 2017). In the LDT, speakers are asked to respond 'yes' or 'no' via a button press to indicate whether a letter string flashed on a computer screen is a real word or not. The time between stimulus onset and response, plus the accuracy of the response, are used to infer the mechanisms behind visual word recognition.

Research has suggested that speakers are influenced by many types of lexical information when accessing word representations during word-nonword identification. Grainger (1990) showed that words that occur more often in printed language were recognized more easily, termed the *frequency effect*. Ziegler and Perry (1998) reported that the number of orthographic neighbors (words like "mouse" and "house") can also affect the speed of responses on an LDT, which is known as a *neighborhood effect*. Acha and Perea (2008) found that younger readers spent more time on longer words but found no comparable effect in older readers, suggesting that word length can impact decision time in some participants. These lexical properties (frequency, neighborhood size, word length) touch on words' orthographic features. Participants' sensitivity to these properties on an LDT indicates that speakers store form-based information about words in their mental lexicon to help them make lexical decisions.

Balota (1990) argued that meaning also plays an important role in word/nonword identification, because speakers have two sources of information to help them complete the task: familiarity and meaningfulness. That is, real words are familiar and possess a semantic representation, and "meaning analysis occurs relatively early in word processing and may in fact contribute to word recognition" (p. 17). Evidence for semantic intervention during word recognition is discussed in Pexman (2012), who mentioned that more imageable words (words that evoke more mental imagery relative to abstract words) are responded to more quickly in LDTs. Pexman explained that the imageability effect can be traced to imageable words having stronger associations with more perceptual information compared to abstract words.

Can animacy analogously affect lexical retrieval? Rawlinson and Kelley (2021) found that participants had more accurate recall of animate words in a free-recall task, and that those animates were associated with a greater number of features as measured in McRae et al. (2005). Consequently, animacy partially mediates word retrieval via the denser semantic content speakers possess about animate entities. This trend suggests that speakers conceptualize the semantic structure of animate and inanimate entities differently, with animates represented by more semantic content. When speakers hold a richer mental representation for a concept, it facilitates lexical access.

Balota (1990) remarked that the “functional utility of words” is to “convey meaning” (p. 17) and that this important variable of language processing is being neglected in present models of lexical access. The importance of semantic information in word retrieval should not be underemphasized when considering that the ultimate purpose of language is indeed to carry meaning, i.e., to communicate something about our mental concepts which words convey. Because animacy is an important attribute of the referential world that speakers pay substantial attention to when constructing and producing language, animacy should play an important role in language processing.

The studies presented in this review point to a processing privilege for animate words in different types of tasks, but is there evidence for animacy effects specifically in the LDT? Bonin et al. (2019) posed this question in a French LDT study. They found that participants did respond to animate stimuli words significantly faster and more accurately, even after controlling for imageability scores between animate and inanimate words. Their findings suggest that animacy is involved in lexical access or representation beyond what is facilitated by the imageability of such words.

However, other studies have not been able to produce similar findings. Radanovic et al. (2016) were unable to detect animacy effects in either an English or Serbian LDT. It is possible that the different orthographies of French, English and Serbian are contributing to these conflicting findings. In Coltheart's (1981) dual-reading model, the uniformity of the mapping between letters and sounds can lead to two different reading strategies, each with varying degrees of semantic mediation. In the regular orthography of Serbian, letter-to-sound mapping is highly consistent, so that a particular letter or combination of letters stands for one unique sound. Serbian readers can therefore rely on converting a visual code into a phonetic code when performing lexical retrieval, accessing word meaning via its corresponding phonetic associate. In the irregular orthographies of French and English, the relationship between letters and sounds is irregular. Some letters and letter combination can represent many different sounds, such as the "ea" in "heart," "easy," and "endeavor." This means that readers cannot depend on converting letters to sounds in order to access words' semantic representations in the mental lexicon. Readers of irregular writing systems learn to associate whole words to their meaning without conducting a sublexical analysis of letters and sounds. Consequently, semantic mediation is more common when reading in French and English, and readers will exhibit stronger semantic effects in reading tasks.

If orthography determines the activation of animacy during word recognition, it is not clear why animacy effects would be found for French but not English, both languages with irregular orthographies. Despite the varying extent of regularity, both languages would be classified as orthographically irregular or *opaque*, so the disparity in findings may be due primarily to methodological differences. Whereas Bonin et al. (2019) tested 54 speakers on 56 nouns, and sought to account for 13 different word properties (e.g., frequency, imageability, age of acquisition) in their statistical analysis, Radanovic et al.(2016) tested 32 speakers and only accounted for word concreteness. The problem with analyzing a small set of responses is that lexical decision responses are sensitive to subject-level effects like reading ability. Consequently, the findings of the Radanovic and colleagues' study must be taken more tentatively.

While Bonin et al. (2019) described the enhanced detection of animate words from a psychological perspective rooted in evolution (humans attend more to animates because they are potential prey, mates, enemies, predators, etc.), I am interested in exploring a hypothesis centered more around lexical storage and procesing. The final section of this background review introduces a model of word recognition that will be used in this study to explain animacy effects.

2.5 Framework

How is meaning computed during the reading process? Seidenberg and McClelland's (1989) *parallel distributed processing* (PDP) model proposes that reading in an alphabetic orthography (such as English and Spanish) involves the interactive activation of semantic, orthographic, and phonetic codes. Each code is the mental representation of the three levels of word knowledge. The semantic code is the representation of the word's meaning, the orthographic code is the representation of a word's constituent letters, and the phonetic code is the representation of its constituent sounds. According to the PDP model, readers' stored knowledge about the semantic, orthographic, and phonetic structure of a word is based on the strength of connections between each code. A connection occurs and gains strength via experience. The codes themselves are composed of "a pattern of activation distributed over a number of primitive representational units" (p. 256).

In the present paper, I focus on the PDP model's hypothesis that activation at one level (semantic, orthographic, or phonetic) propagates to other levels. According to the PDP model, orthographic activity spreads to the phonological and semantic levels, such that the perception of a written input can activate the pronunciation and meaning of stored words that match that input. Because the connections between each level are interactive, activity at the semantic and phonological levels also feeds back to the orthographic level (Cortese & Schock, 2013). Therefore, the semantic code can influence the processing of the orthographic code, providing a pathway for animacy effects to occur.

As we have reviewed in the subsection about mental-lexicon theories, it is possible that animacy is a dimension of word meaning, present either as a category or feature. If animate entities possess a special, perhaps richer, mental representation, then the lemmas corresponding to animate concepts may enjoy facilitated processing. This enhanced semantic processing, according to the PDP model, can then translate to enhanced orthographic processing, and shorten the speed at which animate words can be read, due to stronger activation of the semantic level that feeds back to the orthographic level.

3. METHODOLOGY AND RESULTS

In this section, I present two research questions and two corresponding hypotheses that will guide the design of this study, describe the methodology used to collect, compile, and analyze the data, and report on the results.

