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Lisbon Symbol Database (LSD): Subjective norms for 600 symbols

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Abstract

This paper presents subjective rating norms for a new set of 600 symbols, depicting various contents (e.g., transportation, technology, leisure activities) that can be used by researchers in different fields. Symbols were evaluated in aesthetic appeal, familiarity, visual complexity, concreteness, valence, arousal and meaningfulness. The normative data were obtained from 388 participants and no gender differences were found. Descriptive results (mean, standard deviation and confidence intervals) for each symbol in each dimension are presented. Overall, dimensions were highly correlated. Additionally, participants were asked to briefly describe the meaning of each symbol. Results indicate that the current symbol set is varied, allowing the selection of exemplars with different levels on the seven examined dimensions. This set of symbols constitutes a tool with potential for research in different areas. The database with all the symbols is available as supplemental material.

Keywords: symbols, normative data, subjective ratings, aesthetic appeal, familiarity, visual complexity, concreteness, valence, arousal, meaningfulness

Lisbon Symbol Database: Subjective norms for 600 symbols

Symbols are everywhere. Just think about a typical day. At home we can find them in the box of cereal we eat for breakfast (e.g., brand logo and recyclable package symbol). On our way to work they are on the car dashboard (e.g., fuel symbol) and on the road (e.g., traffic signs). Upon arrival at the office, they are all over our computer screen (e.g., software and internet icons). Symbols are used to quickly and easily communicate a variety of information, such as directions, places and actions, in both the physical and virtual worlds (Tijus, Barcenilla, Lavalette, & Meunier, 2007).

What defines a symbol? From the semiotics standpoint, a sign constitutes a part of a triadic relation composed of an object (the referent), a sign, and an interpretant (connecting the previous elements). Based on the relationship between a sign and its object, three categories are defined: (a) icons - the relationship is based on similarity (e.g., caricature), (b) indexes - the relationship is based on a real direct connection (e.g., fingerprint), and (c) symbols - the relationship is based on an arbitrary convention (e.g., a national flag; for reviews on this matter see Harbeck, 2011; McDougall, Curry, & De Bruijn, 1999; Nakamura & Zeng-Treitler, 2012). However, as noted by Nakamura and Zeng-Treitler (2012), the distinction between different types of signs is not always clear, and authors often redefine these concepts in an attempt to clarify the stimuli they are referring to. In line with McDougall and colleagues (1999), we use the term “symbol” to refer not only to symbols, but also to icons, pictograms and signs. Symbols are generally used to replace written indications and instructions regarding regulatory, mandatory, warning and prohibitory information. They are particularly useful in situations that require information to be

processed quickly and when perceivers have limited linguistic ability (e.g., low levels of literacy; non natives; for a review see Tijus et al., 2007).

Considering the importance and extensive use of symbols in our daily life, as well as in our scientific endeavors, the goal of the present paper is to provide normative ratings for a broad set of 600 symbols that can be used by researchers in different fields. The publication of norms for sets of stimuli is of utmost importance for the scientific community as it provides validated materials that can be used in different experimental paradigms, particularly when the manipulation (and strict control) of stimuli characteristics is required. The proliferation of such publications comes therefore with no surprise. Already in 1999, Proctor and Vu provided an index of norms and ratings published in the Psychonomic Society journals between 1965 and 1999, which includes 142 sets, mostly of verbal materials. We can also find normative data for a variety of visual stimuli, from simple line-drawings sets (e.g., Cycowicz, Friedman, Rothstein, & Snodgrass, 1997; Snodgrass & Vanderwart, 1980) to complex real life pictures depicting a broad range of contents such as people, animals or objects (e.g., Dan-Glauser & Scherer, 2011; Lang, Bradley, & Cuthbert, 2008; Marchewka, Zurawski, Jednorog & Grabowska, 2013; Prada, Cunha, Garcia-Marques, & Rodrigues, 2010). A considerable number of databases with normative ratings of human faces are also available in the literature (e.g., Ebner, Riediger, & Lindenberger, 2010; Goeleven, De Raedt, Leyman, & Verschuere, 2008; Langner et al., 2010). For symbols, however, the amount of published resources is more limited. One important exception is McDougall and colleagues' (1999) 239 symbols set. This set comprises symbols categorized according to the contexts in which they are used, namely: computers (e.g., software packages); traffic and public information (e.g., road signs); industrial (e.g., machinery) and household goods (e.g., domestic appliances).

In this study, the authors presented norms for familiarity, complexity, concreteness, meaningfulness and semantic distance for each symbol. The same set was subsequently tested with regard to aesthetic appeal (McDougall & Reppa, 2008).

The current paper presents 600 new symbols. Each symbol was evaluated in five of the dimensions used by McDougall (McDougall et al., 1999; McDougall & Reppa, 2008): familiarity (subjective frequency), visual complexity, concreteness, aesthetic appeal and meaningfulness. Additionally, we added two new dimensions - valence and arousal - and collected data regarding the meaning attributed to each stimulus. The motivation for developing norms for this new set, entirely different from existing ones (e.g., McDougall et al., 1999), was twofold. First, we wanted to test a broader range of stimuli in order to have a more diverse pool from which different subsets can be selected. For instance, we included symbols that were recently introduced in our lives such as gadgets and social media. Second, the current aesthetics and visual appearance of symbols is not the same as it was 16 years ago. Thus, McDougall and colleagues' (1999) symbol set may appear somewhat outdated in the present days.

