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Affective auditory stimuli: Adaptation of the International Affective Digitized Sounds (IADS-2) for European Portuguese

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Abstract

This study presents the normative values of the adaptation of the International Affective Digitized Sounds (IADS-2; Bradley & Lang, 2007a) for European Portuguese (EP). The IADS-2 is a standardized database of 167 naturally occurring sounds widely used in the study of emotions. The sounds were rated by 300 college students who were native speakers of EP in the three affective dimensions of valence, arousal and dominance by using the Self-Assessment Manikin (SAM). The aims of this adaptation were threefold: (i) to provide researchers with standardized and normatively rated affective sounds to be used with an EP population; (ii) to investigate sex and cultural differences in the ratings of affective dimensions of auditory stimuli between EP and the American (Bradley & Lang, 2007a) and Spanish (Fernández-Abascal et al., 2008; Redondo, Fraga, Padrón & Piñeiro, 2008) standardizations; and (iii) to promote research on auditory affective processing in Portugal.

Our results indicate that the IADS-2 is a valid and useful digitized sounds database for the study of emotions in a Portuguese context, allowing the comparability of results with other international studies that used the same database for stimuli selection. The normative values of the EP adaptation of the IADS-2 database can be downloaded at http://brm.psychonomic-journals.org/content/supplemental.

Key-words: Affective auditory stimuli; IADS; Valence; Arousal; Dominance; European Portuguese.

Running head: IADS-2 adaptation for EP.

INTRODUCTION

The detection of emotional salience in visual and auditory stimuli is a crucial aspect of human existence and social interactions (LeDoux, 1996; Phelps, 2006). However, research on affective processing has focused mainly on the processing of visual emotional stimuli, such as emotional facial expressions as well as emotional pictures and words, whereas less is known about affective processing in the auditory modality. In contrast with the static nature of pictures or words, sound changes dynamically throughout time, and thus the emotional meaning embedded in the acoustic stream - conveyed through the combination of acoustic cues such as fundamental frequency (F0), intensity and duration (e.g., Banse & Scherer, 1996; Juslin & Laukka, 2003) – needs to be continuously perceived, integrated and interpreted (e.g., Shirmer & Kotz, 2006). Differences between stimuli may lead to changes in the way people perceive, process and experience affective information, which demands further investigation.

One of the major reasons for why auditory stimuli are rarely used is possibly the lack of controlled and validated auditory stimuli, adapted to the cultural context of research participants, and allowing the comparison/replication of results from different research teams. This paper addresses this issue, presenting the normative values of the European Portuguese (EP) adaptation of one of the most internationally used databases for the study of auditory affective processing: the International Affective Digitized Sounds (IADS; Bradley & Lang, 1999a, 2007a). The EP adaptation of the IADS aims at providing researchers with a standardized research tool with the potential of promoting research on auditory affective processing in Portugal and that allows the comparability of results with other international studies.

The IADS is part of a system for emotional assessment, developed by the Center for Emotion and Attention (CSEA, University of Florida). This system also includes a database of words - the *Affective Norms for English Words* (ANEW; Bradley & Lang, 1999b; already adapted for EP – Soares et al., 2012), and a database of pictures - the *International Affective Picture System* (IAPS; Lang, Bradley, & Cuthbert, 1999, 2008; whose adaptation for EP is in progress - see Soares et al., 2011). The EP adaptation of these three emotional stimuli databases, which are based on the same emotional theoretical perspective and methodological procedure, represents a powerful tool for research on affective processing in any of the modalities (sounds, words and pictures).

