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Sensory experience ratings (SERs) for 1,659 French words: Relationships with other psycholinguistic variables and visual word recognition

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Abstract We collected sensory experience ratings (SERs) for 1,659 French words in adults. Sensory experience for words is a recently introduced variable that corresponds to the degree to which words elicit sensory and perceptual experiences (Juhasz & Yap *Behavior Research Methods, 45,* 160–168, 2013; Juhasz, Yap, Dicke, Taylor, & Gullick *Quarterly Journal of Experimental Psychology, 64*, 1683–1691, 2011). The relationships of the sensory experience norms with other psycholinguistic variables (e.g., imageability and age of acquisition) were analyzed. We also investigated the degree to which SER predicted performance in visual word recognition tasks (lexical decision, word naming, and progressive demasking). The analyses indicated that SER reliably predicted response times in lexical decision, but not in word naming or progressive demasking. The findings are discussed in relation to the status of SER, the role of semantic code activation in visual word recognition, and the embodied view of cognition.

Keywords Sensory experience ratings (SERs) · Semantic richness · Visual word recognition · Grounded cognition

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Norms collected for various types of stimuli (e.g., nouns, verbs, idiomatic expressions) are very important tools for experimental psychologists. In addition to their usefulness at a methodological level for designing experimental studies, the collection of norms for different types of stimuli has also helped to achieve a better theoretical understanding of the processes and representations that underpin various lexical processing skills, in particular word recognition (e.g., Balota et al., 2007; Ferrand et al., 2011). Recent years have seen an increasing trend to collect norms for impressively large numbers of words. Importantly, however, the different types of norms collected for words have not met the same fates. For example, many normative studies have focused on the imageability (e.g., Schock, Cortese, & Khanna, 2012) and age of acquisition (AoA; Kuperman, Stadthagen-Gonzalez, & Brysbaert, 2012) variables in several languages, whereas collections of some other types of norms have been limited, or even anecdotal (e.g., object size norms; Roux, Bonin, & Kandel, 2014; Sereno, O'Donnell, & Sereno, 2009). Imageability is measured by using a Likert scale to evaluate the ease with which a mental image can be formed from a visual word, whereas AoA norms are generally obtained by asking adults to indicate the age at which they think they have learned a given word. Much debate has also concerned exactly what it is that certain norms index in the field of word-processing studies, and more particularly with regard to rated AoA (Bonin, Barry, Méot, & Chalard, 2004; Zevin & Seidenberg, 2002). Finally, new types of norms that are of potential interest at both the theoretical and empirical levels are emerging, and sensory experience ratings (SERs), which are the focus of the present study, are one of these. These norms have recently been collected for English words, and their influence in visual word recognition has been investigated by Juhasz and colleagues (Juhasz & Yap, 2013; Juhasz et al., 2011; see also Zdrazilova & Pexman, 2013).

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SERs are thought to reflect the extent to which a word evokes a sensory and/or perceptual experience (Juhasz & Yap, 2013). SER is thought to be a (subjective) semantic variable and is measured by asking participants to rate on a Likert scale the degree to which any given word evokes a sensory experience, with higher numbers indicating greater sensory experience. More particularly, in SER ratings, participants are required to judge the extent to which words are able to evoke an actual sensation (taste, touch, sight, sound, or smell) that they experience when reading the word. The sensory experience variable is therefore not limited to a single sensation, and can potentially index the links between lexical–semantics and all sensory/perceptual modalities. SERs have recently been collected for a vast number of words in English (Juhasz et al., 2011), but to our knowledge, comparable ratings are not available for French.

At a theoretical level, the collection of SERs has been conducted within the framework of grounded cognition (Juhasz & Yap, 2013), which views conceptual processing as being rooted in the perceptual systems (e.g., Barsalou, 1999; Barsalou, Simmons, Barbey, & Wilson, 2003). According to the grounded-cognition view, reading a word such as *strawberry* may not only create a mental image in the mind of the reader, but also a slight but perceptible gustatory trace. This type of trace is believed to be available to readers when they are asked to examine their experiences. It is worth mentioning that two types of norms that are related to SERs have been collected on words: body–object interaction (BOI) ratings (Bennett, Burnett, Siakaluk, & Pexman, 2011; Bonin, Guillemard-Tsaparina, & Méot, 2013; Tillotson, Siakaluk, & Pexman, 2008) and *modality exclusivity* norms (Lynott & Connell, 2013). BOI norms correspond to the ease with which a human body can physically interact with a word's referent. It is assumed that words that refer to things with which a human body can easily interact (e.g., *mask*) possess richer motor representations than do words that refer to things that cannot easily be interacted with (e.g., *ship*). Modality exclusivity norms have been provided by Lynott and Connell for 400 randomly selected noun concepts. These norms assess how strongly a given property is experienced across five sensory modalities (i.e., hearing, taste, touch, smell, and vision). Likewise, these norms also provide estimates of modality exclusivity, which corresponds to a measure of the extent to which a specific property may be considered to be perceived through one sense alone.

