Sensory experience ratings for 5,500 Spanish words

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Abstract

Sensory experience rating (SER) is a recently developed subjective lexical index that reflects the extent to which a word evokes a sensory and/or perceptual experience in a reader (Juhász & Yap, 2013; Juhász, Yap, Dicke, Taylor, & Gullick, 2011). In the present study, SERs for a set of 5,500 Spanish words were collected, which makes this the largest set of norms for SER in the Spanish language to date. Additionally, with the aim of further exploring the implications of this new indicator and its relations with other psycholinguistic variables, a variety of correlational and regression analyses are provided. The results showed that SERs significantly correlated with imageability, age of acquisition, and a number of variables related to perception and emotion. In addition, SERs predicted a significant amount of variance in lexical decision times when other variables were controlled.

Keywords Sensory experience ratings (SERs) · Spanish norms · Grounded cognition · Perception · Action · Emotion

Normative studies constitute highly valuable resources for researchers from different domains in cognitive science, since they allow for both manipulation and control in the design of experiments. In addition, these studies often give rise to new knowledge, thereby contributing to the enrichment of theoretical development in psychology. In the last decades, a large number of normative studies have been made available for several languages, mostly for English (see Proctor & Vu, 1999, for a review; see also Vaughan, 2004), but also for other languages, such as Spanish (for a review, see Pérez, Campoy, & Navalón, 2001), French (e.g., Bonin et al., 2003), Italian (e.g., Barca, Burani, & Arduino, 2002), and Chinese (e.g., Liu, Shu, & Li, 2007). Normative data have been collected for a variety of stimuli, among which verbal materials, and particularly words,

predominate over others. Also, numerous psycholinguistic variables, both objective (e.g., number of letters/syllables, word frequency, orthographic, and phonological structure) and subjective (e.g., familiarity, imageability, concreteness, affective values, age of acquisition), have been carefully studied. As a result, an extensive corpus of word ratings is available today, which constitutes a major advantage for researchers.

In recent times, new theoretical points of view in cognitive psychology have led to growing interest in new variables. In this sense, a remarkable perspective in psychology, which has aroused great interest among researchers, is the grounded cognition theoretical framework, which holds that cognition is determined, in multiple ways, by modality-specific simulations, bodily states, and situated action, within a physical and social context (Barsalou, 2008). Thus, all psychological processes and mental activities would be influenced in a significant way by sensorimotor systems, emotions, and the body itself (Glenberg, 2011). For instance, recent studies suggest that language comprehension implies constructing sensorimotor simulations of the situations and events described in sentences. According to this perspective, those simulations involve the activation of the brain's systems of perception, action, and emotion, the same ones that are activated in a real situation (Glenberg, 2011; Glenberg & Kaschak, 2002; Kaschak et al., 2005). In a similar vein, conceptual representations, and therefore our knowledge about the world, have been argued to be grounded in modality-specific systems (Barsalou, Simmons, Barbey, & Wilson, 2003; Kiefer & Barsalou, 2013). More specifically, Barsalou (1999)

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suggested that perceptual states that emerge from sensorimotor systems are stored in long-term memory and can operate as symbols that are modal and analogical in nature.

Due to the considerable interest that this approach has elicited among a good number of researchers, and owing to the importance that sensory systems certainly have for understanding human cognition, it becomes necessary to collect information about sensory properties of concepts, as completely and rigorously as possible. This will allow researchers to conduct further investigation with carefully selected materials and with appropriate control of variables. In this context, Juhasz, Yap, Dicke, Taylor, and Gullick (2011; see also Juhasz & Yap, 2013) were first to present a new variable called sensory experience rating (SER), which reflects the extent to which a word evokes a sensory and/or perceptual experience in the reader. As Juhasz et al. (2011) stated in the original instructions of the task, this sensory experience implies an actual sensation (taste, touch, sight, sound, or smell) that is experienced when a certain word is read. It is noticeable that the SER index is not referred to a single sensorial modality, but it examines all sensations at one time. In that respect, SER is different from other indexes that have focused on individual sensorial modalities. For example, Lynott and Connell (2013) provided modality-specific norms for 400 nouns, including ratings for each of the five sensorial modalities (i.e., auditory, gustatory, haptic, olfactory, and visual). Similarly, Medler, Arnoldussen, Binder, and Seidenberg (2005) collected ratings in four sensorimotor domains (sound, color, manipulation, and motion), as well as emotion ratings, for 1,402 English words. And McRae, Cree, Seidenberg, and McNorgan (2005) collected semantic feature production norms for 541 living (e.g., dog) and nonliving (e.g., chair) concepts, which were then grouped into nine knowledge types, among which the five sensorial modalities are included. Furthermore, Amsel, Urbach, and Kutas (2012) provided ratings for a set of 559 object concepts on seven different perceptual and motor attributes (color, motion, sound, smell, taste, graspability, and pain). Interestingly, these norms include some attributes that, to date, have received little attention in conceptual processing studies, such as smell intensity or likelihood of pain. Another variable that addresses the importance of sensorimotor representations in cognition is the body–object interaction (BOI) index, which reflects the ease with which individuals can physically interact with a word's referent using any part of their body (Bennett, Burnett, Siakaluk, & Pexman, 2011; Tillotson, Siakaluk, & Pexman, 2008). SER, as an integrative measure of the sensory activation that concepts evoke, should encapsulate all individual sensorial modalities and should correlate with different subjective variables that tap perception, action and emotion in different ways. In this vein, one of the main purposes of the present study is precisely to explore these relations.