Normative ratings for a large set of symbols constitute a tool with potential for research in different areas. For example, this type of stimuli is useful for researchers using mere-exposure (i.e., repeated exposure to Chinese-like characters leads to more positive attitudes, Zajonc, 1968) or affective priming paradigms (e.g., ideographs are evaluated more positively when preceded by happy vs. angry faces, Murphy & Zajonc, 1993). Our set may offer alternatives in material selection beyond the foreign language characters typically used (e.g., Greek, see Garcia-Marques, 2005; Japanese, see Hess, Waters, & Bolstad, 2000; Rottevel & Phaf, 2004). Symbols have also been used to prime concepts (see Bargh & Chartrand, 2000). For example, the “dollar”

symbol (embedded in the background of a web page) activates a specific product attribute (i.e., price), increasing its weight in a subsequent decision-making task (Mandel & Johnson, 2002). Other possible uses include the examination of the effects of visual context on memory (Palma, Garrido, & Semin, 2014), of the processes involved in icon comprehension (e.g., McDougall & Isherwood, 2009), theories of attention and visual search tasks (e.g., McDougall, Tyrer, & Folkard, 2006), the refinement of visual process models (e.g., Figl, Mendling, & Strembeck, 2013), and neuroimaging studies examining how icons are processed in the brain (e.g., Huang, Bias, & Schnyer, 2015). Furthermore, this database is also likely to be useful in more applied domains, namely: effective communication of traffic sign messages to road users (e.g., Oh, Rogoff, & Smith-Jackson, 2013); comprehension and use of pharmaceutical pictograms (e.g., Montagne, 2013); warning symbol comprehension (e.g., Lesch, Powell, Horrey, & Wogalter, 2013); cross-cultural comparison in the use of symbols to convey warnings and instructions (e.g., Bleses & Mak, 2012; Chan & Ng, 2012); design of icons that are suitable to specific populations such as the elderly (e.g., Leung, McGrenere, & Graf, 2011) or preschoolers (Chiu, Koong, & Fan, 2012).

In sum, the current symbol set can provide standardized ready-to-use experimental material to Portuguese researchers. It should be noted that this type of norms can be culture-specific. For instance, Snodgrass and Vanderwart's stimulus set (1980), originally evaluated by a North American sample, has been validated in several countries and cultures including Portugal, Italy, Russia and Japan (for a review see Wang, Chen, & Zhu, 2014). Other international normative stimulus sets such as ANEW (Soares, Comesaña, Pinheiro, Simões, & Frade, 2012), IADS (Soares et al., 2013) and IAPS (Soares et al., 2014) have also recently been adapted to the

Portuguese population. Likewise, the current symbol set is also readily available for cross-validation in other countries.

In the following section, we provide an overview of the dimensions used to evaluate the symbols, their relevance to symbols' evaluation, and the relationships between them that have been reported in the literature.

Dimensions of Interest

Familiarity. The familiarity of a symbol refers to the frequency with which it is encountered (McDougall et al., 1999). Familiarity seems to be highly relevant for the accurate understanding of a symbol. Not only familiarity improves comprehension (e.g., Cahill, 1975), it also affects the usability of symbols as shown by the considerable increase in users' performance after learning symbol–function relationships (e.g., Montagne, 2013). Additionally, it has been shown that familiarity and experience with a symbol reduces the impact that other variables (e.g., concreteness level or the use of color) have on its comprehension (e.g., Christ & Corso, 1982; Isherwood, McDougall, & Curry, 2007; Stammers, George, & Carey, 1989). Thus, familiarity appears to be a key-attribute for understanding symbols.

As noted by McDougall and colleagues (1999), having access to objective frequency of occurrence of symbols is a rather difficult task, especially when compared to words for which indexes of frequency of occurrence in the language are available (e.g., Brown corpus for English, Kučera & Francis, 1967; Celex corpus for Dutch, Dutch Center for Lexical Information, 1995). For these reasons, subjective measures are more common, such as subjective estimations of the frequency with which participants encounter a given symbol (e.g., McDougall et al., 1999). Hence, we asked our participants to indicate how frequently they encounter or see the stimulus in their daily routine. More frequently encountered stimuli should be

considered more familiar (1 = *Not familiar*; 7 = *Very familiar*).

Visual complexity. The complexity of a pictorial stimulus refers to the degree of detail or intricacy the symbol contains (e.g., McDougall et al., 1999; Snodgrass & Vanderwart, 1980). Some authors choose to use the opposite term – simplicity, to refer to the same concept (e.g., Chan & Chan, 2013; Ng & Chan, 2007). Due to its influence in the way a stimulus is processed and evaluated, complexity is one of the most frequently measured characteristics by researchers providing normative data for visual stimuli (e.g., Alario & Ferrand, 1999; Bonin, Peereman, Malardier, Méot, & Chalard, 2003; McDougall et al., 1999; Snodgrass & Vanderwart, 1980). Research suggests that complexity determines the easiness with which a stimulus is processed (Alario & Ferrand, 1999). For example, more complex images take longer time to categorize than simpler ones (e.g., Snodgrass & Vanderwart, 1980). Stimuli complexity has also been shown to have a negative influence on performance speed in visual search tasks (Byrne, 1993; McDougall, de Bruijn, & Curry, 2000; McDougall et al., 2006; Reppa, Playfoot, & McDougall, 2008). However, despite the important role of visual complexity in the visual search for symbols, complexity does not seem to be directly involved in symbol identification (McDougall et al., 2000; see also Biederman, 1987; Paivio, Clark, Digdon, & Bons, 1989; Snodgrass & Corwin, 1988; Snodgrass & Yuditsky, 1996). Recently, Gerlach and Marques (2014) showed that the impact of visual complexity on visual object processing depends on task requirements: when difficult decisions regarding an object are required (e.g., decisions that require a great deal of differentiation between objects), complexity seems to hinder performance, while it facilitates performance for easy decisions (e.g., those that require little differentiation between objects).

