Letter-similarity effects in braille word recognition

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Abstract

Letter-similarity effects are elusive with common words in lexical decision experiments: *viotin* and *viocin* (base word: *violin*) produce similar error rates and rejection latencies. However, they are robust for stimuli often presented with the same appearance (e.g., misspelled logotypes such as *anazon* [base word: *amazon*] produce more errors and longer latencies than *atazon*). Here, we examine whether letter-similarity effects occur in reading braille. The rationale is that braille is a writing system in which the sensory information is processed in qualitatively different ways than in visual reading: the form of the word's letters is highly stable due to the standardization of braille and the sensing of characters is transient and somewhat serial. Hence, we hypothesized that the letter similarity effect would be sizeable with misspelled common words in braille, unlike the visual modality. To test this hypothesis, we conducted a lexical decision experiment with blind adult braille readers. Pseudowords were created by replacing one letter of a word with a tactually-similar or dissimilar letter in braille following a tactile similarity matrix (Baciero et al., 2021a; e.g., ⠁⠥⠎⠕⠗[ausor] vs. ⠁⠥⠉⠕⠗ [aucor]; baseword: ⠁⠥⠞⠕⠗ [autor]). Bayesian linear mixed-effects models showed that the responses to tactually-similar pseudowords were less accurate than to tactually-dissimilar pseudowords—the RTs showed a parallel trend. This finding supports the idea that, when reading braille, the mapping of input information onto abstract letter representations is done through a noisy channel (Norris & Kinoshita, 2012).

Keywords: word recognition, orthographic processing, braille, reading

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The act of reading requires multiple cognitive processes that range from sensory to strategic. One of the first steps when recognizing a word is encoding the identity and position of its constituent letters, which is termed *orthographic processing* and is the bridge between perceptual and linguistic processes (see Grainger, 2018). Although most research on word recognition has focused on reading through sight (see Verhoeven & Perfetti, 2021, for a cross-linguistic perspective), it is also possible to read through touch using the braille writing system. The present paper examines the process of letter identity coding in reading by testing if the encoding of letter identities is affected by tactile letter similarity (see Baciero et al., 2022, for a recent examination of letter position coding in braille). Before diving into our study, we first describe theoretical and empirical work on letter identity coding during visual-word recognition. Then, we describe the braille system and why it presents a crucial test case for the generalizability of letter and word processing theories.

Orthographic Processing in Visual Format

Visually presented words are often presented in different fonts, sizes, colors, letter-CaSe, or distortions; yet, these words can be readily identified (e.g., see Hannagan et al., 2012, for evidence with CAPTCHAs). The robustness of visual-word recognition to sensory changes has been taken to suggest that lexical access is driven by the abstract representations of the word's constituent letters (a = a = A = *a*). Evidence for the abstract letter representation assumption comes from early masked priming studies (e.g., Jacobs et al., 1995; see also Bowers et al., 1998): word identification times to the uppercase word *ARTE* are as fast when briefly preceded by the identity prime *ARTE* (i.e., nominally and visually identical to the prime) than by the lowercase identity prime *arte* (i.e., nominally identical but visually different to the prime; see Dehaene et al., 2004, for neuroimaging evidence, and Vergara-Martínez et al., 2015, for electrophysiological evidence). These abstract letter representations are so crucial to reading that they develop early in the development of literacy, as shown by Gomez and Perea (2020) with second-grade readers. Leading models of visual-word recognition assume a hierarchical process where the sensory input is first mapped onto a set of letter features, such as horizontal lines or curves (see Dehaene et al., 2005; Grainger et al., 2008). Subsequently, letter features detectors are mapped onto abstract letter detectors that are insensitive to physical characteristics such as size, format, color, or case (e.g., the detector of the letter **T** would activate similarly for the images "T", "t", or "**t**"). These arrays of abstract letter detectors are understood to drive the process of lexical access. Critically, these models assume that abstract letter identities are equally confusable with each other. Consistent with this tenet, prior lexical decision studies have shown that both accuracy and response times to pseudowords created by replacing a single letter from a baseword are remarkably alike regardless of whether the replacement involves a similar letter (e.g., *viotin* [baseword: violin]) or a different letter (e.g., *viocin*) in both skilled readers and developing readers (Perea & Panadero, 2014; see also Perea et al., 2022, and Gutierrez-Sigut et al., 2022, for converging behavioral and electrophysiological evidence, respectively). Clearly, if visual, non-abstract elements had played a relevant role during word recognition, it would have been more difficult to reject *viotin* as a word than *viocin*.