Furthermore, recent studies have explored how SER is related to semantic or lexical psycholinguistic variables as well

as to performance measures of word recognition. Thus, the most remarkable correlations have been reported between SER and imageability and age of acquisition (AoA), indicating that words with higher SERs are more likely to be more imageable and to have an earlier AoA in comparison with low-SER words (Bonin, Méot, Ferrand, & Bugaïska, 2015; Juhasz, Lai, & Woodcock, 2015; Juhasz & Yap, 2013; Juhasz et al., 2011). Also, a recent study by Bonin, Méot, and Bugaïska (2018) has found a positive correlation between concreteness and SER ratings, indicating that words with higher SERs tend to be more concrete. These researchers argue that, similarly to high-SER words, the representation of concrete words might be mainly based on sensory–perceptual information (see also Kousta, Vigliocco, Vinson, Andrews, & Del Campo, 2011). However, despite the mentioned correlations, SER has been argued to have a unique character as a semantic variable. For example, Juhasz et al. (2011) reported a multiple regression analysis with SER as the dependent variable, in which a total of ten established word recognition variables only predicted 29.4% of the variance in SER. Moreover, and importantly, SERs have proved to reliably predict lexical decision response times (Bonin et al., 2015; Juhasz et al., 2015; Juhasz & Yap, 2013; Juhasz et al., 2011; Kuperman, 2013) when other psycholinguistic variables are controlled, suggesting that it plays a significant role in conceptual lexical–semantic processing, particularly when sensory and perceptual features of concepts are taken into account.

Given the growing interest in this new variable and its potential importance for several research aims in cognitive psychology, SERs started to be collected in languages other than English. For example, Bonin et al. (2015) recently obtained SERs for 1,659 French words. In Spanish, Hinojosa, Rincón-Pérez, et al. (2016b) collected SERs for the 875 words included in the Madrid Affective Database for Spanish (MADS; Hinojosa, Martínez-García, et al., 2016a), including verbs, nouns and adjectives. To the best of our knowledge, this is the only normative SER study in Spanish.

With the aim of further contributing to this growing body of data, the present study's main objective was to provide SERs for a set of 5,500 Spanish words. Importantly, the target words were selected from previous studies collecting Spanish norms for other relevant psycholinguistic variables, so that researchers using verbal stimuli in Spanish can make use of a rich and well-described pool of words for experimental purposes. A second objective was to analyze the relationships between SER and other well-established psycholinguistic objective and subjective indexes, in order to further explore and describe the implications of this variable for information processing. AoA, frequency and imageability are of particular interest here, as these variables have been found to correlate with the SER. Also, because it is argued that SER is a unique semantic variable that encloses diverse individual sensorial modalities that underpin perception, action, and emotion, the

relationship between SER and different subjective psycholinguistic variables associated with those three dimensions will be examined. And finally, as it was done in previous studies in English and French, the predictive value of the SER on Spanish language lexical decision times and word naming will be assessed.

Method

Participants

A total of 420 undergraduate students of the Universities of Salamanca, Valladolid, and La Laguna, all located in Spain, participated in the study in exchange for course credit. All data from 29 participants were discarded due to inadequate performance in the rating task, applying at least one of two criteria: 20 or more trials in a row with the same response, or 50 or more responses made in less than one second. Thus, the final sample included 391 participants (333 female, 58 male), all native speakers of Spanish, with a mean age of 19.7 years ($SD = 3.23$; range = 16–58 years).