The literature suggests the existence of a negative correlation between visual

complexity and familiarity (see Forsythe, Mulhern, & Sawey, 2008). For example, Snodgrass and Vanderwart (1980) showed that visually complex pictures were rated as less familiar (see also Alario & Ferrand, 1999; Bonin et al., 2003; McDougall et al., 1999), although the correlation between the two variables was only small to moderate. Alario and Ferrand (1999) have argued that this negative association emerges because visual complex pictures tend to be perceived as novel stimuli (for a discussion on the possible confound between familiarity and complexity measures see Forsythe et al., 2008). Also, alluding to the association between the two dimensions, the beneficial impact of familiarity on visual search tasks does not seem to be observed in the case of complex stimulus (McDougall et al., 1999; 2006).

Despite the proposed objective metrics to define the visual complexity of pictorial stimuli (e.g., the size of the digitalized stimuli picture files, International Picture Naming Project, Székely & Bates, 2000; number of lines, letters, and simple shapes an icon contains, Garcia, Badre, & Stasko, 1994; for a review see Forsythe et al., 2008), visual complexity is often measured in subjective terms. In this case, instructions must emphasize that participants indicate the complexity level of the visual characteristics of the symbols and not the complexity level of the object or concept they depict (e.g., Alario & Ferrand, 1999; Bonin et al., 2003; Isherwood et al., 2007; McDougall et al., 1999; Sanfeliu & Fernandez, 1996; Snodgrass & Vanderwart, 1980). We used this type of instructions and asked participants to indicate how much visual detail and complexity the stimulus contain. The more details it contains, the more complex should be considered (1 = *Very simple*; 7 = *Very complex*).

Concreteness. According to McDougall and colleagues' (1999) definition, concreteness of a symbol refers to the extent to which the symbol depicts real objects,

materials or people. Thus, concrete symbols depict “objects, places, and people that we are already familiar with in the real world” (p. 488), while abstract symbols have a less obvious link to the real objects, and thus “represent information using graphic features such as shapes, arrows, and so on” (p. 488). Concreteness is considered one of the most relevant properties of symbols and icons (see Isherwood et al., 2007; Moyes & Jordan, 1993). When stimuli depict objects with which individuals are familiar with, people can rely on their knowledge to interpret their meaning.

However, if on the one hand some studies show that people respond faster and more accurately to concrete symbols (e.g., Arend, Muthig, & Wandmacher, 1987; Rogers & Osborne, 1987; Stammers & Hoffman, 1991; Stotts, 1998), others suggest that these performance advantages are not permanent and decrease as a function of individuals’ experience with the symbols (e.g., Green & Barnard, 1990; McDougall et al., 2000).

Concreteness is often associated with the use of extra detail in the symbols, in order to depict objects in an obvious manner and in close connection with real-world items. In other words, concrete symbols are more complex due to the extra detail they include. Garcia and collaborators (1994) provided support for this hypothesis by showing that concrete symbols fared higher in their objective visual complexity measure (see the “Visual complexity” section above for details). Thus, concrete symbols seem to be associated with higher complexity and abstract symbols with higher simplicity. However, McDougall and colleagues (1999) did not find a significant correlation between concreteness and complexity, suggesting that concrete symbols may also be simple, and abstract symbols may be complex. In our study we asked participants to indicate how concrete the symbol is. Stimuli depicting objects, materials or people should be considered concrete, if otherwise they should be considered as more abstract (1 = *Totally abstract*; 7 = *Totally concrete*).

Aesthetic appeal. This dimension refers to how much a symbol is liked by individuals (e.g., McDougall & Reppa, 2008). This characteristic seems to be particularly important, for example, for symbol usability and users' performance with computer interfaces, as it determines the amount of effort individuals are willing to make in order to learn how to use an interface (see Reppa et al., 2008). Aesthetic appeal is also related with other symbol dimensions, the most significant being familiarity and visual complexity: familiar and visually simple symbols are liked more than unfamiliar and complex symbols (see McDougall & Reppa, 2008). The relation between aesthetic appeal and visual complexity can also be observed in visual search tasks. In these tasks, aesthetic appeal facilitates performance when stimuli are complex, but does not have any impact when stimuli are visually simple (Reppa et al., 2008). Following McDougall and Reppa (2008), we asked participants to indicate how visually appealing the symbol is considering its visual characteristics and not the object or concept it may depict (1 = *Visually unpleasant/unappealing*, 7 = *Visually very pleasant/appealing*).

Valence. Valence can be defined as the intrinsic attractiveness or aversiveness of a stimulus (e.g., Fridja, 1986). It is the dimension that captures the positive-negative nature of an object, an event or a situation. In the psychology literature, the term is also applied to characterize and categorize specific emotions (e.g., fear and anger are negatively valenced, while joy and happiness are positively valenced) or behaviors (e.g., positive valence refers to approach behaviors, and negative valence refers to avoidance/withdrawal behaviors; for a review on the uses of the term "valence" since it was introduced in the literature, see Colombetti, 2005).

