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RESEARCH

Do diacritic mismatches disrupt lexical access more for consonants than for vowels?

Arya Ş. Erkınay[1,2] · Zeynep G. Özkan[1] · Melanie Labusch[1,3,4] · Manuel Perea[1,5]

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Abstract
Diacritical marks across Latin-based orthographies serve different linguistic functions, ranging from suprasegmental stress marking (e.g., Spanish) to phonemic contrast (e.g., German, Finnish), and this distinction shapes how readers process diacritic mismatches during visual word recognition. Turkish is particularly well suited to examine this question because it includes an equal number of diacritical vowels (e.g., o /o/ vs. ö /ø/) and diacritical consonants (e.g., s /s/ vs. ş /ʃ/), with diacritical and non-diacritical forms functioning as distinct letters. This balanced distribution makes Turkish ideal for examining whether consonant–vowel status modulates the processing cost of diacritic mismatches relative to intact words. We conducted two semantic categorization experiments (is the word an animal name?) in which native Turkish readers responded to words with a diacritical mark either omitted (Experiment 1) or added (Experiment 2) relative to intact words, with vowel and consonant diacritics included in the same experiment. Bayesian mixed-effects models showed a processing cost for both diacritic omission and addition relative to intact words, and the cost was greater for addition than for omission. Critically, we found no evidence that the response-time cost was modulated by consonant–vowel status. These findings are consistent with an account in which a substantial component of diacritic mismatch effects arises during visual feature-to-letter identity mapping, before consonant–vowel differences in lexical constraint exert a measurable influence.

Introduction

Many languages worldwide are written using variations of the basic Latin alphabet. As this alphabet was originally designed to represent the phonological system of Latin, it does not fully capture the phonemic inventories of other languages. To cope with this limitation, languages often modify the alphabet by adding diacritical marks to represent vowel or consonant phonemes that did not exist in Latin (e.g., ä /ɛ/ in German, š /ʃ/ in Czech) rather than introducing entirely new letters—a notable exception is the letter Þ /θ/ in Icelandic (see Wells, 2000, for review). In addition, in some languages, diacritical marks may serve other functions, such as marking suprasegmental information (e.g., lexical stress in Spanish) without altering the segmental identity of the letter (e.g., paso [ˈpaso] "I pass" vs. pasó [paˈso] "he/she passed").

To examine whether linguistic function plays a key role in how diacritical letters are represented relative to their non-diacritical counterparts, previous research has compared intact diacritical words with words in which the diacritics were omitted, and intact non-diacritical words with corresponding stimuli in which diacritics were added. In languages where diacritics indicate suprasegmental information (e.g., Spanish), readers show little disruption in lexical access when diacritical marks are omitted from vowels (e.g., carcel [original word: cárcel 'prison']) relative to intact words in lexical decision tasks, semantic categorization tasks, and sentence reading tasks (Marcet & Perea, 2022; Perea et al., 2022), whereas adding a diacritic to a non-diacritical word (e.g., mesá; original word, mesa [table]) tends to produce a small, but somewhat larger, cost (see Labusch et al., 2022). In contrast, in German or Finnish, the omission of diacritical marks from vowels (e.g., Lowe for the German

✉ Manuel Perea
mperea@uv.es

1 Department of Methodology and ERI-Lectura, Universitat de València, Av. Blasco Ibáñez, 21, Valencia 46010, Spain

2 University of Bologna, Bologna, Italy

3 Health Research Institute LaFe, Valencia, Spain

4 Universidad de Zaragoza, Teruel, Spain

5 Centro de Investigación Nebrija en Cognición (CINC), Universidad Nebrija, Madrid, Spain

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word Löwe [lion]) produces a sizable reading cost relative to the original word in semantic categorization tasks (Perea et al., 2022), a cost that is magnified when adding a diacritic (e.g., Schwän for the German word Schwan [swan]; see Labusch et al. 2026a). Taken together, these findings favor the view that diacritical vowels can be normalized in orthographies where they indicate stress-marking (e.g., Spanish) but are less readily normalized in orthographies where they signal phonemic identity (e.g., German, Finnish; see Labusch et al. 2026b, for discussion).

The widespread use of diacritical marks across Latin-based orthographies, with contemporary English being one of the very few exceptions, raises important questions about the orthographic front-end of models of visual word recognition. Most implemented models of visual word recognition, developed primarily for English, assume a hierarchy of processing stages ranging from low-level visual features to abstract letter units and whole-word representations, with the letter level typically comprising the 26 basic Latin letters (Coltheart et al., 2001; Conrad et al., 2010; Davis, 2010). A key question for these models concerns the orthographic coding of diacritical letters. The few models implemented in languages with diacritical letters either assume that diacritic and non-diacritic letters activate the same letter units in languages in which diacritics only indicate suprasegmental, lexical-stress information (e.g., Conrad et al., 2010, in Spanish), or that they activate distinct letter units, while leaving the feature-letter mapping underspecified, in languages in which diacritical marks signal distinct phonemes (e.g., Ans et al., 1998, in French; Ziegler et al., 2000, in German).