3.1 Research questions and hypotheses

The present study is a partial replication of Bonin et al. (2019). Bonin and colleagues investigated whether adult readers of French responded to animate nouns more quickly and accurately than inanimate nouns in a visual lexical decision task. In contrast to Bonin et al. (2019) who focused on French, I looked at responses from LDT data collected from Spanish. I also analyzed data generated by thousands of participants responding to thousands of stimuli items, rather than the limited subject pool and stimulus list employed in the original study. Similar to Bonin et al.'s study, I used a type of statistical inference tool known as *linear mixed-effects regression* to test the relationship in response times between animate and inanimate words (Bates et al., 2015), while also modeling the contribution of lexical and semantic variables and the random effects of speakers and items to these responses.

The primary research question in the present study was, does animacy affect Spanish readers' performance in a visual lexical decision task? I hypothesized that animate words would be identified faster. This finding would be in line with Bonin et al. (2019).

Although this study is focused on the phenomenon of animacy, I was additionally able to explore more general predictions about the nature of word recognition processes by including other factors in the statistical model. The secondary research question was, what variables affect lexical decision times in Spanish in addition to animacy? I hypothesized that word frequency, length, orthographic neighborhood, and imageability would impact LDT latencies, with readers responding faster to more frequent, shorter, and more imageable words, and more slowly to words with a larger orthographic neighborhood, as observed by Gonzalez-Nosti et al. (2013).

3.2 Databases

The present study compiled data from three separate databases to create a single, unified corpus of LDT responses with values for animacy status and word properties appended to each stimulus word. The three databases and the process undertaken to combine them are reported below.

3.2.1 SPALEX - Spanish lexical decision data

SPALEX is a database containing response-time and accuracy data from Spanish (Aguasvivas et al., 2018). It is a large-scale, crowdsourced online data collection project that contains millions of visual lexical decision responses collected over a span of several years from more than 169,000 native Spanish speakers from around the world. About half of the participants were from Spain, with the remaining half being from Latin America and the Caribbean. Forty-four percent were female, 46% male, and 9% provided no gender. SPALEX also contains other biographical information such as age, handedness, number of foreign languages known, best foreign language, and education level.

Each remote session consisted of a visual presentation of 70 words and 30 pseudowords on the participant's home computer screen. Participants were instructed to press specific keys on their computers to indicate whether or not they recognized the letter string on the screen. The stimulus items in each session were randomly selected from a pool of 45,389 Spanish words and 56,855 pseudowords. The words consisted of uninflected, non-proper nouns excluding compounds (e.g., “piedra” or “rock”, “nariz” or “nose”, “niño” or “boy”, “gorilla”, “puerta” or “door”). The pseudowords were orthographically and phonotactically acceptable in Spanish (e.g., “taul”). Reaction times and accuracy scores to each stimulus word were automatically recorded by the online platform. Aguasvivas and colleagues report that the average reaction time (RT) to words in the database after eliminating outliers (responses outside of a 200-2,000 ms time window) was approximately 1 second, and average accuracy was 79%.

The present study extracted RT data and demographic information from SPALEX. This created a basis for the new corpus in this thesis. However, SPALEX does not provide extensive word property information in its database. Another repository, known as EsPal, was used as a source of lexical and semantic information for the words in SPALEX. The procedure for retrieving these values is the topic of the next subsection.

3.2.2 EsPal - Word properties

EsPal is an online database of word property information (e.g., frequency, neighborhood size, phoneme count) for the Spanish lexicon (Duchon et al., 2013). EsPal additionally includes semantic properties in the form of subjective ratings for concreteness, imageability, and familiarity. Concreteness and imageability refer to “the extent to which a word evokes mental imagery of events or things” (Pexman, 2012, p. 26). For instance, “truck” is more imageable and concrete than “truth”. Familiarity is the extent to which the speaker thinks about or encounters a concept (Morrison & Ellis, 2000). These ratings were generated for a limited portion of the repository by native Spanish-speaking undergraduate students. Participants were asked, “How imageable/concrete/familiar is this concept?” and were instructed to score the items on a Likert scale from 1 to 7, with “1” being least concrete, imageable, or familiar, and “7” corresponding to most concrete, imageable, or familiar.

The role of EsPal in the present study was to supply word property information to the SPALEX corpus. This enabled the statistical model to take into account variables other than animacy that are known to affect response times in an LDT. By doing so, I could isolate the effects of animacy apart from correlated factors like concreteness and frequency. This step additionally let me explore what other variables characterize lexical access in Spanish, the central focus of my secondary research question. From EsPal, I extracted the following values: frequency (instances per million), number of letters, phoneme count, grammatical gender, orthographic and phonological neighborhood size, imageability ratings, and familiarity scores.

Neither EsPal nor SPALEX include animacy values. To avoid manually entering animacy values for all stimulus words in the present study, a Dutch-language lexicosemantic database was used for animacy-coding in the present study (no animacy-tagged corpus in Spanish could be found). This resource is described in more detail below.

3.2.3 Referentiebestand Nederlands (RBN) - Animacy values

The RBN is a lexical resource composed of lexicosemantic information on 45,000 Dutch words (van der Vliet, 2007). Every entry represents a word and its syntactic, morphological, orthographic, pragmatic, and semantic profile. This includes its plural and singular forms, verb tenses, grammatical gender, article, synonyms, and its inclusion in Dutch idioms and proverbs. The RBN also provides the *semantic type* of each entry, as an economical way to represent meaning. Words are labeled according to 11 categories of semantic types: human, nonhuman, time, place, artifact, dynamic, non-dynamic, place, institution, substance, concrete (other), and time measure. These semantic types can also serve as an animacy classification, since “human” and “nonhuman” are tagged separately from non-animate referents. Because I was solely interested in a possible processing difference between animate and inanimate words, I chose to collapse the 11 categories into two classifications: “animate” and “inanimate”. The “human” and “nonhuman” categories were combined into a single “animate” type. The categories “time”, “place”, “artifact”, “dynamic”, “non-dynamic”, “place”, “institution”, “substance”, “concrete (other)”, and “time measure” animacy types were collapsed under a single “inanimate” type. The final step for using the RBN was to translate the words from Dutch to Spanish. This was performed with DeepL, a machine learning-based translation software (https://www.deepl.com).

3.3 The present corpus

The purpose of using the three databases outlined in the previous section was to generate a new corpus where the stimulus words in SPALEX would feature word property and animacy values that can be analyzed statistically to determine which properties play a role in word recognition. I developed the new corpus using the base version of R (v4.2.2; R Core Team, 2022). The steps taken to create the corpus are outlined below.

3.3.1 Data processing

First, inaccurate responses and pseudoword datapoints from the SPALEX database were removed, because my research questions are exclusively interested in cases when participants successfully accessed the mental representation of real stimulus words. Responses scoring below 200 ms and above 2,000 ms (24.2% of real-word, accurate responses) were considered outliers and eliminated, following the procedure outlined in Semmelmann & Weigelt (2017).

