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RESEARCH

The CASE of brand names during sentence reading

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Abstract
Brand names typically maintain a distinctive letter case (e.g., *IKEA*, *Google*). This element is essential for theoretical (word recognition models) and practical (brand design) reasons. In abstractionist models, letter case is considered irrelevant, whereas instance-based models use surface information like letter case during lexical retrieval. Previous brand identification tasks reported faster responses to brands in their characteristic letter case (e.g., *IKEA* and *Google* faster than *ikea* and *GOOGLE*), favoring instance-based models. We examined whether this pattern can be generalized to normal sentence reading: Participants read sentences in which well-known brand names were presented intact (e.g., *IKEA*, *Google*) or with a modified letter case (e.g., *Ikea*, *GOOGLE*). Results showed a cost for brands written in uppercase, independently of their characteristic letter case, in early eye fixation measures (probability of first-fixation, first-fixation duration). However, for later measures (gaze duration and total times), fixation times were longer when the brand's letter case was modified, restricted to those brands typically written in lowercase (e.g., *GOOGLE* > *Google*, whereas *Ikea* $\lesssim$ *IKEA*). Thus, during sentence reading, both the actual letter case and the typical letter case of brand names interact dynamically, posing problems for abstractionist models of reading.

Introduction

One central topic in cognitive psychology is how experience shapes our mental representations (Grainger, 2018). Within this framework, the present paper examines whether repeated exposure to a type of written word with homogeneous visual features makes their mental representations particularly sensitive to surface elements during sentence reading. We focus on brand names, as they are purposely created with a consistent design, letter case, color, and font to make them more memorable (see Foroudi et al., 2017; Pathak et al., 2019; Wheeler, 2012).

Paralleling neurophysiological models of invariant object recognition (e.g., Riesenhuber & Poggio, 2000), the dominant view in alphabetic orthographies is that the word recognition system filters out the "irrelevant perceptual dimensions" of words (e.g., letter case, color, size, font; Cohen et al., 2002, p. 1054) throughout a hierarchy of processing levels until reaching the invariant representations that guide lexical access (e.g., see Dehaene et al., 2005; Grainger et al., 2008). While this view is consistent with a large number of findings in the word recognition literature (see Bowers, 2000; Grainger & Dufau, 2012, for reviews), recent research has revealed that the identification of a particular type of words, brand names, can be influenced by surface elements (e.g., see Gontijo & Zhang, 2007; Labusch et al., 2024; Pathak et al., 2019; Perea et al., 2021, 2022; Rocabado et al., 2024).

Of particular interest to the present paper are the recent experiments conducted by Labusch et al. (2024). They presented commonly known brand names embedded (1) in their original format (e.g., Google), (2) with a modified letter case (e.g., GOOGLE), or (3) with a modified font (e.g., Google), while maintaining other visual elements consistent. Participants performed a brand decision task (i.e., deciding whether the item corresponded to a brand name; Experiment (1) and a semantic categorization task (i.e., deciding whether the item corresponded to a transportation brand; Experiment (2). In both experiments, identification times were longer for the brands in non-standard fonts or cases than in the original format. Labusch et al. (2024) interpreted their findings as support for instance-based and weakly abstractionist accounts of visual word recognition, where lexical access to

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the brand names is facilitated when the visual input closely matches the stored representation of the brands. They suggested that, given that brand names are typically encountered in the same visual format (e.g., ), their memory traces may contain abstract representations and surface elements. Following Goldinger (1998), they argued that these surface effects could be dramatically reduced for common words because they are encountered in multiple formats, making their representations in lexical memory functionally abstract.

Importantly, the identification of brand names can be affected by perceptual elements even when presented in plain format. In brand decision tasks, response times are faster when brand names are presented in their characteristic letter case configuration (e.g., *Google* is recognized faster than *GOOGLE*; *IKEA* is recognized faster than *ikea*; Gontijo et al., 2002; Perea et al., 2015). While this advantage occurs for (lowercase) *Google*-like brands and (uppercase) *IKEA*-like brands, the difference is greater for the former (e.g., 43 vs. 26 ms, respectively in the Perea et al., 2015, experiment; 39 vs. 22 ms in the Labusch et al., 2024, experiment). One reason for this difference is that we rarely encounter *GOOGLE* in uppercase; however, we may often encounter IKEA in lowercase (e.g., *Ikea* or *ikea*), especially in written texts and web addresses.

A processing advantage for the typical letter case configuration of words has also been reported with other types of stimuli, such as the initial capitalization of proper names (e.g., *John* is recognized faster than *john*; Peressotti et al., 2003; Sulpizio & Job, 2018) and German nouns (e.g., *Haus* is recognized faster than *haus*, as common nouns in German are typically capitalized; Jacobs et al., 2008; Labusch et al., 2022), as well as the capitalization of acronyms (e.g., *NBC* is recognized faster than *nbc*; Henderson & Chard, 1976). Taken together, these findings suggest that not all surface information—letter case, in particular—is filtered out during lexical access (Gontijo & Zhang, 2007; Labusch et al., 2022; Perea et al., 2018, 2021; Peressotti et al., 2003). While instance-based accounts can easily capture these findings, another potential explanation, first proposed by Peressotti et al. (2003) in the framework of abstractionist models, is that—unlike color or size—letter case may form, in some instances, an integral part of a word's mental representation because it has a linguistic role (orthographic cue hypothesis; see also Sulpizio & Job, 2018).