Previous research on diacritic processing has remained largely confined to diacritical vowels, not least because German and Finnish have no diacritical consonants and Spanish has only one (ñ /ɲ/). Consequently, it remains unclear whether consonant-vowel status modulates the impact of diacritic manipulations during visual word recognition. This issue is relevant for models of visual word recognition because consonants and vowels can play different roles during lexical access. In general, consonants are thought to provide more lexical constraint than vowels (Carreiras et al., 2009; Duñabeitia & Carreiras, 2011; New et al., 2008). For instance, New et al. (2008) conducted a masked priming lexical decision task in French in which primes preserved either the consonants of the target (replacing its vowels [e.g., jalu–JOLI, "pretty"]) or its vowels (replacing its consonants [e.g., vobi–JOLI]). Consonant-preserving primes facilitated target recognition relative to unrelated primes, whereas vowel-preserving primes did not, indicating that consonant information imposed stronger constraints on lexical access. Converging evidence for this consonant bias has been reported in other languages (Carreiras et al., 2009; Duñabeitia & Carreiras, 2011; Soares et al., 2014). One key issue here is whether diacritical consonants involve different mechanisms of orthographic encoding and lexical access than diacritical vowels. If lexical access is consonant-biased, then the omission or addition of diacritical marks on consonants might be more disruptive than comparable manipulations on vowels, even when diacritical and non-diacritical forms function as distinct letters. Conversely, if the reading cost due to the omission or addition of diacritical marks primarily reflects feature-level mismatch costs at the orthographic front-end, then omitting or adding vowel and consonant diacritics should produce parallel costs. This last prediction is consistent with leading models of visual word recognition, whose front-end mechanisms encode visual features and letter identities without assigning a distinct processing status to consonants and vowels at this stage (e.g., see Coltheart et al., 2001; Davis, 2010), and with evidence from tasks tapping prelexical processes showing no modulation by consonant–vowel status (e.g., same-different matching task, see Perea & Acha, 2009).

Turkish is particularly well-suited to addressing this research question. Following Atatürk's 1928 alphabet reform, Turkish has been written in a Latin-based script. It includes a set of three diacritical vowels and three diacritical consonants. The six pairs and their principal phonological characteristics are shown in Appendix A. Diacritical and non-diacritical forms function as distinct letters in Turkish and are treated as such in literacy instruction, dictionaries, keyboard layouts, and spelling. Turkish comprises 29 letters (it lacks Q, W, and X), and diacritical letters are taught as separate alphabetic letters rather than as optional accented variants. Thus, these properties of Turkish orthography allow for a direct within-language comparison of vowel and consonant diacritics. Despite this potential, empirical evidence on the processing of diacritics in Turkish remains very scarce.

To our knowledge, the only published study directly addressing this issue was conducted by Ayçiçeği and Harris (2002). They examined the role of diacritics in Turkish using a repetition blindness paradigm with a rapid serial visual presentation (RSVP) technique. They selected word pairs that were (i) identical, (ii) differed by a single diacritic (e.g., words differing only in ş vs. s or ö vs. o), or (iii) were orthographic neighbors differing by a visually dissimilar letter. They found stronger repetition blindness (i.e., more difficulty detecting that there were two stimuli and not one) when the pair differed only by a diacritic (köse-köşe [beardless-corner]) than when it differed by an unrelated letter (e.g., köle-köşe [slave-corner]), and, critically, relative to the visually dissimilar condition, the magnitude of the repetition blindness effect was similar for diacritic-different pairs and for identical repetitions (köşe-köşe [corner-corner]). Thus, at the processing stages tapped by RSVP, diacritic

and non-diacritic letters behaved similarly. Ayçiçeği and Harris (2002) suggested that, despite the linguistic function of Turkish diacritics, diacritical and non-diacritic letters may share the same abstract representations. However, an alternative interpretation is that the early processing stages tapped by repetition blindness are relatively insensitive to the linguistic function of the diacritic. Indeed, in the masked priming technique, the size of the priming effects is very similar regardless of whether the diacritics signal merely suprasegmental information—as in Spanish—or indicate a different phoneme (see Benyhe et al. 2023; Labusch et al. 2026a, for discussion), and differences as a function of the linguistic role of the diacritic are apparent only when using an unprimed paradigm (see Labusch et al. 2026b). Furthermore, given the difficulty of creating word pairs in their experiment, Ayçiçeği and Harris (2002) used 33 word triplets but did not analyze vowel and consonant diacritics separately and did not examine the role of omitting versus adding diacritical marks.

Thus, the present experiments examined the role of diacritics in Turkish using a task that requires successful lexical-semantic access under a single-presentation paradigm, the semantic categorization task (see Labusch et al. 2023, 2026a; Perea et al. 2022, for the same paradigm in the context of diacritical words). In Experiment 1, we examined the potential cost of omitting diacritics relative to the intact words, whereas in Experiment 2, we examined the potential cost of adding diacritics relative to intact words. Critically, we included vowel and consonant diacritics in the same experiment, allowing us to test whether the cost of omitting or adding diacritics is modulated by vowel–consonant status.

Given the orthographic status of diacritics in Turkish, diacritical letters are expected to activate distinct abstract letter identities. Consequently, one would expect a sizable reading cost whenever the diacritic information in the presented stimulus mismatches the stored lexical representation. In addition, consistent with previous findings in languages with phonemic diacritics, the cost of adding a diacritic (Experiment 2) is expected to be greater than the cost of omitting one (Experiment 1) (see Labusch et al. 2023, 2026a).

