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Body–object interaction ratings for 750 Spanish words

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ABSTRACT
An individual's sense of the extent to which her or his body physically interacts with objects in the environment (body–object interaction; BOI) has been empirically shown to modulate lexical and semantic processing of object names. To allow for further exploration of the nature of those effects, BOI ratings for 750 Spanish nouns were obtained from 178 young adult participants. Statistical analyses showed moderate correlations between BOI indicators and some psycholinguistic indexes, such as word imageability and age of acquisition. In addition, an exploration of lexical associative relationships revealed that high-BOI words have a consistent tendency to be associated with words naming parts of the body. The ratings could be useful to researchers who are interested in manipulating or controlling for the effects of BOI in their language-processing studies. The complete norms are available for free downloading at Open Science Framework (https://osf.io/kd5vf/).

Keywords: body–object interaction (BOI); Spanish norms; word attributes; word norms

Precise knowledge about the features of stimuli, both verbal (e.g., words) and pictorial (e.g., drawings), is essential for good experimental control and manipulation. Consequently, stimulus characterization has been an important issue in research and continues to receive substantial attention, as demonstrated by a large number of studies in linguistics, cognitive science, and related fields. In the lexical realm, some properties of stimuli, such as word length or grammatical status, are relatively easy to identify and describe. Other characteristics, such as their emotional value, their age of acquisition (AoA), or their imageability, require a more elaborate and complex specification process. In these cases, it is necessary to undertake well-planned normative studies that can provide this kind of information, often involving demanding data collection and sophisticated inferential procedures.

Among recent initiatives to characterize lexical stimuli in terms of the constituting or descriptive dimensions of the concepts that they denominate, the obtainment of body–object interaction (BOI) indexes can be highlighted for both

empirical and theoretical reasons. BOI reflects an individual's sense of the extent to which her/his body physically interacts with objects in the environment (Tillostson, Siakaluk, & Pexman, 2008). BOI is a word dimension that has been shown to modulate the way in which sensorimotor knowledge affects verbal processing. Yap, Pexman, Wellsby, Hargreaves, and Huff (2012), using regression analyses with a sample of 514 words, obtained results that illustrated the role of BOI in visual word recognition as a significant predictor of response latencies in a variety of tasks: standard lexical decision, word naming, go/no-go lexical decision, and semantic classification. In addition, studies with specific manipulations have shown that motor information associated with a concept, inferred from measuring BOI, has an impact on its recognition. For example, Siakaluk, Pexman, Aguilera, Owen, and Sears (2008) examined visual recognition, using high- and low-BOI words while keeping other variables such as imageability and concreteness constant, and found lexical and phonological facilitation effects (i.e., shorter decision times) for high-BOI words. Moreover, Siakaluk, Pexman, Sears, et al. (2008) examined BOI effects on a categorization task and on a combined semantic categorization-lexical decision task, and found that response times to high-BOI words were shorter in both tasks. Thus, response times to high-BOI words were found to be faster in four different tasks. Other studies have also found BOI-related facilitation effects in visual lexical decision tasks, with both monosyllabic and multisyllabic words (Bennett, Burnett, Siakaluk, & Pexman, 2011; Hansen, Siakaluk, & Pexman, 2012; Siakaluk, Pexman, Dalrymple, Stearns, & Owen, 2011; Tillotson et al., 2008; Tousignant & Pexman, 2012). Likewise, interesting effects have been found in auditory lexical decision tasks. For example, Van Havermaet and Wurm (2014), using words rated in danger and usefulness as experimental materials, found that BOI values attenuated the semantic effects of danger and usefulness on lexical decision times, suggesting that BOI affects lexical processing at a very early stage. This is consistent with a study by Inkster, Wellsby, Lloyd, and Pexman (2016), which showed that children of 6 and 7 years of age had shorter naming times for high-BOI words than for low-BOI words.