The status of SERs and their relation with other psycholinguistic variables

What exactly do SERs measure? Many different psycholinguistic variables (e.g., word frequency, AoA, and imageability) have been used to predict the performance of individuals in several tasks (e.g., lexical decision [deciding whether a string of letters is a word or a nonword], word naming [saying aloud a visually presented word], and object naming [speaking aloud the name of an object from a corresponding picture]), and these variables are generally assumed to index specific components that are involved in the tasks in question. The consensus among researchers differs concerning the specific dimension(s) that certain variables actually measure. Imageability is certainly the most prototypical semantic variable that has been assumed to reliably index semantic code involvement in several tasks, such as word naming and lexical decision (e.g., Yap, Pexman, Wellsby, Hargreaves, & Huff, 2012) or object naming (Bonin, Guillemard-Tsaparina, & Méot, 2013). However, agreement among researchers is clearly less clear-cut as far as other variables, such as the popular subjective AoA ratings, are concerned. In effect, the question of whether these ratings reliably index the real age at which words are learned is still a matter of debate (see Bonin et al., 2004; Bonin, Méot, Mermillod, & Ferrand, 2009; Zevin & Seidenberg, 2002). With regard to SERs, it is believed that they are related to the conceptual sensory dimensions of the words, and are therefore semantic in nature. To better understand the nature of SER, it is interesting to examine the pattern of correlations between this variable and other psycholinguistic variables. If SERs index one aspect of the semantic representations of words, they should be strongly correlated with certain semantic variables, such as imageability or rated AoA, which are believed to reveal the semantic level or the lexical–semantic pathway involved in object-naming or categorization tasks (e.g., Johnston & Barry, 2006). (Indeed, it is important to stress, following Pexman, Hargreaves, Siakaluk, Bodner, & Pope's, 2008, claim, that the different richness dimensions are relatively uncorrelated, leading us to anticipate that perhaps only certain semantic variables will be correlated with SERs.) In the Juhasz and Yap (2013) study, they found a reliable correlation between SER and imageability (see also Juhasz et al., 2011), and the size of the correlation was similar to that found between rated AoA and imageability. According to Juhasz and Yap, SERs provide a more direct measure of the degree of sensory activation by visual word forms. Turning to the correlation between SERs and AoA, the authors also found this to be reliable, and this finding accords with the idea that words learned early in life are more likely to be linked to sensory/perceptual experiences. Amsel, Urbach, and Kutas (2012) collected norms for object attributes (color, motion, sound, smell, taste, graspability, and pain) for a large set of concrete objects. Interestingly, the findings of this study suggested that the SER variable may be weighted more heavily by knowledge types that are most salient in the conceptual representations of edible things. In Juhasz and colleagues' studies (Juhasz & Yap, 2013; Juhasz et al., 2011), the five words with the highest SER ratings (among their 5,857 words) were *garlic*, *walnut*, *water*, *pudding*, and *spinach*. We will examine whether this type of relationship, which has been identified in English, also holds true for French.

Online word processing and SERs

As has been suggested by two recent studies (Juhasz & Yap, 2013; Juhasz et al., 2011), the degree of sensory experience associated with a word influences the processes involved in word recognition. Juhasz et al. showed that SER predicted a significant amount of variance in lexical decision times in two megastudies of lexical processing in English when a large number of well-known psycholinguistic variables were taken into account. Juhasz and Yap also confirmed that SER predicted reliable amounts of variance in both lexical decision and naming times on words taken from the English Lexicon Project (Balota et al., 2007). Finally, Kuperman (2013) showed that SER reliably predicts lexical decision times for English noun–noun compound words (e.g., *deadline*, *pineapple*, *yearbook*), with the result that lexical decision times are faster for high-SER compound words. Interestingly, there is no reliable effect of SER for the constituents (e.g., *year* and *book* in *yearbook*). To account for SER effects in lexical decision, Jushasz et al. referred to the *language and situated simulation* model of conceptual processing (Barsalou, Santos, Simmons, & Wilson, 2008). According to this view, word recognition involves the activation of a linguistic form, together with the activation of a situated simulation that is grounded within the perceptual and sensory systems. It is assumed that activation of the linguistic form typically reaches a peak prior to the situated simulations. Situated simulations of sensory and perceptual information reflect deeper conceptual processing, which may be relied on to a greater extent in certain word recognition tasks. Following this view, the SER variable may be thought of as indexing the degree to which a word evokes a strong or meaningful situated simulation. The influence of SER is not limited to traditional visual word recognition tasks (lexical decision or word naming), since Zdrazilova and Pexman (2013) also reported an influence of SER in a semantic categorization task (i.e., deciding whether a word is an abstract word by pressing a key, or otherwise withholding a response).

The present study

The present study had a number of aims. The first and major goal was to provide SERs for a large set of French words, since no such norms are currently available.

We also wanted to analyze the relationships between SER and other psycholinguistic variables available for these words (e.g., objective and subjective word frequency, AoA, and imageability). Indeed, it remains to be seen whether the pattern of correlations found for English (Juhasz & Yap, 2013) may also hold true for French. In particular, we were interested in the relationship between SER and the rated AoA and imageability variables. Since recent studies have suggested that the SER variable is a reliable determinant of word recognition speed (Juhasz & Yap, 2013; Juhasz et al., 2011), we expected to replicate this finding in word recognition. More particularly, we investigated the influence of SER in French lexical decision times, word naming, and progressive demasking by using response times (RTs) that are available from previous studies (Ferrand et al., 2011; Ferrand et al., 2010). The collection of SER norms is especially important, since no other norms are available in French that also index perceptual or sensorimotor aspects of word recognition performance, such as BOI (Tillotson et al., 2008).

In the following sections, we will first report reliability and descriptive statistics on our SER norms. Then, we will provide analyses of the relationships of the sensory experience norms with other psycholinguistic variables (e.g., imageability and AoA). Finally, we will examine the role of SER in word recognition (for lexical decision, word naming, and progressive demasking).

Method

Participants

A total of 131 native speakers (84 females, 47 males; mean age: 25 years, range 17–58), with normal or corrected-to-normal vision, took part. They were all students from the University of Bourgogne (Dijon, France). All of the participants were volunteers and received course credit for their participation.

Stimuli

We used the 1,493 words for which AoA and subjective frequency ratings have been made available in French (Ferrand et al., 2008). In addition, we included the modal names (i.e., the corresponding French nouns) of 166 pictures taken from the Snodgrass and Vanderwart (1980) norms, since these are very often used in memory or psycholinguistic experiments. The words had a mean length of 4.96 and ranged from two to 13 letters in length.

Procedure

The rating task closely followed the procedure adopted by Juhasz et al. (2011). The 1,659 stimuli were divided into four questionnaires that were administered to three groups of 33 participants, plus one group of 32 participants. Each participant rated about 400 words. In each questionnaire, 20 items were repeated. The entire session lasted about 40 min. On the first sheet of the questionnaire, the participants were given instructions that asked them to rate, on a 1–7 scale, the degree to which each word evoked a sensory experience, with higher numbers indicating a greater sensory experience. Given that SERs have only been infrequently collected in the past, below we reproduce in full the instructions given to the participants. These were taken from the Appendix of the Juhasz et al. (2011) study:

> On the following pages is a list of words. Please read and consider each word based on the degree of sensory experience each one evokes for you. By sensory experience, we mean an actual sensation (taste, touch, sight, sound, or smell) you experience by reading the word. Please rate each word on a 1 to 7 scale, with 1 meaning the word evokes no sensory experience for you, 4 meaning the word evokes a moderate sensory experience, and 7 meaning the word evokes a strong sensory experience. There are no right or wrong answers. We are interested in your personal sensory experience with these words. You can indicate your rating by circling the number you choose next to each word.