The critical research question of the present experiments is whether these mismatch costs are modulated by consonant-vowel status. We can envision two alternative possibilities. According to a perceptual feature-mismatch account, the processing cost arises at an early, pre-lexical stage of visual feature-to-letter mapping which would affect consonants and vowels similarly. On this view, vowel and consonant diacritics would produce comparable mismatch costs (with addition costs exceeding omission costs), as the disruption reflects a low-level featural incompatibility that does not depend on the lexical informativeness of the affected letter. Alternatively, under a lexical-constraint account, diacritical marks are fully incorporated into abstract letter identities that guide lexical access and selection. Because consonants generally provide greater lexical constraint than vowels during visual word recognition (Carreiras et al., 2009; Duñabeitia & Carreiras, 2011; New et al., 2008), a diacritic mismatch on a consonant should be more disruptive than the corresponding mismatch on a vowel. Specifically, altering the identity of a consonant through diacritic omission or addition (e.g., ş → s or s → ş) affects a letter type that generally provides greater lexical constraint and more strongly restricts the set of viable lexical candidates; in contrast, the same change applied to a vowel (e.g., ö → o) affects a letter type that generally provides less lexical constraint. Consequently, this account predicts larger mismatch costs for consonant diacritics than for vowel diacritics in both the omission (Experiment 1) and addition (Experiment 2) conditions. Conversely, if mismatch costs are comparable for vowel and consonant diacritics, this would be consistent with the view that diacritic effects arise primarily during visual feature-to-letter identity mapping, before the differential lexical constraints associated with vowels and consonants exert a measurable influence.

Experiment 1

Method

Participants

We recruited 72 native speakers of Turkish, M_{age} = 24.8 years (SD = 5.0; 44 women), via social media; participation was voluntary. This sample size ensured more than 2,500 observations in each condition of the diacritic congruency × consonant–vowel design. Brysbaert and Stevens (2018) recommend at least 1,600 observations per condition for adequately powered repeated-measures RT experiments; given our critical test concerned an interaction, we targeted a larger number of observations per condition (see Marcet et al., 2026, for a similar logic). All participants provided informed consent before beginning the experiment. The series of experiments was approved by the Research Ethics Committee of the University of Valencia.

Materials

A total of 180 Turkish words were selected for the study, consisting of 60 animal words and 120 non-animal words. The 1:2 ratio reflected the more restricted availability of

suitable animal words compared with the larger, more heterogeneous pool of non-animal words, consistent with previous experiments using the semantic categorization task (e.g., Labusch et al. 2022, 2026a; Perea et al. 2022). All items were obtained from the TS Corpus database (Sezer, 2017). Among the animal words, 36 contained vowel diacritics and 24 contained consonant diacritics. Similarly, the non-animal words comprised 72 vowel-diacritic items and 48 consonant-diacritic items. As in previous studies using this semantic categorization paradigm, the availability of suitable animal words was relatively restricted (Labusch et al. 2022, 2026a; Perea et al. 2022), resulting in unequal numbers of vowel- and consonant-diacritic items. The individual diacritic pairs were also not equally represented, reflecting the availability of suitable items meeting the selection criteria. When selecting non-animal words, we excluded items with semantic associations to animals (e.g., farm, claw, horn). Within each letter-type condition, word length and word frequency were matched across animal and non-animal categories. For vowel-diacritic items, animal and non-animal words had an average length of 6.5 letters (range = 3–14), whereas consonant-diacritic items averaged 5.83 letters (range = 3–10). Mean word frequency was comparable across animal and non-animal categories for both vowel items (39.72 vs. 39.74, respectively; $p > .50$) and consonant items (75.51 vs. 75.67, respectively; $p > .50$). Diacritic omissions occurred in different syllable positions: in the first syllable for some words (e.g., inek [cow] → ınek), in medial syllables for others (e.g., istiridye [oyster] → istıridye), and in final syllables (e.g., kurbağa [frog] → kurbaga). Among these animal words, the omission affected a vowel in inek and istiridye, and a consonant in kurbağa. For non-animal words, the omission similarly affected a vowel in börek [pastry] → borek and a consonant in çilek [strawberry] → cilek. For the purposes of the present Turkish experiments, the dotted–dotless i contrast is a diacritic contrast, although this may be less intuitive for readers of orthographies in which the dot on lowercase i is not contrastive. In all cases, omitting the diacritic produced a pseudoword rather than another existing Turkish word.

For each item, two counterbalanced versions were created: an intact form containing the original diacritic (e.g., güvercin [pigeon]) and the item with the diacritic omitted (e.g., guvercin). Two lists were constructed so that each item appeared in its intact form in one list and its manipulated form in the other; within each list, half of the items were intact, and half had an omitted diacritic. Each participant was assigned to either List 1 or List 2 and saw only one version of any given item. Within each combination of semantic category and letter type, half of the items were assigned to each condition. The list of materials is available at https://osf.io/bmezh.

Procedure

The experiment was designed using PsychoPy 3 software (Peirce & MacAskill, 2018) and conducted online via Pavlovia (www.pavlovia.org). Before starting the experiment, participants completed a LimeSurvey questionnaire that collected demographic information, including age, gender, and education level. Participants were instructed to perform the experiment in a quiet room without distractions.

