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# REPLICATING THE EFFECTS OF ICONICITY IN LEXICAL DECISION TASK: A STUDY IN BRAZILIAN PORTUGUESE

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ABSTRACT

Iconic words are characterized by a sense of resemblance between their form and their meaning. The most common examples are onomatopoeias such as "cock-a-doodle-doo" or "woof-woof," but recent research shows that speakers of various languages perceive a relationship between sound and meaning in various words of their language. This is the case for English words such as *crunchy*, *zigzag* or *wiggle*, whose sonority is perceived as mapping onto their meaning (Winter et al., 2023). Recently, psycholinguistic research has investigated whether iconicity influence language processing. Sidhu, Vigliocco and Pexman (2020) ran a lexical decision task with words varying in their iconicity level. Their results show that the more iconic a word is, the quicker participants react to it, thus suggesting that iconicity may have a facilitatory effect in word recognition. We plan to replicate their study with a sample of Brazilian Portuguese speakers and Brazilian Portuguese words to test their main claim

that reaction times in a classic lexical decision task could be influenced by the stimuli's level of iconicity in a neurotypical population of adults. Our analysis plan closely follows the original study. A successful replication should show that participants react faster to words with higher iconicity ratings.

RESUMO

Palavras icônicas são caracterizadas por uma relação de semelhança entre sua forma e seu significado. Os exemplos mais comuns são as onomatopeias como "cocoricó" ou "au-au", mas pesquisas recentes mostram que falantes de várias línguas percebem uma relação entre som e significado em diversas palavras de sua língua. Este é o caso de palavras do inglês como *crunchy*, *zigzag* ou *wiggle*, cuja sonoridade é percebida como uma forma que mapeia seu significado (Winter et al., 2023). Recentemente, pesquisas em psicolinguística têm investigado se a iconicidade influencia o processamento da linguagem. Sidhu, Vigliocco e Pexman (2020) realizaram uma tarefa de decisão lexical com palavras que variavam seu nível de iconicidade. Seus resultados mostram que quanto mais icônica é uma palavra, mais rapidamente os participantes reagem a ela, sugerindo assim que a iconicidade pode ter um efeito facilitador no reconhecimento de palavras. Planejamos replicar esse estudo com uma amostra de falantes e de palavras do português brasileiro para testar sua principal alegação de que os tempos de reação em uma tarefa clássica de decisão lexical poderiam ser influenciados pelo nível de iconicidade dos estímulos em uma população neurotípica de adultos. Nosso plano de análise segue o estudo original. Uma replicação bem-sucedida deverá mostrar que os participantes reagem mais rapidamente a palavras com notas mais altas de iconicidade.

KEYWORDS

Iconicity; Word Recognition; Lexical Decision; Replication.

PALAVRAS-CHAVE

Iconicidade; Reconhecimento de Palavras; Decisão Lexical; Replicação.

# INTRODUCTION

Iconic words are characterized by a sense of resemblance between their form and their meaning. In Portuguese, for example, words such as *sussurro* ("whisper") or *chiado* ("hiss") mimic in their form, by the use of voiceless fricatives, characteristics of their meaning. In English, onomatopoeic words such *crash*, *bang* or *hiss* are also examples of this sound-to-sound mapping found in many iconic words. Beyond sound, it is also possible that words perceived as highly iconic map form and meaning via cross-modal associations ("non-onomatopoeic iconicity", as defined by Sidhu, Vigliocco and Pexman, 2020). As attested in iconicity norming studies in English and Portuguese (Perry *et al.*; Winter *et al.*, 2017, 2023; Ananias and Godoy, to appear; Godoy, 2026), this would be the case of words that map sound to texture (*crispy*, *fluffy,* and their Portuguese translations *crocante*, *fofo*), movement (*wiggle*, *twirl*, *zanzar* ("wander"), *tremer* ("shake")), visual experiences (*flash*, *cintilante* ("shiny"), *brilho* ("bright")), form (*spiky*, *round* and *bola* ("ball")), and others.