Previous research investigating the role of letter case in brand names has exclusively focused on using word recognition tasks (e.g., Pathak et al., 2019; Perea et al., 2015, 2021, 2022). Although this approach is reasonable, considering that brand names are often encountered in an isolated context (e.g., on billboards, products, and advertising), brand names also appear in sentences, either when referring to a brand (e.g., "Excessive use of Instagram is associated with mental health problems") or in advertising slogans (e.g., "Have a break. Have a KitKat"). In the present experiment, we examined the role of a brand name's letter case configuration during sentence reading while registering the reader's eye movements. Besides generalizing the findings from laboratory single-word identification tasks to a natural reading scenario, having a brand name embedded in a sentence has another advantage: it allows us to examine the interplay between the letter case of sentences—which were predominantly lowercase (save for initial capitalization of proper nouns or the initial letter of the sentence)—and the letter case of the embedded brand names (e.g., *IBERIA* and *Instagram* could be written as such or in a modified letter case [*Iberia*, *INSTAGRAM*]). To track the processing of letter case information, we registered eye movement measures associated with the initial phases of word identification (e.g., the probability of the first-pass fixation and the duration of the first-pass initial fixation on the target word) and measures that reflect later processing stages on the brand names (e.g., gaze duration [sum of the first-pass durations, including refixations], and total time [sum of all fixations, including regressions]). Before presenting the details and predictions of the experiment, we first review the scarce literature on this topic during sentence reading.

The number of experiments involving words with characteristic letter case arrangements during sentence reading is extremely scarce. One of the few exceptions is the study conducted by Slattery et al. (2011), in which abbreviations (e.g., *NASA*) and acronyms (*NCAA*), two types of words typically written in uppercase, were embedded in sentences. In their two experiments, using Rayner's (1975) boundary technique, the abbreviation or acronym (e.g., *NASA*) would replace a parafoveal preview that was identical to the target (e.g., *NASA*), a legal preview (e.g., *NUSO*), or an illegal preview (e.g., *NRSB*). In one experiment, they used lowercase sentences, making the uppercase abbreviations and acronyms visually salient. They used uppercase sentences in another experiment, so the abbreviations and acronyms were not visually salient. Slattery et al. (2011) found a different pattern of preview effects depending on whether the sentences were written in lowercase or uppercase. In particular, target stimuli embedded in uppercase sentences showed the typical pattern of parafoveal preview benefit observed with common words, while this was not the case for lowercase sentences. To explain their findings, Slattery et al. (2011) argued that in lowercase sentences, the low-level cues from the uppercase stimuli (acronyms and abbreviations) in parafoveal vision made the acronyms visually salient. While the Slattery et al. (2011) study made a convincing "case for case" for acronyms and initialisms during sentence reading, we must consider that there is only a limited number of acronyms and initialisms—much less than brand names; indeed, Slattery et al. (2011) had to use separate experiments for sentences in lowercase, or uppercase letters. Furthermore,

another advantage of using brand names over acronyms/abbreviations during sentence reading is that while some brand names are typically written in uppercase (e.g., *IBERIA*), others are written in lowercase (e.g., *Instagram*), thus allowing us to test whether changes in letter case in brand names are the same from uppercase to lowercase and vice versa.

Another line of research has examined eye movement measures when reading German sentences in which the initial letters of nouns were either correctly capitalized according to German orthographic rules (e.g., as in *Haus* [house]) or not (e.g., *haus* [house]), showing shorter fixation times for the nouns that followed German capitalization rules (e.g., see Hohenstein & Kliegl, 2013; Pauly & Nottbusch, 2020; Tiffin-Richards & Schroeder, 2015). While these findings are consistent with instance-based theories, one might argue that initial capitalization has a grammatical role in German (e.g., compare *Lachen* [noun] and *lachen* [verb] in "Ihr Lachen ist ansteckend" [Her laughter is contagious] with "Die Kinder lachen laut" [The children laugh loudly], see also Cutter et al., 2020, for the interplay between the initial capitalization of nouns and syntax). In the case of brand names, whether the brand name is in lowercase, or uppercase is not linguistically based but instead chosen by the brand designers, thus providing a more direct demonstration of the role of letter case on the mental representations in the lexicon.

Recently, Reichle (2021; Veldre et al., 2020) proposed a model of eye movement control in reading whose word recognition module is episodic rather than purely abstract: Über-reader. This model is a generalization of the influential E-Z Reader model (Reichle et al., 1999) that includes both lower-level visual processes and high-level processing, such as a visual-orthographic front end based on Gomez et al.'s (2008) overlap model and an orthographic/lexical module based on Ans et al.'s (1998) instanced-based multiple trace model—in the spirit of Hintzman's (1984) MINERVA 2 model—and a module for discourse representations based on the Kintsch and van Dijk (1978) model. The model can also simulate benchmark findings in word identification tasks (Veldre et al., 2020). In the Über-Reader model, the mechanism that marks imminent lexical access and is responsible for programming a saccade to the following word (parallel to L1 in the E-Z Reader model) is called *echo intensity* (i.e., a concept from the instance-based model MINERVA 2). It is a function of the similarity of the visual input to the memory traces activated in the episodic memory system (Reichle, 2021). If we assume that letter case is not normalized throughout processing by the word recognition system, *Instagram* and *IBERIA* would have created more episodic memory traces than *INSTAGRAM* or *Iberia*, facilitating their initial retrieval. As a result, one would expect shorter gaze durations for the words in their characteristic letter case. Furthermore, these differences may increase after the full retrieval of the brand names, as *Instagram* (or *IBERIA*) would be a better match in episodic memory than *INSTAGRAM* (or *Iberia*) (*echo content* in Über-Reader; L2 in E-Z Reader).