Notably, the centrality of abstract letter representations during word recognition in the visual modality does not exclude the possibility of some perceptual noise when initially encoding letter identities. Indeed, there is some evidence of visual similarity effects in the first processing stages. Using Forster and Davis' (1984) masked priming technique, Marcet and Perea (2017, 2018) found that, for the target word *OBJECT*, the visually similar prime *obiect* is nearly as effective as the identity prime *object* and more effective than its control *obaect* (see Perea, Hyönä, & Marcet, 2022, for converging evidence in Finnish). To examine the time-course of this visual-letter similarity effect, Gutierrez-Sigut et al.

(2019) replicated the Marcet and Perea (2017) experiments by recording the participants' event-related potentials (ERPs). They found that, in a time window usually associated with the initial contact with the abstract representations (N250; Grainger & Holcomb, 2008), the ERP responses were very similar for *object-OBJECT* and *obiect-OBJECT*; in contrast, *obaect-OBJECT* produced larger amplitudes. Only at a later time window commonly associated with lexical-semantic access (N400), the waves evoked by *object-OBJECT* differed from those evoked by the visually similar pair *obiect-OBJECT*. These findings suggest that, in the visual modality, there is some noise associated with letter identity in the initial stages of letter/word recognition that is ultimately resolved (see Kinoshita et al., 2021).

Of particular relevance to the present study work, it has been suggested that the wide variability of visual forms in both handwritten and printed letters aids the emergence of and rapid access to abstract representations of letters during visual word recognition (Li & James, 2016; see also Hannagan et al., 2012). Notably, previous research has shown that skilled readers may show sizeable visual-similarity effects for printed stimuli that lack variability in a format such as logos. Pathak et al. (2019) found that misspelled logotypes like *anazon* (original logo: *amazon*) produced more errors and longer latencies than misspelled logotypes like *atazon*—note that *n* is more visually similar than *t* to the *m* in a*m*azon. Perea et al. (2022) replicated this finding using another set of logotypes; critically, they found no evidence of a letter-similarity effect in parallel experiments with misspelled common words (e.g., *amarillo* [yellow in Spanish]; *anarillo* = *atarillo*). They argued that logos, being typically presented in a single typeface and design, were more susceptible to the effects of perceptual factors than common words.

Braille Reading

While most studies on orthographic processing have relied on the visual presentation of letters and words, it is also possible to read through the sense of touch. As shown below, braille presents some unique characteristics that allow us to better understand the nature of reading in general. To our knowledge, no studies have yet examined the effects of letter similarity in braille word recognition.

Each character in braille is represented in a 2x3 cell (①④ ②⑤ ③⑥), where a total of 64 combinations of raised dots can be configured. Given the constraints imposed by this finite number of configurations, braille letters have a much lower redundancy than printed letters because a single dot's elevation, or not, is sufficient to create another letter (see Millar, 1997; Tobin & Hill, 2015).

To read braille, individuals scan the text from left to right using their fingertips; thus, unlike visual reading, where the sensory process occurs when the eyes fixate on a word, the sensory process in tactile reading occurs during movement (see Millar, 2003). This makes the sensory information in braille somewhat transient due to the seriality of letter processing induced by the finger motion: a given letter ceases to be available once the participant's fingertip(s) moves to the following letter. Notably, the study of word recognition and reading in braille serves as a benchmark for modality-dependent vs. modality-independent processes during lexical access (see Fischer-Baum & Englebretson, 2016). Both braille and visual alphabetic systems are forms of written communication and are bound to have some similarities in processing and neural correlates (see Hannagan et al., 2015; Reich et al., 2012, for evidence of activation in the sometimes-called visual word form area, and Kim et al., 2017, and Tian et al., 2021, for more recent accounts). At the same time, the differences between sensory modalities and the characteristics of braille letters are likely to shape the cognitive processes underlying reading (e.g., see Baciero et al., 2022).

Unlike letters in visually presented words, braille letters are subject to strict norms, and hence they are highly consistent across contexts (e.g., braille displays, thick stock paper, elevators). (Footnote

1) Moreover, unlike the Latin script, there are no separate characters for upper-case letters in braille (i.e., a code is presented before letters/words to indicate upper case; e.g., A = ⠠⠁). (Footnote 2). Thus, the sensory input from braille letters is much less variable than from visually-presented words.

Is There a Letter Similarity Effect in Braille?

To summarize, we have identified three differences between visual and braille reading that we suggest are most relevant for this research:

1. *Structural constraint difference.* Given the limitation imposed by the 2x3 grid, the elevation, or not, of a single dot is sufficient to create a different letter. Hence, braille letters are less redundant than printed letters.

2. *Variability difference*. Given the structural constraint and the regulation and norms in braille characters, the braille writing system lacks the variability in font, case, and format present in visual reading. Therefore, braille letters are more consistent across contexts than printed letters.