From a theoretical point of view, focusing on BOI can be of particular relevance in developing more complete accounts of the nature of semantic representations and the mechanisms by which such representations are formed and used in everyday cognition. Current approaches incorporate assumptions aimed at amending, or even substituting, traditional accounts based on amodal arbitrary symbols, and advance proposals based on grounded perceptual and motor representations (Kiefer & Barsalou, 2013) and consistent with brain structure and functional patterns (Patterson & Lambon Ralph, 2016). As highlighted by theoretical frameworks such as embodied cognition, the body may well play a causal role in cognition, and conceptual processing is likely to depend on the simulation of bodily and neural states, related to perception, action, and emotion, that become active during the interaction of the body with the environment (Glenberg, 2015).

The manipulation and control of reliable BOI estimators requires the availability of normative data, which in turn must be drawn from normative studies in

which subjective ratings are requested from samples of participants. The number of published normative studies in which BOI indexes have been obtained is limited, so far, and, with one exception (the Russian norms for 260 words collected by Bonin, Guillemard-Tsaparina, & Méot, 2013), they all report values for English-language stimuli. Specifically, Siakaluk, Pexman, Aguilera, et al. (2008) initially provided ratings for 234 words, and Tillotson et al. (2008) collected and provided ratings for 1,618 monosyllabic nouns; Bennett et al. (2011) provided norms for 599 multisyllabic nouns; and Van Havermaet and Wurm (2014) reported BOI ratings for a set of 102 nouns that had priorly being normed on danger and usefulness. Thus, there is a potential contribution that could be made by expanding the normative data in this domain by collecting normative data in other languages, at least in languages that are used in the investigations of a substantial number of linguistic and cognitive researchers. To initiate that effort in Spanish is the main goal of the present study. An interest in sensorimotor aspects of lexical items in Spanish led Moreno-Martínez, Montoro, and Rodríguez-Rojo (2014) to collect manipulability indexes for nouns that belonged to natural and artificial categories. Although tapping a relevant dimension, these indicators cannot be considered identical to BOI values, because they reflect the degree to which the hand is necessary for functionally interacting with a given being or object, rather than reflecting the easiness of a wider range of interaction possibilities between the body, with its varied parts, and other entities, as is the case with BOI values. Therefore, the present study represents the first attempt to assemble standard BOI normative values in Spanish, focusing on a set of nouns that are already well normed on a range of psycholinguistic dimensions by other normative studies and, in this way, contribute to a more complete and systematic characterization of an emerging corpus of linguistic stimuli in Spanish.

METHOD

Participants

A total of 178 psychology students (84% female) from the University of Salamanca participated voluntarily in the study and received academic credit for their participation. All of them were Spanish native speakers, and 11 were self-declared bilinguals, with Spanish as their first language. Their mean age was 19.97 ($SD = 1.5$), ranging from 19 to 26 years. The experimental protocol was approved by the bioethics committee of the University of Salamanca.

Materials

A total of 750 nouns, between one and five syllables in length, were included in the to-be-normed set. The words were drawn from an extensive pool of over 7,000 stimuli normed for AoA by Alonso, Fernandez, and Díez (2015), using as selecting criteria that they were normed and quantitatively characterized in several other psycholinguistic dimensions, such as free association (Fernandez, Díez, Alonso, & Beato, 2004), subjective imageability and familiarity (Algarabel, 1996;

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Duchon, Perea, Sebastián-Gallés, Martí, & Carreiras, 2013; Sebastián-Gallés, Martí, Carreiras, & Cuetos, 2000), written frequency (Alameda & Cuetos, 1995; Duchon et al., 2013), and naming and lexical decision times (Davies, Barbón, & Cuetos, 2013; González-Nosti, Barbón, Rodríguez-Ferreiro, & Cuetos, 2014). The selected nouns ranged in frequency from 1.19 to 769.38 per million, averaging 40.77 per million, and care was taken not to restrict the set to concrete words by assuring that approximately 25% of them were low in imageability (averaging 3.8 on a 7-point scale), while keeping familiarity at similar levels ($M = 5.2$ for the words with lower imageability, and $M = 5.6$ for the words with higher imageability).