Importantly, we need to consider that the overall outcome in the present experiment, in which the sentences are predominantly in lowercase—except for the initial capitalization of proper nouns or the initial letter of the sentence—is that an UPPERCASE item (regardless of their characteristic letter case) may stand out as visually salient and attract attention (Slattery et al., 2011; see Itti & Koch, 2000, for an attentional model of visual saliency). Indeed, when a word in a sentence has a different color than the rest (e.g., the word house in the present paper), the proportion of skipping rates is reduced relative to the words in the standard ink (Fitzsimmons et al., 2019). Fitzsimmons et al. (2019) argued that this could be due to the visual salience of the word (i.e., being in a different color) or to attract attention (i.e., the different color may signal that it is important and meaningful)—notably, the effect of skipping the target word was reduced when there was more than one colored word in the sentence. Given that an uppercase word in a lowercase sentence may be particularly salient in terms of high-spatial frequencies relative to a lowercase word, this may particularly affect early visual processing, reducing the skipping rate on uppercase target words within a sentence. Importantly, this would be the case for all uppercase brand names (regardless of whether this is their original or modified format) embedded in lowercase sentences would show such eye-movement patterns.

To sum up, the present eye movement experiment tested the role of the letter case configuration of brand names embedded in lowercase sentences. We selected two types of brand names: those typically encountered in uppercase (e.g., *IBERIA*) and those typically encountered in lowercase (e.g., *Instagram*)—for the latter, we kept the initial capital letter, if it was their typical presentation. Each sentence contained a brand name that could be written either in lowercase (e.g., *Iberia*, *Instagram*) or uppercase (e.g., *IBERIA*, *NUTELLA*) (see Table 1 for examples).

There are two main scenarios in the experiment. One scenario would correspond to instance-based models of word identification (e.g., Goldinger, 1998; Jamieson et al., 2022; Marsolek, 2004) and reading (Über-Reader model: Reichle, 2021; Veldre et al., 2020) for which the mental representations of brand names would contain surface information such as letter case—it would also apply to those abstractionist models that assume that letter case is part of the words' orthographic representation (Peressotti et al., 2003) and those abstractionist models that assume that, under some circumstances, the specific instances of a word may help word identification (weakly abstractionist theories; see Tenpenny, 1995). In this first scenario, two forces would be at work: (1) brand names in their usual

Table 1 Example sentences of the experiment

	Typical letter case configuration	Modified letter case configuration
Typically lowercase brand names	Carolina quería mirar Instagram para ponerse al día con las noticias [Carolina wanted to check Instagram to catch up on the news.]	Carolina quería mirar INSTAGRAM para ponerse al día con las noticias
Typically uppercase brand names	Mi madre siempre elige IBERIA para viajar a América Latina [My mother always chooses IBERIA to travel to Latin America.]	Mi madre siempre elige Iberia para viajar a América Latina

letter case configuration (e.g., *Instagram*, *IBERIA*) would reach the echo intensity threshold, marking imminent lexical access (Reichle, 2021), signaling a saccade towards the following word than those in brand names in a modified letter case configuration. This would result in a higher chance of moving the eye gaze to the following word for *Instagram* or *IBERIA* than for INSTAGRAM or *Iberia*, resulting in shorter gaze durations (via fewer refixations) and (2) uppercase items, being in a different letter case configuration than the other words in the sentence, may attract extra attention and disrupt reading (e.g., *Instagram* and *Iberia* would have a processing advantage over *INSTAGRAM* and *IBERIA*), including less skipping—as happens with color information (Fitzsimmons et al., 2019). These two processes may involve a different time course: The visual cues regarding the differences in letter case of an incoming uppercase item in a lowercase sentence are likely to play a larger role in the very early visual-oriented processing stages (as deduced from the findings of Slattery et al., 2011, manipulating letter case, and Fitzsimmons et al., 2019, manipulating color), whereas the characteristic letter case of brand names would play a role when the visual input is matched with the representations in lexical memory (see Labusch et al., 2024).

The second scenario corresponds to purely abstractionist accounts of word recognition (Dehaene et al., 2005; Grainger et al., 2008) and reading (e.g., Rayner et al., 2012; Snell et al., 2018). If perceptual dimensions of visually presented words, including letter case, are quickly filtered out during lexical access, one would *only* expect an early reading cost for those brand names printed in uppercase due to their visual salience or attention-grabbing role (see above), regardless of the typical letter case configuration of a brand name. Therefore, faster reading times would be expected for *Instagram* and *Iberia* than for *INSTAGRAM* and *IBERIA*. This outcome would pose limits to the generality of the findings obtained in word recognition tasks (e.g., Labusch et al., 2024; Perea et al., 2015); instead, this outcome would favor that case-invariant letter representations drive the word identification module in the models of eye movement control in reading (e.g., in the form of open bigrams, as in the OB-1 model, Snell et al., 2018).

Methods

Participants

Forty psychology students from the University of Valencia (*mean age* = 21.4 years, *SD* = 3.7 years, 25 women), all native speakers of Spanish, participated in the study. This sample size allowed us to have 2000 observations in each level of brand name (intact, modified), following the suggestions from Brysbaert and Stevens (2018). All participants had normal (or corrected) vision with no history of reading or writing problems. They gave informed consent to participate and received a small monetary compensation. The ethics committee for experimental research at the Universitat de València approved the experiment.

Materials

The experiment employed 100 sentences, each including a well-known brand name around the middle of the sentence (i.e., after the third to sixth word, with an average sentence length of 10.9 words; see Table 1 for examples). We ensured that all 100 brand names were familiar to the participants by conducting a pre-study in which we recruited 12 native Spanish individuals (mean age = 28.8 years, five female) who rated 130 brand names on a 5-point Likert scale according to their familiarity (1 = "completely unfamiliar" to 5 = "completely familiar")—the brand names were written with their characteristic letter case. From this list, we selected 100 brand names for the experiment (M = 4.83 on a 1–5 Likert scale [1 = not familiar; 5 = highly familiar], 50 typically written in lowercase (e.g., *Instagram*) and 50 typically written in uppercase (e.g., *IBERIA*). Both types of brand names had a comparable familiarity and number of letters (4.9 and 7.1, respectively, for *Instagram*-like brands and 4.8 and 6.5, respectively, for *IBERIA*-like brands). We

selected popular brands in the second half of 2023–the year of data collection.