Results

The mean ratings (and their standard deviations) collected for each stimulus are available in the supplementary materials. The items are listed alphabetically according to the French names of the pictures. Starting from the leftmost column, the following information is provided for each item: (1) the word, in both French and English, and (2) the mean SER and its standard deviation.

Reliability and descriptive statistics of the SER norms

The correlation between the scores obtained from the means of the even and odd participants was .85, and the correlation between the 80 items repeated over the different lists was .96. Although the difference between the means of the even and odd participants was reliable, $t(1658) = -7.9$, $p < .001$, it was weak ($M_{odd} = 3.02$ and $M_{even} = 3.13$). The difference on the repeated items was not significant, $t(79) = 1.98$, $p > .05$ ($M_1 = 3.01$, $M_2 = 2.94$). The ratings on sensory experience are therefore reliable at the levels of both items and participants.

Descriptive statistics for the SERs on item means are reported in Table 1.

As can be seen in Fig. 1, there was a slight positive asymmetry in the distribution of SERs. We found virtually no difference between the mean and the median, and very few words had scores located at the top of the scale—namely, beyond the value of 6 (see Table 2 for examples). In Table 1, descriptive statistics are also reported as a function of the grammatical category of the words belonging to a unique category. Only categories for which at least 30 words were available in the sample were taken into account. Consequently, only nouns, verbs, and adjectives were analyzed. To illustrate, in Table 2 we report the five words in each grammatical category having the highest versus the lowest SERs. A close examination of the words having the highest SERs revealed that, simply among the nouns, four words referred to potentially edible things. This tendency was less clear when all types of words were taken into account, in which case, for instance, the 15 highest SERs included seven potentially edible things.

Nouns and verbs exhibited very similar characteristics (see Table 1). The distribution of SERs for adjectives was shifted approximately 0.5 points to the left on the scale. Finally, in Table 1, we report the distribution of the SERs for words corresponding to the object names of the Snodgrass and Vanderwart (1980) pictures.

Table 3 shows the correlations between SER scores and other psycholinguistic variables. These were subjective variables—namely, AoA and subjective frequency (taken from Ferrand et al., 2008) and imageability (obtained from Bonin, Méot, Ferrand, & Roux, 2011). We took into account the following objective variables: film subtitle and book frequencies (in logs), numbers of letters and phonemes, numbers of orthographic and phonological neighbors, orthographic and phonological distances to the 20 nearest neighbors, and

Table 1 Descriptive statistics for sensory experience ratings

	N	Min	Max	Mean	*SD*	Q1	Med.	Q3	Skew
Total	1,659	1.09	6.13	3.08	.97	2.33	2.97	3.70	.47
Nouns	805	1.30	6.13	3.27	.95	2.52	3.18	3.94	.37
Verbs	46	1.82	5.15	3.15	.85	2.53	3.06	3.71	.57
Adjectives	39	1.36	4.61	2.77	.77	2.21	2.70	3.27	.46
Nouns S&V	252	1.41	6.13	3.72	.84	3.12	3.67	4.30	.17

Total = all normed words, Nouns S&V = words from the Snodgrass and Vanderwart database

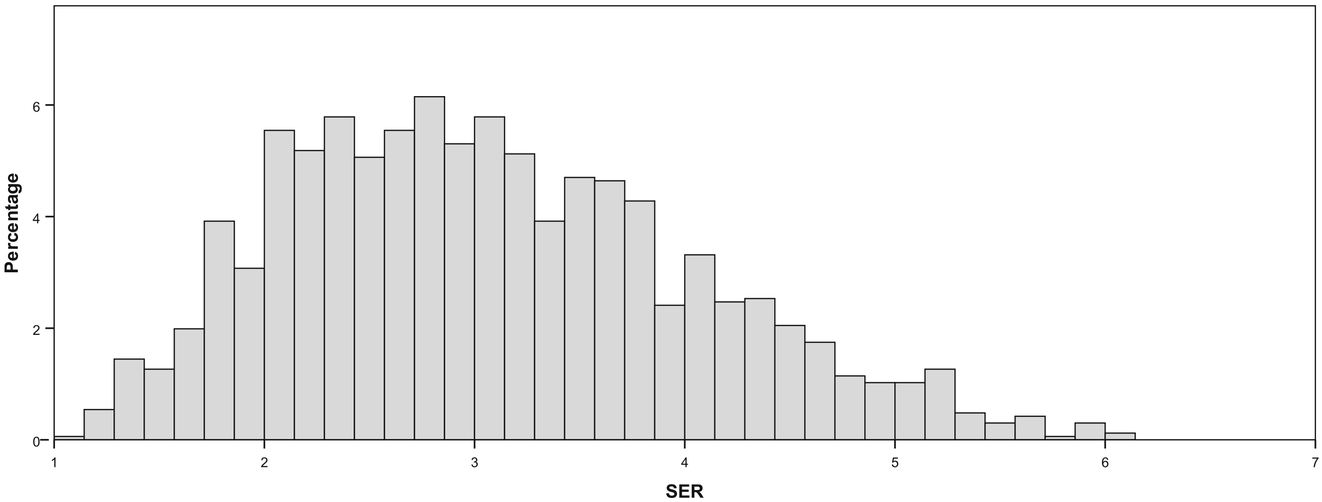

Fig. 1 Distribution of sensory experience rating (SER) scores for the whole set of words.

numbers of homographs and homophones. The values for the objective variables were all taken from Lexique 3 (New, Brysbaert, Véronis, & Pallier, 2007). It is important to note that because some words belong to different grammatical categories, the frequencies that we took into account were the cumulative frequencies—that is to say, for any given word, the sum of the frequencies across the categories to which the word belongs.