There is now substantial evidence that iconicity is a fundamental feature of all human languages, both spoken and signed. This observation is supported by analysis showing that form-meaning correspondences are found in thousands of typologically diverse natural languages (Blasi *et al.*, 2016; Winter *et al.*, 2022), and studies indicating that certain phonemes are prevalent in the words used in languages from different families to denote concepts related to perceptual categories (Sidhu *et al.*, 2021; Erben Johansson *et al.*, 2020; Joo, 2020). As a result, the study of lexical iconicity and its role in linguistic structure – long overlooked as minor or anecdotal within language research – has been gaining prominence in experimental studies.

Beyond shaping linguistic structure, lexical iconicity also influences the cognitive aspects of language. There is empirical evidence that iconicity in the lexicon of oral languages plays a role in language acquisition (Perry *et al.*, 2015, 2018, 2021; Ananias and Godoy, to appear; Imai *et al.* 2008), word learning and recall (Sidhu; Vigliocco; Pexman, 2023; Van Hoey *et al.*, 2023; Dingemanse *et al.*, 2016), and language emergence and evolution (Vinson *et al.*, 2021; Perlman, Dale and Lupyan, 2015; Verhoef, Kirby and de Boer, 2016). These studies indicate that iconicity significantly influence the cognitive dimension of language by providing a way to link linguistic structure with speakers' perceptual experience (Perniss, Thompson and Vigliocco, 2010).

The relationship between iconicity and language acquisition/emergence has been investigated for spoken languages by the use of corpora and experimental research (Perry *et al.*, 2015, 2018; Massaro and Perlman, 2017; Imai *et al.*, 2008 *inter alia*). However, comparatively little research has addressed whether linguistic processing is modulated by the degree of iconicity in linguistic stimuli. Sidhu, Vigliocco and Pexman (2020) examine the role of iconicity in word recognition, focusing on whether iconic words possess distinctive connections between phonological and semantic features that could ease their processing. Their initial hypothesis – that more iconic words would facilitate

faster recognition – builds upon previous findings demonstrating that words with an iconic form-meaning link elicit greater negative amplitude in the N2 and N400 components relative to control words (Peeters, 2016) and exhibit greater resistance to aphasia-related loss (Meteyard *et al.*, 2015).

The authors frame their theory using triangle models of word recognition because they specify a route by which meaning is retrieved via phonology. According to these models, word recognition encompasses three elements: a word's meaning, its orthography and its phonology. The word's meaning would be accessed via two paths: directly from its orthography, and indirectly from its orthography via its phonology. The connections among these components are bidirectional, and the relative weighting of each pathway shifts according to task demands (Balota, Paul and Spieler, 1999). Supporting evidence comes from findings that phonological variables (e.g., spelling-sound regularity; Hino and Lupker, 1996) exert greater or lesser influence on word recognition depending on the degree to which the orthography-phonology pathway is engaged.

As Sidhu, Vigliocco and Pexman (2020) emphasize, triangle models consider the mappings between phonology and semantics to be arbitrary and learned through experience. The authors' hypothesis, on the other hand, is that some of these mappings might arise or occur naturally – or be easier to acquire – because of the intrinsic similarity between phonology and semantics. Iconic words with more natural (or direct) links between semantics and phonology would, then, be easier to process. This hypothesis was tested in two experiments.

The authors operationalized iconicity on a gradient scale, using the iconicity ratings from Perry *et al.* (2015) and Winter *et al.* (2017) to determine each word's level of iconicity. In Experiment 1, a lexical decision task, participants were asked to judge if a string of letters was a word ("Is this letter string a word?"). In Experiment 2, a phonological lexical decision task, they were asked whether the string of letters sounded like a word ("Does this letter string SOUND like a word?"). By changing the question, Sidhu, Vigliocco and Pexman (2020) directed participant's attention to phonology in Experiment 2. In both experiments, words used as stimuli varied in their iconicity. In Experiment 1, presentation condition was also manipulated: for half of participants, item presentation was visually degraded, a manipulation known to increase reliance on phonology. Results from both experiments showed a facilitatory effect of iconicity in word recognition, with faster reaction times for more iconic words. This effect did not interact with condition (clear or degraded) in Experiment 1. Further statistical analysis that combined the data from Experiment 2 and the data from the non-degraded condition in Experiment 1 also found no interaction between iconicity and task. Taken together, these results show that iconicity plays a role in language processing – specifically, word recognition – in typical adults. More importantly, this effect seems robust enough not to be affected by differences in task or how the stimuli are presented to participants.