3. *Perceptual difference.* Given the finger(s) motion needed to read braille, it is more transient and serial than visually presented stimuli.

The issue at stake in the present work is whether these differences make braille readers uniquely sensitive to letter similarity effects. We can envision two possible outcomes: The first one is that due to the structural constraint, skilled braille readers become highly efficient at encoding the word's abstract letter identities. In this scenario, proficient braille readers would show a null or negligible sensitivity to letter similarity. The second scenario is that braille readers may be more susceptible to noise during the encoding of letter identities given the variability and perceptual differences outlined above and, as a result, braille readers would show letter similarity effects. Hence, we believe that if the structural constraint difference dominates, we would find a small to negligible letter similarity effect; conversely, if the variability and perceptual differences dominate, we would see a sizable letter similarity effect.

Overview of the Experiment

We designed a lexical decision experiment to test whether letter-similarity effects are present in braille word recognition. As is common in the literature on the visual modality, the focus of our analysis was on the pseudowords. These pseudowords were created by replacing one letter from a baseword, either with a tactually similar or a tactually dissimilar letter. For instance, from the baseword: ⠁⠥⠞⠕⠗ [autor; author in Spanish], we created a tactually-similar pseudoword (⠁⠥⠎⠕⠗ [ausor]) and a tactually-dissimilar pseudoword (e.g.,⠁⠥⠉⠕⠗ [aucor]; *s* is more similar to *t* than *c* in a braille similarity matrix; Baciero et al., 2021a). The critical question here is whether the tactually-similar pseudowords make the *no* decision more difficult in a lexical decision than the tactually-dissimilar pseudowords. This "interference" manipulation has proved to be a valuable paradigm both in the visual modality (e.g., Mirault & Grainger, 2021; Pathak et al., 2019; Perea & Lupker, 2004; Perea & Panadero, 2014) and in the tactile modality (e.g., Perea et al., 2012, for letter position coding).

In sum, if there is some confusability due to letter similarity during tactile word recognition, a tactually-similar pseudoword like ⠁⠥⠎⠕⠗ [ausor] would be more perceptually similar to its baseword ⠁⠥⠞⠕⠗ [autor] than a tactually-dissimilar pseudoword like ⠁⠥⠉⠕⠗ [aucor]. In this scenario, one would expect worse performance in a lexical decision (i.e., lower accuracy or longer response times) for tactually-similar than tactually-dissimilar pseudowords.

Method

This study was pre-registered on the OSF before data collection (https://osf.io/329cn/).

Participants

With the help of the National Organization of Spanish Blind People, we recruited twelve participants that were diagnosed with either blindness (8) or severe visual impairment (4) at birth (5 male; M = 39.83 y.o.; range: 19-58). They were all native Spanish speakers and braille readers from childhood (5–6 y.o.). 2 participants had finished high school, 3 were undergraduate students, 5 had completed a university degree, and 2 had completed a post-graduate degree. All participants gave informed consent before participating in the study and received an incentive for participating (7.5€). We used a Sequential Bayes Factor Design (Schonbrodt & Wagenmakers, 2018) to determine the number of participants, as established in the pre-registration form. Specifically, we computed the Bayes Factor for the critical effect (i.e., similar vs. dissimilar pseudowords) after the first twelve participants via a paired Bayesian t-test (with default priors) by subjects using the BayesFactor package (Morey & Rouder, 2014) in R (R Core Team, 2021). Bayes Factors (BFs) exceeded 3 (i.e., the criterion in the pre-registration) for accuracy (BF_{10} = 366.01); hence, sampling stopped at n = 12. For response times, the general pattern was the same as in accuracy, but the BF did not exceed such criterion—note that response times in braille reading are long and highly variable (Bertelson et al., 1992).

Materials

We selected 120 Spanish words from the EsPal database (Duchon et al., 2013) to act as base words (mean length: 6.74 letters [range: 5-8]; mean frequency: 75.23 per million [range: 10.15–727.42]). We used the Baciero et al. (2021a) tactile letter similarity matrix to generate two pseudowords by replacing one internal letter. (Footnote 3) The replacement letter could be either *tactually-similar* (TS) or *tactually-dissimilar* (TD) to the original letter (see Table 1). The pseudowords had no orthographic neighbor (substituted-letter neighbor) other than their corresponding basewords. We created two counterbalanced lists so that if a *similar* pseudoword was presented in List 1, its corresponding *dissimilar* pseudoword would be presented in List 2. Each list was composed of 120 pseudowords (60 TS and 60 TD). We also selected a separate set of 120 words that were unchanged to act as the positive items experiment (mean length: 6.74 letters [range: 5-8]; mean frequency: 74.07 per million [range: 10.42–585.02]). All items are presented in Appendix A.