Three different response booklets were prepared, each containing a total of 250 words in a randomly determined set that kept the imageability proportion. The first page of the booklet had a statement about the full confidentiality of the data, and requested demographic information from the participants (age, gender, college major, native language, and bilingual status). The second page included the instructions for the rating task (closely translated into Spanish from the English instructions used by Tillotson et al., 2008). Specifically, participants were told that the task consisted of rating, for each word, "the ease with which a human body can physically interact with the word's referent." The words were presented in the following pages (7 pages with 33 words each, and a last page with the remaining 19 words). The words were ordered randomly, with two different orders, aimed at countering possible order effects on the ratings. A 7-point rating scale was presented beside each word, where 1 reflected low BOI, 7 reflected high BOI, and 2–6 should be used to indicate intermediate values. The participants were instructed to use the full range of the scale in providing their ratings and to mark their choice by circling with their pen the number of their choice.

Procedure

Data collection followed the same steps as in previous normative studies of the kind (e.g., Bennet et al., 2011; Tillotson et al., 2008), with several group sessions (each involving 20 to 25 participants) lasting approximately 30 min. Before starting the rating task, participants filled out the demographic data on the first page of the response booklet, and then read the instructions on the second page. Once the instructions were understood, participants could turn to the next page and start with their ratings. One booklet was completed by 60 participants, and the other two booklets were completed by 59 participants each. The individual responses were coded as values between 1 and 7 into a database and submitted to an assorted range of computations, as reported below.

RESULTS AND DISCUSSION

Average BOI indices were calculated for each of the 750 words in the normed set using the provided ratings. Our online-only Supplemental Materials include a spreadsheet-format file available at Open Science Framework (https://osf.io/kd5vf/) that contains these data and additional information for each word entry.

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The nouns are listed in alphabetical order, each followed by four columns presenting descriptive values. Provided in the columns are, in this order, the English translation of the word, its average BOI score, the corresponding standard deviation, and the number of participants who provided a valid rating.

The possibility that the rating of the normed words could be spuriously affected by their position in a given ordering of the stimuli was evaluated, and discounted, by the results of correlational analyses between mean ratings for each word in the two versions of each booklet. The Spearman correlations were high and significant for the three booklets (0.96, 0.95, and 0.95, respectively; $p < .001$ in all cases). For completeness, intraclass correlation coefficients (*ICC* [2,k]) were also calculated for each version. The results showed almost identical *ICC*s for all the versions, with values ranging from 0.96 to 0.97.

The overall average value for the resulting distribution of BOI scores was 3.84 ($SD = 1.64$), on the 7-point scale, with values ranging from 1.10 for *DIABLO* (*devil*) to 6.75 for SILLA (*chair*). The distribution of scores did not conform to a normal distribution, as can be observed in Figure 1 and quantitatively supported by a Shapiro–Wilk test ($W = .93$, $p < .0001$).

In order to assess interrater reliability, the intraclass correlation (ICC) and Cronbach's alpha were calculated for each booklet (average two-way random consistency model). As shown in Table 1, results indicated a very good interrater reliability (Hallgren, 2012) and internal consistency.