Although compelling, evidence of the relationship between language processing and iconicity in the natural lexicon of spoken languages remains scarce. Unlike the study conducted by Sidhu, Vigliocco and Pexman (2020), research reporting an iconicity effect have primarily focused on

onomatopoeias and/or ideophones, and have typically relied on electrophysiological data (Meteyard *et al.*, 2015; Peeters, 2016; Vigliocco *et al.*, 2020; Lockwood and Tuomainen, 2015). More recent studies that relied primarily on behavioral measures have also shown that iconicity correlates positively with with word guessing accuracy (Bonnie, Dunn and Dingemanse, 2023; Van Hoey *et al.*, 2023), but their goal was not to assess whether iconicity in one's native language would facilitate language processing.

When it comes to the effect of iconicity on reaction times in a word-recognition lexical decision task, the available evidence is limited to data from English speakers in Sidhu, Vigliocco and Pexman (2020). Because it is unknown whether the findings in this study generalize to languages other than English, we propose replicating their study with speakers of Brazilian Portuguese. Specifically, we aim to the test the author's claim that "iconicity provides a benefit to visual word recognition in typical adults" (Sidhu; Vigliocco; Pexman, 2020, p. 179). In order to do so, we plan to replicate their non-degraded condition in Experiment 1 with a sample of Brazilian Portuguese words.

## 1. THE CASE FOR A REPLICATION

The decision to replicate only the non-degraded condition in Experiment 1 was based on the absence of task or condition effects in both experiments of the original study. The hypothesis that participants would rely more heavily on phonological cues in certain contexts – and that this would modulate iconicity effects on written word recognition – was not supported. The author's final remarks on this topic are not conclusive, as they recognize their data do not support that iconicity effects necessarily arise from special links between phonology and semantics. They note that the main effect of iconicity observed in both experiments is consistent with Meteyard *et al.*'s (2015) speculation that iconic words may have additional connections between semantic representations and modality-specific features. Therefore, we choose to concentrate our efforts in replicating the main finding that reaction times in a classic lexical decision task paradigm could be influenced by the stimuli's level of iconicity[1].

The choice of Brazilian Portuguese (BP) as the target language for replication also warrants some consideration. BP is a specific variety of Portuguese, a Romance language of the Indo-European language family. It differs from European Portuguese and varieties used in Portuguese-speaking African countries, and it is the language of more than 200 million inhabitants of Brazil.

1 Additionally, we note that a replication of the whole study, including both experiments in their entirety, would not be feasible given the time constraints imposed by the deadline of this special issue: six months from the approval of the registered report to publication, an insufficient time to run, analyze and write the final report on a study that would gather data from 120 participants.

Experimental studies have shown that BP speakers display patterns similar to those of speakers of other languages with respect to sound symbolism, a phenomenon related to iconicity. BP speakers tend to use low vowels and longer words to name larger objects, and high vowels and shorter words to name smaller objects (Godoy *et al.*, 2020). They are also sensitive to the bouba-kiki effect, associating segments such as /p, t, k/ with spiky objects and /m, l, b/ with rounded objects (Godoy *et al.*, 2018; Silva and Bellini-Leite, 2020; Godoy and Ananias, 2022). As in English and Japanese (Kawahara *et al.*, 2021), they also associate voiced obstruents to semantic categories such as 'evil' when asked to name fictional characters (Godoy *et al.*, 2021). These studies have focused on the elicitation or judgement of pseudo-words, and did not look for iconic mappings in BP. Recent studies examining the ionicity of the BP lexicon have shown a negative correlation between subjective iconicity ratings and age of acquisition (Godoy, 2026; Ananias and Godoy, to appear), an effect already reported for other languages (Perry *et al.*, 2015).

Similarly to other languages, BP has a set of lexical items that are believed to be etymologically derived from onomatopoeias (e.g., *miar* ("to meow"), *bufar* ("to snort"), *roncar* ("to snore")). However, like in any language, these words have undergone morphophonological changes, and they can rarely function both as a noun and an onomatopoeia, especially if one considers its spelling[2] (e.g., *miau*! (meow!"), but "o *miado* do gato" (the cat's meow); *ronc*!, but "o *ronco* do homem" ("the man's snoring")). In that sense, BP differs from English, a language in which the same word, with the same spelling or pronunciation, can often be read/interpreted both as a noun/verb or as a mimetic/onomatopoeic sound (e.g., "pop!" and "the pop of the ballon"; "crash!" and "I heard the car crash"; "splash!" and "The splash was so big that it soaked us all", or "I added a splash of color in my wall"; "crack!", and "Crack the egg into the pan").