Additionally, we conducted a cloze test with another group of 12 adult participants who were not involved in the eye-tracking experiment to ensure that the target words were not predictable. If any participants could predict a target word in the sentence, we either excluded that sentence or modified it to ensure it was no longer predictable. The final set of experimental sentences was rated for their grammatical correctness by another group of 12 participants ($M = 8.76$ in a 1–9 Likert scale [1 = not understandable to 9 = perfectly understandable]).

In the eye-tracking experiment, all brand names were presented either in their typical letter case configuration (50 brands in lowercase letters [e.g., *Instagram*], 50 brands in uppercase letters [e.g., *IBERIA*]) or a modified letter case configuration (e.g., uppercase, as in *INSTAGRAM*; lowercase, as in *Iberia*). To avoid repetition of the brand names, we created two counterbalanced lists of 100 sentences each. In this way, each participant saw each target word only once, either in lowercase or uppercase letters. In each list, the participants read 50 sentences with a lowercase brand name (25 in the original letter case configuration and 25 in the modified letter case configuration) and 50 sentences with an uppercase brand name (25 in the original letter case configuration and 25 in the modified letter case configuration). Assignment of the participants to the two lists was randomized. The sentences of the experiment are available at https://osf.io/ka2py/?view_only=3cf716571db24426b2b214f620fea216

All sentences were presented in a monospaced font (Courier New). Thus, each word would occupy the same visual space on the screen independently of its letter case configuration. Eye movement data was recorded using an Eyelink Portable Duo eye-tracking device (SR Research Ltd, Canada) with a 1000 Hz sampling rate. Viewing was binocular, but only the right eye was tracked. The sentences were presented on a 144 Hz 24-inch LCD Asus VG248 monitor with the freely available EyeTrack software v.7.10 from the University of Massachusetts (https://websites.umass.edu/eyelab/software/) on a Windows computer.

Procedure

The experiment was conducted in a quiet, dimly lit room. Each participant was seated approximately 60 cm in front of the screen, using a chinrest to reduce motion artifacts. The eye-tracker was calibrated with a 3-dot matrix—this process was repeated during the experiments when necessary and when participants wanted to take a break. Eight practice sentences were presented before the start of the experiment. Participants were instructed to read each individually presented sentence carefully, as they would normally read. There was no time limit for reading the sentences; participants had to press a button to advance to the next sentence. One out of four sentences was followed by a yes/no comprehension question to ensure participants read the sentences attentively. All sentences were presented in a randomized order for each participant. The entire experiment took around 30 min to complete.

Data analyses

To preprocess the eye movement data, we employed the automated Python script Robodoc and the EyeDry software, both developed by the eye tracking lab of the University of Massachusetts (https://websites.umass.edu/eyelab/software/). Screening included the exclusion of fixation durations less than 80 ms or greater than 800 ms, as well as trials with a blink or track loss during the first-pass reading of the target word. The target region was defined as the region of the target word plus the space directly before it. For this region, we calculated the probability of first fixations, the first-pass first-fixation duration, the gaze duration (i.e., the sum of the first-pass durations, including refixations), and the total time (i.e., the sum of all fixations, including regressions).

The eye movement data were analyzed with Bayesian linear mixed-effects models using the brms package (Bürkner, 2017) and RStan package (Stan Development Team, 2023) in the R statistics environment (R Core Team, 2023). We used the default priors from the brms package. The fixed factors in the models were the characteristic letter case configuration of the brand name (lowercase [*Instagram*-like], uppercase [*IBERIA*-like], encoded as −0.5 and 0.5, respectively) and the printed letter case configuration of the brand name (lowercase, uppercase, encoded as −0.5 and 0.5, respectively). We modeled the data with the Bernoulli distribution for the probability of first-pass fixations. For the data from first-fixation, gaze duration, and total time we modeled the data with the exgaussian distribution—in this case, we obtained estimates of the μ component of the Gaussian distribution and the β component (the inverse of λ parameter of the exponential distribution; see Angele et al., 2024, for a similar procedure). In all the models, we used the maximal random effect structure[1]:

Dep.Var. = Characteristic_Letter_Case * Printed_Letter_Case +

[1] Since Characteristic_Letter_Case is a fixed property of each item (e.g., *IKEA* in uppercase, *adidas* in lowercase), it does not vary within items, so a random slope for this factor cannot be estimated at the item level. A parallel scenario occurs in experiments with Word-Frequency as a factor, where each word is either high- or low-frequency; in such cases, the random structure would be specified as (1 + Word-Frequency | subject) + (1 | item).

Table 2 Average eye fixation times (probability of first-pass fixation, first-fixation duration, gaze duration, total time) for typically lowercase and typically uppercase brand names in the two formats: lowercase and uppercase

	Probability of first-pass fixation		First-fixation duration		Gaze duration		Total time	
	Typically lowercase (*Instagram*)	Typically UPPERCASE (*IBERIA*)	Typically lowercase (*Instagram*)	Typically UPPERCASE (*IBERIA*)	Typically lowercase (*Instagram*)	Typically UPPERCASE (*IBERIA*)	Typically lowercase (*Instagram*)	Typically UPPERCASE (*IBERIA*)
Format								
Lowercase	95.8%	92.5%	235 ms	229 ms	296 ms	288 ms	365 ms	369 ms
Uppercase	97.2%	94.1%	245 ms	234 ms	329 ms	302 ms	414 ms	385 ms
Difference	1.4%	1.6%	10 ms	5 ms	33 ms	14 ms	49 ms	16 ms

(1 + Characteristic_Letter_Case * Printed_Letter_Case | subject) +

(1 + Printed_Letter_Case | item)

Each Bayesian linear mixed-effects model was run for 5000 iterations (1000 for warmup). The output of the models provides an estimate for each effect, a measure of the estimation error, and a 95% credible interval (CrI). We interpreted evidence for an effect when the parameter's value was not included in the 95% CrI.