Table 1. Example of pseudoword stimuli

Condition	Pseudoword	Base word [in English]
Tactile similar [TS]	ausor ⠁⠥⠎⠕⠗	autor [author] ⠁⠥⠞⠕⠗
Tactile dissimilar [TD]	aucor ⠁⠥⠉⠕⠗	

Procedure

We used a refreshable braille display (i.e., Active Braille, Help Tech; Saladino, 2019) to present the stimuli to participants. This display was connected via USB to a MacOS, and we created a shell script both to present the stimuli on the braille display (enabling the OS-X's VoiceOver accessibility feature) and to record participant's responses.

The experiment took place in a quiet room and one participant at a time. We conducted a lexical decision task (i.e., "is the string a Spanish word?") in which we instructed participants to use the index finger of their preferred reading hand to perceive the stimuli, and to use two fingers of the other hand to make the responses by pressing one of the two possible keys on the computer's keyboard (M for "word", N for "nonword"). At the beginning of the experiment, we showed participants where their index finger had to be placed before each trial. We instructed participants to read the letter string in a continuous manner without making any regression and to be as quick and accurate as possible in their responses. The stimuli remained in the braille display until a response was made. Response times (RTs) were measured from each trial presentation onset. Inter-trial-interval was 1.3 seconds, allowing participants to reset their index finger to the start position. We included 12 practice items at the beginning of the session, and the order of target trials was randomized.

Results

Both accuracy and reaction times were collected in each trial. As established before data collection, trials in which responses were either shorter than .25 seconds or greater than 8 seconds were excluded from the analysis (0.42%). For the latency analyses, error responses (6.28%) were also excluded. Table 2 shows the mean accuracy and correct RTs per condition.

Table 2. Mean accuracy (proportion) and response times (ms) for correct and incorrect responses for each condition

Lexicality	Type	Accuracy	RT correct
Pseudoword	Tactually-Dissimilar	0.971	2836
Pseudoword	Tactually-Similar	0.897	2863
Word		0.941	2269

To examine the effect of tactile letter-similarity on the pseudowords, we conducted Bayesian linear mixed-effects models using *brms* (Bürkner, 2017) in R (R Core Team, 2021), with default priors. (Footnote 4) We employed the Bernoulli link function for the accuracy model and the ex-Gaussian link function for the RT model. Both models included similarity (*similar* [-0.5] vs. *dissimilar* [+0.5]) as a fixed factor, and all random effects allowed by the experimental design:

```
DependentVariable ~ Similarity +
                    (1+Similarity|Subject)+
                    (1+Similarity|Item)
```

Each model had four chains of 5,000 iterations (warmup = 1,000). The output provides each estimate's value, standard error, and the 95% credible interval (95% CrI) of their posterior distributions. Evidence in favor of an effect is taken when the 95% CrI does not contain zero. All the models converged, and $\hat{R}$ was 1.00 in all cases. (footnote 5)

The analyses of the accuracy showed substantially higher accuracy in the tactually-dissimilar pseudowords than in the tactually-similar pseudowords (0.971 vs. 0.897, respectively), *b* = 1.59, *SE* = .041, 95% CrI [0.86, 2.47]. RT analysis showed that responses were faster for the tactually-dissimilar pseudowords than for the tactually-similar pseudowords (2836 vs. 2863 ms, respectively); however, we did not find evidence for an effect, as the credible interval crossed zero, *b* = 50.87, *SE* = 55.53, 95% CrI [-60.48, 160.77] (see Figure 1 for a depiction of letter-similarity effects by participants).