English also differs from BP in regarding the presence of systematic submorphemic sound-meaning mappings known as phonaestemes. The most well-known case of phonaestheme in English is *gl-*, frequently used in words denoting visual experiences (*glitter*, *glimmer*, *gleam* etc.). Other cases are *sn-*, for words with nose-related meanings (*sniff*, *snore*, *snout*), *tw-*, for words denoting a twisting motion (*twist*, *twirl*, *tweak*), *i/url-* for circular motion (*twirl*, *curl*, *furl*, *whirl*, *swirl*), *inter alia* (cf. Bergen, 2004; Kwon and Round, 2015). The concept of systematicity and iconicity are orthogonal (Nielsen and Dingemanse, 2020), as systematic associations may or may not be iconic. For example, the curling of the tongue necessary to produce *-i/url* in words such as *twirl*, *curl*, *furl* or *whirl* may be perceived as a mimic to their meaning. However, there seems to be no iconic association between *gl-* and vision; the reason one identifies a form like *gl-* as a phonaestheme is because it appears repeatedly with related meanings across different words. In that case, the systematicity emerges

2 Some cases in which a word with the same spelling can function both as a noun and as an onomatopoeia involve recent borrowings from English, such as *clique* ('click') or *bipe* ('beep').

from statistical patterns found in the lexicon of the language. To the best of our knowledge, scholarly work on BP has no mention of phonaestemes or other systematic sound-meaning associations on a submorphemic level. Although this does not mean that such phonaestemes are absent from the language, the scarcity of literature on this topic probably indicates that, if it exists, the phenomenon is not as prevalent as in English.

It remains an open question to what extent the presence of both non-arbitrary sound-meaning associations (such as phonaesthemes) and onomatopoeic-sounding nouns and verbs (e.g., *crash*, *pop*, *crack*) may affect how English speakers use iconicity as a cue during language processing. These speakers may be more prone to take iconicity into account in experimental tasks involving written language processing, as they are exposed to these iconic and/or systematic mappings across a wider range of contexts. On the other hand, BP employs specific spellings for onomatopoeic words, limiting the contexts in which its speakers encounter these forms. Moreover, onomatopoeia-derived words such as *piar* ("to tweet") or *miado* are turned into nouns or verbs by the use of morphological markers, which may attenuate the perception of their iconic origins. If these cross-linguistic differences do play a role in language processing, the iconicity effect reported by Sidhu, Vigliocco and Pexman (2020) may not readily generalize to speakers of other languages. Replicating this study in languages such as BP provides an opportunity to test whether iconicity effects in language processing are not language-dependent.

Finally, it is worth mentioning that BP does use full or partial reduplication to create expressive vocabulary, the most productive of this process being the reduplication of verbs[3] (Gonçalves and Vialli, 2016; Couto, 1999). Other cases include the reduplication (or retriplication) of seemingly onomatopoeic units[4], partial suffixal reduplication to denote intensity[5], and also some specific cases for which it is not possible to identify the reduplicated base, but which likewise indicate intensity[6]. These processes of reduplication are not common in European Portuguese and are typical to the Brazilian variety of this language (Villalva and Gonçalves, 2016). Although these words are perceived by BP speakers as highly iconic expressions of their language (Godoy, 2026), they will not be

3 As described by Gonçalves and Vialli (2016), these reduplications can result in conventionalized forms already depicted in dictionaries (*e.g.*, *corre-corre*: *run-run*, a fuss, a turmoil; *esconde-esconde*: *hide-hide*, the game *hide-and-seek*), but they can also serve to the productive creation of new expressions by Brazilians in everyday language (*e.g.*, empurra-empurra: push-push, people pushing each other in a multitude; beija-beija: *kiss-kiss*, people kissing each other effusively).

4 Some examples are *lenga-lenga* (monotonous, boring conversation), *vuco-vuco* (a fuss, a noisy turmoil with a multitude of people), *vapt-vupt* (said of something fast), *zum-zum-zum* (repetition of a sound: people talking, bees, other insects), *nhem-nhem-nhem* (*blah blah blah*).