Results

The comprehension questions showed an average accuracy of 97% across participants, indicating that they were reading for comprehension. During data preprocessing, we excluded 2.8% of trials (107), primarily due to participant blinks while fixating on the target region. Additionally, as noted above, we excluded fixations shorter than 80 ms or longer than 800 ms, removing another 4.7% of trials (179). Two participants were excluded from the final analysis due to their very large number of fixations. The descriptive statistics per experimental condition for the four dependent variables are displayed in Table 2. All Bayesian linear-mixed effects models converged successfully in the four dependent variables (all Rhat values = 1.00). There were no divergent transitions.

Probability of first-pass fixation

The probability of a first-pass fixation on the brand names was lower when presented in lowercase than uppercase format, $b = 0.58$, $SE = 0.28$, *95% CrI* [0.08, 1.19]. In addition, the probability of first-pass fixation was higher for *Instagram*-like than *IBERIA*-like brands, $b = -0.71$, $SE = 0.31$, *95% CrI* [−1.32, −0.11]. We found no signs of an interaction between these two factors, $b = -0.14$, $SE = 0.41$, *95% CrI* [−0.94, 0.68].

First fixation duration

The analyses on the μ component showed that first-fixation durations on brand names were shorter when presented in lowercase than uppercase, $b = 7.18$, $SE = 2.50$, *95% CrI* [2.27, 12.12]. In addition, first-fixation times were longer for *Instagram*-like than *IBERIA*-like brand names ($b = -7.46$, $SE = 3.60$, 95% CrI [−14.49, -0.45]). There was no evidence of an interaction between the two factors, $b = -4.39$, $SE = 4.75$, *95% CrI* [−13.59, 5.03]. We found no evidence of effects on the β component—all credible intervals crossed zero.

Gaze duration

Gaze durations on brand names were shorter when presented in lowercase than in uppercase—this effect occurred in both the μ component ($b = 18.73$, $SE = 4.98$, *95% CrI* [9.23, 28.79]) and the β component ($b = 0.13$, $SE = 0.05$, *95% CrI* [0.04, 0.22]). There were no overall differences between the gaze durations of *Instagram*-like and *IBERIA*-like brands on either μ or β components. More importantly, we found evidence of an interaction between the two factors in the μ component ($b = -16.48$, $SE = 7.61$, *95% CrI* [−31.53, -1.65]), revealing a lowercase advantage for brand names for *Instagram*-like brands ($b = -26.9$, *95% CrI* [−39.2, −14.3]), but not for *IBERIA*-like brands ($b = -10.3$, *95% CrI* [−22.7, 1.2]).

Total time

The total time on the brand names was shorter when written in lowercase than uppercase letters—this occurred in both the μ component ($b = 25.90$, $SE = 7.22$, *95% CrI* [12.05, 40.15]) and the β component ($b = 0.09$, $SE = 0.04$, *95% CrI* [0.01, 0.17]). There was no evidence of differences between *Instagram*-like and *IBERIA*-like brands

on either component. Finally, we found evidence of an interaction between the two factors in the μ component ($b = -26.27$, *Estimation Error* = 12.41, *95% CrI* [−51.41, −2.97]): there was a lowercase advantage for *Instagram*-like brands ($b = -38.8$, *95% CrI* [−58.1, −20.7]) but not for *IBERIA*-like brands ($b = -12.6$, *95% CrI* [−31.0, 5.8]).

Discussion

When thinking of brand names (e.g., *Coca-Cola* or *IKEA*), their characteristic letter case, lettering style, design, and color will likely come to mind. Due to this unique feature of brand names, their lexical representations may contain not just purely abstract information (i.e., letter identities, letter positions; Grainger, 2018) but also surface details (e.g., letter case, font; see Gontijo & Zhang, 2007; Labusch et al., 2024; Rocabado et al., 2024). This claim is consistent with faster recognition times for brand names when presented in their typical letter case or font compared to when the brand's letter case or font is modified (e.g., *IBERIA* is recognized faster than *Iberia*, or *Instagram* faster than *INSTAGRAM*; see Gontijo & Zhang, 2007; Labusch et al., 2024; Perea et al., 2015).

The main question addressed in the present experiment was whether the characteristic letter case in brand names plays a role beyond single-word identification tasks, using a more natural sentence reading scenario. To that end, the brand names (either characteristically encountered in lowercase [*Instagram*] or uppercase [*IBERIA*]) were embedded in a sentence. Brand names were written in their characteristic letter case (either lowercase [*Instagram*] or uppercase [*IBERIA*]) or not and were written in lowercase—as the rest of the sentence—or uppercase (see Table 1). This allowed us to examine (1) whether brand names, like *Instagram* and *IBERIA*, written in their characteristic letter case configuration would produce shorter fixation times than *INSTAGRAM* and *Iberia,* and (2) whether the previous effect was modulated by the congruence in letter case with the surrounding text, as an uppercase item may be visually salient and disrupt reading in sentences that are otherwise written in lowercase.