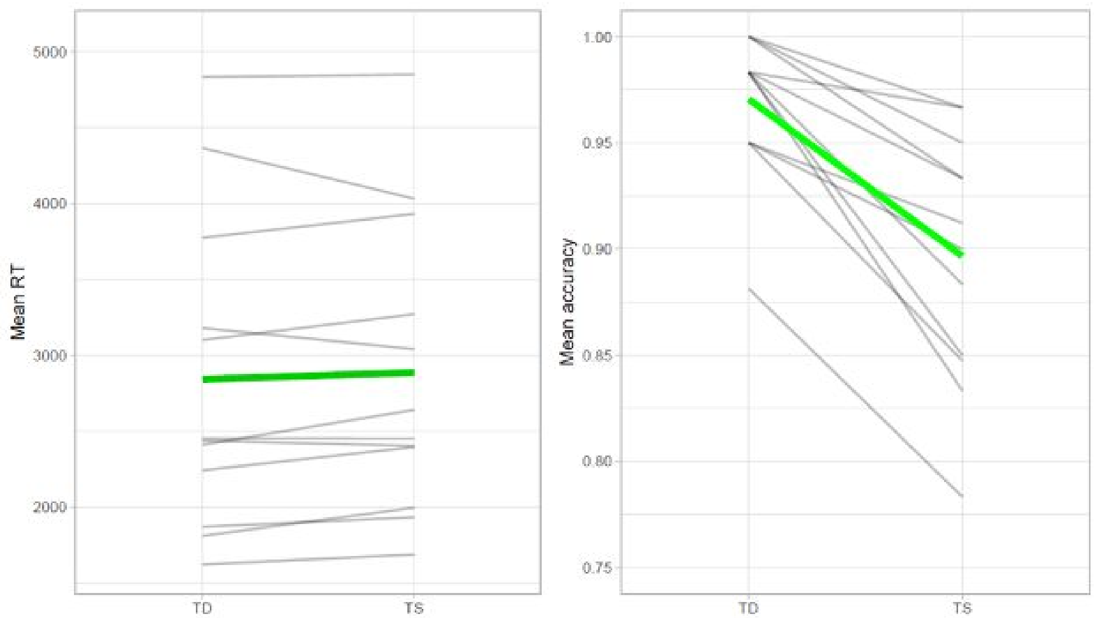

Figure 1. Mean response times in milliseconds (left) and accuracy (right) per similarity condition and subject. Each grey line links the mean of a particular subject in each of the conditions (tactually dissimilar [TD] and tactually similar [TS]). The green line represents the overall mean per condition across subjects.

Discussion

The present study examined whether letter identity coding in braille word recognition is susceptible to perceptual noise, measured by letter-similarity effects. Adult blind individuals performed a lexical decision task in which the pseudowords were created by replacing one letter of a word by either a tactually-similar letter (e.g., ⠁⠥⠎⠕⠗ [ausor], baseword: ⠁⠥⠞⠕⠗ [autor]) or a tactually-dissimilar letter (e.g., ⠁⠥⠉⠕⠗ [aucor]). Unlike previous experiments in the visual modality with misspelled common words in lexical decision, results showed higher accuracy for *dissimilar* than *similar* pseudowords (97.1% vs. 89.7%, respectively). While weaker, we found the same trend in latency data (2836ms for dissimilar vs. 2863ms for similar pseudowords; see the exploratory data analysis in the online appendix for further support of this effect). This result in the response times may be due to the fact that participants were instructed not to perform any regression, which, although common, could have increased the variability of the latency data. Nonetheless, it is worth mentioning that other studies on orthographic processing in the visual domain have also found effects rather in accuracy than in latency (e.g., transposition effects with symbols; see Duñabeitia et al., 2012; Massol et al., 2011, or in word recognition tasks with young readers; see Gómez et al., 2021). Likewise, in a recent study on letter position coding in braille using the same group of participants as the present study, Baciero et al. (2022) found a substantial transposed-letter effect in accuracy (e.g., the transposed-letter pseudoword LABOARTORIO was more error-prone than the replacement-letter pseudoword LABOESTORIO [the base word was LABORATORY, the Spanish for laboratory]), but not in response times. While response times and accuracy are two sides of the same coin, further research should examine why accuracy data may be more sensitive to experimental manipulations than latency data in some scenarios.

Our findings have relevant theoretical implications for models of word recognition. The better performance for dissimilar than similar pseudowords favors the idea that perceptual noise is an intrinsic part of letter identity coding when reading braille. A pseudoword like ⠁⠥⠉⠕⠗ [aucor] is perceptually less similar to its tactually-similar baseword ⠁⠥⠞⠕⠗ [autor] than a tactually dissimilar pseudoword like ⠁⠥⠎⠕⠗ [ausor]. If the mapping from the tactile input to the activation of abstract letter representations had been fully precise, both similar and dissimilar pseudowords would have been classified equally quickly and accurately as nonwords. This pattern rules out the idea that abstract letter representations during braille reading are achieved with great efficiency due to braille's low redundancy. Instead, our findings favor the idea of perceptual noise in letter identity encoding. This perceptual noise introduces uncertainty in the identification of the constituent letters of words, as described by the noisy-channel models (see Norris & Kinoshita, 2012 for a full model of visual orthographic processing, and

Gomez, 2008 for a model of letter position coding using the same principle). This perceptual noise would be more prominent in the tactile than in the visual modality—as indicated in the Introduction, letter similarity effects can be found in the very earliest stages of word recognition, but they resolve quickly during word processing (Gutierrez-Sigut et al., 2019).