Second, a list of the real-word stimuli was extracted from SPALEX *(N* = 45,232). Following that, all the words in the RBN database and their corresponding animacy values were extracted, and the RBN entries were translated from Dutch to Spanish. The SPALEX wordlist, the translated RBN word and animacy file were then merged using the inner join function in R. This created an index consisting of the words both files had in common *(n* = 7,601) plus their corresponding animacy values. I then manually confirmed the animacy value for each word and excluded words with ambiguous animacy or multiple senses, and mistranslations into adjectives or adverbs (43 words in total). Ambiguous items included supernatural beings (e.g., "fantasma" or "ghost," "dios" or "god," "alma" or "soul", "duende" or "elf") and microscopic organisms ("bacteria"). An example of a word with both animate and inanimate senses that was excluded is "boa," denoting a large snake or a feathered scarf.

I submitted the SPALEX wordlist with animacy values to EsPal to retrieve the words' lexical and semantic properties and merged the EsPal word property file to the SPALEX list, providing word property values to each datapoint. Note that EsPal could not provide values for all word properties to each unique word. Of the final dataset, 54.1% of responses featured “N/A” values for one or more word properties.

Participant biographical and demographic information was added to the new corpus such that every response was also coded for subject-level factors like education level and age. At this stage, the final corpus consisted of 1,859,770 responses to 7,462 unique words. An estimated 21% of the words (*n* = 1,600) denoted animate referents. Each response includes categorization of the stimulus word’s animacy and measurements for seven separate word properties (frequency, word length, orthographic neighborhood size, phoneme count, familiarity score, imageability score, and gender). Responses were also coded for values regarding participant demographics and biographical information (the respondent’s age, educational level, knowledge of second languages, most proficient second language, gender, handedness, and region of origin). In the next section, I describe the statistical analyses applied to the data.

3.4 Statistical Analysis

The present thesis carried out two separate statistical analyses on the corpus. First, linear mixed-effects model was conducted to calculate the significance of each independent variable to response times. Then, a Random Forest was used to better understand the ranking of animacy among other factors known to affect RTs in LDTs and help explain why its effects might not have been significant in previous studies. The subsections below describe how the analyses were run in R.

3.4.1 Linear mixed-effects model

The decision to use a linear mixed-effects model was based on its ability to take into consideration participant performance, which can vary for a multitude of complex reasons (Baayen, 2008). Linear mixed-effects models can calculate those portions of the data variance that the known independent variables do not account for. Additionally, these models use *within-subject sampling*, or data that has been collected from the same participant more than once. In SPALEX, each participant contributed dozens of LDT responses. Other statistical methods do not have these benefits.

Using the lme4 package in R (Bates et al., 2015), I ran a linear mixed-effect model with random intercepts for subjects and items and the following predictors as fixed effects: animacy, frequency, number of letters, phoneme count, familiarity, imageability, and grammatical gender. I used the subset of corpus without "n/a" values for this analysis, which contained a total of 776,211 response datapoints generated from 3,246 words by 149,372 participants. Significance was calculated using the lmerTest package, which uses Satterthwaite's method for estimating degrees of freedom and producing p-values (Kuznetsova et al., 2017).

3.4.2 Random Forest

A *Random Forest* is a machine-learning algorithm that can be used to order the independent variables according to the magnitude of their contribution (Tagliamonte & Baayen, 2012). Most basically, it works by training the algorithm to generate a subset of data based on what it observes to be significant splits in the predictor variables, and comparing the results for hundreds or thousands of randomly selected subsets. The Random Forest can be employed for testing the significance of the predictor variables and for weighing the importance of each variable. In the present study, I applied it to see how much animacy was contributing to RTs in comparison to the other available variables (e.g., frequency, imageability, participant gender, etc.). This step can provide insights into how important animacy might be in an LDT. If the effect is minor, this might help illustrate why animacy effects can be difficult to detect in this task.

I used the random forest function in the Ranger package in R (Wright & Ziegler, 2017). The lexical variables were animacy, frequency, number of letters, word gender, phoneme count, number of orthographic neighbors (transposed, addition, and deletion), overall neighborhood size, familiarity, and imageability. The participant variables included gender, age, region of origin, education level, number of foreign languages known, most proficient foreign language, and handedness. Incomplete cases (i.e., responses with any “n/a” value for word properties, animacy, or participant information) were not included in this analysis. The number of iterations was 1,000.

3.5 Results

The results generated by linear mixed-effects model and the Random Forest are presented in this section.

3.5.1 Linear mixed-effects model

The results of the linear mixed-effects model can be found in Table 1. In the table, *intercept* refers to a hypothetical RT with all independent variables set to 0 and semantic type set to ‘animate.’ *P* denotes the *p-value*, or the significance of the effect on the dependent variable. P-values below .05 are considered significant (marked with bolding). Numbers under the “Estimate” column reflect the approximated change in RT for every unit increase. SE refers to *standard error*, or the estimated disparity between the sample and the true population mean.

Table 1.

Effects of predictor variables on RT

Effect	Estimate	*SE*	*p*
Fixed effects			
Intercept	904.6	8.66	< .001
Inanimate	**11.03**	**2.49**	**< .001**
Frequency	**-0.12**	**-0.01**	**< .001**
Number of letters	**17.55**	**2.32**	**< .001**
Neighborhood size	**1.37**	**0.16**	**< .001**
Phoneme count	-1.56	2.28	0.495
Familiarity	**-30.63**	**1.03**	**< .001**
Imageability	**-2.07**	**0.85**	**0.015**
Gender - Common	-1.87	5.89	0.750
Gender - Feminine	4.26	4.39	0.332
Gender - Masculine	4.23	4.36	0.332