Prior to the main experiment, participants completed 18 practice trials to familiarize themselves with the task. During this practice phase, feedback was provided after each response, indicating whether the answer was correct, incorrect, or too slow. The main task was a semantic classification task in which participants decided whether the word presented on the screen was an animal name. Participants pressed the M key to respond "yes" if the word was an animal word and the Z key to respond "no" if it was not. They were instructed to respond as quickly and accurately as possible. Participants were informed that some stimuli could contain an omitted diacritic (or added diacritic, in Experiment 2) and were instructed to base their response on the intended word, regardless of the diacritic manipulation. Each trial began with a brief blank screen, after which the stimulus appeared and remained on the screen until a response was made or until 2000 ms had elapsed. A short break was provided after every 60 trials. The entire experiment lasted approximately 10 min.

Data analysis

Response times (RTs) and accuracy data were analyzed with Bayesian mixed-effects models using the *brms* (version 2.23.0) package (see Bürkner, 2017) in R (R Core Team, 2026). The models included fixed effects of diacritic congruency (omitted vs. intact, coded as −0.5 and 0.5), letter type (consonant vs. vowel, coded as −0.6 and 0.4), and category (animal vs. non-animal, coded as −2/3 and 1/3) using weighted effect coding to account for unequal numbers of items in each condition, as well as all interactions, with the maximal random-effect structure allowed by the design (Barr et al., 2013): (1 + diacritic * letter_type * category | subject) + (1 + diacritic | item). Semantic category was included to account for baseline differences between animal and non-animal responses and to test whether the diacritic effect varied by response category (see Labusch et al. 2026a, for a similar procedure). A Gaussian distribution was used to model the RT data after applying a −1000/RT transformation, which corrected the positive skewness of the latency distribution and provided values in units of responses per second in the same direction as the raw data. A Bernoulli distribution (1 = correct, 0 = error) was used to model the accuracy data. All models were run for 5,000 iterations across four chains,

with the first 1,000 iterations per chain used as warm-up and excluded from the final analyses. We used the default priors implemented in the *brms* package (Bürkner, 2017). We retained these defaults rather than specifying informative priors because previous estimates were obtained with different orthographies and/or diacritic manipulations; moreover, prior-sensitivity analyses in related work yielded essentially unchanged posterior estimates (see Labusch et al. 2026a). Effects were interpreted as credible when the 95% credible interval of the posterior distribution did not include zero.

Results and discussion

Responses faster than 250 ms and incorrect responses were excluded from the RT analyses; the response deadline was 2000 ms—no response by that time was automatically categorized as an error. Descriptives (means and standard deviations) for RTs and error rates for animal and non-animal words as a function of diacritic congruency (intact vs. omitted) and letter type (consonant vs. vowel) are reported in Table 1. Convergence was achieved for both reaction time and accuracy models, with all parameters yielding $\hat{R}$ values of 1.00.

Latency data Response times were comparable across letter types (713 ms vs. 713 ms for consonants and vowels, respectively; b = -0.00, SE = 0.02, 95% CrI [-0.04, 0.03]) and categories (716 ms vs 712 ms for animal and non-animal conditions, respectively; b = -0.03, SE = 0.02, 95% CrI [-0.06, 0.01]). More importantly, we found longer response times for words with omitted diacritics (720 ms) than for intact words (705 ms), b = -0.03, SE = 0.01, 95% CrI [-0.04, -0.02]. In addition, we found a diacritic congruency × category interaction (b = -0.03, SE = 0.01, 95% CrI [-0.05, -0.00]), which revealed that the omission cost occurred for non-animal words but not for animal words (see Table 1). We found no evidence of other interactions (diacritic congruency × letter type; b = -0.01, SE = 0.01, 95% CrI [-0.03, 0.02]; letter type × category, b = -0.01, SE = 0.04, 95% CrI [-0.09, 0.06]; and three-way interaction, b = -0.00, SE = 0.03, 95% CrI [-0.05, 0.05]).

Table 1 Mean response times (in ms) and error rates (in percentages) for non-animal and animal words in the experimental conditions (Experiment 1). Standard deviations are shown in parentheses

	Intact		Omitted Diacritic	
	Response time	% Errors	Response time	% Errors
Consonants				
Non-Animal	703 (214)	1.6 (0.13)	722 (225)	2.1 (0.14)
Animal	715 (215)	8.4 (0.28)	712 (198)	10.4 (0.31)
Vowel				
Non-Animal	700 (220)	2.2 (0.13)	722 (229)	2.1 (0.14)
Animal	716 (220)	9.0 (0.29)	720 (216)	9.2 (0.29)

Standard deviations are in parentheses

Accuracy data Error rates were higher for animal than for non-animal words (animal: 9.2% vs. non-animal: 2.0%), b = 1.70, SE = 0.18, 95% CrI [1.35, 2.04]. Error rates were comparable across diacritic congruency conditions (omitted: 4.6% vs. intact: 4.3%; b = 0.09, SE = 0.14, 95% CrI [-0.19, 0.37]) and letter types (consonant: 4.4% vs. vowel: 4.5%; b = -0.11, SE = 0.18, 95% CrI [-0.47, 0.25]). We did not find evidence of two-way or three-way interactions: diacritic congruency × letter type (b = -0.33, SE = 0.25, 95% CrI [-0.82, 0.16]), diacritic congruency × category (b = -0.07, SE = 0.22, 95% CrI [-0.49, 0.37]), letter type × category (b = -0.19, SE = 0.35, 95% CrI [-0.88, 0.52]), the three-way interaction (b = -0.14, SE = 0.43, 95% CrI [-0.97, 0.70]).