5 Gonçalves and Vialli (2016) mention the cases of *chor+o* → *chororô* (cry → excessive cry), bol+o → bololô (a significant amount of something, usually people → large crowd), *bafafá* (*breath* → shouting, outcry).

6 Gonçalves and Vialli (2016) mention *piriri* (excessive diarrhea) and *sururu* (a *turmoil*, a *mess*), to which we can also add jururu (*sad*, *melancholic*).

included in the replication due to their idiosyncratic morphophonological characteristics and, above all, their low frequency in written language.

This decision also aims at replicating the original study as faithfully as possible. Reduplication is also present in English, and words formed by this morphological process are also perceived as highly iconic in this language (cf. Winter *et al.* (2023) for the mean iconicity ratings of *flip-flop* (5.2), *ping-pong* (6.36), *zigzag* (6.07) or *yo-yo* (6.1)). However, Sidhu, Vigliocco and Pexman (2020) did not include words created by reduplication in their study. By not using reduplicated words in our experiment, we ensure that our stimuli remain comparable to those in the original study, and avoid employing morphological strategies that may be more typical of BP (in the case of partial suffixal reduplication in words such as *chororô* or *piriri*).

Differences in the expressive vocabularies of English and BP may influence the extent to which speakers of each language are affected by iconicity during word recognition tasks. At the same time, social and cultural differences between Canada and Brazil – particularly within their academic communities, which were the sample populations in the original study and our replication – may also influence how language is processed. Psycholinguistic research involving typologically diverse languages and heterogeneous populations provide an opportunity to test experimental hypotheses in new contexts, and to gain insights into the universality of their findings. This is the case of the proposed replication: our main goal is to investigate whether the main finding in Sidhu, Vigliocco and Pexman (2020) can be generalized to a different target language and its speakers.

## 2. METHODS

We will run a word recognition lexical decision task to evaluate whether iconicity influences language processing in typical adults. Our replication of the original study aims to generalize its findings by running the same experiment with a sample of Brazilian Portuguese speakers and by using a sample of Brazilian Portuguese words. Each of these samples is described in detail below.

### 2.1. STIMULI SELECTION

Sidhu, Vigliocco and Pexman (2020) sampled English words from Perry *et al.*'s (2015) and Winter *et al.*'s (2017) iconicity norming studies. In these studies, participants were presented with a Likert scale that ranged from -5 (the word's sound seemed to contradict its meaning) to 5 (the word was highly iconic). Rating a word as 0 would indicate that the sound/meaning relation was completely arbitrary. The lexical decision task to be replicated selected 120 words from these studies: 40 non-iconic words, with ratings ≥ -0.5 and ≤ 0.5; 40 onomatopoeic words and 40 non-onomatopoeic words, all

of which were highly iconic, with ratings ≥ 2.5. Onomatopoeic words had a phonology intended to mimic a sound (e.g., *crash*, *screech*), while non-onomatopoeic iconic words did not (e.g., *twirl*, *fluff*).

In order to draw a sample of Portuguese words following the same criteria described in the original study, we will use preliminary data from an iconicity norming study in Brazilian Portuguese (Godoy, 2026). In this study, 7,000+ Brazilian Portuguese words were subjected to an iconicity rating task. Participants were shown 40 words and asked to rate the extent to which they believed each word sounded like its meaning. Instructions were adapted from Winter *et al.* (2023) and probed participants to think of iconicity as a continuum. Ratings ranged from 1 to 7, reflecting recent discussions in iconicity research suggesting that this scale more accurately captures perceptions of iconicity than the –5 to 5 range used in previous studies (Winter *et al.*, 2023; Hinojosa *et al.*, 2021).

The main difference between the iconicity norms from the BP study and those used by Sidhu, Vigliocco and Pexman (2020) lies in the range used to measure iconicity. We propose using the samples' mean and standard deviation as cut-off points to select the words to be included in the replication. In Sidhu, Vigliocco and Pexman (2020), the non-iconic stimuli were selected from words with iconicity ratings at least 0.3 standard deviations below the sample mean[7]. Iconic words (onomatopoeic or not) were at least 1.57 standard deviation above the sample mean. We will use these cut-off points to select 40 non-iconic, 40 iconic onomatopoeic and 40 iconic non-onomatopoeic words from Godoy (2026). In case we cannot sample 40 onomatopoeic iconic words from the BP iconicity dataset, we will replace them by iconic non-onomatopoeic words.