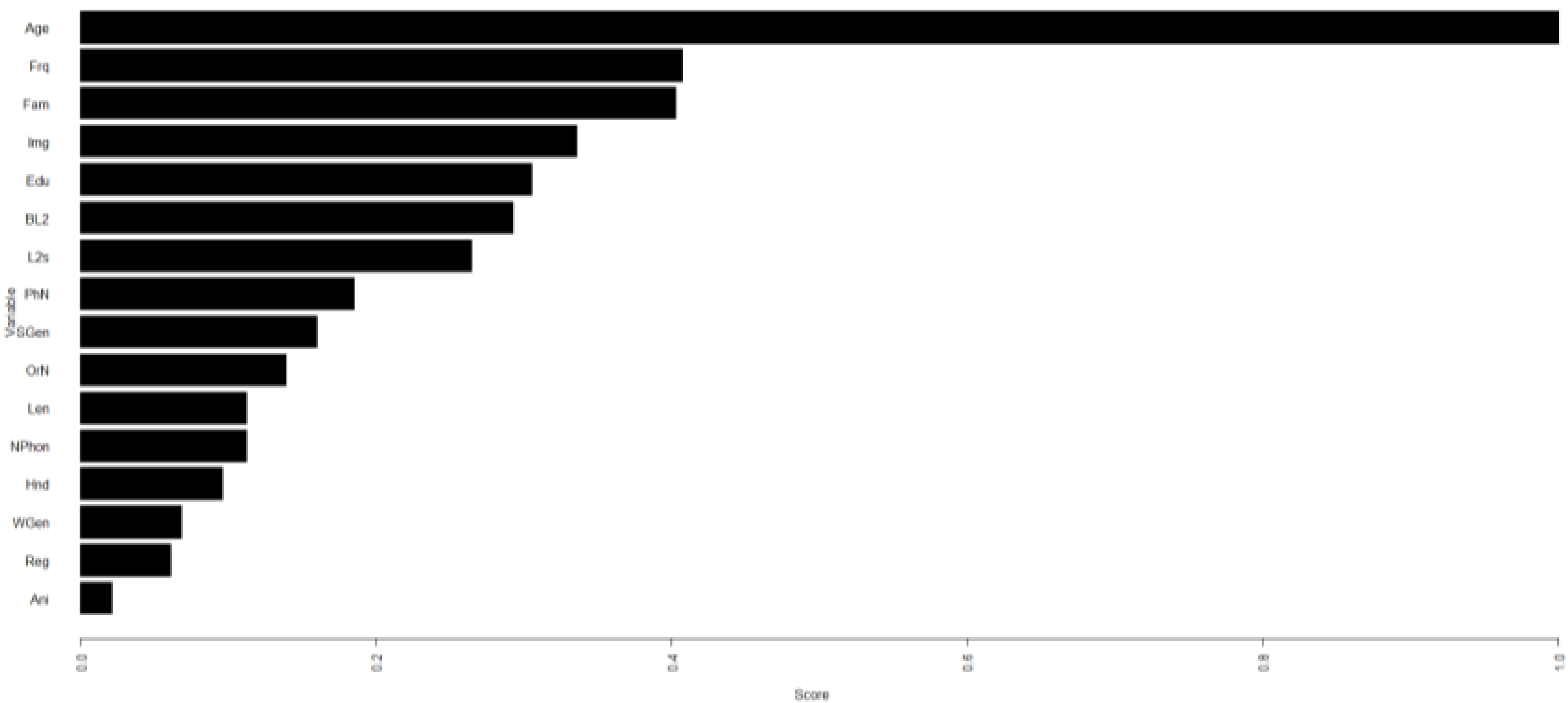
The model indicates that animacy, frequency, number of letters, neighborhood size, familiarity, and imageability significantly impacted RTs (all $p < .05$). Participants responded to inanimate words more slowly than animates, by approximately 11 ms. A ten-unit increase in frequency shed 12 ms from the RT. Every unit in number of letters, or, more simply, every letter added around 18 ms. Every orthographic neighbor added 1 ms. One unit increase of familiarity subtracted 30 ms, and an equal increase in imageability subtracted 2 ms. The results reveal that participants responded more quickly to words that were animate, shorter, more frequent, more familiar, more imageable, and with fewer orthographic neighbors. In contrast, participants slowed down when they encountered words that were inanimate, longer, less frequent, less familiar, less imageable, and came from bigger orthographic neighborhoods. Phoneme count and word gender did not significantly influence RTs (all $p > .05$).

3.5.2 Random Forest

Figure 1 visualizes in descending order the magnitude of contribution of each variable to RTs (see Table A in Appendix for specific values).

Figure 1.

Relative contribution of each variable to response times.



Note: Age = age of participant, Frq = word frequency per million, Fam = familiarity, Img = imageability, Edu = educational level, BL2 = best foreign language, L2s = number of foreign languages known, PhN = phoneme count, SGen = participant gender, OrN = orthographic neighborhood size, Len = number of letters, NPhon = phonological neighborhood size, Hnd = handedness, WGen = word gender, Reg = participant region of origin, Ani = animacy

Participant age influenced RTs most, followed by frequency and familiarity. Imageability and participant education level showed similar magnitudes of effect. Animacy had the lowest ranking in the plot, appearing toward the end of the list. This suggests that animacy played a smaller role relative to other factors in the LDT. Note that the Random Forest algorithm as used in the present study did not calculate the significance of the contribution itself, but presents the magnitude of the contribution relative to the other factors. This observation does not conclusively state that animacy or any other factor did not affect RTs, but only that some factors were more influential than others on the response variable.

4. DISCUSSION

Previous findings in animacy literature have indicated that words with animate referents possess a processing advantage in a variety of experimental linguistic tasks across many languages (e.g., Branigan et al., 2018; Prat-Sala, 1997; Bonin et al., 2019; Rawlinson and Kelley, 2021). Researchers attribute this effect to several diverse causes, like the cognitive salience of animate referents, attentional and memory processes, and special semantic representations among animate words. However, the findings for the role of animacy have not been consistent. Bonin et al. (2019) reported that French speakers responded to animate words significantly faster in a visual LDT, but Radanovic et al. (2016) did not find a similar effect among English and Serbian speakers. One possibility why these findings differ may be due to the use of a limited sample size of participants and stimulus items. A solution is to test a greater number of speakers and words, in order to improve the statistical modeling of animacy effects in lexical decision responses. Additionally, the different orthographies of French, English, and Serbian may also have contributed to inconsistent results. The present thesis explored animacy effects in a large corpus of lexical decisions with a focus on Spanish, due to a lack of LDT studies about animacy in this language.

Below, I examine the implications of the findings of the present study in terms of two models of lexical access, and how the results compare to prior research on word recognition. Additionally, limitations in the present study and possible avenues for future research are discussed.

4.1 Animacy

The present study found that Spanish-speaking participants responded to animate words significantly faster than inanimate words. This pattern of results indicates that animacy facilitates the recognition of animate words. Seidenberg and McClelland's (1989) PDP model can provide insights into the animacy effects observed here and in Bonin et al., (2019). The PDP model proposes that orthographic activation is under the influence of semantic activation in a feedback loop. It predicts that semantic properties such as imageability can provide feedback to orthographic processing, facilitating visual word recognition. For example, a more imageable word like "car" generates greater semantic activation than a low-imageable word like "justice", due to the former's association with relatively more perceptual information (Pexman, 2012). This model can explain findings such as Pexman's observation that more imageable words are recognized more quickly. Expanding the PDP model to animacy, there seems to be some dimension of animate words that enhances their semantic representation and therefore, via the feedback of the semantic code, influences the orthographic level and enables speakers to identify animate words more quickly.

No prior literature has reported shorter response latencies for animate words in a Spanish-language LDT, although such findings were observed in French (Bonin et al., 2019). However, Radanovic et al. (2016) presented no significant differences in response latencies between animate and inanimate words in a Serbian LDT. How can we account for these conflicting findings? As mentioned in the Literature Review, the lack of results in Radanovic et al. (2016) can be traced to its small dataset. Furthermore, while Radanovic and colleagues did control for the concreteness of their animate and inanimate conditions, they did not verify that the target nouns were equal on other factors known to impact reading times, like frequency or orthographic neighborhood size. The present study used a large sample of words and participants, and, moreover, coded responses for several word properties. Both these measures help mitigate confounding variables.

Previously, more research has been conducted on imageability than on animacy (for a review of imageability effects in the LDT, see Pexman, 2012). Despite their differences, both imageability and animacy are semantic dimensions of word meaning, so we can extrapolate some of the findings and interpretations from imageability studies to explain patterns observed for animacy. For example, Izura and Hernandez-Munoz (2017) did not find imageability effects in a Spanish LDT. They proposed that their results were in line with the dual-route model of Coltheart (1981), mentioned previously in this thesis in the Literature Review. That model argues that Spanish speakers, like Serbian speakers, can rely predominantly on grapheme-to-phoneme conversion, and not on meaning during reading, due to the regular orthography of Spanish. In contrast, readers of French and English (languages possessing irregular orthographies) must learn associations between whole words and their meanings for efficient reading, entailing a greater degree of reliance on the semantic system for word recognition.