Stimuli

The set of words to be normed was constructed by obtaining stimuli from existing lexical databases in Spanish, with the aim of assembling a pool of words for which other norms of psycholinguistic interest were currently available. Specifically, the set was formed to include (a) 2,765 mono- and multisyllabic words with known lexical-decision and word-naming times (Davies, Barbón, & Cuetos, 2013; González-Nosti, Barbón, Rodríguez-Ferreiro, & Cuetos, 2014); (b) 1,512 words with known affective norms (Redondo, Fraga, Comesaña, & Perea, 2005; Redondo, Fraga, Padrón, & Comesaña, 2007); (c) 750 words with known BOI norms (Alonso, Díez, Díez-Álamo, & Fernandez, 2018); (d) 238 one-word names denoting Snodgrass and Vanderwart's (1980) drawings (Fernandez, Díez, Alonso, & Beato, 2004; Sanfeliu & Fernandez, 1996); (e) the 1,109 adjectives with known AoA norms from Alonso, Fernandez, and Díez (2015); and (f) a subset of 1,024 verbs with known AoA norms from Alonso, Díez, and Fernandez (2016), representing the complete range of AoA (from 3 to 15). We also added six other nouns corresponding to months and days of the week, in order to complete those categories. Once redundant entries were eliminated, the final set was composed of a total of 5,500 Spanish words of varied length, frequency, and part-of-speech category (i.e., grammatical category).

Procedure

The 5,500 stimuli were randomly divided into 11 questionnaires, which were administered using Online Ratings of Visual Stimuli (OR-Vis), an open-source software tool (Hirschfeld, Bien, de Vries, Lüttmann, & Schwall, 2010) developed to conduct rating studies. Each questionnaire contained 500 different words, as well as 23 repeated words, selected randomly from among the words within each questionnaire, that would allow for a subsequent intrasubject reliability test. Each target word was rated by an average of 35 participants, with a minimum of 33 valid observations for each word.

The task was performed in groups of 15 to 25 participants at a time, using individual computers in a large computer room. Each participant was randomly assigned to one of the questionnaires, with the only restriction that a similar proportion of male and female participants' responses were recorded across questionnaires. Participants were required to rate the 523 target words, which were randomly presented. In each trial, a target word was presented in the center of a computer screen and a 7-point rating scale was displayed below, with verbal labels at both extremes indicating the scale values. Participants had to rate the degree of sensory experience that each word evoked for them by selecting a single number on the scale, via mouse click. Participants were asked to answer quickly, but as accurately as possible.

The rating instructions were taken from Juhasz et al.'s (2011) seminal study. These instructions were translated into Spanish (see the exact instructions in the Appendix) and were displayed on the computer screen before the experimental trials. The duration of the experimental sessions was between 45 and 60 min. Although no breaks were scheduled during the experimental session, participants were instructed to work at their own pace and allowed to take brief breaks between stimuli when needed.

Results and discussion

The complete set of SER ratings for the 5,500 stimuli are available for downloading from the journal website as supplementary materials (SpanishSER.xlsx). The file includes a column listing the 5,500 Spanish words in alphabetical order, with a matching column listing their English translations. In adjacent columns, the mean rating (SER_m) and the corresponding standard deviation (SER_sd) are provided for each word.

The distribution of the mean SERs was characterized by an average score of 3.63, a standard deviation of 0.86, a median of 3.57, and a range of 5.07, with a minimum value of 1.47 and a maximum value of 6.54. As can be seen in Fig. 1, ratings were well distributed along the 7-point scale, with a skewness of 0.32 ($SE = 0.03$) and a kurtosis of -0.35 ($SE = 0.07$). For completeness, descriptive statistics were calculated for the

Fig. 1. Distribution of sensory experience ratings (SERs) for the 5,500 words

words in each part-of-speech category (i.e., word class/grammatical category), which was extracted from the EsPal database¹ (Duchon, Perea, Sebastián-Gallés, Martí, & Carreiras, 2013). Very small differences were found between the overall mean scores of the different categories. These data are presented in Table 1. Words pertaining to categories with less than 15 members in this study were grouped in a single category, under the name *Other*.