The concurrent validity of the present norms was assessed by correlating the BOI values obtained in the study with ratings of the same kind available for equivalent words in other studies (two in English and one in Russian). With that aim, the Spanish words were translated into English, and then matched against the two English word sets and the English translations of the words in the Russian

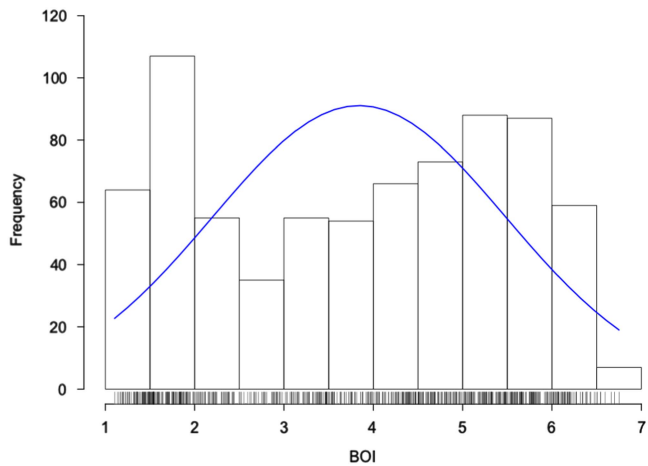

Figure 1. Distribution of average body–object interaction (BOI) scores for the normed set of 750 words.

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Table 1. *Intraclass correlation (ICC) and Cronbach's alpha for the three booklets*

Booklet	ICC(2,k)	Cronbach's alpha
Booklet 1	0.97	0.98
Booklet 2	0.98	0.98
Booklet 3	0.98	0.98

set. As can be seen in Figure 2, despite a moderate overlap between the words in the present norms and the words in the two other norms (ranging from 22% to 34%), the values can be taken as indicative of concurrent validity: the Spearman correlations were all significant, relatively large (ranging from .71 to .82), and in line with the value of .76 found by Bonin et al. (2013) when correlating BOI ratings for shared words in English and Russian.

A correlational approach was also used to explore the nature of the relations between BOI values and other psycholinguistic variables of potential interest available in Spanish. Figure 3 presents data and plots for significant Spearman's correlations, and a more extensive list of correlation coefficients is presented in Appendix A. With respect to perceptual and motor attributes (recently normed by Díez-Álamo, Díez, Alonso, Vargas, & Fernandez, 2017), BOI shows a particularly strong positive association with graspability ($r = .79$, $p < 001$), reflecting the fact that the interaction between objects and one's body are frequently mediated by our hands; and a lower but significant negative relation to sound intensity ($r = –.20$, $p < 001$), suggesting that people could be less likely to interact closely with loud objects. When more general aspects were considered, a strong association ($r = .65$, $p < 001$) was found with imageability scores (obtained from Duchon et al., 2013), consistent with the findings of other studies (e.g., Tillotson et al., 2008) and consistent with the assumption that BOIs are more likely to be performed or simulated when they involve more concrete/imageable objects.

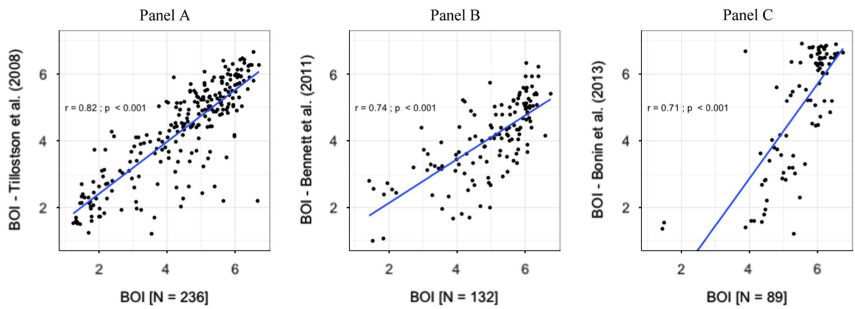

Figure 2. Scatter plots and Spearman correlation coefficients between current body–object interaction (BOI) ratings and other available BOI norms (shared words *N* are specified for each plot). (a) The norms in English by Tillotson et al. (2008). (b) The norms in English by Bennett et al. (2011). (c) The norms in Russian by Bonin et al. (2013).