Finally, we will ensure that words in each group are matched on length, number of morphemes, log subtitle word frequency, orthographic Levenshtein distance, phonological Levenshtein distance, and mean bigram frequency. For that, we will use Alzahrani (2025) metrics for Brazilian Portuguese. In case this is not possible, we can resort to the P-PAL dataset (Soares *et al.*, 2018) for orthographic and phonological Levenshtein distance, and mean bigram frequency. Sidhu, Vigliocco and Pexman (2020) also matched the words in the three groups considering their age-of-acquisition, concreteness, and initial syllable rime phonological consistency. We may be able to control for the first two variables, as there are normative studies on age-of-acquisition and concreteness in Portuguese (e.g., Cameirão and Vicente, 2010; Ananias and Godoy, 2024; Soares *et al.*, 2017; Santos *et al.*, 2017). For the third variable, syllable rime phonological consistency, there are no normative studies in Portuguese.

Additionally, 120 nonwords will be created. These nonwords will conform to Brazilian Portuguese phonotactics, and we will avoid creating pseudo-homophones with real words (e.g., *felis*). They will be matched with the 120 real words on length and number of syllables. Sidhu, Vigliocco and Pexman

7 This value was derived from the mean of the standard deviations observed in the datasets of Perry *et al.*s (2015) and Winter *et al.* (2023).

(2020) also matched words and nonwords in regard to their number of orthographic neighbors and mean bigram frequency. In Portuguese, we can use the *Wuggy* tool to control orthographic neighbors by means of orthographic Levenshtein distance metrics, and the *Fonology* package (Garcia, 2025) to match words and pseudowords in regard to their log bigram probability.

### 2.2. PARTICIPANTS

The original study sampled a total of 80 participants (40 for the non-degraded condition) from the undergraduate student body of a Canadian university (60 female; *M* age = 21.01; SD = 3.38). Participants were compensated with course credit for their time. Our participants will be students from the Universidade Federal do Rio Grande do Norte. Given the greater age diversity among students in Brazil, we will restrict our analyses to those between 18 and 35 years of age to match the original study's sample. The target sample size is 40 participants (the same number as in the original study's non-degraded condition), all native Brazilian Portuguese speakers, with normal or corrected-to-normal vision. Recruitment will initially focus on undergraduate students, but may be expanded to graduate students within the specified age range. We also aim at recruiting from 28 to 32 women to maintain a similar balance regarding participant's gender.

As stipulated by the national guidelines on research ethics involving human participants, no participant will receive any form of compensation for taking part in the study. The research plan must be approved by the Research Ethics Committee of the university where the experiment will be conducted.

### 2.3. STUDY PROCEDURES

Participants will take part in a lexical decision task in which they have to categorize a presented letter string as a word or nonword using the keyboard. For each trial, participants will see a fixation cross for 400ms, then a blank screen for 200ms, and then the target stimuli. Target stimuli will remain on the screen until participants respond to them. Response will trigger a 500ms blank screen, and then the next trial will be presented. If there is an error, they saw the word "Incorrect", and hear a brief sound during the blank screen. Stimuli will be presented in random order in two consecutive blocks, with a break between them. In each block, participants will see an equal proportion of stimulus type. All these procedures were adapted from the original study.

# 3. ANALYSIS PLAN

Reaction times and response accuracy will be analyzed to replicate the original analyses by Sidhu, Vigliocco and Pexman (2020). Before fitting statistical models, raw data will be processed.

## 3.1. PRE-PROCESSING DATA

Consistent with the original study, we will apply the following steps to clean our data for the analysis of reaction times:

1. All incorrect responses will be excluded;
2. Trials with reaction times less than 200msec or more than 3000msec will be removed;
3. Remaining trials that fall over 2.5 standard deviations from a participant's mean will also be removed.

These steps will also be used in the analysis of accuracy data, except for step 1.