Valence has a well-documented impact on the way people process and judge stimuli. For example, Angrilli, Cherubini, Pavese and Manfredini (1997) showed that

participants judge negatively valenced images as being presented for shorter durations than positive images. In the domain of memory, Adelman and Estes (2013) showed that in a recognition test of words individuals' performance improved when the stimuli became more extreme in either positivity or negativity.

However, valence has not been thoroughly explored in the domain of normative ratings for symbols. This may be due to the fact that when aesthetic appeal is assessed (see the "Aesthetic appeal" section above), that dimension already captures part of the positive-negative nature of the stimuli. However, since symbols may vary in the meaning they convey, it is also relevant to evaluate the valence associated with that meaning, as it has been the case for words (e.g., Bradley & Lang, 1999a; Moors et al., 2013; Söderholm, Häyry, Laine, & Karrasch, 2013; Warriner, Kuperman, & Brysbaert, 2013). Like aesthetic appeal, valence is highly associated with familiarity. Not only familiar stimuli seem to be associated with positive feelings, being preferred over new ones (the mere exposure effect, Zajonc, 1968), but also individuals tend to judge positive stimuli as more familiar than negative ones (e.g., Garcia-Marques, Mackie, Claypool, & Garcia-Marques, 2004; Monin, 2003). Additionally, studies that use physiological measures (e.g., facial muscle activity) have shown that the exposure to repeated pictures is associated with a higher activation of the smiling muscle (*zygomaticus major*; e.g., Harmon-Jones & Allen, 2001), while the contraction of that same muscle leads to stimuli being judged as familiar (e.g., Phaf & Rotteveel, 2005).

In the present study we asked participants to indicate the extent to which they considered each symbol refers to something positive/pleasant or to something negative/unpleasant (1 = *Refers to something very negative/unpleasant*; 7 = *Refers to something very positive/pleasant*).

Arousal. Along with valence, arousal appears as one of the fundamental dimensions of affect, differentiating states of high activation/excitement from more relaxed/calm emotional states (Osgood, Suci, & Tannenbaum, 1957). Like valence, arousal was rarely assessed in the available normative ratings for symbols. However, this dimension is frequently measured in other types of stimuli, such as words (e.g., ANEW, Bradley & Lang, 1999a; Moors et al., 2013; Warriner et al., 2013), sounds (IADS, Bradley & Lang, 1999b; Redondo, Fraga, Padrón, & Piñeiro, 2008), and also real-life pictures of diverse contents (IAPS, Lang et al., 2008; see also Grühn & Scheibe, 2008).

Most studies that measure the arousal elicited by pictorial stimuli (i.e., IAPS images) have found that the association between valence and arousal follows a U-shaped function. That is, stimuli that are more extreme in positive or negative valence are also rated as more arousing (Bucks, da Silva, & Han, 2005; Ito, Cacioppo, & Lang, 1998; Lang, Bradley, & Cuthbert, 1998; Libkuman, Otani, Kern, Viger, & Novak, 2007; but for exceptions see Grühn & Scheibe, 2008 and Ribeiro, Pompéia, & Bueno, 2005). In the current study we asked participants to evaluate the extent to which the symbol refers to something arousing/exciting or passive/calm (1 = *Refers to something very passive/calm*; 7 = *Refers to something very arousing/exciting*).

Meaningfulness. In their early study providing normative ratings of symbol characteristics, McDougall and collaborators (1999) asked participants to indicate the extent to which a symbol conveyed meaning (in a continuum ranging from totally meaningless to totally meaningful). As in previous studies (see Rogers, 1989; Rogers & Osborne, 1987), meaningfulness was highly correlated with concreteness. The authors suggested that the association between these two symbol dimensions rests on the fact that concrete symbols depict familiar and well-known objects, thus, their

meaning can be extracted directly from the obvious representation of real-world items. In fact, the three dimensions were all highly correlated, so that concrete symbols were also evaluated as familiar, and the most familiar symbols were the most meaningful. In this study we asked participants to indicate the extent to which the symbol conveys a meaning (1 = *It has no meaning at all*; 7 = *It has a lot of meaning*).

The brief literature review presented on the most commonly used dimensions to evaluate and classify symbols suggests the relevant role they play in the selection of stimuli to examine psychological phenomena. In the following sections we present the subjective norms in each of these dimensions for a new and comprehensive set of symbols, the correlations between them, as well as a descriptive analysis of each symbol's meaning.

Method

Participants

A sample of 388 Portuguese respondents (72.4% female; $M_{age} = 28.90$, $SD = 11.23$) volunteered to participate in a web survey. The sample comprised mostly students (49.5%) and active workers (35.1%), with at least a High School education degree.

Development of the Stimulus Set

To create the stimulus set, free icon-based fonts were downloaded from the website www.1001fonts.com (license agreements were checked and all fonts are free for commercial use). In these fonts, each character (letters, numbers, punctuation, etc.) corresponds to a symbol (see Figure 1). Each symbol was generated in black on a white background and saved as a single image file (250x250px, 72dpi, Grayscale, JPG format). The stimulus set ($N = 600$) comprises symbols depicting various

contents, for example, social media and technology (e.g., “Modern Pictograms” font), transportation (e.g., “Glyphyx One” font), leisure activities (e.g., “Glyphyx Two” font). The set also comprises nonfigurative stimuli (e.g., “SF Distant Galaxy Symbols” font). Symbols containing written information (e.g., the word “Danger”) were not included in the set. The full stimulus set (and corresponding database in Excel format, organized by symbol code and by each of the evaluated dimensions) is provided as supplementary material and can also be obtained upon request to the first author. This set is also available in higher resolution (500x500px).


