Reliability and validity

Prior to exploring SER's relationship with other variables, we established the reliability and validity of our study. To assess interrater reliability, the intraclass correlation (ICC) was calculated (two-way random consistency model, average measures) for each one of the 11 questionnaires. ICC values ranged from .89 to .92, with a mean of .91, indicating a good interrater reliability (Hallgren, 2012). Also, a mean Cronbach's alpha of .91 (with values ranging from .89 to .92) indicated good internal consistency. In addition, as mentioned above, each questionnaire contained 23 words that were presented twice, making a total of 253 repeated stimuli in the study (23 words $\times$ 11 questionnaires), which allowed for analyzing intrasubject reliability. A high positive correlation ($r = .969$, $p < .001$) revealed very good intrasubject reliability.

The validity of the present norms was assessed in two ways. First, we translated our stimuli into English² and compared the ratings with the norms provided by Juhasz and Yap (2013) for a set of 2,988 shared words. The correlation was

Table 1. Descriptive statistics for the sensory experience ratings as a function of part-of-speech category (word class)

Word Class	<i>N</i>	Mean	<i>SD</i>	Minimum	Maximum
Total	5,500	3.63	0.86	1.47	6.54
Nouns	2,689	3.62	0.90	1.47	6.37
Adjectives	1,169	3.68	0.81	1.68	6.11
Verbs	1,611	3.62	0.84	1.70	6.54
Other*	31	3.55	0.80	2.18	5.49

* Other = prepositions, adverbs, dates, determiners and interjections

positive and significant, although moderate ($r = .435$, $p < .001$), probably due to the fact that different meanings exist for superficially equivalent words in the two languages, and other translation issues. However, in a second validity analysis we compared our results with the norms provided by Hinojosa, Rincón-Pérez, et al. (2016b), the only published study that has collected SER ratings in Spanish to date, and a correlation of $r = .818$ ($p < .001$) was found for a set of 471 shared words. Although translation issues are the most likely explanation for the difference between the correlations of our norms with those from the aforementioned SER studies in English and Spanish, cross-cultural differences in SER ratings should also be considered and explored in more detail in the future, since a few normative studies have found substantial differences in normative measures as a function of culture (e.g., Umla-Runge, Zimmer, Fu, & Wang, 2012; Yoon et al., 2004).

Relation to other psycholinguistic variables

Pearson correlation analyses were carried out to explore the correlations between SER and objective and subjective lexical descriptors, obtained from different available sources (see Table 2). The correlations between SER and several objective variables—such as log written frequency, number of letters, number of syllables, number of homophones, number of orthographical neighbors, and number of phonological neighbors (extracted from the EsPal database; Duchon et al., 2013)—were low. However, and interestingly in terms of language processing, a moderate negative correlation ($r = -.331$, $p < .001$) was found between SERs and lexical decision times (from González-Nosti et al., 2014; shared $n = 2,765$), in that words with higher SER tended to be processed faster. This finding replicates the results obtained in previous SER studies in other languages (Bonin et al., 2015; Juhasz & Yap, 2013; Juhasz et al., 2011). In contrast, the correlation between SER and word-naming latencies (from Davies et al., 2013; shared $n = 2,764$), although significant, was very weak ($r = .060$, $p = .002$), and hence does not allow us to draw firm conclusions on the relationship between these two variables.

As a way to further explore the role of SER in word recognition performance, two four-step hierarchical linear regression

¹ The part-of-speech categories for four words that were not contained in EsPal, as well as their numbers of letters and syllables, were assigned by the first author.

² The 5,500 Spanish words were initially translated into English using Google Translate. In a second step, all the resulting translations were revised by two of the authors (A.M.D.-Á. and D.Z.W.), who are proficient in both Spanish and English.