Why would misspelled common words show a sizeable tactile letter-similarity effect in lexical decision with skilled braille readers? We believe that two differences between visual and braille reading explain this effect. First, there is a perceptual difference, as the letters of a word in braille are read one by one for a short amount of time (7.5 characters/second; Legge et al., 1999); in contrast, all the letters in visually presented words (at least for 4-7 letter strings) are available simultaneously. Thus, the processes underlying letter identity coding in braille may resemble those reported with briefly presented stimuli (see Gutierrez et al., 2019; Marcet & Perea, 2017, 2018) – note that, although there is conscious perception for braille letters, the encoding of letter identity in the tactile modality may not be resolved as quickly as in the visual modality due to the fleeting exposure to the stimuli. Second, there is a variability difference because the physical characteristics of braille letters are highly homogenous across contexts: braille letters follow standardized norms, so a word like ⠏⠁⠏⠑⠗ [paper] is always presented in that format; instead, visually presented common words can have different physical characteristics (e.g., paper = paper = PAPER). This lack of variability among braille letters may make braille reading more susceptible to the influence of perceptual factors (see Perea et al., 2022, for evidence with logos and brand names).

We attribute the letter similarity effect in braille lexical decision (which is not present in visual lexical decision experiments) to both the perceptual and the variability differences between braille and visual reading. Unfortunately, these two factors cannot be disentangled and cannot be manipulated experimentally. Along the same lines, any comparison between braille and visual reading faces the limitation that there are many differences between the decoding process reading in these two modalities. In this paper, we have identified three critical differences: structural constraint, variability, and perceptual. Of course, there are other significant differences, such as the quality of orthographic representations due to the limitations of the haptic/tactile system and the fact that there is likely to be more exposure to text for sighted vs. blind readers. To make matters more complicated, there are differences not only between the reading systems but also between the readers. Indeed, in the visual modality, readers with dyslexia and deaf readers are more sensitive to perceptual cues (e.g., more errors to *viotin* and to *viocin* [base word: *violin*] in readers with dyslexia; see Perea & Panadero, 2014; different ERP waves for *viotin* and *viocin* in deaf readers; see Gutierrez-Sigut et al., 2022) than normotypical hearing readers, presumably because of differences in the quality of the orthographic representation (see Bélanger & Rayner, 2015; Lavidor, 2011, for discussion). Nonetheless, despite the intrinsic difficulties interpreting differences between braille and sighted reading, our findings are clear: Tactually-similar pseudowords are more confusable with their basewords than tactually-dissimilar pseudowords.

In sum, our findings reinforce the view that letter identity coding has some perceptual noise, providing evidence for modality-independent, noisy-channel models of word recognition (see Kinoshita et al., 2021). Importantly, such perceptual noise seems to be modulated by 1) the specific characteristics of the stimuli (i.e., it is larger for those stimuli that are constant across contexts), and 2) how the stimuli are sensed (i.e., it is larger when the exposure to the stimuli is limited). We believe that the present study opens the door to examine in further detail the nuances of orthographic processing in braille using a standard reading situation (e.g., how does letter identity coding interact with predictability and contextual effects during braille sentence reading? see Drieghe et al., 2005; Slattery, 2009, for evidence in sighted reading).

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Footnotes

Footnote 1. Braille specifications are the following: 0.48mm dot-height; 1.44mm dot-base-diameter, 2.4mm distance between horizontal/vertical dots of the same character, 6.2mm distance of corresponding dots in a contiguous character, and 10mm between corresponding dots in adjacent lines (see Spanish Braille Commission, 2015; UK Association for Accessible Formats, 2017).

Footnote 2. Note that this varies for some languages (e.g., in Russian braille, the symbol for capital letters is: ⠨ instead of ⠠). Furthermore, refreshable braille displays may use eight-dot braille cells which are useful in some contexts (e.g., mathematics); for instance, in this format, the bottom row represents some text characteristics such as capitalization (e.g., A = ⡁).

Footnote 3. The tactile similarity matrices can be found in the following link: https://osf.io/q2y7r/. They are based on the performance of blind braille readers in a same-different judgment task.