Font					
GlyphxOneNF character / symbol code	 P / S015	 U / S019	 k / S033	 . / S061	 # / S068
GlyphxTwoNF character / symbol code	 F / S084	 U / S097	 Z / S102	 s / S119	 x / S122
MaritimeFlags character / symbol code	 A / S343	 d / S346	 l / S354	 0 / S370	 % / S369
ModernPictograms character / symbol code	 A / S207	 G / S212	 O / S220	 P / S221	 w / S246
SFDistantGalaxySymbols character / symbol code	 K / S303	 P / S306	 b / S314	 f / S318	 n / S325

Figure 1. Examples of symbols included in the stimulus set along with the icon font information and indication of the corresponding character and symbol code.

Procedure and Measures

The study was conducted using Qualtrics® software. Participants were invited (e.g., institutional email, social network websites) to collaborate on a web survey about the perception and evaluation of visual stimuli. By clicking on a hyperlink,

participants were directed to a secure webpage in which they were again informed about the goals of the study and its expected duration (approximately 25 minutes). Participants were also informed that all the data collected would be treated anonymously and that they could abandon the study at any point by simply closing the browser (for best practices in conducting web surveys, see Barchard & Williams, 2008). After consenting to collaborate in the study (by checking the “I agree” option), participants were asked to provide information regarding their age, sex, educational level and current occupation.

Instructions were provided simultaneously for all symbol dimensions. Participants were asked to evaluate each stimulus regarding: aesthetic appeal, familiarity (subjective frequency), visual complexity, concreteness, valence, arousal, and meaningfulness (for detailed instructions see Table 1). The symbol dimensions were always presented in this order. Instructions highlighted that responses should be fast and spontaneous and that there were no right or wrong answers.

Table 1
Instructions and Scale Anchors for each Dimension

Dimension	Instructions	Scale
1. Aesthetic appeal (e.g., McDougall & Reppa, 2008)	In your opinion, considering the visual characteristics of the symbol (and not the object or concept it may depict), how visually appealing is the symbol?	1 = <i>Visually unpleasant/unappealing</i> , 7 = <i>Visually very pleasant/appealing</i>
2. Familiarity (e.g., McDougall et al., 1999)	How frequently do you encounter or see this stimulus in your daily routine? More frequently encountered stimuli are more familiar.	1 = <i>Not familiar</i> ; 7 = <i>Very Familiar</i>
3. Visual complexity (e.g., McDougall et al., 1999; Snodgrass & Vanderwart, 1980)	Considering the complexity of the visual characteristics of the stimulus, and not those of the object or concept that can be related to the symbol, how much visual detail and complexity does this stimulus contain? The more details the symbol contains, the more complex it is.	1 = <i>Very simple</i> ; 7 = <i>Very complex</i>
4. Concreteness (e.g., McDougall et al., 1999)	How concrete is this stimulus? Stimuli that, in your opinion, refer to objects, materials or people should be considered concrete. Otherwise, they should be considered as more abstract.	1 = <i>Totally abstract</i> ; 7 = <i>Totally concrete</i>
5. Valence (Moors et al., 2013)	To what extent do you consider this stimulus refers to something positive/pleasant or negative/unpleasant.	1 = <i>Refers to something very negative/unpleasant</i> ; 7 = <i>Refers to something very positive/pleasant</i>
6. Arousal (Moors et al., 2013)	To what extent do you consider this stimulus refers to something arousing/exciting or passive/calm?	1 = <i>Refers to something very passive/calm</i> ; 7 = <i>Refers to something very arousing/exciting</i>
7. Meaningfulness (e.g., McDougall et al., 1999)	Please indicate to what extent this stimulus conveys a meaning.	1 = <i>It has no meaning at all</i> ; 7 = <i>It has a lot of meaning</i>

After evaluating how meaningful a symbol was, participants were asked to succinctly describe the first meaning that came to their mind, or to select the option “I do not know” if they were not able to provide a specific meaning. Before initiating their evaluations, participants were presented with a practice trial to guarantee that they understood the instructions and all the evaluation scales. The stimulus used in the practice trial was not included in the final set. Then, participants proceeded to the main task. In order to prevent fatigue and demotivation, the software was programmed

to select a random sub-set of 50 symbols from the total pool of 600 stimuli for each participant. Each symbol was presented in a single page of the online questionnaire, with the symbol on the top left corner of the page and all the ratings scales below. The presentation order of the stimuli was randomized for each participant. Upon completing the task, participants were thanked and debriefed.

Results

The full set of symbols and the norms for aesthetic appeal, familiarity, visual complexity, concreteness, valence, arousal and meaningfulness can be downloaded as a supplemental archive from [enter BRM web link].

In the following sections, we first present the preliminary analysis regarding outliers, gender differences and reliability. We then examine subjective rating norms for each dimension and present the frequency distribution of symbols across dimensions levels (i.e., Low, Moderate, and High). Subsequently, we present the association between dimensions. Finally, we present the symbols' meaning analysis and its frequency distribution across dimensions.