Table 2. Correlations between sensory experience ratings and other objective and subjective variables

Variable	Study	<i>r</i>	<i>p</i>	<i>N</i>
Lexical decision times	González-Nosti et al. (2014)	–.331	<.001	2,765
Naming times	Davies et al. (2013)	.060	.002	2,764
Semantic neighborhood density	Fernandez et al. (2017), Fernandez et al. (2004)	.096	<.001	3,452
Number of letters	Duchon et al. (2013)	–.079	<.001	5,500
Number of syllables		–.057	<.001	5,500
Number of homophones		–.001	.968	5,496
Number of orthographical neighbors		.006	.639	5,496
Number of phonological neighbors		.005	.702	5,496
Phonological uniqueness point		–.085	<.001	5,496
Orthographic uniqueness point		–.082	<.001	5,496
Levenshtein distance		–.037	.006	5,496
Familiarity		.381	<.001	3,463
Concreteness		.169	<.001	3,465
Imageability		.321	<.001	3,383
Log written frequency		.067	<.001	5,496
Oral frequency	Alonso et al. (2011)	.128	<.001	4,998
AoA	Alonso et al. (2016); Alonso et al. (2015)	–.376	<.001	4,911

analyses were performed, with lexical decision and word-naming response times (RTs) as dependent variables, and a set of common predictor variables entered in successive steps, before adding SERs in the last step. Specifically, in Step 1, several lexical variables were entered: 11 initial phoneme features (vowel, alveolar, palatal, velar, bilabial, dental, voiced, occlusive, nasal, fricative, and liquid), coded as 0 or 1 for each feature (obtained from Davies et al., 2013), and also six variables related to the lexical-word-form level—namely, number of letters, number of syllables, orthographic neighborhood size, phonological neighborhood size, log written frequency (from EsPal; Duchon et al., 2013), and oral word frequency (from Alonso, Fernandez, & Díez, 2011). In Step 2, a measure of the objective semantic properties of the words was entered—namely, semantic neighborhood density (see Mirman & Magnuson, 2006), based on the number of nonidiosyncratic associates with a frequency of production of >1 for the word, taken from a large Spanish free-association database (Fernandez, Díez, & Alonso, 2017; Fernandez et al., 2004). In Step 3, two subjective measures thought to be related to semantic processing were included, namely imageability (from EsPal; Duchon et al., 2013) and AoA (from Alonso et al., 2016; Alonso et al., 2015). Finally, following the procedure of Juhasz and Yap (2013), SERs were entered in the final step of both analyses. As is shown in Table 3, the amount of change in the variance predicted by SERs was low but significant for lexical decision times ($\Delta R^2 = .013$) and nonsignificant for naming times. The same pattern of results was obtained by Juhasz et al. (2011) and Bonin et al. (2015). In contrast, Juhasz and Yap (2013) found that SER predicted a reliable, although small, amount of variance in both lexical

decision and naming response times. The fact that SER and other semantic variables did not significantly predict naming RTs in the present study, as compared with the results obtained by Juhasz and Yap, could be attributed to a very particular linguistic characteristic. Specifically, Spanish, like Italian or Finnish, but unlike languages such as English, has a very transparent orthography, and any word can be correctly named by applying basic pronunciation rules, making semantic access unnecessary in naming most of the words, or allowing for a

Table 3. Proportions of variation (adjusted R^2) in lexical decision and naming response times (RTs), explained by several predictor variables (hierarchical linear regression analyses)

Predictor Variable	Lexical Decision RTs (<i>n</i> = 1,758)	Naming RTs (<i>n</i> = 1,758)
Step 1: Lexical variables		
Adjusted R^2	.387	.013
Change in R^2	.393***	.023**
Step 2: Objective semantic variables		
Adjusted R^2	.400	.013
Change in R^2	.014***	.0001
Step 3: Subjective semantic variables		
Adjusted R^2	.510	.013
Change in R^2	.11***	.0009
Step 4: Sensory experience ratings		
Adjusted R^2	.523	.0126
Change in R^2	.013***	.0004

** $p < .01$. *** $p < .001$

combination of lexical and sublexical processes (Kwok, Cueto, Avdyli, & Ellis, 2017).