Results showed that eye movement measures that reflect early visual processing of the target stimuli (probability of first-pass fixation, first-fixation duration) showed less skipping and longer first-fixation durations for brand names written in uppercase (e.g., *INSTAGRAM*, *IBERIA*) than in lowercase (*Instagram*, *Iberia*), independently of their characteristic letter case. This outcome supports the idea that the visual salience of an uppercase item embedded in a lowercase sentence draws attention during reading, having a detrimental effect in the very early phases of the reading process. Thus, the findings reported by Fitzsimmons et al. (2019) with colored target words can also be extended to the letter case configuration of words. This pattern stresses the role of spatial frequency information and early visual processes in eye movement control (see Slattery et al., 2011, for evidence with [uppercase] acronyms in the parafovea).

Notably, the effect of letter case configuration differed in the eye movement measures that considered refixations (gaze durations) and regressions (total time). For these measures, eye fixation times for *Instagram*-like brand names were substantially faster when written in lowercase (i.e., the usual letter case configuration; e.g., *Instagram* was faster than *INSTAGRAM*; 33 ms faster for gaze durations; 49 ms for total times). In contrast, gaze durations and total duration times for *IBERIA*-like brand names were comparable, regardless of letter case (*IBERIA*, *Iberia*)—if anything, they were shorter when written in lowercase. As noted in the Introduction, in experiments involving isolated word presentations (e.g., Labusch et al., 2024; Perea et al., 2015), the advantage of *Instagram* over *INSTAGRAM* is larger than the advantage of *IBERIA* over *Iberia* (around 40 vs. 24 ms, respectively). We believe that the differences between the identification of *IBERIA*-like brand names in word identification tasks and during sentence reading are due to the following reasons. First, an uppercase word in a predominantly lowercase sentence is visually salient and may disrupt parafoveal processing (Slattery et al., 2011)—this is consistent with the lower skipping rates for uppercase items, regardless of their characteristic letter case configuration. Second, another non-exclusive reason is that in sentences, the Spanish Real Academia (Real Academia Española, 2010) advises that brand names should be treated as if they were proper nouns (i.e., with an initial capitalization); thus, in written texts, readers may be inadvertently familiar with the word form *Iberia* (e.g., "The Spanish carrier Iberia continues to increase its flights to Asia").

Overall, the present findings reveal that both the letter case of the printed word and the typical letter case of brand names interact dynamically during sentence reading. This pattern may be captured by a recent development of Reichle et al.'s (1999) E-Z Reader model of eye movement control during reading, the Über-Reader model (Reichle, 2021). This model proposes the existence of a word identification module based on the principles of instance-based models of memory and word recognition (Ans et al., 1998; Hintzman, 1984). The model includes a familiarity check responsible for programming a forward saccade. Following Hintzman's (1984) MINERVA 2 model, this parameter, called *echo intensity*, reflects the number of memory traces matching the probe. As those brand names that are presented in their characteristic format would reach that criterion faster than those in a modified format, the model can capture the observed advantage in gaze durations and

total time durations of brand names like *Instagram* over *INSTAGRAM* during sentence reading—as noted earlier, the story for *IBERIA*-like items might be more complex. We should also add that during early visual processing stages, when the eyes are landing on the *n-1* word, brand names written in uppercase letters may have a detrimental effect, leading to a lower skipping probability of items written in uppercase regardless of the characteristic letter case configuration. This last pattern could be due to the visual salience of the uppercase words—being physically different—or because these words tend to attract more attention (see Fitzsimmons et al., 2019, for a discussion with colored target words). Modeling work with the Über-Reader model is necessary to examine these claims.

At a general level, the present experiment represents an important step towards understanding the processing of words typically presented in a visually consistent form, such as brand names. While previous research focused on isolated presentations in word recognition tasks (e.g., lexical decision, semantic categorization; see Gontijo et al., 2002; Perea et al., 2015, 2024; Labusch et al., 2024), here we found an effect of the characteristic letter case configuration of brands in a natural, sentence reading setting. These findings favor those models that assume that the word recognition system may retain some surface-level information in the memory traces in the mental lexicon, at least for items typically presented in a characteristic letter case. Thus, our findings are in line with instance-based accounts (Goldinger, 1998; Hintzman, 1984; Jamieson et al., 2022) and weakly abstractionist models (Bowers, 2000; Tenpenny, 1995; see also Peressotti et al., 2003). At the same time, the present findings challenge the claims of purely abstractionist models for which the word recognition system filters out a dimension like letter case (e.g., Dehaene et al., 2005). Further research is necessary to examine whether other elements, such as the font or color of the brand names, also play a role during sentence reading (e.g., having the brand name *Coca-Cola* embedded in a sentence in red or blue color). While the present study highlights the importance of the typical presentation format of brand names during sentence reading, it also emphasizes the suitability of the chosen paradigm for exploring this issue. Since written language in the Roman script is predominantly in lowercase, this paradigm enabled us to observe effects even for brand names typically presented in uppercase within a natural reading context.

To sum up, we demonstrated that the typical letter case configuration of brand names plays a role during sentence reading, favoring instance-based (or weakly abstractionist) models of word recognition and reading. Specifically, the representations in lexical memory of printed stimuli with a characteristic format, such as brand names, may retain some surface characteristics (e.g., Google, Coca-Cola) that aid in their retrieval. At a practical level, maintaining the visual identity of brand names is crucial for their efficient recognition, suggesting that any rebranding may disrupt this process if the modified elements (e.g., letter case) deviate significantly from the original design—as an example, in 2023, PEPSI moved from the lowercase logo introduced in 2008 [pepsi] to a stylized version of their pre-2008 uppercase logo [PEPSI]).

Author contributions Both authors (M.L. and M.P.) contributed to the study conception and design. Material preparation was performed by M.L. and M.P. Data collection was performed by M.L. Statistical analyses were performed by M.L. and M.P. The first draft of the manuscript was written by M.L. and M.P. and both authors commented on previous versions of the manuscript. Both authors (M.L. and M.P.) read and approved the final manuscript.