As had been observed in the two English studies (Juhasz & Yap, 2013; Juhasz et al., 2011), the highest correlations of SER with other psycholinguistic variables were observed for rated AoA and imageability, with the result that higher SERs were observed in connection with more-imageable and earlier-acquired words than with less-imageable and later-acquired words. The correlations of SERs with imageability and AoA were of same sign and were roughly similar to those observed in English. In French, but not in English, there were reliable but lower relationships between SERs and word length (i.e., higher SERs for longer words) and orthographic neighborhood (i.e., lower SERs for words having more neighbors). The correlation of SERs with cumulative objective frequency was nearly zero, whereas it had been negative but low in Juhasz et al.'s (2011) study. The correlations with subjective frequency ratings were negligible in both English and French when all the words were taken into account. However, this was not the case when "noun-only" included in the sample were examined separately, thus suggesting that for this grammatical category, the more frequently the words were estimated to be encountered, the greater the sensory experience they evoked (*r*s = .27 with subjective frequency and .24 and .22 with film subtitle and book frequencies). For this type of word, the correlation with AoA ($r = -.47$) was also higher than that observed for all the words taken together. The relationships between SER and AoA and imageability were, however, the highest for "adjective-only" words ($r = -.52$ and .66, respectively). For these words, the correlation of SER with the subjective frequency variable ($r = .23$) was similar to that observed for nouns, whereas the correlations with the other two objective frequency measures were not reliable ($r = .09$ and .13, respectively). Finally, for verbs, the correlation between SER and AoA was lower ($r = -.25$) than that observed with the entire set of words, whereas a reliable negative correlation was obtained between number of letters and SER ($r = -.33$), with the result that longer verbs were perceived as giving rise to a lower level of sensory experience. It is worth noting, however, that given the small numbers of adjectives and verbs (46 and 39, respectively), the reported correlations must be treated with caution.

In order to explore in more depth the relations that existed between SER and the other psycholinguistic variables, two stepwise regression analyses with SER as the dependent variable were performed: one on all words (over all grammatical categories), and one on nouns only[1] (Table 4). In both analyses, the percentages of explained variance were roughly similar. For the analyses with all words included, imageability was entered first, followed by AoA, whereas the opposite ordering was used for "only noun" words. (The orders of entry of imageability and AoA in these two regression analyses were different essentially because, among the "all-words" set, several items were early acquired or had lower imageability or sensory experience ratings. These words (generally adverbs, pronouns, or prepositions) greatly increased the variability of SER scores for early-acquired words, thus leading to a poorer fit when this variable was taken into account.)

Imageability reliably predicted sensory experience scores, with the result that with increasing imageability values, the sensory experience scores attributed to words were higher. In addition, rated AoA was a reliable predictor of sensory

[1] Given the small numbers involved, we did not run any analyses on either verbs or adjectives.

Table 2 The five items (among all words, nouns only, verbs only, adjectives only, and words represented in the Snodgrass & Vanderwart, 1980, database [S&V words]) having the lowest versus the highest sensory experience ratings, with their approximate English translations

All words		Nouns		Verbs		Adjectives		S&V Words	
Aux (to)	1.09	Cas (a case)	1.30	Louer (to rent)	1.82	Sûr (sure)	1.36	Rouet (spinning wheel)	1.41
Du (of)	1.21	Badge (badge)	1.41	Mettre (to put)	1.84	Moindre (lesser)	1.66	Bouton de porte (doorknob)	1.58
Que (that)	1.21	Rouet (spinning wheel)	1.41	Rouer (beat up)	1.85	Piètre (mediocre)	1.75	Casque de joueur (player's helmet)	1.76
Cesse (stop)	1.24	Valve (a valve)	1.45	Feindre (to feign)	1.97	Mixte (mixed)	1.76	Cruche (jar)	1.88
Le (the)	1.24	Terme (term)	1.47	Ruer (to kick out)	2.16	Prompt (quick)	1.79	Bureau (desk)	2.09
Froid (cold)	5.91	Eau (water)	5.61	Voir (to see)	4.64	Ivre (drunk)	3.83	Télévision (television)	5.50
Soleil (sun)	5.95	Pluie (rain)	5.63	Tuer (to kill)	4.66	Moite (clammy)	3.84	Violon (violin)	5.58
Larme (tear)	5.97	Soleil (sun)	5.95	Mordre (to bite)	4.69	Tiède (warm)	4.00	Cerise (cherry)	5.88
Gâteau (cake)	6.13	Larme (tear)	5.97	Jouir (to enjoy)	5.09	Saoul	4.48	Soleil (sun)	5.95
Rire (laugh)	6.13	Gâteau (cake)	6.13	Puer (to stink)	5.15	Triste (sad)	4.61	Gâteau (cake)	6.13

experience scores, so that the later the words were estimated to be acquired, the less intense the sensory experiences they evoked. The number of orthographic neighbors[2] was entered in the third step in both cases (all words included vs. "only noun" words included). The multiple regression analyses revealed that words with a large number of neighbors tended to evoke less intense sensory experiences than did words with fewer neighbors. Finally, the objective film frequency and number of homophones variables were entered in the regression performed with "only noun" words: More objectively frequent nouns (and nouns with more homophones) were rated as leading to more intense sensory experiences.

The role of SER in word recognition (lexical decision, word naming, and progressive demasking)

Word recognition RTs were taken from the French Lexicon Project (FLP) database (Ferrand et al., 2010) and from the Ferrand et al. (2011) study. In the FLP database, lexical decision times are available for 38,840 words, whereas the Ferrand et al. (2011) study provides RTs for a total sample of 1,826 monosyllabic words, ranging from two to eight letters in length, obtained in lexical decision, word naming, and progressive demasking. In order to assess the influences of SER in the three word recognition tasks, we took the following independent variables into account in addition to the SER scores: number of letters and film subtitle frequency (cumulated over grammatical categories and log-transformed) and their squares (after standardization), orthographic distance to the 20 nearest neighbors (OLD20), AoA ratings, subjective frequency, and imageability.[3] In addition, we included 11 initial phoneme features (coded as 0 or 1 on each feature) as predictors, following Treiman, Mullennix, Bijeljac-Babic, and Richmond-Welty's (1995) classification. It is important to include initial phoneme characteristics (e.g., voiced) in multiple regression analyses, since they are known to make a strong contribution when predicting word-naming latencies (e.g., Morrison & Ellis, 2000; Treiman et al., 1995). In order to make it easier to compare the different lexical tasks, only the 1,413 words for which scores were available for all dependent variables and independent variables (IV) were analyzed.

The descriptive characteristics and the correlations concerning RTs and the different psycholinguistic variables are provided in Tables 5 and 6. As can be seen from Table 6, the correlations between SER and RTs were all negative, thus suggesting that in all word recognition tasks, words linked with more sensory experiences are processed faster than those linked with fewer sensory experiences. However, it should be noted that the correlations were also relatively low, with the largest correlations being observed for the lexical decision task. This was also the case in Juhasz and Yap's (2013) lexical decision study.