Besides the correlations described above, moderate correlations were found between SER and other subjective variables of common use in psycholinguistics. For instance, SER correlated positively with imageability ($r = .321, p < .001$) (from EsPal; Duchon et al., 2013; shared $n = 3,383$), and negatively with AoA ($r = -.376, p < .001$) (obtained from Alonso et al., 2016; Alonso et al., 2015; shared $n = 4,911$).³ Thus, words with higher SERs tend to be more imageable and to be acquired earlier than low-SER words. These results replicate the most notable pattern of correlations with subjective indexes found in previous English and French SER studies (Bonin et al., 2015; Juhasz et al., 2015; Juhasz & Yap, 2013; Juhasz et al., 2011). Importantly, the relation between SER and AoA supports the idea that concepts acquired earlier in life tend to be associated with sensory-perceptual experiences (Juhasz & Yap, 2013), and it is in line with grounded-cognition approaches claiming that sensorimotor experiences are essential to reaching a comprehensive understanding of what AoA represents (Thill & Twomey, 2016). Furthermore, SER also correlated positively with familiarity (from EsPal; Duchon et al., 2013; shared $n = 3,463$) ($r = .381, p < .001$), which is consistent with Juhasz et al.'s (2015) results, indicating that words that evoke a greater sensory experience tend to be more familiar. In this sense, it also seems that high-SER words tend to be more frequent in spoken language, as reflected by the correlation between SER and oral frequency ($r = .128, p < .001$) (from Alonso et al., 2011; shared $n = 4,998$). The correlation with log written frequency (from EsPal; Duchon et al., 2013; shared $n = 5,496$), though, was lower ($r = .067, p < .001$). Additionally, in line with the correlations reported by Hinojosa, Rincón-Pérez, et al. (2016b) and Bonin et al. (2018), concreteness (from EsPal; Duchon et al., 2013; shared $n = 3,465$) correlated positively with SER ($r = .169, p < .001$), suggesting that words that imply a high sensory experience also tend to denote more concrete concepts.

Relation to perception, action and emotion variables

It has been argued that SER is an integrative semantic variable that encloses diverse individual sensorial modalities that underpin perception, action, and emotion. To study the relationship between SER and those three dimensions, correlational analyses were conducted between SER and different subjective psycholinguistic variables associated with perception, action, and emotion in different ways. Table 4 presents a tentative organization of relevant subjective variables into these three domains, as well as the correlation with SER in each case. Most variables had

significant correlations with SERs, with larger values being observed for perceptual attributes such as color, taste, or smell, and for emotional values such as happiness or fear.

With the aim of studying in more detail the relationship between SER and individual perceptual-sensorial modalities, we examined the correlations between SER and subjective ratings for seven different perceptual and motor attributes of object concepts—namely, color vividness, visual motion, sound intensity, smell intensity, taste pleasantness, graspability, and likelihood of pain (from Díez-Álamo, Díez, Alonso, Vargas, & Fernandez, 2017; shared $n = 506$), dimensions that engage the five Aristotelian sensory modalities (vision, touch, hearing, smell, and taste), in addition to a related sense, namely the likelihood that an object will cause pain. The highest values corresponded to positive correlations between SER and color vividness ($r = .419, p < .001$), taste pleasantness ($r = .355, p < .001$), and smell intensity ($r = .296, p < .001$), reflecting that high-SER words tend to elicit higher ratings particularly in these three dimensions. Interestingly, these three variables formed a statistically determined cluster in studies by Amsel et al. (2012) and by Díez-Álamo et al. (2017), as shown by principal component analyses (PCAs) and supported by the patterns of intercorrelations among the seven attributes. In both studies, the cluster was interpreted as a factor related to survival, described as “locating nourishment,” and included mostly objects with vivid colors, good taste, and a strong smell (mostly foods). Thus, the SER variable may be connected, to a large extent, to knowledge types that are most notable in the conceptual representations of edible things (Amsel et al., 2012). It should be kept in mind, though, that the studies by Amsel et al. and Díez-Álamo et al. only included nouns denoting object concepts, so further exploration will be needed to examine the relationship between SER and the sensory modalities for words representing other grammatical categories.

In terms of action, two different subjective variables were taken into consideration. The first of these was graspability (the likelihood that an object can be grasped by someone with a hand, as reported in Díez-Álamo et al., 2017), which besides being related to the sense of touch is also regarded as an action-related dimension. However, the correlation between SER and graspability was not significant ($r = -.071, p = .113$). The other examined action variable was the body-object interaction (BOI) index, which reflects the ease with which individuals can physically interact with an object using any part of their body (Bennett et al., 2011; Tillotson et al., 2008). Again, there was no relationship between BOI ratings (reported in Alonso et al., 2018; shared $n = 750$) and SER ($r = -.007, p = .846$). It seems, therefore, that SER does not show a clear association with action variables, in contrast to its more obvious relationship with variables that address perceptual dimensions.

Two different but complementary approaches have been used to study emotion and affective language. One approach

³ In the cases that a word was present in both studies, the average of the two numbers was used.