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Data availability All materials, data, scripts, and output are available at the Open Science Foundation repository: https://osf.io/ka2py/?view_only=3cf716571db24426b2b214f620fea216.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval The procedures involving human participants in this study were approved by the Experimental Research Ethics Committee of the Universitat de València (ref #1894511) and were in accordance with the Declaration of Helsinki. All participants in the experiment provided written informed consent.

References

Angele, B., Gutiérrez-Cordero, I., Perea, M., & Marcet, A. (2024). Reading (,) with and without commas. *Quarterly Journal of Experimental Psychology, 77*, 1190–1200. https://doi.org/10.1177/17470218231200338

Ans, B., Carbonnel, S., & Valdois, S. (1998). A connectionist multiple-trace memory model for polysyllabic word reading. *Psychological Review, 105*, 678–723. https://doi.org/10.1037/0033-295x.105.4.678-723

Bowers, J. S. (2000). In defense of abstractionist theories of repetition priming and word identification. *Psychonomic Bulletin & Review, 7*, 83–99. https://doi.org/10.3758/BF03210726

Brysbaert, M., & Stevens, M. (2018). Power analysis and effect size in mixed effects models: A tutorial. *Journal of Cognition, 1*, 9. https://doi.org/10.5334/joc.10

Bürkner, P.-C. (2017). brms: An R Package for Bayesian multilevel models using stan. *Journal of Statistical Software, 80*, 1–28. https://doi.org/10.18637/jss.v080.i01

Cohen, L., Lehéricy, S., Chochon, F., Lemer, C., Rivaud, S., & Dehaene, S. (2002). Language-specific tuning of visual cortex?

Functional properties of the visual word form area. *Brain, 125*, 1054–1069. https://doi.org/10.1093/brain/awf094

Cutter, M. G., Martin, A. E., & Sturt, P. (2020). Capitalization interacts with syntactic complexity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 46*, 1146–1164. https://doi.org/10.1037/xlm0000780

Dehaene, S., Cohen, L., Sigman, M., & Vinckier, F. (2005). The neural code for written words: A proposal. *Trends in Cognitive Sciences, 9*, 335–341. https://doi.org/10.1016/j.tics.2005.05.004

Fitzsimmons, G., Weal, M. J., & Drieghe, D. (2019). The impact of hyperlinks on reading text. *PLoS ONE, 14*(2), e0210900. https://doi.org/10.1371/journal.pone.021090

Foroudi, P., Melewar, T. C., & Gupta, S. (2017). Corporate logo: History, definition, and components. *International Studies of Management & Organization, 47*, 176–196. https://doi.org/10.1080/00208825.2017.1256166

Goldinger, S. D. (1998). Echoes of echoes? An episodic theory of lexical access. *Psychological Review, 105*, 251–279. https://doi.org/10.1037/0033-295X.105.2.251

Gomez, P., Ratcliff, R., & Perea, M. (2008). The overlap model: A model of letter position coding. *Psychological Review, 115*, 577–600. https://doi.org/10.1037/a0012667

Gontijo, P. F. G., & Zhang, S. (2007). The mental representation of brand names: Are brand names a class by themselves? In T. M. Lowrey (Ed.), *Psycholinguistic phenomena in marketing communications* (pp. 23–37). Erlbaum.

Gontijo, P. F., Rayman, J., Zhang, S., & Zaidel, E. (2002). How brand names are special: Brands, words, and hemispheres. *Brain and Language, 82*, 327–343. https://doi.org/10.1016/S0093-934X(02)00036-6

Grainger, J. (2018). Orthographic processing: A "mid-level" vision of reading. *Quarterly Journal of Experimental Psychology, 71*, 335–359. https://doi.org/10.1080/17470218.2017.1314515

Grainger, J., & Dufau, S. (2012). The front end of visual word recognition. In J. S. Adelman (Ed.), *Visual word recognition: Models and methods, orthography and phonology* (pp. 159–184). Psychology Press.

Grainger, J., Rey, A., & Dufau, S. (2008). Letter perception: From pixels to pandemonium. *Trends in Cognitive Sciences, 12*, 381–387. https://doi.org/10.1016/j.tics.2008.06.006

Henderson, L., & Chard, J. (1976). On the nature of the facilitation of visual comparisons by lexical membership. *Bulletin of the Psychonomic Society, 7*, 432–434. https://doi.org/10.3758/bf03337238

Hintzman, D. L. (1984). MINERVA 2: A simulation model of human memory. *Behavior Research Methods, Instruments & Computers, 16*, 96–101. https://doi.org/10.3758/BF03202365

Hohenstein, S., & Kliegl, R. (2013). Eye movements reveal interplay between noun capitalization and word class during reading. In M. Knauff , M. Pauen , N. Sebanz , & I. Wachsmuth (Eds.), In: 2013 *Proceedings of the 35th Annual Conference of the Cognitive Science Society* (pp. 2254–2259). Cognitive Science Society.

Itti, L., & Koch, C. (2000). A saliency-based search mechanism for overt and covert shifts of visual attention. *Vision Research, 40*, 1489–1506. https://doi.org/10.1016/S0042-6989(99)00163-7

Jacobs, A. M., Nuerk, H. C., Graf, R., Braun, M., & Nazir, T. A. (2008). The initial capitalization superiority effect in German: Evidence for a perceptual frequency variant of the orthographic cue hypothesis of visual word recognition. *Psychological Research Psychologische Forschung, 72*, 657–665. https://doi.org/10.1007/s00426-008-0168-0

Jamieson, R. K., Johns, B. T., Vokey, J. R., & Jones, M. N. (2022). Instance theory as a domain-general framework for cognitive psychology. *Nature Reviews Psychology, 1*, 174–183. https://doi.org/10.1038/s44159-022-00025-3