## 3.2. INITIAL ANALYSIS: REACTION TIME

We will take a confirmatory approach and run linear mixed models to test the main experimental hypothesis that iconicity can affect reaction times. We will also rely on the same model reported in the original study: a linear mixed effect model with reaction times as the response variable, Iconicity score as a predictor, and length, log frequency and orthographic Levenshtein distance as co-variates. The model, summarized in (1), will also include (following the original study) random intercepts for participants and items. The statistical model used in Sidhu, Vigliocco and Pexman (2020) did not include a random slope for iconicity per participant due to convergence issues, but we will add this random effect if the model converges. Although Iconicity will be treated as a factor for stimuli selection, it will be coded as a continuous variable in the analyses to match the original study. Therefore, we will use Iconicity scores from Godoy (2026).

(1) reaction time ~ iconicity + length + log frequency + orthographic Levenshtein distance + (1+iconicity|participant) + (1|word)

This initial analysis will corroborate or not the original finding we are trying to replicate. Our main interest here is the effect of iconicity on reaction times: if we find a negative and significant correlation between these two variables, one can say we were able to replicate the main finding of the original

study. Failure to find iconicity effects in this model, or a positive, significant correlation between ionicity and reaction times, will both be interpreted as a failure to replicate the original finding.

Following the original study, we will use the packages *lme4* (Bates *et al.*, 2015) and *lmerTest* (Kuznetsova, Brockhoff and Christensen, 2017) to perform this initial analysis in R (R Core Team, 2025).

### 3.3. INITIAL ANALYSIS: ACCURACY

Following the original study's analysis, we will also run a logistic mixed effects model with accuracy as the response variable and the same fixed and random variables as in the reaction time analysis. If we find that iconicity increases the chance of a correct response, we can say we successfully replicated the main finding of the study regarding the effect of iconicity on accuracy. Failure to find iconicity effects in this model, or a negative, significant effect between iconicity and accuracy (i.e., more iconic words lead to less accuracy), will both be interpreted as a failure to replicate the original finding.

### 3.4. ADDITIONAL ANALYSIS 1: GOODNESS OF FIT

The analysis carried by Sidhu, Vigliocco and Pexman (2020) in their dataset follow the standards currently used by the academic community for the analysis of reaction time data, so we do not intend to run our data on other models to test the generalizability of their finding. Our main goal, as previously stated, is to test their finding against a new target language, not against other statistical tools. However, we plan to run additional analysis depending on the distribution of our data. Sidhu, Vigliocco and Pexman (2020) do not mention whether their model violates linear model's assumptions, specifically, multicollinearity, homoscedasticity and normality of the residuals. We will perform a residual analysis to assess the goodness of fit of the initial statistical model. In case residuals violate one of the aforementioned assumptions, we will take on the following steps to model our data:

- In case of **violation of multicollinearity**, we will drop one of the redundant variables that may be causing multicollinearity.
- In case of **violation of the normality assumption**, we will log-transform reaction times. This transformation is the most commonly applied to reaction time data due to their tendency to be right-skewed.
- In case of **violation of homoscedasticity,** even in the face of log-transformation (which tend to resolve heteroscedasticity issues), we will explore other options to transform the data taking into account the type of the violation present in the model, and how the data behave after these transformations are applied to it.

The *performance* package (Lüdecke *et al.*, 2021) will be used to check the model's goodness-of-fit.

### 3.5. ADDITIONAL ANALYSIS 1: ICONICITY X TRIAL NUMBER

We will run an additional analysis to explore the interaction between iconicity and trial number on reaction times. This will be done to replicate an exploratory analysis described in the original study.

Apart from their main analysis, Sidhu, Vigliocco and Pexman (2020) also examined whether the effect of iconicity on reaction times could also be observed in the English Lexicon Project dataset (ELP; Balota *et al.*, 2007). They fitted a linear model similar to those described in Section 3.2, but without random effects. The analysis showed no effect of iconicity ratings on either reaction times or accuracy. The authors argue that a list context effect could explain why iconicity effects differ between the two datasets. In their dataset, but not in the ELP, two thirds of all words presented to participants (or 30% of all stimuli) were highly iconic. This could trigger participants to use iconicity in the experimental setting as a cue to solve the task.