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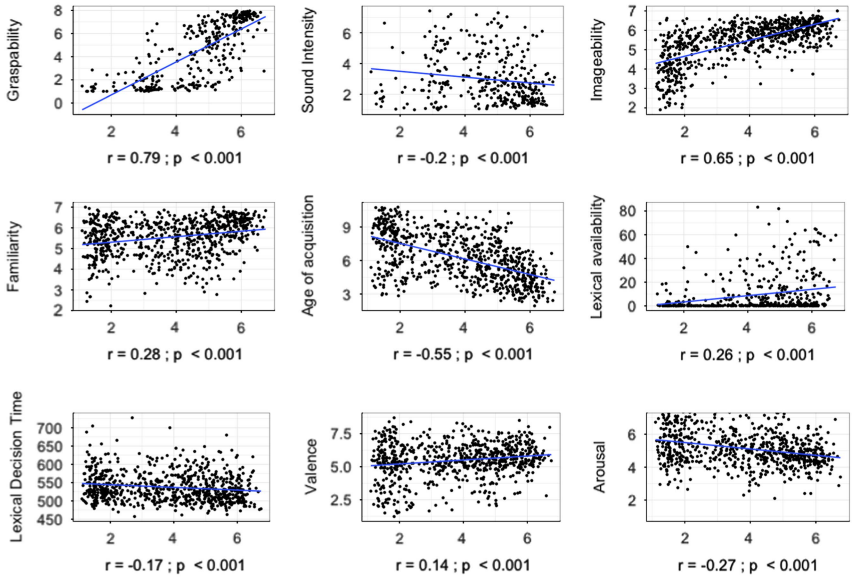

Figure 3. Scatter plots and Spearman correlation coefficients for variables that had a significant correlation with body–object interaction (BOI). See Appendix A for sources of data sets and a more extensive list of correlations.

A sizable negative correlation ($r = –.55$, $p < 001$), and larger than reported in other studies (Bennet et al., 2011; Bonin et al., 2013), was also found between BOI and AoA (with the latter values obtained from Alonso et al., 2015), indicating higher BOI values for words that tend to be acquired earlier in life. Other moderate significant correlations of BOI indicated that high-BOI words tended to score higher in lexical availability (the easiness with which an exemplar is generated as a member of a semantic category, as normed by Marful, Díez, & Fernandez, 2015; $r = .26$, $p < 001$), in familiarity (as normed by Duchon et al., 2013; $r = .28$, $p < 001$), and in the speed with which they are recognized in a lexical decision task (as normed by González-Nosti et al., 2014; $r = –.17$, $p < 001$), but not in the speed with which they are named (as normed by Davies et al., 2013, $r = –.03$).

To further clarify the contributions of BOI to language processing, and in the same vein as earlier studies of the same kind (e.g., Bennett et al., 2011), we conducted hierarchical multiple regression analyses to test the value of BOI rating in predicting both lexical decision times and naming times. In both cases, control variables were included in the first step and imageability and BOI ratings in the second step. As can be seen in Table 2, for lexical decision times, the increase in explained variance owing to the added predictors in Step 2 (imageability and BOI) was very low and only marginally significant. In the case of naming times, none of the variables showed any significant contribution to explain the variance. The fact that naming times were not related to BOI in the analysis of this set of

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Spanish words, while at odds with the findings for English reported by Bennett et al. (2011), goes in the same direction found in Spanish with other semantic variables, such as AoA (Alonso, Díez, & Fernandez, 2016; Alonso et al., 2015) or perceptual motor attributes like color vividness or sound intensity (Díez-Álamo et al., 2017). One reason for this pattern of results can be that Spanish (like Italian or Finnish) has a highly transparent orthography, allowing for a greater role of a orthography (a nonsemantic factor), on the phonological activation leading to fast word naming. The effects of semantic variables on single-word reading are still a matter of debate (see Bates, Burani, D'Amico, & Barca, 2001; Kwok, Cuetos, Avdyli, & Ellis, 2017), and definitive conclusions about the contributions of semantic, lexical, and sublexical factors to word naming can be premature in the absence of more exhaustive and theoretically guided analyses.