The results of the present study and Gonzalez-Nosti et al. (2013) challenge this hypothesis. Two reasons why Izura and Hernandez (2017) may have failed to identify imageability effects originates in their study design and the unreliability of imageability as a measurement of semantic intervention. First, Izura and Hernandez-Munoz’s study looked at 150 stimulus words, whereas Gonzalez-Nosti and colleagues collected responses on over 5,500 items. Similarly, my study was based on a large dataset. Again, paralleling the animacy effect, it is possible that imageability effects (and semantic intervention in reading in general) requires a lot of data, due to the more marginal effect of semantic variables in comparison to other highly relevant factors like frequency in languages with irregular writing systems. Gonzalez-Nosti et al. reported that reading in all types of orthographies depends on a mixture of both letter-to-sound and word-to-meaning routes, depending on the word's length, frequency, familiarity, and other interrelated variables. If so, then the use of large datasets can enable researchers to pick up effects occurring during both types of reading strategies across different orthographies.

It is important to note that the animacy effects detected in the present study were relatively small. The Random Forest analysis specified that animacy was the variable of least importance out of all the factors inputted into the algorithm. While the mixed-effects model validated the significance of the contribution, it seems that detection of animacy effects relies on very large datasets. Animacy may exert a perceptible but minor influence on reading.

4.2 Other lexical and semantic variables

The present study also sought to investigate what variables other than animacy influence reading times in Spanish. The pattern of findings indicates that frequency, orthographic neighborhood size, word length, phoneme count, and familiarity significantly contributed to shorter RTs. These results echo those of prior lexical decision studies. For frequency, Grainger's (1990) Dutch study, for example, found that speakers recognized more frequent words quicker, like the participants in the present study. This finding can be accommodated in many models of lexical access, such McClelland & Rumelhart (1981), where frequent encounters with a word lower its threshold activation in the mental lexicon.

Regarding the positive relationship between orthographic neighborhood size and RT, the present study found that speakers responded more slowly to words with many similar-looking neighbors, which parallels the findings of Ziegler and Perry (1998). This may be a result of inhibitory effects in which the perception of a word immediately activates all potential candidates based on the visual similarity to the input, until further processing can refine the candidate list, although some studies have found facilitatory effects with greater neighborhood size (for a review of the contradictory evidence and models, see Andrews, 1997).

Speakers also responded more slowly to longer words. Acha and Perea (2008) interpreted similar findings in their Spanish lexical decision experiment according to a model where readers of orthographies with regular letter-to-sound mapping rely on grapheme-to-phoneme translation as a reading strategy. Because orthographic words with more letters represent phonetic words with more phonemes, speakers must spend more time translating the graphemic code into phonetic code to access the word in their lexicon, which predicts a positive correlation between word length and RT.

The significant effect of subjective familiarity on LDT RTs has been reported in Chedid et al. (2019), who cite prior research as well as their own lexical decision experiment to show that participants respond faster to words they rate as more familiar. This facilitatory effect can be observed independently of words' frequency ratings as traditionally measured by corpus analysis, since more familiar words are not necessarily more frequent. The effect of familiarity on lexical decisions is a new topic in word recognition research, and very few models accommodate this variable in their framework of lexical access. This includes Perfetti (1985), who offered greater efficiency and automaticity as a possible reason why more familiar concepts are easier to cognitively process. Lewellen et al. (1993) expanded Perfetti's framework into linguistic processing in order to describe the finding that participants with more vocabulary knowledge and greater self-reported language experience responded more quickly to items with higher subjective familiarity ratings. With more exposure to words and concepts, including words, speakers can more efficiently process linguistic inputs.

Returning to imageability, this variable has been shown to consistently affect LDTs in English. More imageable words yield faster RTs because of facilitated access to concepts with greater perceptual and semantic mental representation (e.g., Balota et al., 2004; Morrison & Ellis, 2000). The present study detected imageability effects in reading times, echoing the findings of Gonzalez-Nosti et al. (2013), but not of Izura and Hernandez-Munoz (2017). A possible interpretation for these differing results can be found in Connell and Lynott (2012), who proposed that imageability and concreteness were poor measures of *perceptual strength*, or the extent to which speakers report experiencing a concept in all five sense modalities. The authors conducted regression analysis on words featuring ratings for perceptual strength, imageability, and concreteness, and showed that each rating was dissociated from one another. Greater perceptual strength did not consistently translate to greater imageability or concreteness.

Connell and Lynott suggested that imageability and concreteness ratings are not dependable ratings when trying to operationalize the semantic content of concepts. They proposed perceptual strength as a more accurate measure. In an English LDT, Connell and Lynott found that perceptual strength outperformed concreteness and imageability ratings in predicting response times and accuracy. They concluded that "these perceptibility effects are stronger than those elicited by concreteness or imageability" (p. 464). The findings of Connell and Lynott can help explain the lack of imageability effects in Izura and Hernandez-Munoz (2017) but the presence of such effects in the present study and Gonzalez-Nosti et al., (2013).

4.3 Limitations and future research

Some of the limitations of the present study include an absence of variables known to impact Spanish lexical decisions, plus the interdependence of these variables, problems inherent to remote data collection, and the reduced dataset used for final statistical analysis. Additionally, it is important to comment on the controversial use of the LDT in faithfully reproducing real linguistic processing. These limitations and their respective roles in this study are summarized below.

As extensively described in this thesis, many factors can affect the speed and accuracy of lexical decision responses. One of these factors is *age-of-acquisition* (AoA), or the age at which words are typically acquired. Cuetos and Barbon (2006), Izura and Ellis (2002), and Izura and Hernandez-Munoz (2017) reported that AoA strongly predicts reading times in Spanish LDTs independent of other related factors like frequency. Their results indicated that words learned earlier in life are processed. Earlier AoA signifies greater exposure to the word over the lifespan, which enables strengthening the association between form and meaning (Izura and Hernandez-Munoz, 2017) .

The present study did not account for AoA, since it was not a measure available in the word property database EsPal. AoA seems to be especially pertinent to animacy research because, according to Wilson et al. (2013), AoA is highly correlated with imageability. Referents to animate words are always highly imageable, but inanimate words can include abstract referents like "love" and "loyalty." Low-imageable words in their Spanish LDT experiment tended to exhibit more AoA effects than high-imageable words in terms of RT. Consequently, AoA effects may have introduced a significant confound to my results. Future research would need to address this issue by coding LDT responses with the AoA of the stimulus word so that the regression model can take possible AoA effects into account.