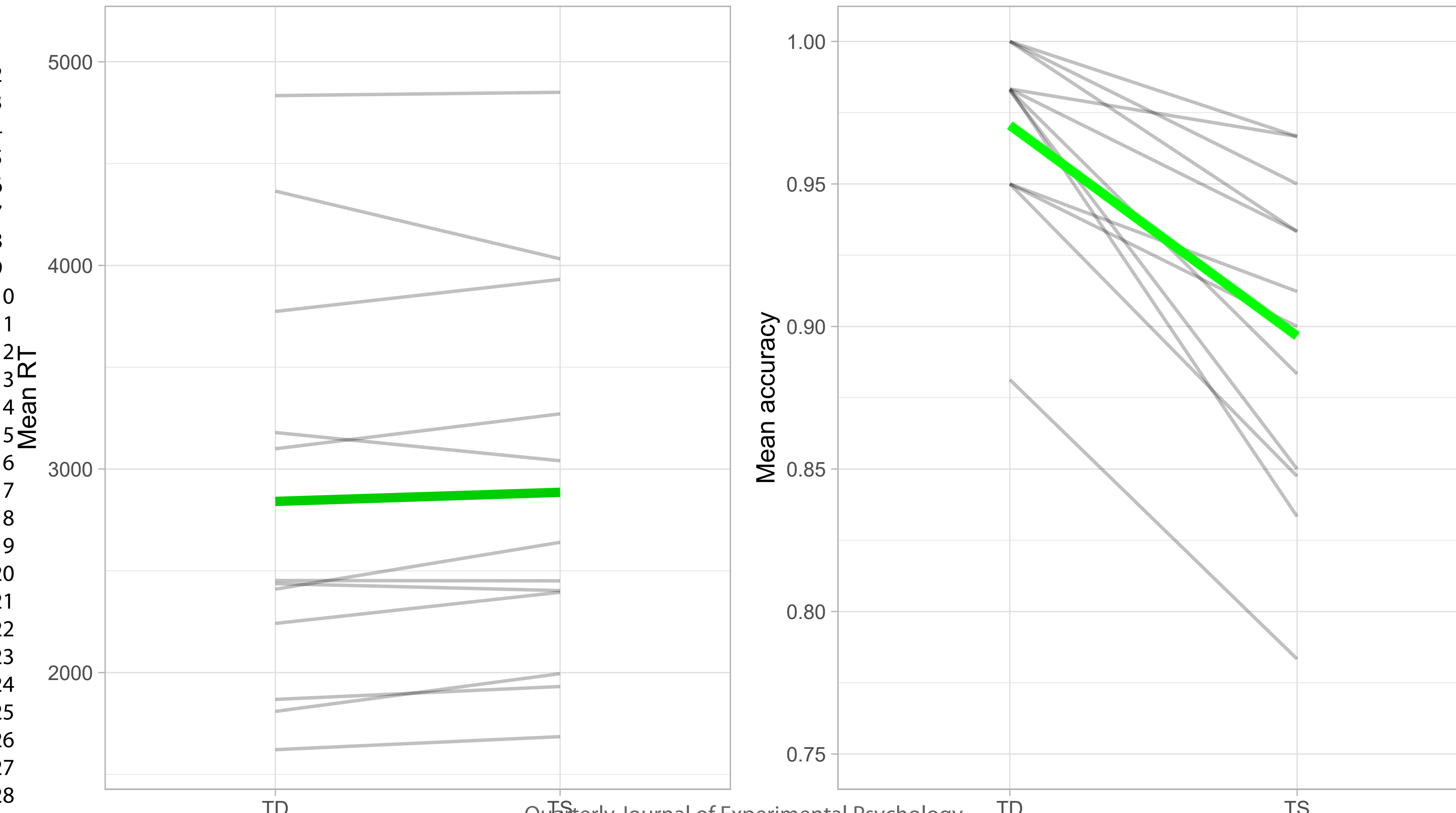
Footnote 4. The default priors are generally well suited for most experimental situations (see Rouder & Morey, 2012).

Footnote 5. For completeness, we also analyzed the effect of word-frequency for the word stimuli. We did find the typical word frequency effect both for RTs (CrI [13.16, 7.86]) and accuracy (CrI [0.02, 1.05]). These data are reported in the OSF repository, together with some exploratory analyses (i.e., delta plots and conditional accuracy functions).

APPENDIX A. Stimuli (words, pseudowords) presented in the experiment

Word trials: razón, familia, equipo, número, fiesta, palabra, general, correcto, cambio, hospital, secreto, sistema, vista, traje, maestro, permiso, servicio, gracioso, terrible, amable, suelo, relación, basura, destino, canción, sorpresa, vestido, posición, planeta, energía, cerveza, respeto, espalda, anillo, valor, batalla, estilo, memoria, camión, bosque, espada, enorme, silla, asiento, extraña, animal, sombrero, presente, cuento, diario, mercado, herida, amenaza, aspecto, camisa, empleo, ciencia, regreso, abrigo, semana, escuela, palacio, curioso, molesto, cuerda, divorcio, armario, excusa, altura, incendio, castigo, piscina, experto, chiste, urgente, auxilio, escape, escritor, leyenda, hombro, decente, puente, manzana, traición, pueblo, cabina, columna, capital, gimnasio, amarillo, evento, cerebro, corbata, alianza, cantante, abrazo, juguete, complejo, oficial, tarta, romance, dibujo, cirujano, huella, certeza, valioso, pensión, barco, nuevo, grosero, retrato, bondad, habitual, injusto, conjunto, hermano, volumen, simple, oración, cicatriz