Preliminary Analysis

Only fully complete surveys were included in the data analysis. Thus, there were no missing cases. Outliers were determined considering the criterion of 2.5 standard deviations above or below the mean evaluation of each stimulus in a given dimension. The result of this analysis yielded an unexpressive percentage (1.33%) of outlier ratings. There was also no indication of participants responding systematically in the same way, that is, always using the same value of the scale. Therefore no responses were excluded.

In order to test for gender differences in the way participants rated the symbols, mean evaluations on each dimension were compared between male and female participants. No gender differences were found (see Table 2).

Table 2

Evaluations (Mean and Standard Deviation) in each Dimension for the Total Sample, Males and Females and Mean Difference Tests

Dimension	Total Sample ($N = 388$)		Males ($n = 107$)		Females ($n = 281$)		Difference Test	
	M	SD	M	SD	M	SD	t (386)	p
Aesthetic appeal	4.18	0.67	4.21	0.63	4.17	0.69	0.46	.644
Familiarity	4.45	0.76	4.44	0.74	4.46	0.76	-0.14	.887
Visual complexity	3.26	0.85	3.36	0.81	3.22	0.86	1.49	.138
Concreteness	4.64	0.65	4.59	0.63	4.65	0.66	-0.90	.371
Valence	4.34	0.42	4.29	0.40	4.36	0.43	-1.40	.162
Arousal	4.34	0.48	4.33	0.44	4.34	0.49	-0.24	.807
Meaningfulness	4.62	0.67	4.61	0.63	4.62	0.68	-0.11	.911

To test response consistency of participants' ratings in each dimension, we compared two sub-samples of equal size ($n = 194$) randomly selected from the main sample. No differences between sub-samples emerged, all $t < 1$. These analyses were repeated for males ($n_1 = 50$; $n_2 = 57$) and females ($n_1 = 144$; $n_2 = 137$) separately. Again, no significant differences were found, all $t < 1$. Therefore, all the subsequent analyses were performed using the total sample. Moreover, ratings across the seven quantitative dimensions were reliable for the whole sample and the sub-samples of males and females (Cronbach's alpha = .78, .82 and .77, respectively, and Spearman-Brown split-half reliability = .86, .89 and .84, respectively).

Subjective Rating Norms

In order to define subjective rating norms, data was coded and analyzed by symbol. The number of participants evaluating each symbol varied between 30 and 39. Frequencies, means, standard deviations and confidence intervals on each dimension were calculated for each symbol and are presented in Appendix 1. Based on these results, we categorized symbols as Low, Moderate or High in each dimension. Specifically, when confidence intervals included the response scale midpoint (i.e., 4) symbols were considered as “Moderate” in a given dimension. Symbols with upper bound of the confidence interval below the scale midpoint were considered as “Low” in a given dimension. Symbols with lower bound of the confidence interval above the scale midpoint were considered as “High” in a given dimension. See for instance symbol S001's evaluation on aesthetic appeal ($M = 2.92$, $SD = 1.77$, 95% CI [2.33; 3.51]). Because the upper bound was below the scale midpoint, this symbol was categorized as Low in this dimension.

Frequencies observed for each level (low, moderate, high) of the dimensions are presented in Table 3.

Table 3

Symbols' Frequency Distribution Across Dimensions' Levels

	Familiarity			Visual complexity			Concreteness			Valence			Arousal			Meaningfulness			Total
	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	
Aesthetic appeal																			
Low	91	20	10	68	42	11	76	29	16	55	65	1	24	78	19	75	30	16	121
Moderate	53	104	111	160	94	14	53	75	140	43	152	73	17	181	70	46	80	142	268
High	9	20	182	119	85	7	8	13	190	0	21	190	4	80	127	5	11	195	211
Familiarity																			
Low				75	51	27	124	25	4	39	101	13	26	113	14	122	29	2	153
Moderate				73	66	5	13	72	59	21	78	45	11	91	42	4	82	58	144
High				199	104	0	0	20	283	38	59	206	8	135	160	0	10	293	303
Visual complexity																			
Low							75	73	199	47	141	159	37	199	111	67	70	210	347
Moderate							39	39	143	41	80	100	7	118	96	39	42	140	221
High							23	5	4	10	17	5	1	22	9	20	9	3	32
Concreteness																			
Low										30	96	11	24	104	9	117	20	0	137
Moderate										17	68	32	10	88	19	9	86	22	117
High										51	74	221	11	147	188	0	15	331	346
Valence																			
Low													15	42	41	28	20	50	98
Moderate													20	183	35	90	76	72	238
High													10	114	140	8	25	231	264
Arousal																			
Low																25	9	11	45
Moderate																95	88	156	339
High																6	24	186	216
Total																126	121	353	

Notes. N = 600 symbols. Levels across dimensions L = Low; M = Moderate; H = High.

Most symbols were evaluated as: moderately or highly appealing ($n = 268$ and $n = 211$, respectively); highly familiar ($n = 303$); simple ($n = 347$); highly concrete ($n = 346$); neutral or positive ($n = 238$ and $n = 264$, respectively), moderately arousing ($n = 339$) and highly meaningful ($n = 353$). Examples of symbols for each level in each dimension are presented in Figure 2.











































	Low		Moderate		High	
Aesthetic appeal	 S161	 S274	 S158	 S131	 S500	 S002
Familiarity	 S320	 S489	 S021	 S175	 S483	 S221
Visual complexity	 S359	 S333	 S045	 S538	 S579	 S584
Concreteness	 S324	 S252	 S284	 S427	 S018	 S459
Valence	 S138	 S565	 S226	 S274	 S101	 S282
Arousal	 S049	 S157	 S082	 S109	 S085	 S422
Meaningfulness	 S303	 S346	 S191	 S381	 S022	 S194

Figure 2. Sample symbols in each level across dimensions (symbol codes are included).