The present experiment showed slower response times for Turkish words with omitted diacritics than for intact words, extending findings reported in German and Finnish (Labusch et al. 2026a) for vowel diacritics. Critically, we found no evidence that the omission cost in response times differed between vowel and consonant diacritics. In addition, error rates were comparable for words in their intact form and words with omitted diacritics, suggesting that participants were able to reconstruct the correct words.

An unexpected finding was that the cost of omitting diacritics was present for non-animal words but absent for animal words. One potential, admittedly post hoc, explanation is that participants can reach affirmative ("yes") decisions with somewhat greater tolerance for the missing diacritic, whereas negative ("no") decisions require more thorough semantic verification (see Forster & Shen, 1996, for a similar reasoning). For example, an animal word presented without its diacritic (güvercin [pigeon] → guvercin) may still be recognized as an animal. A similar, albeit smaller, reduction in mismatch costs for animal words was reported in German by Labusch et al. (2026a).

In Experiment 2, we compared word recognition for intact words and words with an added diacritical mark on consonants and vowels.

Experiment 2

Method

Participants

We recruited an additional sample of 60 native Turkish speakers using the same recruitment procedure as in Experiment 1 (M_{age} = 24.9 years, SD = 4.4 years, 42 women).

Materials

Experiment 2 included a new set of 192 Turkish words, consisting of 64 animal words and 128 non-animal words. The stimulus set was constructed following the same selection principles as in Experiment 1. All words were selected from the TS Corpus database (Sezer, 2017), and non-animal items with semantic associations to animals were excluded. Among the animal words, 32 corresponded to vowel-diacritic words and 32 corresponded to consonant-diacritic words; among non-animal words, 64 corresponded to vowel-diacritic words and 64 corresponded to consonant-diacritic words. As in Experiment 1, the individual diacritic pairs were not equally represented, reflecting the availability of suitable items meeting the selection criteria.

Among animal words, vowel-diacritic items had a mean word length of 6.13 letters and a mean lexical frequency of 77.38, whereas consonant-diacritic animal items had a mean word length of 6.81 letters and a mean lexical frequency of 35.39. For non-animal words, vowel-diacritic items had a mean word length of 6.13 letters and a mean frequency of 64.25, while consonant-diacritic non-animal items had a mean word length of 6.81 letters and a mean frequency of 41.06. Word length and lexical frequency did not differ between animal and non-animal items within either letter-type condition (all *p*s > 0.24).

As in Experiment 1, the position of the orthographic manipulation was controlled across syllable positions. For vowel-diacritic animal items, the mean position of diacritic addition was 3.47, while for vowel-diacritic non-animal items it was 3.22. For consonant-diacritic items, the mean position of diacritic addition was 3.72 for animal words and 3.09 for non-animal words. The manipulation position did not differ between animal and non-animal categories within either letter-type condition (all *p*s > 0.24).

For vowel-diacritic items, diacritics were added to base vowels (e.g., uçurtma [kite] → üçurtma), and for consonant-diacritic items, diacritics were added to base consonants (e.g., zincir [chain] → zinçir). In all cases, only one diacritic was added per word, and all other letters remained identical. Thus, the two versions of each item differed only in the presence versus absence of the added diacritic; word length and the identities and positions of all other letters remained unchanged. In all cases, adding the diacritic produced a pseudoword rather than another existing Turkish word. As in Experiment 1, we created two counterbalanced lists. For each item, the intact version appeared in one list and the diacritic-added version in the other; thus, each list contained 96 intact and 96 diacritic-added items, and each participant saw only one version of any given item. The full list of stimuli is provided on OSF (https://osf.io/bmezh).

Procedure

The procedure was the same as in Experiment 1.

Data analysis

The data analysis followed the same procedure as in Experiment 1, with one exception: the contrast coding for letter type was adjusted to reflect the equal ratio of vowel and consonant diacritic items (coded as 0.5 and −0.5, respectively).

Results and discussion

As in Experiment 1, responses faster than 250 ms and incorrect responses were excluded from the RT analyses. Descriptives for RTs and error rates for animal and non-animal words as a function of diacritic congruency (intact vs. added) and letter type (consonant vs. vowel) are reported in Table 2. Both the RT and accuracy models converged adequately (all $\hat{R}$ values were 1.00).

Latency data The analysis showed longer response times for words with added diacritics than for intact words (723 ms vs. 682 ms, respectively), b = -0.08, SE = 0.01, 95% CrI [-0.10, -0.06]. As in Experiment 1, response times were comparable across letter types (706 ms vs 699 ms for consonants and vowels respectively; *b* = -0.01, SE = 0.02, 95% CrI [-0.04, 0.02]) and categories (698 ms vs 705 ms for animal and non-animal words, respectively; *b* = -0.01, SE = 0.02, 95% CrI [-0.05, 0.03]). We found no evidence for any of the interactions (diacritic congruency × letter type, *b* = 0.01, SE = 0.01, 95% CrI [-0.02, 0.03]; diacritic congruency × category, *b* = 0.00, SE = 0.01, 95% CrI [-0.02, 0.03]; letter type × category, *b* = 0.02, SE = 0.03, 95% CrI [-0.05, 0.09]; three-way interaction, *b* = -0.02, SE = 0.03, 95% CrI [-0.08, 0.04]).