The original database of the IADS (Bradley & Lang, 1999a), validated with an American English population, consisted of 111 digitally recorded sounds, each lasting for 6 seconds and characterized along the affective dimensions of valence, arousal and dominance. The tridimensional assessment of the IADS stimuli follows a dimensional account of emotions. Based on the semantic differential work developed by Osgood and associates (Osgood, Suci, & Tannenbaum, 1957), Bradley and collaborators (Bradley & Lang, 1994; Bradley, Codispoti, Sabatinelli, & Lang, 2001a) proposed that emotional reactions and subjective experiences arise from the activation of two anatomically distinct motivational systems (defensive *vs.* appetitive) that have evolved to mediate the behaviors that sustain and protect life. The *defensive system* is primarily activated in contexts involving threat to the physical survival of the organism, with a basic behavioral repertoire that includes withdrawal or attack. Conversely, the *appetitive system* is activated in contexts that promote the organism's well-being and survival. These two systems account for two basic dimensions of emotion - *valence* and *arousal* - with valence indicating which system is active (defensive or appetitive) and emotional arousal reflecting the intensity of motivational activation. Hence, these constructs can be characterized by two bipolar dimensions representing the positivity-negativity (valence or pleasure) and the intensity (arousal or energy level) of a stimulus. Additionally, Bradley and Lang (1994) proposed a third dimension, *dominance*, which represents the level of control that a stimulus evokes. To measure these affective dimensions, the authors developed a nonverbal pictographic self-report measure: the Self-Assessment Manikin (SAM). IADS sounds were originally normalized using the SAM (see Figure 1).

The second version of the IADS (IADS-2; Bradley & Lang, 2007a), and whose adaptation for EP is presented in this paper, differs from the original version in the number of sounds included. The IADS-2 provides researchers with a standardized and reliable database of 167 naturally occurring sounds, which are associated with a wide number of contexts that can elicit a broad range of emotional reactions. These sounds can be related to humans (e.g., 'baby', 'erotic couple', 'boy laugh', 'giggling', 'female cough', 'man wheeze', 'child abuse'), animals (e.g., 'cat', 'puppy', 'growl', 'dog', 'seagull', 'robin'), objects (e.g., 'music box', 'typewriter', 'polaroid', 'doorbell'), musical instruments (e.g., 'bugle', 'harp', 'guitar', 'bagpipes'), means of transport (e.g., 'jet', 'helicopter', 'train', 'plane crash', 'bike wreck'), or scenarios (e.g., 'tropical', 'country night', 'restaurant', 'brook'). Of note, the IADS database was already adapted to the Spanish population (Fernández-Abascal et al., 2008; Redondo et al., 2008) and, beyond this three-dimensional assessment, a categorical assessment of the IADS sounds along five discrete categories (happiness, sadness, fear, disgust, and anger) is also available with a sample of American English participants (see Stevenson & James, 2008).

The relevance of this type of database is highlighted by evidence suggesting that non-verbal emotional sounds present several advantages over speech stimuli commonly used in research, such as affective prosody in sentences or words (e.g., Brosch, Grandjean, Sander, & Scherer, 2008; Liu et al., 2012; Pinheiro et al., 2012). Non-verbal emotional sounds seem to be the auditory analog of emotional face expressions, representing 'pure' vocal expressions of emotion (Sauter & Eimer, 2010). As pointed out by Scherer, Ladd and Silverman (1984), results of studies on affective prosody processing may be biased by the interaction between lexical and supra-segmental features of speech signal, including the affective meaning carried by prosody and the affective meaning carried by the semantic content of speech. Therefore, the use of naturalistic auditory stimuli, such as sounds from the IADS database, may represent a suitable option for the study of affective processing, with minimal linguistic confounds.

Studies that used IADS stimuli revealed that auditory emotional stimuli activate the appetitive and defensive motivational systems similarly to pictures. In terms of autonomic responses, Bradley and Lang (2000), provided evidence that listening to affective (pleasant and unpleasant) sounds elicits physiological responses, such as the startle reflex, facial electromyographic activity (EMG) or heart rate, that are similar to those elicited by affective pictures. Partala and Surakka (2003) have observed similar effects in terms of pupillary responses for both emotionally negative and positive auditory stimuli in comparison with neutral stimuli, a finding that was recently replicated by Tressoldi, Martinelli, Semenzato, and Cappato (2011) for alerting vs. neutral sounds. The similar pattern of emotional reactivity to both affective sounds and pictures has supported the idea that responses to affective stimuli represent the activation of a common emotional system rather than a modality-specific system (see Scharpf, Wendt, Lotze, & Hamm, 2010).

Moreover, neuropsychological research has revealed a differential processing of auditory stimuli, with positive and negative valence, including a stronger activation of the auditory cortex by positive (laughing) relative to negative (crying) sounds (e.g., Sander & Scheich, 2001). In addition, greater left-hemisphere fronto-temporal activation was reported in response to positively valenced auditory stimuli, while bilateral fronto-temporal activation was observed in response to negatively valenced auditory stimuli (e.g., Alltenmuller, Schurmann, Lim, & Parlitz, 2002). The latter evidence supports a valence asymmetry hypothesis, suggesting that the left hemisphere is specialized in the processing of positive emotions, while the right hemisphere is specialized in the processing of negative emotions (e.g., Heilman, 1997). This asymmetry hypothesis, though, has not received unequivocal support (see, for example, Royet et al., 2000).