The results of the simultaneous regression analyses[4] are given in Table 7. It is worth noting that, since the highest variance inflation factor for all of the IVs was 4 (1.5 for SER), we considered that multicollinearity problems could not have drastically affected the results of the regression analyses.

For each task, the line entitled "Ph1" shows the percentage of variance accounted for by the initial phoneme

[2] OLD20 was entered in the regression equation at this step when the number of orthographic neighbors (*N*; Coltheart, Davelaar, Jonasson, & Besner, 1977) was excluded from the independent variables.

[3] The independent variables were the same as in the Ferrand et al. (2011) study, except that no cubic splines for the number of letters, objective word frequency, and OLD20 were used. It is worth stressing that the number of norms available for the entire set of words was more limited in French than in English. It was therefore not possible to include certain other semantic or consistency variables without excluding many of the words.

[4] It is important to note that, unlike Juhasz and Yap (2013), and except for the initial phoneme characteristics, we did not use a hierarchical approach. Indeed, such an approach had been adopted in the Ferrand et al. (2011) analysis. The SER tests performed in the simultaneous analyses were equivalent to those obtained when SER was taken into account in the last run of a hierarchical approach.

Table 3 Correlations between sensory experience ratings and other psycholinguistic variables

	AoA	Imageability	Subjective Frequency	Film Frequency	Book Frequency	Letters (nb)	Phonemes (nb)	Orthographic Neighbors (nb)	Phonological Neighbors (nb)	OLD20	PLD20	Homographs (nb)	Homophones (nb)
r	–.309	.532	–.039	–.060	–.067	.169	.161	–162	–.120	.180	.138	–.129	–.069
p	.000	.000	.136	.015	.007	.000	.000	.000	.000	.000	.000	.000	.006
N	1,481	1,481	1,481	1,632	1,632	1,632	1,632	1,632	1,632	1,632	1,632	1,632	1,632

AoA = age of acquisition; nb = number; OLD20 = orthographic distance to the 20 nearest neighbors; PLD20 = phonological distance to the 20 nearest neighbors

characteristics and the corresponding results of the *F* test when these characteristics were the only IVs entered in the regression equation. The first aspect of note is that the results were consistent with those reported by Ferrand et al. (2011)—that is to say, we found a strong effect of the initial phoneme characteristics in word naming, as well as a noticeable but weak effect in progressive demasking. However, an important difference was observed with the English word-naming data (Juhasz & Yap, 2013), in which, surprisingly, phoneme onsets accounted for only 19 % of the variance in the first step of the regression analysis.

In Table 7, we also report the individual tests of the other IVs obtained from the regression analyses. The results are in line with those obtained in the Ferrand et al. (2011) study. For lexical decision, there were considerable differences between the explained variances in the two sets of RTs analyzed by Ferrand et al. (2011, p. 7), even though the SER variable was reliable in both analyses, as had previously been found in English (Juhasz & Yap, 2013; Juhasz et al., 2011). The effect of SER, which was reliable in lexical decision, was weak and not reliable in either the word-naming or the progressive demasking task. The same result was observed for monosyllabic words in word naming by Juhasz et al. (2011, note 2). However, the effect of SER was reliable when the monosyllabic words were analyzed together with the disyllabic words (Juhasz et al., 2011). As had been found for the English language, the percentages of variance uniquely explained by SER were low, and this might partly explain the discrepancies found between the different analyses (monosyllabic vs. monosyllabic plus bisyllabic words). This was probably the case when "only noun" words were analyzed using the same procedure: Although roughly similar estimations of partial coefficients and part correlations were obtained, no reliable effect of SER was found.

Discussion

SERs are among the most recent psycholinguistic variables to have been collected for a very extensive number of words in English (Juhasz & Yap, 2013). The main goal of the present study was to provide SERs for a large set of French words, since no such data were previously available and SERs appear to be of importance in accounting for visual word recognition performance. As we stressed in the introduction, it is important to bear in mind that new psycholinguistic variables do not always play a reliable role in lexical processing. Thus, certain variables collected for words may turn out to be useless. For instance, norms on the size of objects have been collected from visually presented words in English (Sereno et al., 2009) and French (Roux et al., 2014). However, thus far these norms have not proven to be useful, since they do not account for

Table 4 Stepwise regressions between sensory experience rating and other psycholinguistic variables

All Words (N = 1,481; R^2 = .309)					Nouns Only (N = 673; R^2 = .297)				
Variables	*b*	*t*	*p*	DR2	Variables	*b*	*t*	*p*	DR2
Imageability	.47	19.88	.000	.283	Age of acquisition	–.24	–4.29	.000	.218
Age of acquisition	–.17	–7.32	.000	.021	Imageability	.32	7.10	.000	.056
Orthographic neighbors (nb)	–.08	–3.36	.001	.005	Orthographic neighbors (nb)	–.12	–3.41	.001	.009
					Film Frequency	.10	2.35	.019	.007
					Homophones (nb)	.07	1.98	.048	.004

Results are given for the final equation with independent variables in the order they were entered. nb = number; DR2 = R-square change at each step

lexical performance in the tasks of lexical decision (Kang, Yap, Tse, & Kurby, 2011) or spoken picture naming (Roux et al., 2014). In the present study, beyond the collection of SERs for words in French and their usefulness for a better understanding of word recognition, we also questioned the status of SERs by examining (1) the correlations among several psycholinguistic variables and (2) which of these variables reliably predict the SERs assigned to words. In the following sections, we discuss these different aspects in turn.

The status of SER

In the present study, we questioned the status of SER. The findings reported by Juhasz and colleagues (Juhasz & Yap, 2013; Juhasz et al., 2011) had already suggested that SER is a semantic variable. To further examine the nature of SER, we investigated the relationships between this variable and other psycholinguistic variables by means of correlational and multiple regression analyses. Of particular interest were the relationships between SER and certain variables that are assumed to be semantic in nature (e.g., imageability; see, e.g., Evans, Lambon Ralph, & Woollams, 2012), certain variables that are in part semantic but also lexical in nature (rated AoA; see, e.g., Brysbaert, Van Wijnendaele, & De Deyne, 2000), and finally, certain variables that are considered truly lexical in nature (objective word frequency; see, e.g., Mädebach, Jescheniak, Oppermann, & Schriefers, 2011).