Table 4. Correlations between sensory experience ratings and subjective variables related to perception, action, and emotion

Dimension	Variable	Study	<i>r</i>	<i>p</i>	<i>N</i>
Perception	Color	Diez-Álamo et al. (2017)	.419	<.001	506
	Pain		.098	.027	506
	Sound		.149	.001	506
	Taste		.355	<.001	506
	Smell		.296	<.001	506
	Visual motion		.183	<.001	506
Action	Graspability	Diez-Álamo et al. (2017)	–.071	.113	506
	BOI	Alonso et al. (2018)	–.007	.846	750
Emotion	Happiness	Ferré et al. (2017); Hinojosa, Martínez-García, et al. (2016a); Stadthagen-González, Ferré, et al. (2017a)	.361	<.001	4,498
	Disgust		.117	<.001	4,498
	Anger		.157	<.001	4,498
	Fear		.290	<.001	4,498
	Sadness		.249	<.001	4,498
	Valence	Stadthagen-González, Imbault, et al. (2017b)	.105	<.001	4,421
	Arousal		.254	<.001	4,421

is that of dimensional models, which conceptualize all human emotions as being based on three underlying affective dimensions: valence (ranging from pleasant to unpleasant), arousal (ranging from calm to excited), and dominance or control (ranging from out of control to in control) (Bradley & Lang, 1999). The dominance dimension has been shown to be less consistent across languages than valence (Redondo et al., 2007; Warriner, Kuperman, & Brysbaert, 2013), a weaker predictor of variance than valence and arousal (Bradley & Lang, 1994), and to be highly correlated with valence (Warriner et al., 2013). As a result, most modern studies in a variety of domains (such as language, memory, and emotion) usually do not include dominance in their models (e.g., Ferré, Guasch, Moldovan, & Sánchez-Casas, 2012; Kensinger & Corkin, 2004; Kuperman, Estes, Brysbaert, & Warriner, 2014; Stadthagen-González, Imbault, Pérez Sánchez, & Brysbaert, 2017b). Thus, for the purpose of this study, we also decided to focus on the valence and arousal dimensions. As we explained in the **Method** section, we initially selected 1,512 words with known affective norms from Redondo et al. (2005, 2007). However, during the final stages in the preparation of the present report, a much larger normative study with norms of valence and arousal was published (Stadthagen-González, Imbault, et al., 2017b), including all the words in Redondo et al. (2007) and over 95% of the words in Redondo et al. (2005). Consequently, to maximize the number of shared items with our study, we decided to use the norms provided by Stadthagen-González, Imbault, et al. to calculate the correlations between our SER ratings and valence and arousal for a total of 4,421 shared words. A positive significant correlation was found between SER and valence ($r = .105$, $p < .001$), reflecting a tendency for high-SER words to be judged as

more positive. A larger positive correlation was found between SER and arousal ($r = .254$, $p < .001$), indicating that, as was previously found by Hinojosa, Rincón-Pérez, et al. (2016b), words with higher SERs were more likely to be judged as being relatively more arousing than words with lower SERs.

An alternative approach for studying emotion, supported by research in facial expressions (Ekman, 1993, 1999), is based on the existence of a limited number of discrete basic emotions. Although there is no complete consensus regarding the number of discrete basic emotions, five of them (happiness, disgust, anger, fear, and sadness) have received stronger support (Oatley & Johnson-Laird, 1987; Power & Dalgleish, 1997). To further explore the role of SER in the emotional domain, we examined the correlations between SER and those five discrete emotions, using subjective emotional ratings for a set of 4,498 shared items obtained from a combination of three normative studies (Ferré, Guasch, Martínez-García, Fraga, & Hinojosa, 2017; Hinojosa, Martínez-García, et al., 2016a; Stadthagen-González, Ferré, Pérez-Sánchez, Imbault, & Hinojosa, 2017a). SER correlated significantly with the five discrete emotions, and all the correlations were positive (see Table 4). This is consistent with the results observed in Hinojosa, Rincón-Pérez, et al.'s (2016b) study. The highest correlation was found between SER and happiness ($r = .361$, $p < .001$), indicating that words with a higher SER tend to denote more pleasant concepts.