A negativity bias in attention allocation to auditory stimuli has also been demonstrated. For example, Smith, Cacioppo, Larsen, & Chartrand (2003) showed that negative information captures attention more automatically than positive stimuli and also that positive and negative stimuli are differentiated in early stages of information processing (around 100 milliseconds [ms] after stimulus onset). In self-report measures of emotion, negative stimuli also tended to be assessed using more extreme scores for arousal than positive stimuli (e.g., Bradley et al., 2001a; Cacioppo, Gardner, & Berntson, 1997). Erotic voice stimuli seem to represent the only exception, being rated as arousing as angry voice stimuli, especially if spoken by actors of opposite than of the same sex as the listener (e.g., Ethofer et al., 2007), and as more arousing than other pleasant stimuli (e.g., Bradley et al., 2001a; Lang et al., 1998; Lykins, Meana, & Kambe, 2006).

Studies on auditory affective processing have also demonstrated sex differences in response to sounds (e.g., Gohier et al., 2011; Lewis et al., 2004; Schirmer, Striano, & Friederici, 2005), as previously observed for pictures (e.g., Bradley, Codispoti, Sabatinelli, & Lang, 2001b; Bradley & Lang, 2007b; Lithari et al., 2010), showing a female advantage in the decoding of the affective proprieties of stimuli. Some studies pointed to the greater sensitivity of women to distinguish stimuli with negative valence, such as negative non-verbal human vocalizations (e.g., scream) (e.g., Gohier et al., 2011). Moreover, studies on emotional prosody showed that women use emotional prosody earlier than men (e.g., Schirmer, Kotz, & Friederici, 2002), integrating emotional prosody into word processing even when emotional prosody is task-irrelevant (e.g., Schirmer & Kotz, 2003).

The present study aimed at collecting normative ratings of valence, arousal and dominance of the IADS-2 for the EP population. Given the abovementioned differences in the way males and females seem to perceive, process, and respond to emotional stimuli, we also investigated potential sex differences in ratings of the affective dimensions of auditory stimuli in the EP standardization. In line with previous research described earlier, we expected increased reactivity to affective auditory stimuli in females relative to males, particularly for negatively-valenced stimuli.

Since the IADS dataset norms are already available for other languages, we have additionally explored whether cross-cultural differences in sounds' affective ratings are observed when comparing the EP adaptation presented in this paper with the American (Bradley & Lang, 2007) and Spanish (Fernández-Abascal et al., 2008; Redondo et al., 2008) IADS standardizations, as in the recent adaptation of the ANEW to EP (Soares et al., 2012). As pointed out by Mesquita and Walker (2003), emotions are biological as well as socio-cultural phenomena. Therefore, cultural practices may foster culture-specific appraisal tendencies giving rise to differences in the way individuals from different cultures respond to emotionally salient stimuli. Cultural differences in emotional processing involve beliefs and social practices that define and reinforce what is considered moral, imperative, and desirable within each culture, and this is expected to affect emotional outputs (see Mesquita & Walker, 2003). For example, in the EP adaptation of the ANEW (Soares et al., 2012), cross-cultural differences were observed in the way Portuguese, American, and Spanish individuals react to affective words, with a greater similarity in the ratings between EP and Spanish standardizations, than between the EP and American English standardizations. Greater geographic and cultural proximity was the reason evoked by the authors to explain these results. Thus, as in Soares et al. (2012) study, we expected that the geographic and cultural similarities between Portugal and Spain would lead to a greater similarity in ratings of affective sounds between EP and Spanish standardizations, than between the EP and American English standardizations.

METHOD

Participants

A total of 300 college students (254 women and 46 men) from the University of Minho, with ages between 17 and 45 years (*M* = 21.27; *SD* = 4.49) participated in the study. Participants received course credit for their participation in the experiment. The total sample does not include participants whose responses demonstrated non-discriminative ratings and suggested random ratings or inattention (e.g., choosing the same number for all sounds - 2%) or whose nationality and native language were not EP (4.7%). All participants had normal audition and had normal or corrected-to-normal visual acuity. The majority of participants were right-handed (92%).