In line with the hypothesis that SER is a semantic variable, the findings from the correlational analyses revealed that SER correlated most highly with rated AoA and imageability, with higher SERs being attributed to more-imageable and earlier-acquired words (interestingly, the relationships of SER with AoA and imageability were at their highest in the case of adjectives). In effect, imageability is thought to be a typical semantic variable and, according to Plaut and Shallice (1993), this variable in fact indexes the richness of a conceptual representation. One implication of the strong correlation of SER with imageability is that both index the richness of conceptual representations. Rated AoA has also been thought to have a semantic component, as suggested, for example, by the greater role that it plays in picture naming (a semantic task) than in word naming (a task that is less dependent on semantics). It should be remembered that the correlations between SER and imageability, on the one hand, and between SER and AoA, on the other hand, were of the same sign and very similar to the correlations found in English. However, the fact that the correlation between SER and imageability was high, but not higher, suggests that the two variables index different aspects of semantic representations. Also, the multiple regression analyses with SER taken as a dependent variable revealed that imageability and rated AoA were reliable determinants of SER. Finally, indirect support for the hypothesis that SERs are semantic in nature has come from the observation that the correlation of SER with cumulative objective frequency was

Table 5 Descriptive statistics of variables used in the response time analyses

	Lexical Decision	Word Naming	Progressive Demasking	Lexical Decision (FLP)	Letters (nb)	Film Frequency	OLD20	PLD20	AoA	Subjective Frequency	Imageability	SER
Min	534.47	401.74	993.91	529.83	2	0.01	1	1	2.82	2.32	1.07	1.09
Max	868.12	615.39	1,484.19	963.47	8	4.41	2.85	2.4	15.45	7	6.93	6.13
Mean	662.85	484.57	1,191.84	657.74	4.73	1.31	1.5	1.21	7.68	4.28	4.56	3
Standard Deviation	63.31	37.62	82.05	61.37	1.13	0.85	0.31	0.29	2.3	1.03	1.57	0.95
Asymmetry	0.48	0.45	0.54	0.72	–0.11	1.01	0.24	1.16	0.41	0.63	–0.25	0.54

AoA = age of acquisition; nb = number; OLD20 = orthographic distance to the 20 nearest neighbors; PLD20 = phonological distance to the 20 nearest neighbors

Table 6 Correlations between variables used in response time analyses

	Lexical Decision	Word Naming	Progressive Demasking	Lexical Decision (FLP)	Letters (nb)	Film Subtitle Frequency	OLD20	AoA	Subjective Frequency	Imageability
SER	–.20	–.11	–.14	–.27	.05	–.06	.08	–.31	–.05	.53
Lexical decision		.33	.56	.62	.34	–.60	.15	.56	–.55	–.12
Word naming			.21	.25	.24	–.21	.17	.21	–.21	–.01
Progressive demasking				.43	.38	–.33	.11	.31	–.29	–.09
Lexical decision (FLP)					.10	–.36	.06	.41	–.35	–.19
Letters (Nb)						–.37	.49	.20	–.29	.15
Film Frequency							–.28	–.58	.80	–.30
OLD20								.22	–.21	.09
AoA									–.56	–.33
Subjective frequency										–.29

Using 1,413 words, correlations with absolute values beyond .09, .07 and .06 are significant at .001, .01 and .05 levels. FLP = French Lexical Project database (Ferrand et al., 2010; Ferrand et al., 2011); AoA = age of acquisition; nb = number; OLD20 = orthographic distance to the 20 nearest neighbors

virtually nonexistent (in the English study by Juhasz et al., 2011, it was negative but also low). In sum, SER should be added to the list of psycholinguistic variables that have been assumed to index the semantic richness of words, such as, for example, the image variability (i.e., the degree to which a word evokes few vs. many different mental images), BOI, and imageability variables. As far as BOI ratings are concerned, it is assumed that words that elicit high scores on this dimension have richer motor representations than do those with lower ratings on these dimensions. Thus, BOI more specifically indexes the richness of motor information, whereas SER indexes the richness of sensory information. Although the correlation of SER with imageability in the present study was high (.532), it is important to stress that it is not exceptional. It seems clear that these different measures do not tap a common, undifferentiated construct. What remains to be ascertained is which precise aspects of semantic knowledge are captured by imageability and SER. We suggest that imageability more readily captures the visual information corresponding to the semantic aspects of the words, whereas SER captures this dimension along with other sensory information (e.g., gustatory, olfactory, and auditory information).

In the introduction, we mentioned the Amsel et al. (2012) findings, which suggested that the SER variable may be weighted more heavily by knowledge types that are most salient in the conceptual representations of edible things. More precisely, Amsel et al. ran a principal-components analysis with a varimax rotation on seven object attribute ratings (e.g., taste pleasantness, smell intensity, and color vividness) and found that the three largest correlations of object attribute ratings with the SERs taken from Juhasz's studies (Juhasz & Yap, 2013; Juhasz et al., 2011) were the same three object

Table 7 Results of the multiple regression analyses on response times in lexical decision, word naming, and progressive demasking

	Lexical Decision–Clex (R^2 = .58)			Lexical Decision–FLP (R^2 = .35)			Word Naming (R^2 = .55)			Progressive Demasking (R^2 = .40)		
	Coef	*t/p*	DR2	Coef	*t/p*	DR2	Coef	*t/p*	DR2	Coef	*t/p*	DR2
Ph1			.009			.010			.46			.07
Letters (nb)	.24	11.28***	.038	.03	1.16	.001	.15	6.63***	.014	.44	16.88***	.123
Letters^2 (nb)	.01	1.02	.000	.07	4.11***	.008	–.01	–0.56	.000	.11	6.40***	.018
Film frequency	–.60	–16.98***	.087	–.46	–10.47***	.051	–.09	–2.38*	.002	–.34	–7.98***	.027
Film frequency^2	.19	13.39***	.054	.19	11.16***	.058	.07	5.22***	.009	.14	8.26***	.029
OLD20	–.12	–5.45***	.009	–.06	–2.10*	.002	.06	2.58**	.002	–.14	–5.53***	.013
AoA	.07	2.25**	.002	.04	1.09	.001	.13	4.09***	.005	.05	1.31	.001
Subjective frequency	–.20	–6.35***	.012	–.18	–4.60***	.010	–.07	–2.12*	.001	–.07	–1.84	.001
Imageability	–.21	–7.70***	.018	–.15	–4.34***	.009	.01	0.38	.000	–.09	–2.66**	.003
SER	–.04	–2.07*	.001	–.13	–4.79***	.011	–.02	–0.76	.000	–.03	–1.35	.001