Apart from AoA, Pexman (2012) offers an extensive review on factors that have been shown to influence reading times, including associated concepts, co-occurring concepts, polysemy, and emotional affect. Further research would need to explore the association between animacy and these variables to clarify whether animacy effects occur completely independently of other related semantic variables. For example, VanArsdall and Blunt (2022) analyzed the link between six animacy dimensions (e.g., ability to think, similarity to humans, movement likelihood) and fifteen lexical and semantic variables among concrete words, including frequency, imageability, imagery, valence, and arousal. The authors found that ratings on the animacy scales were statistically distinct and therefore conceptually different from the other variables, supporting the theory that animacy effects are separate from those of other related semantic variables. Again, researchers should be mindful of the possible links between each semantic dimension, and recognize that the way we consciously attempt to delineate, define and measure the world for the sake of experimental studies may not always correspond to the way speakers intuitively do so, linguistically or cognitively.

Another possible drawback of the present study is the remote data collection method employed of the SPALEX corpus. Internet-platform studies enable researchers to collect massive amounts of data that would otherwise be impossible to gather. The main benefit of remote data collection is the powerful statistical analysis that can be performed on the thousands or even millions of datapoints generated by numerous participants. This has led to a recent trend of researchers employing digital platforms for their experiments or conducting statistical analysis on the data obtained via this method (Aguasvivas et al., 2018)., However, remote data collection cannot guarantee a controlled environment during data collection. Researchers cannot assume that participants were not distracted during the task or misinterpreted the provided instructions. In contrast, lab studies take place in quiet, distraction-free settings where assistants are present to ensure that the experiment runs smoothly and as intended. This distinction means that crowdsourced data may not be as reliable as lab data. Conversely, Semmelmann and Weigelt (2017) support the use of online data collection as a suitable complement or substitute to lab collection. They successfully replicated four popular experimental paradigms in cognitive psychology on a web-based platform, finding that task-specific effects and error rates were highly similar between in-person and online settings. Their study offsets some of the concerns previously raised about remote data gathering.

A third limitation in the present study is the reduced number of responses available for statistical analysis. The statistical modelling used in the present study required responses coded with one or more “N/A” values to be eliminated from final analysis. Over one-half of the corpus (54%) developed for this study was subsequently not included in the statistical analysis, resulting in a significantly smaller dataset (n = 3,246) relative to the original corpus created for this thesis (N = 7,462), and an even smaller subset of the entire SPALEX corpus (N = 45,232). While the number of responses analyzed in the present study is still larger than that of traditional LDT studies, future research on a more complete and therefore larger dataset can yield further insights into the effect of animacy and other variables in word recognition.

The final limitation under discussion is the validity of the LDT for investigating processes relating to the mental lexicon. Libben and Jarema (2002) found that the LDT is a very popular paradigm in psycholinguistic research, primarily due to its simple design and the ease with which the dependent variables (response latency and accuracy) can be measured. Nonetheless, the LDT, like all other experimental tasks, has drawbacks. First, the authors contend that the vast majority of LDT studies rely on visual presentation of stimuli. The results collected from visual LDTs, and the theoretical models built upon them, might only be applicable to reading processes, not necessarily processes extending to all language modalities. Second, lexical decisions in an LDT are made in isolation. Experimental control requires that stimulus items be present one at a time in random order, with no discourse or sentence background provided to the participant. This lack of situational, social, or linguistic context has been seen as a benefit of the LDT, but it has led Libben and Jarema to argue that the task does not represent a “natural testing environment” (p. 6). Considering the important role of pragmatics and communicative intent in language, studies conducted on LDT data should be aware of these limitations when extrapolating results to more general language processes (see Perea et al., 2002, for further discussion).

Steps can be taken to improve the ecological validity of lexical decision responses. For example, Kleiman (1980) and Klepousniotou (2002) developed sentence-priming lexical decision paradigms, where lexical decisions were performed after the presentation of a sentence. Perea et al. (2002) explored the use of the go/no-go paradigm instead of the word/nonword identification task, where participants were instructed to press a button only if they see a real word but withhold responses to nonwords. This change in the response selection process might reduce task demands and therefore minimize artifacts emerging from the nature of the task itself, rather than the lexical processes under investigation. Future research interested in employing the LDT for exploring lexical processes should keep in mind the potentially small generalizability of the task when interpreting results or developing theories, and seek to continue improving the tasks that are utilized for this line of research in order to produce more authentic linguistic data.

5. CONCLUSION

This thesis set out to explore how lexical access is influenced by animacy and other factors. Analyzing Spanish lexical decision responses from a corpus, I found that participants responded to words with animate referents significantly faster, predicted by the PDP model set forward by Seidenberg and McClelland (1989). These findings suggest that animate words generate greater semantic activation, consequently triggering greater orthographic activation and facilitating the retrieval of the orthographic codes of animate words. The mechanism through which semantic activation is increased for animates can be interpreted via the proposal in Rawlinson and Kelley (2021), who suggested that speakers possess a more extensive semantic profile for animates. This provides support for the animacy effect hypothesis promulgated in Bonin et al. (2019) and introduces the parallel distributed process model of visual word recognition as a possible avenue through which we can understand how animate words are processed more easily. By showing that speakers attend to animacy during word recognition, this thesis can help clarify which aspects of the referential world are linguistically relevant and contribute to the organization and processing of the mental lexicon.

Beyond animacy, the current thesis shows that frequency, word length, orthographic neighborhood size, imageability, and familiarity influenced reading times. Participants processed more quickly words with greater frequency, a shorter length, smaller neighborhood size, and greater familiarity and imageability, and spent more time reading longer, less frequent, less familiar, and less imageable words with many orthographically similar words.

The present study is a point of departure for future research on animacy. It contributes LDT findings in Spanish that were not seen in previous animacy research, which has focused on French, English, and Serbian. Additional studies should be conducted in other languages and orthographies in order to explore the influence of animacy on lexical access in the context of different linguistic structures and writing systems.

APPENDICES

Appendix A

Values for predictors in the Random Forest.

Variable	Score
Age	1
Frequency	0.407
Familiarity	0.402
Imageability	0.335
Education level	0.306
Best foreign language	0.292
Number of foreign languages known	0.264
Phonological neighborhood size	0.186
Participant Gender	0.160
Orthographic neighborhood size	0.139
Number of letters	0.112
Phoneme count	0.112
Handedness	0.096
Gender	0.068
Region of origin	0.060
Animacy	0.022

Appendix B

R Functions for Linear Mixed-Effects Model and Random Forest

This appendix lists the R functions used to run the linear mixed-effects model and the Random Forest.