As shown in Table 3, the intersection of levels across dimensions shows, for instance, that none of the symbols was simultaneously evaluated as: negative and highly appealing; highly complex and highly familiar; very abstract and highly familiar; meaningless and highly

familiar or highly concrete; or meaningful and very abstract. On the contrary, large sub-sets of symbols are evaluated simultaneously as: highly familiar and very concrete ($n = 283$), positive ($n = 206$) or meaningful ($n = 293$); more simple and more meaningful ($n = 210$); positive and very concrete ($n = 221$) or meaningful ($n = 231$); or more concrete and more meaningful ($n = 331$).

Associations Between Dimensions

The associations between dimensions were also explored. Overall results show positive and strong correlations (see Table 4). Specifically, and in line with the literature, we observed a strong positive correlation between familiarity and several other dimensions, such as: aesthetic appeal ($r = .470$, $d = 1.06$), concreteness ($r = .709$, $d = 2.01$), valence ($r = .355$, $d = 0.76$), and meaningfulness ($r = .753$, $d = 2.29$). Also, as expected, familiarity was negatively correlated with visual complexity ($r = -.061$, $d = 0.12$). The small effect size of this association parallels past evidence described in the literature (e.g., Bonin et al., 2003; McDougall et al., 1999; for a review see Forsythe et al., 2008). Furthermore, congruent with the finding reported by McDougall and colleagues (1999; see also Rogers, 1989; Rogers & Osborne, 1987) concreteness was positively correlated with meaningfulness ($r = .727$, $d = 2.12$). The analysis also revealed two further associations of interest. First, we found a positive correlation between visual complexity and aesthetic appeal ($r = .103$, $d = 0.21$), which diverges from McDougall and Reppa's (2008) results. Second, we found a negative correlation between visual complexity and concreteness ($r = -.042$, $d = 0.08$), which differs from the absence of correlation between these dimensions reported by McDougall and colleagues (2008). In both cases the effect sizes of these correlations are very small and thus should be interpreted with caution.

Table 4
*Pearson's Correlations (and Effect Sizes, Cohen's *d*) Between the Dimensions*

Dimensions	1	2	3	4	5	6
1. Aesthetic appeal	-					
2. Familiarity	.470*** (<i>d</i> = 1.06)	-				
3. Visual complexity	.103*** (<i>d</i> = 0.21)	-.061*** (<i>d</i> = 0.12)	-			
4. Concreteness	.424*** (<i>d</i> = 0.94)	.709*** (<i>d</i> = 2.01)	-.042*** (<i>d</i> = 0.08)	-		
5. Valence	.567*** (<i>d</i> = 1.38)	.355*** (<i>d</i> = 0.76)	.043*** (<i>d</i> = 0.07)	.341*** (<i>d</i> = 0.73)	-	
6. Arousal	.322*** (<i>d</i> = 0.68)	.287*** (<i>d</i> = 0.60)	.178*** (<i>d</i> = 0.36)	.312*** (<i>d</i> = 0.66)	.314*** (<i>d</i> = 0.66)	-
7. Meaningfulness	.461*** (<i>d</i> = 1.04)	.753*** (<i>d</i> = 2.29)	-.012 (<i>d</i> = 0.02)	.727*** (<i>d</i> = 2.12)	.357*** (<i>d</i> = 0.76)	.366*** (<i>d</i> = 0.79)

*** Correlation is significant at the .001 level (2-tailed).

Analysis of Symbols' Meaning

Besides asking participants how meaningful the symbols were, we also asked them to provide the actual meaning they thought the symbol had. We computed the proportion of valid responses considering the sample size that evaluated a given stimulus. Responses such as “I cannot name it” or idiosyncratic descriptions (e.g., “The father of my friend John”) were not included in these analyses (0.42% of responses). The mean number of valid responses per symbol varied between 0 and 38 ($M = 21$; $SD = 8.75$). Two independent judges coded the meaning provided by the participants for each symbol and categorized them in a broader theme (for a similar strategy see, for example, Massey, 2010; Soares et al., 2012). Interjudge agreement was obtained for 96% of the meanings provided. The 500 meanings that failed to gain prior consensus were resolved by agreement between the two judges.

Synonyms (e.g., “iPhone” and “smartphone”, S220), singular/plural forms (e.g., “car” and “cars”, S432), and exemplars of the same category (e.g., “boat” and “ship”, S493) were included in the same category. Semantically related concepts referring to different actions (e.g., “airplane” and “airplane takeoff”, S016), different objects or agents (e.g., “babies” and “baby

stroller”, S041) or specificities inherent to a symbol (e.g., “turn left” and “directions”, S286) were coded as distinct categories. The meaning of 55 symbols was not categorized due to a low frequency of valid responses ($M = 5.09$), high heterogeneity of descriptions (e.g., S576 was only described as “shapes”, “Rorschach test” or “metamorphosis”), and/or a lack of consensus between judges. Also, the sum of percentages of categories does not necessarily equal 100%, due to heterogeneity of the meanings provided. For example, symbol S006 was described by 70.4% of participants as "mail" and by 14.8% of participants as "post office", the remaining responses ($n = 4$) were diverse and unrelated to any of these categories. The complete content analysis can be found in Appendix 2.