Clex = chronolex; FLP = French Lexicon Project; Ph1 = initial phonemes characteristics; OLD20 = orthographic distance to the 20 nearest neighbors; AoA = age of acquisition; DR2 = R-square change at each step. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

attributes that contributed to a second principal component of their principal-components analysis—namely, smell, color, and taste. In particular, they pointed out that the five words with the highest SERs in Juhasz et al.'s studies were *garlic*, *walnut*, *water*, *pudding*, and *spinach*. In our study, we did not find such a straightforward relationship, but, interestingly, among the five nouns with the highest SERs were four words that—even though they are not all strictly speaking food-related words—refer to potentially edible things: *tear*, *rain*, *cherry*, and *cake*. However, when all types of words were taken into account, the relationship was less obvious, even though some "edible words" were among the 15 words with the highest sensory experience scores. At a general level, we performed cross-linguistic comparisons with Juhasz and Yap (2013) on translation equivalents. This revealed a correlation of .55 between the SER scores of the 952 words present in both languages. It is interesting to note that a correlation of .47 was found when we took account of French imageability scores (taken from Bonin et al., 2011) and the American-English SER. (The latter correlation was computed on the basis of 862 words for which scores were available in the two languages.) Thus, although the correlation between French and in English was relatively high for SERs, it was not "very high," thus suggesting that cultural and linguistic differences may account for the different ratings assigned to the "same" words in the two languages.

The influence of SER in visual word recognition

From a theoretical point of view, the collection of SERs is useful because these items can be used to test certain aspects of the grounded-cognition framework (Juhasz & Yap, 2013). According to this view, conceptual processing is rooted in the perceptual systems (e.g., Barsalou et al., 2003). The finding of Juhasz and colleagues that SERs account for a reliable amount of variance in word recognition performance in adults is in line with the grounded-cognition framework. To account for SER effects in visual word recognition within the perceptual-symbol-systems framework (Barsalou, 1999), it is assumed that multiple neural systems are involved in the retrieval of lexical conceptual knowledge, and that some of these systems are dedicated to the processing of sensory knowledge (e.g., visual, auditory, olfactory), emotional knowledge (e.g., fear, anger), introspective knowledge (e.g., thought), and motor, kinesthetic, and proprioceptive knowledge. The retrieval of lexical conceptual knowledge from memory is a process of simulation—that is to say, one that requires the partial reenactment of the states of the various neural systems that were involved at the time of encoding. Therefore, during the course of recognition, words with a high SER will elicit richer visual, auditory, olfactory, and so forth, simulations than will words with a low SER.

In our study, we were able to replicate the observation of a reliable influence of SERs in visual word recognition. First of all, we found that the correlations between SER and RTs were all negative, suggesting that words with higher SERs were processed faster than those with lower SERs in the word recognition tasks. Importantly, the multiple regression analyses performed on RTs taken from two recent studies in French (Ferrand et al., 2011; Ferrand et al., 2010) revealed that SER are one of the reliable determinants of the word recognition speed in the lexical decision task (but see also Zdrazilova & Pexman, 2013). One limitation is that the effect of SERs was not significant in either word naming or progressive demasking.

Before examining in greater detail why there would be differential impacts of SER in lexical decision, word naming, and progressive demasking, it should be remembered that, thus far, very few studies have investigated the influence of SERs in different lexical tasks. In the Juhasz et al. (2011) study, although the influence of SERs in word naming was reliable when both monosyllabic and disyllabic words were analyzed, it was nevertheless somewhat weaker than in lexical decision. Importantly, the effect of SERs was not reliable when only monosyllabic words were included (Juhasz et al., 2011, note 2).

In sum, we found that SERs have a reliable influence in lexical decision, but not in word naming or progressive demasking. If it is assumed that word naming and progressive demasking are less dependent than lexical decision on the activation of semantic codes, and given that SER seems to be a variable that indexes semantic code activation, the differential pattern of reliable effects of SERs makes sense at the theoretical level. Interestingly, this line of reasoning has been applied to the differential influences of frequency trajectory in different lexical processing tasks. Frequency trajectory, which corresponds to the variation over time in the frequency of exposure to words from childhood to adulthood, has been assumed to be a variable that indexes the activation of lexical–semantic codes and is predicted to play a role in lexical tasks that strongly rely on semantics, such as spoken/written naming (i.e., speaking words aloud vs. writing them down from pictures) or lexical decision. In accordance with this prediction, Bonin et al. (2004) found a reliable influence of frequency trajectory on RTs in lexical decision and spoken and written picture naming, but not in word naming or spelling to dictation—that is, two tasks that are thought to be less dependent upon semantics. It should also be remembered that the differential influences of imageability in word naming and lexical decision have been interpreted in the same way. Since imageability is a semantic variable, its influence should be stronger in tasks that rely more on semantic code activation. Indeed, it has often been reported that imageability plays a greater role in lexical decision than in word naming. However, as was claimed by Yap, Pexman, Wellsby, Hargreaves, and Huff (2012), more recent studies that have used large sets of words (e.g., Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004) have provided evidence that semantic effects (e.g., imageability effects), though weaker, can be reliably observed in word naming. Thus, the available evidence suggests that semantic information plays a stronger role in the lexical decision task than in the word-naming task, because semantic information is used to discriminate between words and nonwords, a process that is specifically involved in lexical decision (Balota & Chumbley, 1984; Chumbley & Balota, 1984). Turning to the finding that SERs did not reliably influence progressive demasking, this is in line with the findings reported by Ferrand et al. (2011) that progressive demasking performance was primarily influenced by perceptual/visual factors such as number of letters. Since SER effects are assumed to be semantic effects, it is not surprising that SERs do not play a reliable role in the progressive-demasking task (PDT). These findings are also consistent with those of Yap et al. (2012), who found that speeded naming and progressive demasking were relatively insensitive to the influence of semantic richness, as compared to lexical decision and semantic categorization. However, it is worth noting that we found an effect of imageability in the PDT. Since imageability is assumed to be a prototypical semantic variable, this suggests that the PDT is not insensitive to semantic effects. However, the reason why an effect of imageability, but not of SER, was found in the PDT may be that these two variables do not index the same kinds of semantic information. As we suggested earlier, it is possible that imageability more readily captures the visual-related information that is a dominant feature of sensory representations, and that the PDT might therefore not be the most appropriate task for revealing differential and subtle facets of semantic representations, and in particular of sensory dimensions other than the visual ones that are captured by SER.