1. Linear mixed-effects model formula:

RT ~ binary.sem.type + frq + num_letters + es_num_phon + familiarity + imageability + gender + N + (1 | exp_id) + (1 | spelling), data = d2Comp)

2. Random Forest formula:

ranger (rt ~ "sem.type", "frq", "num_letters", "es_num_phon", "familiarity", "imageability", "gender", "N", "es_NP", "gender_rec", "age", "location_rec", "education_rec", "no_foreign_lang", "best_foreign", "handedness_rec"., data=dSub, num.trees = 1000, importance = "impurity")

REFERENCES

Acha, J., & Perea, M. (2008). The effects of length and transposed-letter similarity in lexical decision: Evidence with beginning, intermediate, and adult readers. *British Journal of Psychology, 99*(2), 245-264. https://doi.org/10.1348/000712607X224478

Aguasvivas, J. A., Carreiras, M., Brysbaert, M., Mandera, P., Keuleers, E., & Duñabeitia, J. A. (2018). SPALEX: A Spanish lexical decision database from a massive online data collection. *Frontiers in Psychology, 9*(1), 1-6. https://doi.org/10.3389/fpsyg.2018.02156

Andrews, S. (1997). The effect of orthographic similarity on lexical retrieval: Resolving neighborhood conflicts. *Psychonomic Bulletin & Review, 4*(4), 439–461. https://doi.org/10.3758/BF03214334

Baayen, R. H. (2008). *Analyzing linguistic data: A practical introduction to statistics using R.* Cambridge University Press.

Balota, D. A. (1990). The role of meaning in word recognition. In D. A. Balota, G. B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 9–32). Lawrence Erlbaum Associates, Inc.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1), 1–48. https://doi.org/

10.18637/jss.v067.i01

Bonin, P., Gelin, M., & Bugaiska, A. (2014). Animates are better remembered than inanimates: Further evidence from word and picture stimuli. *Memory &Cognition*, *42*(3), 370-382. https://doi.org/10.3758/s13421-013-0368-8

Bonin, P., Gelin, M., Dioux, V., & Méot, A. (2019). "It is alive!" Evidence for animacy effects in semantic categorization and lexical decision. *Applied Psycholinguistics*, *40*(4), 965-985. https://doi.org/10.1017/S0142716419000092

Branigan, H. P., Pickering, M. J., & Tanaka, M. (2008). Contributions of animacy to grammatical function assignment and word order during production. *Lingua*, *118*(2), 172-189. https://doi.org/10.1016/j.lingua.2007.02.003

Capitani, E., Laiacona, M., Mahon, B., & Caramazza, A. (2003). What are the facts of semantic category-specific deficits? A critical review of the clinical evidence. *Cognitive Neuropsychology*, *20*(3), 213–261. https://doi.org/10.1080/02643290244000266

Chedid, G., Wilson, M. A., Bedetti, C., Rey, A. E., Vallet, G. T., & Brambati, S. M. (2019). Norms of conceptual familiarity for 3,596 French nouns and their contribution in lexical decision. *Behavior Research Methods*, *51*(5), 2238–2247. https://doi.org/10.3758/s13428-018-1106-8

Chomsky, N. (1965). *Aspects of the theory of syntax*. MIT Press.

Coltheart, M. (1981). Disorders of reading and their implications for models of normal reading. *Visible Language*, *15*, 245–286.

Connell, L., & Lynott, D. (2012). Strength of perceptual experience predicts word processing performance better than concreteness or imageability. *Cognition*, *125*(3), 452–465. https://doi.org/10.1016/j.cognition.2012.07.010

Corbett, G. G., & Fraser, N. M. (2000). Gender assignment: A typology and model. In G. Senft (Ed.), *Systems of nominal classification* (pp. 293-325). Cambridge University Press.

Cuetos, F., & Barbón, A. (2006). Word naming in Spanish. *European Journal of Cognitive Psychology, 18*(3), 415–436. https://doi.org/10.1080/13594320500165896

Dahl, Ö. & Fraurud, K. (1996). Animacy in grammar and discourse. In T. Fretheim & J.K. Gundel (Eds.), *Reference and referent accessibility* (pp. 47–64). John Benjamins.

De Bot, K., & Lowie, W. M. (2010). On the stability of representations in the multilingual lexicon. In M.Pütz & L. Sicola (Eds.), *Cognitive processing in second language acquisition* (pp. 117–134). John Benjamins Publishers.

De Swart, P., & de Hoop, H. (2018). Shifting animacy. *Theoretical Linguistics, 44*(1-2), 1-23. https://doi.org/10.1515/tl-2018-0001

Doczi, B. (2019). An overview of conceptual models and *theories* of lexical representation in the mental lexicon. In S. Webb (Ed.), *Routledge handbook of vocabulary studies* (pp. 46-65). Routledge.

Duchon, A., Perea, M., Sebastián-Gallés, N., Martí, A., & Carreiras, M. (2013). EsPal: One-stop shopping for Spanish word properties. *Behavior Research Methods, 45*(4), 1246-1258. https://doi.org/10.3758/s13428-013-0326-1

Gardelle, L., & Sorlin, S. (2018). Introduction: Anthropocentrism, egocentrism and the notion of animacy hierarchy. *International Journal of Language and Culture,* *5*(2), 133-162. https://doi.org/10.1075/ijolc.00004.gar

Geeaerts, D. (2006). Prototype theory: prospects and problems of prototype theory. In D. Geeaerts (Ed..), *Cognitive linguistics: Basic readings* (pp. 141-166). Mouton de Gruyter. https://doi.org/10.1515/9783110199901.141

Gonzalez-Nosti, M., Barbón, A., Rodríguez-Ferreiro, J., & Cuetos, F. (2014). Effects of the psycholinguistic variables on the lexical decision task in Spanish: A study with 2,765 words. *Behavior Research Methods, 46*(2), 517-525. https://doi.org/10.3758/s13428-013-0383-5

Grainger, J. (1990). Word frequency and neighborhood frequency effects in lexical decision and naming. *Journal of Memory and Language, 29*(2), 228–244. https://doi.org/10.1016/0749-596X(90)90074-A

Harris, C. L. (2006). Language and cognition. In L. Nadel (Ed.), *Encyclopedia of cognitive science* (pp. 1-6). https://doi.org/10.1002/0470018860.s00559

Hodos, W., & Campbell, C. B. G. (1969). Scala Naturae: Why there is no theory in comparative psychology. *Psychological Review, 76*(4), 337-350. https://doi.org/10.1037/h0027523

Izura, C., & Ellis, A. W. (2002). Age of acquisition effects in word recognition and production in first and second languages. *Psicológica, 23*(2), 245–281.

Izura, C., & Hernández-Muñoz, N. (2017). The role of semantics in Spanish word recognition: An insight from lexical decision and categorization tasks. *Open Linguistics, 3*(1), 500-515. https://doi.org/10.1515/opli-2017-0025

Jarema, G., & Libben, G. (2007). *The mental lexicon: Core perspectives*. Elsevier Press.

Kleiman, G. M. (1980). Sentence frame contexts and lexical decisions: Sentence-acceptability and word-relatedness effects. *Memory & Cognition 8*(1), 336–344. https://doi.org/10.3758/BF03198273

Klepousniotou, E. (2002). The processing of lexical ambiguity: Homonymy and polysemy in the mental lexicon. *Brain and language, 81*(1-3), 205-223. https://doi.org/10.1006/brln.2001.2518.

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software, 82*(13), 1–26. https://doi.org/10.18637/jss.v082.i13

Langacker, R. W. (1991). *Foundations of cognitive grammar, Vol. 2: Descriptive application.* Stanford University Press.

Lakoff, G. (1987). *Women, fire, and dangerous things.* The University of Chicago Press.