Kintsch, W., & van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review, 85*, 363–394. https://doi.org/10.1037/0033-295X.85.5.363

Labusch, M., Kotz, S. A., & Perea, M. (2022). The impact of capitalized German words on lexical access. *Psychological Research Psychologische Forschung, 86*, 891–902. https://doi.org/10.1007/s00426-021-01540-3

Labusch, M., Duñabeitia, J. A., & Perea, M. (2024). Visual word identification beyond common words: The role of font and letter case in brand names. *Memory & Cognition, 52*, 1673–1686. https://doi.org/10.3758/s13421-024-01570-3

Marsolek, C. J. (2004). Abstractionist versus exemplar-based theories of visual word priming: A subsystems resolution. *Quarterly Journal of Experimental Psychology, 57A*, 1233–1259. https://doi.org/10.1080/02724980343000747

Pathak, A., Velasco, C., & Calvert, G. A. (2019). Identifying counterfeit brand logos: On the importance of the first and last letters of a logotype. *European Journal of Marketing, 53*, 2109–2125. https://doi.org/10.1108/EJM-09-2017-0586

Pauly, D. N., & Nottbusch, G. (2020). The influence of the German capitalization rules on reading. *Frontiers in Communication, 5*, 15. https://doi.org/10.3389/fcomm.2020.00015

Perea, M., Jiménez, M., Talero, F., & López-Cañada, S. (2015). Lettercase information and the identification of brand names. *British Journal of Psychology, 106*, 162–173. https://doi.org/10.1111/bjop.12071

Perea, M., Marcet, A., & Vergara-Martínez, M. (2018). Are you taking the fastest route to the RESTAURANT? *Experimental Psychology, 65*, 98–104. https://doi.org/10.1027/1618-3169/a000391

Perea, M., Baciero, A., Rocabado, F., & Marcet, A. (2021). Does the cowl make the monk? Detecting counterfeits in brand names vs. logos. *Psychonomic Bulletin and Review, 28*, 969–977. https://doi.org/10.3758/s13423-020-01863-z

Perea, M., Baciero, A., Labusch, M., Fernández-López, M., & Marcet, A. (2022). Are brand names special words? Letter visual similarity affects the identification of brand names, but not common words. *British Journal of Psychology, 113*, 835–852. https://doi.org/10.1111/bjop.12557

Perea, M., Labusch, M., Fernández-López, M., Marcet, A., Gutierrez-Sigut, E., & Gómez, P. (2024). One more trip to Barcetona: On the special status of visual similarity in city names. *Psychological Research Psychologische Forschung, 88*, 271–283. https://doi.org/10.1007/s00426-023-01839-3

Peressotti, F., Cubelli, R., & Job, R. (2003). On recognizing proper names: The orthographic cue hypothesis. *Cognitive Psychology, 47*, 87–116. https://doi.org/10.1016/s0010-0285(03)00004-5

R Core Team (2023). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing.

Rayner, K. (1975). The perceptual span and peripheral cues in reading. *Cognitive Psychology, 7*, 65–81. https://doi.org/10.1016/0010-0285(75)90005-5

Rayner, K., Pollatsek, A., Ashby, J., & Clifton, C., Jr. (2012). *Psychology of reading*. Psychology Press.

Real Academia Española (2010). *Ortografía de la Lengua Española*. Santillana.

Reichle, E. D., Rayner, K., & Pollatsek, A. (1999). Eye movement control in reading: Accounting for initial fixation locations and refixations within the E-Z Reader model. *Vision Research, 39*, 4403–4411. https://doi.org/10.1016/S0042-6989(99)00152-2

Reichle, E. D. (2021). *Computational models of reading: A handbook*. Oxford University Press.

Riesenhuber, M., & Poggio, T. (2000). Models of object recognition. *Nature Neuroscience, 3*, 1199–1204. https://doi.org/10.1038/81479

Rocabado, F., Labusch, M., Perea, M., & Duñabeitia, J. A. (2024). Dissociating the effects of visual similarity for brand names and

common words. *Journal of Cognition, 7*(1), 67. https://doi.org/10.5334/joc.397

Slattery, T. J., Schotter, E. R., Berry, R. W., & Rayner, K. (2011). Parafoveal and foveal processing of abbreviations during eye fixations in reading: Making a case for case. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37*, 1022–1031. https://doi.org/10.1037/a0023215

Snell, J., van Leipsig, S., Grainger, J., & Meeter, M. (2018). OB1-reader: A model of word recognition and eye movements in text reading. *Psychological Review, 125*, 969–984. https://doi.org/10.1037/rev0000119

Stan Development Team (2023). *RStan: The R interface to Stan*. R package version 2.21.8, https://mc-stan.org/

Sulpizio, S., & Job, R. (2018). Early and multiple-loci divergency of proper and common names: An event-related potential investigation. *Neuropsychologia, 119*, 107–117. https://doi.org/10.1016/j.neuropsychologia.2018.07.034

Tenpenny, P. L. (1995). Abstractionist versus episodic theories of repetition priming and word identification. *Psychonomic Bulletin & Review, 2*, 339–363. https://doi.org/10.3758/BF03210972

Tiffin-Richards, S. P., & Schroeder, S. (2015). Children's and adults' parafoveal processes in German: Phonological and orthographic effects. *Journal of Cognitive Psychology, 27*, 531–548. https://doi.org/10.1080/20445911.2014.999076

Veldre, A., Yu, L., Andrews, S., & Reichle, E. D. (2020). Towards a complete model of reading: Simulating lexical decision, word naming, and sentence reading with Über-Reader. In *Proceedings of the 42nd Annual Conference of the Cognitive Science Society.* Cognitive Science Society.

Wheeler, A. (2012). *Designing Brand Identity: An Essential Guide for the Whole Branding Team*. Wiley and Sons.