Table 2 Mean response times (in ms) and error rates (in percentages) for non-animal and animal words in the experimental conditions (Experiment 2). Standard deviations are shown in parentheses

	Intact		Added Diacritic	
	Response time	% Errors	Response time	% Errors
Consonant set				
Non-Animal	688 (206)	3.6 (0.19)	724 (219)	2.7 (0.16)
Animal	679 (180)	7.2 (0.26)	732 (217)	8.6 (0.28)
Vowel set				
Non-Animal	683 (203)	2.3 (0.15)	725 (215)	3.5 (0.18)
Animal	671 (166)	5.4 (0.23)	711 (193)	7.0 (0.25)

Standard deviations are in parentheses

Accuracy data Error rates were higher for animal than for non-animal words (animal: 7.1% vs. non-animal: 3.0%, b = 1.02, SE = 0.18, 95% CrI [0.67, 1.38]). As in Experiment 1, error rates were comparable across diacritic congruency conditions (added: 4.7% vs. intact: 4.1%; b = 0.13, SE = 0.13, 95% CrI [-0.13, 0.38]) and letter types (consonant: 4.8% vs. vowel: 4.0%; b = 0.18, SE = 0.17, 95% CrI [-0.14, 0.52]). Unlike Experiment 1, there was evidence of a diacritic congruency × letter type interaction (b = 0.49, SE = 0.24, 95% CrI [0.01, 0.96]), reflecting a small increase in error rates following diacritic addition for vowels (1.28%) and a minimal decrease for consonants (0.14%). We found no evidence for the remaining interactions: diacritic congruency × category (b = -0.26, SE = 0.22, 95% CrI [-0.69, 0.18]), letter type × category (b = -0.06, SE = 0.35, 95% CrI [-0.74, 0.64]), and the three-way interaction (b = 0.56, SE = 0.46, 95% CrI [-0.35, 1.47]).

The results of the present experiment showed substantially longer response times for words with added diacritics than for intact words—similar to the German and Finnish experiments conducted by Labusch et al. (2026a). To test whether the magnitude of the cost for adding diacritics (present experiment) was greater than for omitting diacritics (Experiment 1), we conducted a combined analysis of both experiments, adding Experiment as a factor. The experiment × diacritic congruency interaction was credible (b=0.05, SE=0.01, 95% CrI [0.03, 0.07]), indicating a greater cost for adding than for omitting diacritics, and extending to Turkish the findings of Labusch et al. (2026a)—the full output is on OSF.

As in Experiment 1, we found no evidence that the addition cost in response times differed between vowel and consonant diacritics. While we found some evidence for a congruency × letter type interaction in the error data, the effect was very small (approximately 1.4% in the difference between the addition effects for vowels and consonants), and we prefer to interpret it with caution.

The RT distributions for both experiments, separately by diacritic congruency and letter type, are shown in Fig. 1.

General discussion

We designed two semantic categorization experiments to examine whether omitting or adding a diacritical mark produces a processing cost during word recognition in Turkish, an orthography in which diacritical and non-diacritical forms function as distinct letters (consonants, e.g., c /d͡ʒ/ vs.