Pseudoword trials [baseword]: [corazón] coranón, coralón; [fuerza] fuerna, fuerla; [pedazo] pedano, pedaco; [mezcla] mencla, mepcla; [juzgado] jungado, julgado; [veneno] vezeno, vejeno; [dinero] dizero, dibero; [reunión] reuzión, reubión; [mundo] muzdo, mujdo; [genial] gezial, gevial; [minuto] mizuto, mibuto; [persona] pertona, percona; [posible] potible, pomible; [asesino] asetino, asedino; [mensaje] mentaje, mencaje; [deseo] deteo, deceo; [iglesia] igletia, igledia; [visita] vitita, vimita; [montaña] monsaña, mondaña; [riesgo] rietgo, rielgo; [tesoro] tetoro, tedoro; [fiscal] fitcal, fimcal; [soltero] solsero, solmero; [pescado] petcado, pelcado; [rescate] retcate, relcate; [batería] basería, bamería; [fresco] fretco, frelco; [museo] muteo, mudeo; [reserva] reterva, remerva; [desnudo] detnudo, delnudo; [absurdo] abturdo, abmurdo; [ensayo] entayo, endayo; [musical] mutical, mulical; [lotería] losería, lodería; [cosecha] cotecha, codecha; [ansioso] antioso, anmioso; [masaje] mataje, macaje; [mascota] matcota, madcota; [presión] pretión, predión; [misión] mitión, midión; [decisión] decitión, decilión; [bolsillo] boltillo, boljillo; [gasolina] gatolina, gacolina; [episodio] epitodio, epicodio; [ensalada] entalada, endalada; [ausencia] autencia, aulencia; [invasión] invatión, invamión; [doctor] docsor, docbor; [sentido] sensido, senlido; [tatuaje] tasuaje, tavuaje; [futuro] fusuro, fumuro; [hotel] hosel, hocel; [mitad] misad, mivad; [autor] ausor, aucor; [ventana] vensana, venmana; [partido] parsido, parlido; [mentira] mensira, menbira; [entrada] ensrada, encrada; [motivo] mosivo, mobivo; [botella] bosella, bocella; [apetito] apesito, apevito; [militar] milisar, milicar; [teatro] teasro, teacro; [natural] nasural, namural; [entero] ensero, enlero; [fortuna] forsuna, forvuna; [antiguo] ansiguo, andiguo; [montón] monsón, monlón; [pintura] pinsura, pincura; [actor] acsor, ardista; [ventaja] vensaja, venbaja; [tortuga] torsuga, tormuga; [detalle] desalle, defalle; [partida] parsida, parmida; [lealtad] lealsad, lealcad; [actual] acsual, acbual; [cultura] culsura, culbura; [rutina] rusina, rudina; [retiro] resiro, reliro; [capitán] capisán, capibán; [editor] edisor, edibor; [contacto] consacto, conlacto; [objetivo] objesivo, objelivo; [frontera] fronsera, froncera; [criatura] criasura, criabura; [oficina] ogicina, opicina; [enfermo] engermo, enmermo; [informe] ingorme, invorme; [defensa] degensa, desensa; [efecto] egecto, ebecto; [refugio] regugio, remugio; [infeliz] ingeliz, inveliz; [perfil] pergil, persil; [perfume] pergume, persume; [desfile] desgile, desbile; [disfraz] disgraz, dispraz; [perfecto] pergecto, permecto; [profesor] progesor, provesor; [edificio] edigicio, edipicio; [profundo] progundo, prosundo; [infancia] ingancia, inpancia; [infantil] ingantil, insantil; [seguro] sefuro, semuro; [sangre] sanfre, sanvre; [bigote] bifote, bilote; [milagro] milafro, milabro; [negocio] nefocio, nemocio; [regalo] refalo, remalo; [peligro] pelifro, pelivro; [origen] orifen, oripen; [imagen] imafen, imapen; [siglo] siflo, sivlo; [ligero] lifero, lizero; [alegre] alefre, alebre; [tigre] tifre, tijre; [sargento] sarfento, sarzento; [registro] refistro, remistro; [lenguaje] lenfuaje, lenvuaje; [tragedia] trafedia, tramedia; [progreso] profreso, procreso.


Mean RT
5000
4000
3000
2000
TD
TS
Mean accuracy
1.00
0.95
0.90
0.85
0.80
0.75
TD
TS