Materials and procedure

The stimuli consisted of 167 sounds that are part of the IADS-2 and that were used by Bradley and Lang (2007a) in their normative study. The physical properties of these sounds were controlled to avoid clipping and were normalized in terms of intensity.

The ratings session was programmed with SuperLab Pro 4.5 (Cedrus Corporation, San Pedro, California, USA). This allowed the controlled presentation of instructions and sounds.

The 167 sounds were divided into three randomized blocks (block 1 contained 56 sounds, block 2 contained 56 sounds, and block 3 included 55 sounds) in order to avoid fatigue. Thus, each participant rated only one of these three blocks, but we assured that, across blocks, each sound was rated at least by 93 participants (M_{block1} = 99.1 participants, 86 females and 14 males ; M_{block2} = 98.3 participants, 82 females and 18 males; and M_{block1} = 98.8 participants, 86 females and 14 males).

Data collection followed the procedure described by Bradley and Lang (1999a, 2007a). The experiment was run in groups in a laboratory setting (groups did not exceed 10 participants *per* experimental session) by using, as in the original American standardization, a paper-and-pencil version of SAM. In the SAM scale, each affective dimension is represented by a series of graphical figures illustrating a range of values for each of the three affective dimensions measured. Figure 1 illustrates the SAM version used in the present study: it contains five graphical figures defining a 9-point scale for each dimension: valence (ranging from 1 – ‘unpleasant’ to 9 – ‘pleasant’), arousal (ranging from 1 – ‘calm’ to 9- ‘aroused’), and dominance (ranging from 1 – ‘controlled’ to 9 – ‘in control’).

<INSERT FIGURE 1>

After obtaining informed consent, participants received a booklet that provided the numerical code of the sounds presented in a given experimental block and were instructed in the use of the 9-point scale of the SAM. Three practice sounds that were not included in the database (‘baby laughter’, ‘water drop’, ‘woman yelling’) but that had the same characteristics of the experimental stimuli, were used to illustrate the valence range of the IADS sounds and to allow the practice of ratings using the SAM scale. After listening to each practice sound, participants were instructed to choose the scale number that better represented the way they felt while they were listening to that sound, for each affective dimension (i.e., valence, arousal, and dominance). Any questions or doubts were answered. In the booklet, participants also provided socio-demographic (e.g., sex, age, nationality, lateralization, auditory and visual acuity) and linguistic (e.g., native language, second language learned) information.

During the experimental session, participants were seated in front of a computer screen at a distance of approximately 60 cm. Each subject was randomly assigned one of the three experimental blocks. The presentation of sounds in each block was randomized *per* participant. The structure of a trial for any of the three blocks was the following. Before listening to each of the experimental sounds, the instruction “*Por favor avalie o próximo som na linha número*__ [Please rate the next sound in line number__]” appeared in the center of the screen (Arial font, 14) for 5 seconds. Following the instructions, participants searched that numerical code in their response sheet (that corresponded to the row where that specific sound would be rated in the valence, arousal and dominance affective dimensions). The sound was then presented for 6 seconds through headphones. Immediately after the sound presentation, participants saw in the center of the screen (Arial font, 14) the instruction: “*Por favor avalie o som nas três dimensões afectivas* [Please rate the sound in the three affective dimensions now]" signaling the beginning of the response time (15 seconds), after which the next stimulus would be presented. Each trial lasted 26 seconds and the entire procedure took approximately 30 minutes. Figure 2 presents the sequence of events of the experimental procedure that was followed.

<INSERT FIGURE 2>

RESULTS AND DISCUSSION

The affective norms of valence, arousal, and dominance for the 167 auditory stimuli of the IADS-2 (Bradley & Lang, 2007a) that represent the adaptation of the IADS for EP language can be downloaded as a supplemental archive from at http://brm.psychonomic-journals.org/content/supplemental. The supplemental archive shows the mean values (*M*) and standard deviations (*SD*) for valence (*Val*), arousal (*Aro*), and dominance (*Dom*) of each of the 167 sounds of the adaptation of the IADS-2 to EP, considering the total sample (*All*) as well as female (*Fem*) and male (*Mal*) subsamples separately. Sounds were organized according to their original number (*Sound Number*) in the IADS-2 database (Bradley & Lang, 2007a). After the number of each sound, the original description is presented (*Description*) followed by its translation to the EP language (*EP Description*).