We computed the proportion of valid responses for each symbol (number of valid meaning responses for a given symbol/ number of participants evaluating that symbol). Based on that proportion, we classified each symbol as having a low meaning (Q1, proportion $\leq .45$), a moderate meaning (Q2 and Q3, $.45 < \text{proportion} < .88$) or a high meaning (Q4, proportion $\geq .88$). The intersection of these indicators with the indicators of the three levels in each dimension, we observed that none of symbols with low subjective meaning (i.e., those with a lower number of valid responses) was categorized as highly familiar, concrete or meaningful. Not surprisingly, none of the symbols with high subjective meaning (i.e., those with a higher number of valid responses) was categorized as unfamiliar, highly complex, abstract or meaningless (see Table 5 for full results).

Table 5

Symbols' Frequency Distribution According to Meaning Level Across Dimensions

Meaning	Aesthetic appeal			Familiarity			Visual complexity			Concreteness			Valence			Arousal			Meaningfulness			Total
	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	
Q1	82	56	7	133	12	0	80	42	23	123	22	0	29	105	11	23	112	10	120	25	0	145
Q2 - Q3	33	172	110	20	129	166	172	134	9	14	93	208	46	114	155	18	187	110	6	96	213	315
Q4	6	40	94	0	3	137	95	45	0	0	2	138	23	19	98	4	40	96	0	0	140	140
<i>Total</i>	<i>121</i>	<i>268</i>	<i>211</i>	<i>153</i>	<i>144</i>	<i>303</i>	<i>347</i>	<i>221</i>	<i>32</i>	<i>137</i>	<i>117</i>	<i>346</i>	<i>98</i>	<i>238</i>	<i>264</i>	<i>45</i>	<i>339</i>	<i>216</i>	<i>126</i>	<i>121</i>	<i>353</i>	<i>600</i>

Notes. $N = 600$ symbols. Levels across dimensions L = Low; M = Moderate; H = High. Q1 = low proportion of valid responses. Q2-Q3 = medium proportion of valid

responses. Q4 = high proportion of valid responses.

Discussion

The aim of this study was to develop a normative database of symbols that can be used as a research tool in different psychological research domains. In comparison with other type of stimulus (e.g., words or even real-life pictures), validated norms of symbol sets are scarce. The exception is McDougall and colleagues' (1999) 239 symbols data set. We present a new and larger set (600 new symbols) - LSD - that includes more contemporary symbols in both content and design. Furthermore, we tested each symbol in several dimensions, namely aesthetic appeal, familiarity, visual complexity, concreteness, valence, arousal and meaningfulness. The provision of valence and arousal ratings constitutes an important addition to the mainstream measures in the field, offering researchers objective evaluative indicators in these dimensions. Additionally, we analyzed the meaning participants ascribed to each symbol, uncovering their most common interpretations.

LSD includes an extensive and diverse set of symbols, and descriptive analysis showed that the symbols vary in the evaluated dimensions. This variety allows disentangling between the effects of different dimensions. For example, in the memory research domain, advantages in recognition and recall have been observed for both extreme valence (e.g., Adelman & Estes, 2013) and valence and arousal (Bradley, Greenwald, Petry, & Lang, 1992). Thus, the variation in ratings across dimensions constitutes an advantage for the selection of stimuli in one or several dimensions of interest, while controlling for others.

The overall pattern of correlations between the dimensions is in line with the literature. Namely, we observed strong positive correlations between familiarity and several other dimensions (e.g., aesthetic appeal, concreteness, valence and meaningfulness), as well as a positive correlation between concreteness and

meaningfulness. Additionally, meaning analysis results showed that symbols with a lower number of valid responses (less subjective meaning ascribed) were the least familiar, concrete or meaningful, whereas symbols with higher number of valid responses (more subjective meaning ascribed) were the less complex, more familiar, concrete and meaningful. These results also indicate that our set varies in terms of depicted contents (e.g., animals, objects, people, geometric shapes, patterns, etc.). This diversity of contents represented in our symbol set permits the selection of stimulus for priming specific concepts (see Bargh & Chartrand, 2000). For instance, the cross (S595) or the star of David (S570) symbols may be used for activating spirituality or religion-related concepts (e.g., Johnson et al., 2014).

Altogether, these findings provide robustness to our database and offer several possibilities in what concerns the selection of symbols based on the required level on each dimension, as well as their combinations. Yet, the cultural specificity of symbol interpretation must be acknowledged along with the need for cross validation. Few symbols are universally understood, and usually some learning of the correct interpretation is required (Tijus, et al., 2007). Moreover, the interpretation of a particular symbol may not be independent of the context (e.g., Cahill, 1975; Wolff & Wogalter, 1998). For example, the symbol of a key (S511) in a shopping mall could indicate the location of a key-duplicating store, while in a computer it may indicate the need for a password. This sensitivity to contextual influences may constitute a problem from the communication point of view (e.g., McDougall et al., 1999), in which symbol efficiency is equated to unequivocal interpretation (see Ng & Chan, 2009). Regarding the use of symbols in experimental paradigms to investigate other phenomena (e.g., evaluation processes), this plasticity may be an advantage by conferring flexibility to the material.

The present paper presents the subjective norms of symbols with relevance to the work of researchers in several areas of cognitive research (e.g., memory, perception, language, decision, making), as well as its potential use in more applied domains such as communication, safety and design. We consider that our database - LSD - constitutes a valuable addition to the existing pool of pre-tested pictorial materials that researchers recurrently need to use in their studies.

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