Additional regression analyses

Finally, to explore more deeply the nature of SER ratings, two hierarchical regression analyses were conducted with SER as

Table 5. Proportions of variation (adjusted R^2) in sensory experience ratings (SERs) explained by several predictor variables (hierarchical linear regression analyses)

Predictor Variable	SER ($n = 2,272$)	SER ($n = 318$)
Step 1: Lexical variables		
Adjusted R^2	.04	.032
Change in R^2	.043***	.05*
Step 2: Objective semantic variables		
Adjusted R^2	.047	.062
Change in R^2	.007***	.033***
Step 3: Subjective semantic variables		
Adjusted R^2	.113	.150
Change in R^2	.066***	.09***
Step 4: Perception variables		
Adjusted R^2		.324
Change in R^2		.18***
Step 5: Action variables		
Adjusted R^2		.371
Change in R^2		.05***
Step 6: Emotion variables		
Adjusted R^2		.594
Change in R^2		.22***

* $p < .05$. *** $p < .001$

the dependent variable. The first analysis included the objective and subjective lexical and semantic variables used in the previously described regression analyses on lexical decision and naming times as successive predictors of SER ratings—excluding the 11 initial phoneme features—for the set of 2,272 words that had all the scores available. A second analysis also included the perception, action, and emotion variables (listed in Table 4) in successive steps, but in this case for a reduced set of 318 words, since not all scores were available for the normed words. Table 5 shows the results of both analyses. Importantly, the nine lexical and semantic predictor variables only accounted for 11.3% of the variance in SERs (15% in the reduced-set analysis), with the entering of subjective semantic variables in the model producing the greater increment in the explained variance. However, the greatest increments of explained variance were produced by entering perception ($\Delta R^2 = .18$), action ($\Delta R^2 = .05$), and emotional ($\Delta R^2 = .22$) variables, which together raised R^2 up to .59.

Conclusion

In the present study, we provide SERs for a set of 5,500 Spanish words, which constitutes, to date, the largest set

of norms for SER in Spanish language. Reliability and validity analyses showed that the norms provide adequate estimators of SER for this large set of words. In addition, with the exception of four entries, all of the words from the present study are contained in the EsPal database (Duchon et al., 2013). As a result, a very large amount of lexical information is available for all the words, including lemma information, word written frequency, and orthographic and phonological characteristics, as well as different subjective ratings for a subset of over 3,300 words. Additionally, almost 5,000 of the words are also described in oral frequency norms (Alonso et al., 2011), and AoA norms (Alonso et al., 2016; Alonso et al., 2015), and over 4,400 of the words are present in affective norms databases, including valence and arousal norms (Stadthagen-González, Imbault, et al., 2017b) and ratings for five discrete emotions (Ferré et al., 2017; Hinojosa, Martínez-García, et al., 2016a; Stadthagen-González, Ferré, et al., 2017a). Finally, lexical decision (González-Nosti et al., 2014) and naming response times (Davies et al., 2013) are available for approximately half of the words, and additional indexes of psycholinguistic interest can be found for smaller subsets of words. From a methodological point of view, the availability of SERs for a large set of words that are well characterized in many other dimensions has the potential to be of use to researchers interested in designing studies of conceptual representation, semantic memory, processing of affective language and other related issues with samples of Spanish-speaking participants. The norms also have the potential to be useful in studies on different aspects of bilingualism, and they might provide indications for future research efforts on cross-cultural issues. And from a broader theoretical perspective, our results are important for understanding the nature of the construct captured by SERs. Finally, the materials and the information about the relation between SER and other variables might be helpful for the strengthening and development of new lines of research in psychology, especially recent brain-inspired proposals about conceptual representation and conceptual processing that consider the need to integrate perceptual, motor and emotional information (e.g., Binder et al., 2016; Glenberg, 2015; Kiefer & Barsalou, 2013; Lambon Ralph, Jefferies, Patterson, & Rogers, 2017).

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Appendix: Rating instructions

“A continuación se te presentará una serie larga de palabras. Por favor, lee y considera cada palabra basándote en el grado de experiencia sensorial que cada una evoca en ti. Por experiencia sensorial, entendemos una sensación real (gusto, tacto, vista, sonido, u olfato) que experimentas al leer la palabra. Por favor, evalúa cada palabra en una escala del 1 al 7, donde 1 significa que la palabra no evoca ninguna experiencia sensorial en ti, 4 significa que la palabra evoca una experiencia sensorial moderada, y 7 significa que la palabra evoca una experiencia sensorial fuerte. No hay respuestas correctas o incorrectas. Estamos interesados en tu experiencia sensorial personal con estas palabras. Puedes indicar tu respuesta para cada palabra señalando el número que elijas en la escala.”

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