In the literature, it is not uncommon for different semantic variables to have an influence in certain lexical processing tasks but not in others (Yap et al., 2012; Yap, Tan, Pexman, & Hargreaves, 2011). Take, for instance, the Yap et al. (2012) study, in which the impacts of several dimensions of semantic richness (number of features, semantic neighborhood density, imageability, number of senses, and BOI) were investigated across different visual word recognition tasks (i.e., lexical decision, speeded pronunciation, semantic classification, progressive demasking, and go/no-go lexical decision). Without describing the findings in detail, it is obvious from this study that the strength of certain semantic richness effects is systematically and adaptively modulated by the specific demands of a given lexical processing task. Indeed, Zdrazilova and Pexman (2013) have claimed that semantic representations are undoubtedly multidimensional and that the processing of lexical–semantic information is dynamic, with the result that the task demands influence the meanings that are accessed (see also Hargreaves & Pexman, 2014). For example, the effect of semantic ambiguity is helpful in lexical decision, but null or inhibitory in semantic categorization (Yap et al., 2012). As far as lexical decision is concerned, it is also the case that semantic involvement can vary on the basis of the nature of the nonwords (pseudohomophones or legal or illegal nonwords) that are used (e.g., Evans et al., 2012).

Thus far, SER effects have rarely been explored in semantic tasks such as semantic categorization (e.g., is the word's referent concrete? edible?). One intriguing issue is the extent to which SER effects are observed in various semantic tasks. Bennett et al. (2011) have found that imageability and BOI effects are at their greatest in semantic categorization tasks and are smaller in lexical decision. Since SER, like BOI and imageability, is a semantic variable, one would expect SER effects to show up in semantic tasks (e.g., is the word's referent easy to sense or not?), and indeed to be stronger than in word naming or lexical decision. The only study that we are aware of that has investigated SER effects using a semantic task is the one conducted by Zdrazilova and Pexman (2013). These authors examined the influence of SER (and of other semantic variables, such as number of associates and semantic neighborhood) for abstract words. An influence of SER was found in a semantic categorization task that took the form of a go–no-go abstract decision task, with the result that faster latencies were associated with words evoking a richer sensory experience. Because the building of semantic representations varies as a function of the task demands (Zdrazilova & Pexman, 2013), future studies should investigate the influence of SER in various semantic tasks. The examination of this issue is especially important in light of the work by Tousignant and Pexman (2012), who found that the influence of BOI varied as a function of the types of decision made on the words. More particularly, participants were told about one (*is it an action* vs. *is it an entity?*) or both (*action or entity?* vs. *entity or action?*) categories of words in the decision task, and facilitatory BOI effects showed up only when the participants were informed that "entity" was part of the decision category.

It could be asked whether our findings mean that the sensory experiences evoked by words (e.g., the smell of a rose, the touch of fur) lie at the core of the conceptual/semantic representations—that is to say, whether concepts are grounded in the same neural systems that are activated in processing real-world perceptual, motor, and affective experience. Indeed, a currently keenly debated issue in cognitive science is the extent to which motor knowledge—but also sensory and perceptual knowledge—is constitutive of conceptual representations, or whether conceptual knowledge might be better described as consisting of amodal representations. According to the latter view, semantic/conceptual representations can be accessed independently of modality, with the result that the orthographic form of the word *cat* activates similar conceptual content to that resulting from a drawing of a cat (Fairhall & Caramazza, 2013). This view assumes that sensory and motor information from the environment is transformed into an amodal symbolic representation format that lacks a direct representation of sensory or motor events. It is not our intention to discuss the widely debated and controversial issue of the precise nature of conceptual memory traces in detail here, since this would be beyond the scope of the present study. However, since the influence of SER has been discussed within the theoretical framework of the embodied view of cognition, we would like, before concluding, to provide readers with a little background information concerning this ongoing debate.

A growing body of evidence based on behavioral, neuropsychological, and neurophysiological data tends to favor a grounded-cognition or embodiment view of cognition (see Kiefer & Pulvermüller, 2012, for a recent review). For instance, there is evidence that reading the words *garlic* or *cinnamon* causes activation in the primary cortex, relative to control words (Gonzalez et al., 2006). Similarly, it has been found that the processing of action words activates motor areas that are related to the body part involved in the action, so that reading *kick* activates primarily dorsal parts of the motor cortex, whereas *lick* activates the lateral and ventral parts of the motor cortex (e.g., Hauk & Pulvermüller, 2004). However, the finding that motor and/or sensory information plays a role in several cognitive skills such as word naming or speaking words aloud from pictures, as reported earlier, does not necessary mean that motor and sensory forms of information lie at the core of conceptual knowledge. To illustrate the latter point, we consider a recent study that investigated the issue of whether motor experiences (and, by extension, sensory experiences, although this was not investigated in the study in question) lie at the heart of conceptual/semantic representations (Vannuscorps, Andres, & Pillon, 2014). Vannuscorps et al. investigated the identification of manipulable artifacts in a patient (D.C.) who was totally deprived of hand motor experience, due to upper limb aplasia. As a result, he was unable to interact with most manipulable artifacts, with regard to which he therefore possessed no motor knowledge. However, he did possess motor knowledge of certain artifacts that he routinely used with his feet. Accordingly, if one assumes that the richer the conceptual representation of an object is, the more easily that object is identified, manipulable artifacts that are associated with motor knowledge should be identified more accurately and/or faster than manipulable artifacts that are not. The performance of the patient was examined in a picture-naming task using manipulable artifacts for which he had motor knowledge, which were compared with manipulable artifacts for which he had no motor knowledge. No reliable difference in naming performance emerged for the artifacts associated with motor knowledge versus those not associated with motor knowledge, thus leading Vannuscorps et al. to suggest that motor knowledge is not part of the concepts of manipulable artifacts. Thus, the nature of conceptual representations is currently a matter of debate, and we hope that the collection of SERs will be of value in the design of studies intended to shed light on this debate.

To conclude, we have provided SERs for words in French, which we think will be useful to researchers who are interested in investigating the roles of sensory and perceptual information during the processing of words in different lexical tasks and/or the encoding of words for subsequent recall.

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