They tested this hypothesis by adding trial number and its interaction with iconicity to the model described in section 3.2. Results showed a significant interaction between those factors, such that iconicity had a greater effect on reaction times for later trials. A detailed inspection of the data showed that iconicity had no effect on reaction times for the first 60 experimental trials, but the negative correlation between those two variables were evident for the last two third of trials. This corroborates the list context effect and indicates that participants may "learn" to use iconicity as a valuable cue during the task.

In case we successfully replicate the findings in Sidhu, Vigliocco and Pexman (2020) with the main analyses described in section 3.2, we will run this analysis to test whether Brazilian participants are also prone to this interaction effect. In case we fail to replicate the main finding that iconicity negatively correlates with reaction time, this additional analysis may help us gain insight on the differences between participants. It may be the case that there is no iconicity effect at all for the Brazilian cohort, or it may be the case that an effect only emerges in the final trials of the experimental items, making it too subtle to be observed as a main effect in the dataset.

### 3.6. ADDITIONAL ANALYSIS 2: ICONICITY AS A FACTOR

In case our main analysis finds a null result, we will run an additional analysis to explore some alternative hypothesis. Cnudde, Sidhu and Pexman (in preparation) reanalyzed the data of Sidhu, Vigliocco and Pexman's (2020) Experiment 2 to investigate the role of individual differences on reaction times, and found that participants with greater pseudohomophone accuracy showed larger iconic facilitation in the task. In a subsequent phonological lexical decision task experiment, they controlled the imitativeness of the iconic stimuli used: some iconic words were highly imitative of their meaning (e.g., *crunch*, *meow*), while others were not (*bland*, *dense*). The degree to which a word was imitative was determined in a previous norming study. Cnudde *et al.* (in preparation) again

observed that individual differences in phonological processing interacted with iconic facilitation, but such effects emerged only for imitative iconic words. They concluded that imitativeness plays an important role in iconic facilitation.

In light of these findings, we may run the same model described in section 3.2, but this time dummy-coding Iconicity as a factor with three levels: non-iconic words, non-onomatopoeic iconic words and onomatopoeic iconic words. If imitativeness plays a greater role than iconicity itself in word recognition, we may observe faster reaction times for this latter group. The aim of this additional analysis is not to replicate the original study's main findings, but rather to shed light on the causes of a possible null effect. Regardless of its outcome, the analysis will be described as exploratory and will not be used to claim that the replication was successful or unsuccessful. As previously stated, we will only run this analysis in case our main analysis finds a null result.

## 4. TIMELINE

Data collection will only start after the approval of this registered report. We anticipate that data collection and statistical analysis will require approximately three months to complete. We also note that data collection cannot be conducted in January and February due to the academic recess (summer break) in Brazil. Drafting and submitting the final manuscript will take an additional month.

## 5. DATA SHARING PLAN

The data that support the findings of this study will be openly available in Open Science Framework at https://doi.org/10.17605/OSF.IO/D827B

## 6. SCIENTIFIC DISSEMINATION IN THE GLOBAL SOUTH

Iconicity in the lexicon remains an understudied topic in Brazil and, more broadly, in Latin America. At the same time, there is a large international community dedicated to this topic, as attested by the international publication cited in this work and scientific conferences such as the *International Symposium on Iconicity in Language and Literature* (currently in its 15$^{th}$ edition). This presents a challenge to academics working on the topic in Brazil. Publishing our results in English will allow us to reach a broad international community of researchers working on this phenomenon. On the other hand, by not making our study available in Portuguese, we miss an opportunity to share our findings

with undergraduate students and other members of the national scientific community who are not fluent in English. This may undermine local scientific collaboration and hinder the dissemination of lexical iconicity as a research topic within the country. Therefore, pending the approval of the Editors and Reviewers, the authors propose to make the final manuscript of this study available both in English and Portuguese[8].

## ADDITIONAL INFORMATION

### CONFLICT OF INTEREST

The authors declare no competing interests.

### AI USAGE STATEMENT

The authors declare that no AI tools were used in the creation of this manuscript or in any aspect of the research reported in it.

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### REVIEW AND AUTHORS' REPLY

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8 Since this research is publicly funded, we also plan to submit a Portuguese written text to *Roseta*, the Science Communication outlet of the Brazilian Linguistics Association aimed at a non-academic audience. This publication is to be distinghished from the publication of a complete translation of the final manuscript, encompassing all its theoretical and methodological details.

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