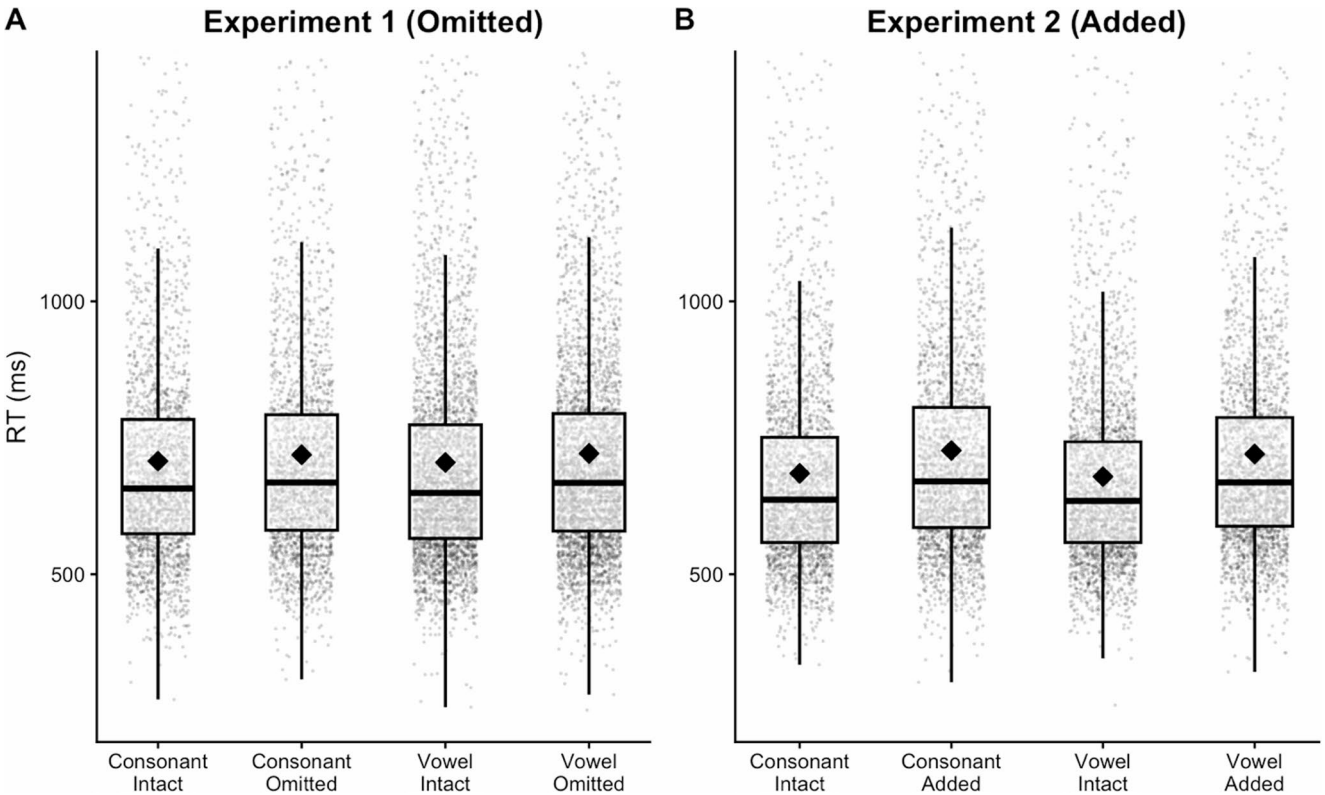


Fig. 1 Response-time (RT) distributions for intact and diacritic-mismatching words as a function of letter type in Experiment 1 (diacritic omission; Panel A) and Experiment 2 (diacritic addition; Panel B). Gray points represent individual correct RT observations included in the analyses; boxplots show the median and interquartile range, and black diamonds indicate condition means. Data are collapsed across semantic category

ç /t͡ʃ/; vowels, e.g., o /o/ vs. ö /ø/; see Appendix A), and, more critically, whether these effects are modulated by the vowel–consonant status of the affected letter. The main findings were straightforward. First, response times were longer for words with omitted or added diacritics than for intact words, showing that Turkish readers are sensitive to the presence or absence of diacritics during lexical access. Second, the cost was higher when diacritics were added than when they were omitted, a pattern consistent with findings for German and Finnish reported by Labusch et al. (2026a). Third, and most important for the present purposes, we found no evidence in the latency data that the mismatch cost differed according to whether the altered letter was a vowel or a consonant.

The presence of a cost in the response times for mismatched diacritical words (i.e., words with an omitted diacritical mark in Experiment 1; words with an added diacritical mark in Experiment 2), with little evidence of an overall congruency cost in accuracy, suggests that Turkish readers were generally able to access the intended lexical representations despite the mismatched diacritical input—note that diacritical and non-diacritical counterparts are visually very similar. In addition, as in previous research, we found an asymmetry between the costs of the omission versus addition of diacritics (see Labusch et al. 2026a, for discussion). The greater cost of adding than omitting diacritics is consistent with the idea that added features may provide positive evidence for an incorrect letter identity, whereas missing features leave a degraded but partially compatible input (see Kinoshita et al., 2021; Rey et al., 2009). Notably, a similar addition–omission asymmetry is not restricted to diacritical letters; recently, it has been reported with Serbian Cyrillic letters that differ by an integrated visual feature (e.g., л vs. љ, see Solaja & Perea, 2026). The smaller cost of omitted diacritics may also reflect Turkish readers' frequent exposure to diacritic-degraded text, for example, through devices or keyboards that do not render Turkish characters (Özer et al., 2018; see also Mifsud & Mitterer, 2020). A secondary observation from Experiment 1 was an interaction between diacritic congruency and semantic category, with the omission cost appearing only for non-animal items. Given that there were no signs of a parallel interaction in Experiment 2 and it did not alter the primary pattern of results on consonant-vowel differences, we refrain from speculating about its source.

Thus, our data extend Labusch et al. (2026a) findings in German and Finnish to Turkish. This pattern differs from that observed in Spanish, where diacritics primarily indicate the stressed syllable and the addition or omission of diacritics produces little disruption (Labusch et al., 2023; Perea et al., 2022), and from French, where omission effects are relatively small whereas addition effects are more substantial (Labusch et al., 2023). Overall, the Turkish pattern is consistent with diacritical and non-diacritical letters being represented as distinct letter identities, in line with their treatment as distinct units in literacy instruction, dictionaries, and the official alphabet (Çapan, 1989; Kornfilt, 1997).

A large body of research has shown that consonants and vowels do not play equivalent roles in visual word recognition, with consonants typically providing stronger constraints on lexical access than vowels (New et al., 2008; Carreiras et al., 2009; Duñabeitia & Carreiras, 2011). If the effects with diacritical letters were mainly driven by the lexical informativeness of the affected letter, then altering a consonant by omitting or adding a diacritic should have produced larger costs than altering a vowel. However, this prediction was not supported.

This finding constrains accounts of the orthographic front-end in models of visual word recognition. The absence of a vowel–consonant modulation in the latency data is consistent with an account in which a substantial component of the diacritic-mismatch effect arises during visual feature-to-letter identity mapping, at an early stage at which the potential lexical constraint associated with consonants and vowels has not yet exerted a measurable influence. Importantly, however, the present data do not exclude contributions from later lexical processes. One possible source of variation across individual diacritic pairs is functional load—that is, the extent to which a particular phonological contrast distinguishes words in a language (e.g., as indexed by the number of minimal pairs it distinguishes; Pellegrino et al., 2012; Wedel et al., 2013).