In the following sections, we first present the distribution of ratings in the bidimensional affective space of valence and arousal based on the EP adaptation of the IADS database. We then explore sex differences in these ratings. Finally, we present data on cross-cultural differences between the EP adaptation of the IADS and the American (Bradley & Lang, 2007a) and Spanish (Fernández-Abascal et al., 2008; Redondo et al., 2008) standardizations.

1. EP ratings of IADS-2 stimuli

Figure 3 illustrates the distribution of the 167 EP sound ratings (mean values) in the bidimensional affective space of valence and arousal.

<INSERT FIGURE 3>

The distribution presented in Figure 3 fits the typical boomerang shape found by Bradley and Lang in the first (1999a) and second (2007a) edition of the IADS, as well as by Redondo et al. (2008) and Fernández-Abascal et al. (2008) in the Spanish standardizations of the first edition of the IADS database. As demonstrated by the inspection of Figure 3, the mean scores for each of the 167 sounds of the IADS-2 are distributed along two axes stretching from a midpoint of neutrality in valence and arousal towards either high-arousal positive or negative valence ends.

Thus, highly pleasant and highly unpleasant sounds were rated as highly arousing, resulting in a quadratic relationship superior to its pairwise linear correlations. Even though the linear correlation between valence and arousal (r = -.79, p < .001) in the EP standardization accounted for 62% of the variance, the quadratic correlation between the two dimensions (*r* = .85, *p* < .001) accounted for 72% of the variance. This quadratic correlation was higher than what was previously found in the American (*r* = .74; *p* <.001; see Bradley & Lang, 2000) and Spanish (*r* = .70; R^2= .472, *p* <.001; see Redondo et al., 2008) IADS standardizations.

Nevertheless, it is important to note that the association between valence and arousal for unpleasant sounds (i.e., sounds with valence ratings below 5 points, the midpoint of the 9 point-scale used) is stronger (*r*= -.91, *p* < .001) than the association between valence and arousal for pleasant sounds (i.e., sounds with valence ratings above 5) that did not reach statistical significance (*r* = -.13, *p* =.30). Indeed, as seen in Figure 3, most of the pleasant sounds (that are located in the upper half of the chart) were distributed along the arousal dimension (*M* = 4.75, *SD* = .92, *range* = 3.06 - 6.64). This seems to indicate that valence is independent of arousal for positive sounds. However, for unpleasant sounds (that are located in the lower half of the chart) the ratings were more concentrated in the right inferior quadrant of the chart (*M* = 6.39; *SD* = 1.13, *range* = 4.23 - 8.46), suggesting a strong negative relationship between valence and arousal for this type of sounds. For example, sounds 285 (Attack2), 290 (Fight1) and 279 (Attack1) were assessed, simultaneously, as the least positive sounds (M_{valence} = 1.13, 1.24 and 1.26 respectively) and as the most arousing sounds (M_{arousal} = 8.46, 8.07 and 8.42 respectively) of this database. However, the same was not observed for pleasant sounds. For example, sounds 110 (Baby), 220 (Boy laugh) and 817 (Bongos) were assessed with the highest valence scores (M_{valence} = 8.62, 8.37 and 8.12 respectively), but not with equivalent arousal scores (M_{arousal} = 3.45, 4.91 and 5.22 respectively). This seems to be the case only for erotic stimuli, such as sounds 215 (EroticCouple), 200 (Erotic Couple) and 201 (EroticFemale), which present simultaneously higher valence scores ($M_{valence}$ = 7.03, 7.43 and 7.21 respectively) and higher arousal scores ($M_{arousal}$ = 6.64, 6.63 and 6.63 respectively).