Levelt, W. J. M., (1989). *Speaking. From intention to articulation.* MIT Press.

Lewellen, M. J., Goldinger, S. D., Pisoni, D. B., & Greene, B. G. (1993). Lexical familiarity and processing efficiency: Individual differences in naming, lexical decision, and semantic categorization. *Journal of Experimental Psychology: General, 122*(3), 316–330. https://doi.org/10.1037/0096-3445.122.3.316

Libben, G., & Jarema, G. (2002). Mental Lexicon Research in the New Millennium. *Brain and Language, 81*(1-3), 2–11. https://doi.org/10.1006/brln.2002.2654

McDonald, J. L., Bock, K., & Kelly, M. H. (1993). Word and world order: Semantic, phonological, and metrical determinants of serial position. *Cognitive Psychology, 25*(2), 188–230. https://doi.org/10.1006/cogp.1993.1005

McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: I. An account of basic findings. *Psychological Review,* *88*(5), 375–407. https://doi.org/10.1037/0033-295X.88.5.375

McRae, K., Cree, G. S., Seidenberg, M. S., & McNorgan, C. (2005). Semantic feature production norms for a large set of living and nonliving things. *Behavior Research Methods*, *37*(4), 547–559. https://doi.org/10.3758/bf03192726

Morrison, C. M., & Ellis, A. W. (2000). Real age of acquisition effects in word naming and lexical decision. *British Journal of Psychology, 91*(2), 167–180. https://doi.org/10.1348/000712600161763

Nieuwland, M. S., & Van Berkum, J. J. (2006). When peanuts fall in love: N400 evidence for the power of discourse. *Journal of Cognitive Neuroscience, 18*(7), 1098–1111. https://doi.org/10.1162/jocn.2006.18.7.1098

Norcliffe, E., Harris, A. C., & Jaeger, T. F. (2015). Cross-linguistic psycholinguistics and its critical role in theory development: Early beginnings and recent advances. *Language, Cognition, and Neuroscience, 30*(9), 1009-1032. https://doi.org/ 10.1080/23273798.2015.1080373

Perea, M., Rosa, E., & Gomez, C. (2002). Is the go/no-go lexical decision task an alternative to the yes/no lexical decision task? *Memory & Cognition*, *30*(1), 34-45. https://doi.org/10.3758/BF03195263

Perfetti, C. A. (1985*). Reading ability.* Oxford University Press.

Pexman, P. M. (2012). Meaning-based influences on visual word recognition. In J. S. Adelman (Ed.), *Visual word recognition: Meaning and context, individuals and development* (pp. 24–43). Psychology Press.

Prat-Sala, M. (1997). *Production of different word orders: a psycholinguistic and developmental approach* [Doctoral dissertation, University of Edinburgh].

Edinburgh Research Archive. https://era.ed.ac.uk/handle/1842/21470

R Core Team (2022). R: A language and environment for statistical computing [Computer software]. Vienna: R Foundation for Statistical Computing.

Radanovic, J., Westbury, C., & Milin, P. (2016). Quantifying semantic animacy: How much are words alive?. *Applied psycholinguistics, 37*(6), 1477-1499. https://doi.org/10.1017/S0142716416000096

Rawlinson, H. C., & Kelley, C. M. (2021). In search of the proximal cause of the animacy effect on memory: Attentional resource allocation and semantic representations. *Memory & Cognition, 49*(1), 1137–1152. https://doi.org/10.3758/s13421-021-01154-5

Sa-Leite, A., Haro, J., Comesaña, M., & Fraga, I. (2021). Of beavers and tables: The role of animacy in the processing of grammatical gender within a picture-word interference task. *Frontiers in Psychology*, *12*(1), 1-17. https://doi.org/10.3389/fpsyg.2021.661175

Santazilia, E. (2020). The two faces of animacy. *Studies in Language, 44*(4), 812-830. https://doi.org/10.1075/sl.19089.san

Seidenberg, M. S., & McClelland, J. L. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review, 96*(4), 423-568. https://doi.org/10.1037/0033-295x.96.4.523

Semmelmann, K, & Weigelt, S. (2017). Online psychophysics: Reaction time effects in cognitive experiments. *Behavior Research Methods, 49*, 1241-1260. https://doi.org/10.3758/s13428-016-0783-4

Siewierska, A. (2004). *Cambridge textbooks in linguistics: Person*. Cambridge

University Press.

Smith, E. E., Shoben, E. J., & Rips, L. J. (1974). Structure and process in semantic memory: A featural model for semantic decisions. *Psychological Review*, *1*, 214–241. https://doi.org/10.1037/h0036351

Trompenaars, T., Kaluge, T. A., Sarabi, R., & De Swart, P. (2021). Cognitive animacy and its relation to linguistic animacy: Evidence from Japanese and Persian. *Language Sciences, 86,* 1-17. https://doi.org/10.1016/j.langsci.2021.101399

VanArsdall, J.E., & Blunt, J.R. (2022). Analyzing the structure of animacy: Exploring relationships among six new animacy and 15 existing normative dimensions for 1,200 concrete nouns. *Memory & Cognition 50*, 997–1012. https://doi.org/10.3758/s13421-021-01266-y

VanArsdall, J. E., Nairne, J. S., Pandeirada, J. N. S., & Blunt, J. R. (2013). Animacy processing produces mnemonic advantages. *Experimental Psychology, 60*(3), 172-178. https://doi.org/10.1027/1618-3169/a000186

Van der Vliet, H. (2007). The Referentiebestand Nederlands as a multi-purpose lexical database. *International Journal of Lexicography*, *20*(3), 239-257. https://doi.org/10.1093/ijl/ecm027

Vihman, V. A., & Nelson, D. (2019). Effects of animacy in grammar and cognition: Introduction to special issue. *Open Linguistics, 5*(1), 260-267. https://doi.org/10.1515/opli-2019-0015

Wilson, M. A., Cuetos, F., Davies, R., & Burani, C. (2013). Revisiting age-of-acquisition effects in Spanish visual word recognition: The role of item imageability. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39*(6), 1842–

1859. https://doi.org/10.1037/a0033090

Wiltschko, M., & Ritter, E. (2015). Animating the narrow syntax. *The Linguistic Review, 32*(4), 869-908. https://doi.org/10.1515/tlr-2015-0011

Wright, M. N., & Ziegler, A. (2017). Ranger: A fast implementation of random forests for high dimensional data in C++ and R. *Journal of Statistical Software, 77*(1), 1–17. https://doi.org/10.18637/jss.v077.i01

Yamamoto, M. (1999). *Animacy and reference: A cognitive approach to corpus linguistics.* John Benjamins

Zanini, C., Rugani, R., Giomo, D., Peressotti, F., & Franzon, F. (2020). Effects of animacy on the processing of morphological number: A cognitive inheritance? *Word Structure*, *13*(1), 22-44. https://doi.org/10.3366/word.2020.0158

Ziegler, J. C., & Perry, C. (1998). No more problems in Coltheart's neighborhood: Resolving neighborhood conflicts in the lexical decision task. *Cognition, 68*(2), B53–B62. https://doi.org/10.1016/s0010-0277(98)