Finally, for each normed word, we calculated a probability score that reflects the extent to which that word tended to be related to a particular body part (body-part relationship, or BPR). Free association norms available for Spanish (Fernandez, Díez, & Alonso, 2016; Fernandez et al., 2004) were consulted to

Table 2. *Results of hierarchical multiple regression analyses for lexical decision times and naming times*

Variable	*B*	*SEB*	ß	R^2	ΔR^2
Lexical decision times					
Step 1 (control variables)				.473***	
Step 2				.477	.004†
Control variables					
Log-frequency	–27.18	2.15	–0.40***		
Syllables	–1.86	1.20	–0.04		
LOD	12.10	1.95	0.18***		
AoA	6.22	0.77	0.33***		
Imageability ratings	–1.46	1.53	–0.04		
BOI ratings	2.06	0.93	0.08*		
Naming times					
Step 1 (control variables)				.002	
Step 2				.002	.0004
Control variables					
Log-frequency	1.92	5.40	0.02		
Syllables	–0.71	3.03	–0.01		
LOD	4.54	4.90	0.04		
AoA	0.05	1.92	0.001		
Imageability ratings	0.11	3.84	0.002		
BOI ratings	–1.11	2.33	–0.03		

Note: LOD, Levenshtein orthographic distance. AoA, subjective age of acquisition. BOI, body–object interaction. The *B*, *SEB*, and β values are for the final step in the analysis, where all the predictor variables were included in the equation.
†$p = .08$. *$p < .05$. **$p < .01$. ***$p < .001$.

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determine the probability that each normed word generated a body part when it was used as a cue (forward association), and the probability that the normed word was generated as a response when a body part was used as a cue (backward association). Then, an overall BPR score for each normed word was calculated, based on the cross products of those probabilities. Finally, these BPR scores were submitted to a one-way analysis of variance, with the BOI quartile as the main factor. The results of this associative structure analysis (presented in Figure 4) revealed that high-BOI words tended to have a stronger associative connection with words denoting parts of the body.

In sum, the BOI database presented here for a sizable number of words in Spanish has properties that make it both a reliable and a valid tool for establishing the extent to which each of the included items refers to an object that can be easily used in body-based interactions. As described above, BOI is proving to be a semantic indicator with the power to predict linguistic processing and the potential of illuminating theoretical accounts of mental representations. On the assumption that information is obtained through interaction with the environment, registered in different modalities, and represented in motor, kinesthetic, proprioceptive, or emotional systems, there is a basis for focusing on the relationship between perception, action, and cognition derived from sensory, motor, and emotional experiences. In this regard, information about the extent to which objects can interact with the human body can be instrumental in empirical and theoretical advances, as it becomes another feature or dimension with which to characterize verbal stimuli in terms of their semantic richness (Yap et al., 2012), and by enabling to the testing of specific hypotheses derived from recent neuroscience-oriented cognitive approaches, such as grounded cognition (Barsalou, 2008), embodiment theory (Glenberg, Witt, & Metcalfe, 2013) or controlled semantic cognition (Lambon Ralph, Jefferies, Patterson, & Rogers, 2017). As an example, BOI norms are likely to contribute to the design of studies aimed

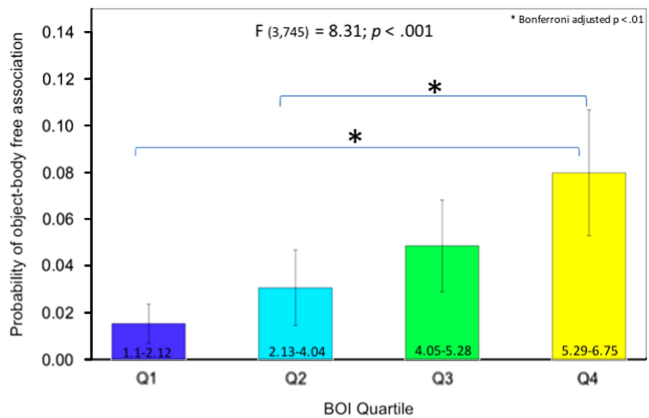

Figure 4. Probability of words being associated to body parts as a function of body–object interaction (BOI) quartile.