Overall, our findings can potentially be captured by interactive models of visual word recognition in which visual features activate letter representations, which in turn activate lexical representations, with competition operating at both letter and word levels (McClelland & Rumelhart, 1981; Grainger et al., 2008; Rey et al., 2009). On this view, and assuming that diacritical features are represented at the feature level and diacritical letters at the letter level, adding a diacritic to a base letter provides evidence for an incorrect diacritical-letter unit, whereas omitting a diacritic reduces the evidence for the correct diacritical-letter unit and increases support for a visually similar base-letter unit. This logic applies similarly to consonant pairs (e.g., s–ş) and vowel pairs (e.g., o–ö), and is compatible with evidence from prelexical matching tasks showing no consonant–vowel modulation at early stages of orthographic processing (see Perea & Acha, 2009, for discussion). On this account, diacritical marks in Turkish appear to constrain letter-identity encoding in much the same way for vowels and consonants.

The present findings also help to clarify the relation to the earlier Turkish repetition blindness study of Ayçiçeği and Harris (2002). In that study, Turkish word pairs differing only by a diacritic produced repetition blindness comparable to that of identical repetitions, suggesting that diacritical and non-diacritical letters may behave similarly at the early stages

of orthographic processing. The present findings qualify that conclusion. That is, an early-stage tolerance to diacritic variations does not imply a similar degree of tolerance during lexical access. Repetition blindness is sensitive to rapidly extracted orthographic codes under severe temporal constraints, whereas semantic categorization requires access to word meaning from a single presented stimulus. Early insensitivity to diacritics may reflect the nature of the task and the processing stage it taps, rather than the absence of diacritic-specific orthographic representations. Indeed, in the masked priming technique, diacritical target words can be primed equally well by identity primes and by primes in which one of the diacritics is omitted, and this occurs for both vowel diacritics (see Benyhe et al., 2023) and consonant diacritics (e.g., muneca is as effective as muñeca for the Spanish target word MUÑECA [doll], see Marcet et al., 2020).

Finally, the present experiments measured diacritic processing at the level of lexical-semantic access. A lexical decision task using diacritic substitutions could provide a complementary test by assessing whether consonant and vowel mismatches differentially affect nonword responses. Another useful comparison would be between diacritic mismatches and visually similar letter substitutions, which could help determine whether tolerance for diacritic mismatches reflects visual similarity or a more specific relation between diacritical and non-diacritical letter forms (Rayner & Kaiser, 1975; Rodd, 2004). Moreover, masked priming or parafoveal preview experiments would be useful for determining whether vowel and consonant diacritics are treated similarly during earlier stages of orthographic encoding. A further limitation is that response times may fail to capture transient earlier interactions with consonant–vowel status that are no longer detectable at the time of the response; event-related potentials could provide a more temporally sensitive test of this possibility (e.g., see Chauncey et al., 2008; Vergara-Martínez et al., 2015).

In sum, in two semantic categorization experiments, both omission and addition of diacritical marks slowed lexical-semantic access in Turkish, suggesting that Turkish readers do not simply treat diacritical letters as variants of their base-letter counterparts. Most importantly, the mismatch cost in response times was comparable for vowel and consonant diacritics, consistent with the view that, in the present task, diacritic mismatch costs are largely independent of vowel–consonant status. Whether this comparable processing of vowel and consonant diacritics extends to orthographies with less balanced or functionally mixed diacritic systems remains an open empirical question. More generally, computational models of visual word recognition in orthographies where the presence of a diacritic changes letter identity should specify how diacritical features are mapped onto abstract letter representations, rather than simply assuming separate letter units.

Appendix A

Table 3 Turkish diacritical letter pairs and their phonological correspondences

Pair	IPA correspondence	Main phonological characterization
ı–i	/ɯ/ vs. /i/	backness (back vs. front, both unrounded)
o–ö	/o/ vs. /ø/	backness (back vs. front, both rounded)
u–ü	/u/ vs. /y/	backness (back vs. front, both rounded)
c–ç	/d͡ʒ/ vs. /t͡ʃ/	voicing (voiced vs. voiceless, both palato-alveolar affricates)
s–ş	/s/ vs. /ʃ/	place (alveolar vs. palato-alveolar, both voiceless fricatives)
g–ğ	/g/ vs. context-dependent realization	contrast with /g/; realization of ⟨ğ⟩ is context-dependent

IPA correspondences and phonological characterizations are based on Özçelik (2024). The phonetic realization of ⟨ğ⟩ is context- and dialect-dependent in modern Turkish

Author contributions All authors contributed to the study's conception and design. Material preparation was performed by A.E. Data collection was performed by A.E. and M.L. Statistical analyses were performed by Z.Ö. and M.P. The first draft of the manuscript was written by A.E. and Z.Ö. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. The order of the first two authors is alphabetical (joint first authors).

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Data availability Data availability statement. All data, materials, and code used for all analyses are available on OSF: https://osf.io/bmezh.

Declarations

Competing interests 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. # 2024-PSILOG-366319) and complied with the Declaration of Helsinki. The participants provided written informed consent before starting the experiments.

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