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at understanding language acquisition, especially those focused on identifying the role of critical sensory-motor factors affecting vocabulary learning, either in young children (Iverson, 2010; Yu & Smith, 2012) or in adults learning a second language (Macedonia & Mueller, 2016).

In addition, it is worth noting that the BOI data in Spanish presented here are in high agreement with equivalent indexes available in English and Russian for equivalent terms. Although extracted from a limited database, the data point toward the generalizability of this interactive dimension across languages, as is the case with other semantic features (e.g., the crosslinguistic consistency of survival-relevant conceptual attributes found by Díez-Álamo et al., 2017). It is the case that, traditionally, knowledge advances in linguistics and cognition have benefitted from intensive research within particular languages, and especially so in the case of the languages that are of use in communities where there is a sizable number of committed language-focused researchers (most notably English). However, recent research has started to show the benefits of studies in which different languages are compared or contrasted, as exemplified in work on the acquisition of quantifiers by speakers of 31 languages (Katsos et al., 2016) or on the neural structures involved in reading and speech understanding in contrasting languages such as Hebrew, Spanish, English, and Chinese (Rueckl et al., 2015). Increasing the availability of precisely normed verbal stimuli in a variety of dimensions (e.g., very recent work in Spanish by Díez-Álamo et al., 2017; by Haro, Ferré, Boada, & Demestre, 2017; or by Stadthagen-González, Ferré, Pérez-Sánchez, Imbault, & Hinojosa, 2017) and in a wider range of languages will undoubtedly be of help in continuing with this research effort.

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SUPPLEMENTARY MATERIAL

To view supplementary material for this article, please visit https://doi.org/10.1017/S0142716418000309

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APPENDIX A

Table A.1. *Spearman rank correlations between Spanish body–object interaction values and other psycholinguistic variables*

Variable	Study	*r*	*p*	*N*
Oral frequency	Alonso et al. (2011)	–.07	.2299	336
Log written frequency	Duchon et al. (2013)	–.01	.7569	750
Number of syllables	Duchon et al. (2013)	–.08	.0340	750
Lexical availability	Marful et al. (2015)	.26	< .0001	444
Imageability	Duchon et al. (2013)	.65	< .0001	739
Familiarity	Duchon et al. (2013)	.28	< .0001	748
Concreteness	Duchon et al. (2013)	.58	< .0001	747
Manipulability	Moreno-Martínez et al. (2014)	.61	< .0001	132
Typicallity	Moreno-Martínez et al. (2014)	.40	< .0001	132
Age of acquisition	Alonso et al. (2015, 2016)	–.55	< .0001	750
Color vividness	Díez-Álamo et al. (2017)	.04	.4625	342
Visual motion	Díez-Álamo et al. (2017)	.00	.9751	342
Graspability	Díez-Álamo et al. (2017)	.79	< .0001	342
Likelihood of pain	Díez-Álamo et al. (2017)	–.04	.4444	342
Sound intensity	Díez-Álamo et al. (2017)	–.20	.0002	342
Taste pleasantness	Díez-Álamo et al. (2017)	.10	.0572	342
Smell intensity	Díez-Álamo et al. (2017)	.08	.1404	342
Emotional valence	Stadthagen-Gonzalez, Imbault, et al. (2017)	.14	.0001	729
Arousal	Stadthagen-Gonzalez, Imbault, et al. (2017)	–.27	< .0001	729
Naming response times	Davis et al. (2013)	–.03	.4026	750
Lexical decision times	González-Nosti et al. (2014)	–.17	< .0001	750

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