The finding that erotic sounds were assessed with both higher valence and higher arousal scores confirms the 'special' status of erotic sounds within the category of positively valenced stimuli and supports the notion that they are processed differently from other positive stimuli. Even though negative stimuli tend to elicit higher arousal levels than positive stimuli (e.g., Bradley et al., 2001a; Cacioppo et al., 1997), there is evidence suggesting that erotic stimuli represent the only type of positive stimuli that elicit arousal levels similarly to negative stimuli (e.g., Bradley et al., 2001a; Lang et al., 1998), and causing similar interference to that caused by aversive distracters (see, for example, Most, Smith, Cooter, Levy, & Zald, 2007; Yu et al., 2012). The results obtained in this study demonstrate that the potential of erotic stimuli to elicit high levels of valence and arousal is not restricted to the visual modality (e.g., pictures), but also generalizes to the auditory domain of information processing.

Nonetheless, it is worth noting that in the EP adaptation of the IADS-2 it is easier to find unpleasant than pleasant sounds with higher scores of arousal, $t(165) = 9.88$, $p < .001$. If we assume, as for valence, 5 as the cutoff value in the classification of arousing (above 5) and not arousing (below 5) sounds, it is possible to observe that there is not only a higher number of sounds classified as unpleasant than pleasant (98 *vs*. 69, respectively), but also, for the unpleasant ones, a higher number of sounds classified as high- (84) than low-arousing sounds (*t*(14), $\chi^2(1) = 33.34$, $p <. 001$). For the pleasant sounds, we observed the opposite pattern, i.e., more sounds were assessed as low- (39) than high-arousing (30).

The negativity bias observed for unpleasant stimuli in this study, and that was previously reported for pictures (e.g., Bradley et al., 2001a, 2007b), sounds (e.g., Bradley & Lang, 2000; Fernandez-Abascal et al., 2008), and affective words (e.g., Bradley & Lang, 1999b; Soares et al., 2012), may hinder research using pleasant or unpleasant sounds when the manipulation of the arousal level is intended. Nevertheless, besides this asymmetry, the dispersion of results observed both for valence (*range* = 1.13 - 8.62) and arousal (*range* = 3.06 - 8.46) dimensions will allow EP researchers to control and/or manipulate the affective properties of sounds according to their research interests.

2. Sex differences in EP ratings of IADS-2 stimuli

Table 1 presents means, standard deviations and range values for each of the affective dimensions of valence, arousal and dominance, for the global EP sample and also for the subsamples of females and males separately.

<INSERT TABLE 1>

In order to explore sex differences in the IADS-2 EP ratings, a multivariate analysis of variance (MANOVA) was conducted with sex (females *vs.* males) and sound valence (unpleasant *vs.* pleasant - classified on the basis of the ratings of the global sample) as between-subjects factors and the ratings of valence, arousal and dominance as dependent variables. The analyses were thus run on items and not on subjects. Nonetheless, given the discrepancy in the number of males and females in our sample, we have decided first to run the analysis with a random subsample of 46 females from the total sample of females (*N*=254) to ensure that the number of females equated the number of males. This random subsample was obtained by creating a numbered list of all 254 female students and then by selecting 46 out of 254 cases. In a second analysis, we have computed the same statistical analysis with the total sample of females, in order to assess the stability of the results obtained. The results of the first MANOVA with 46 males and 46 females showed a main effect of sounds' valence in the affective dimensions of valence, $F(1, 330) = 700.06$, $p < .001$, $\eta^2 = .68$, arousal, $F(1, 330) = 127.44$, $p < .001$, $\eta^2 = .28$, and dominance, $F(1, 330) = 346.38$, $p < .001$, $\eta^2 = .51$, as well as a significant main effect of sex in the affective dimension of dominance, $F(1, 330) = 4.81$, $p < .05$, $\eta^2 = .02$. A significant interaction between sex and sounds' valence for the arousal, $F(1, 330) = 3.7$, $p < .05$, $\eta^2 = .02$, and valence, $F(1, 330) = 2.92$, $p = .09$, $\eta^2 = .01$ dimensions were also observed, although in the later case only at a marginally significant level.

The results of the second MANOVA conducted with the total sample have replicated the results of the first analysis. As in the first MANOVA, we have observed a main effect of sounds' valence in the affective dimensions of valence, $F(1, 330) = 755.50$, $p < .001$, $\eta^2 = .69$, arousal, $F(1, 330) = 134.49$, $p < .001$, $\eta^2 = .29$, and dominance, $F(1, 330) = 432.25$, $p < .001$, $\eta^2 = .57$, even though the main effect of sex in the dominance dimension observed in the first analysis did not reach statistical significance, $F(1, 330) = 2.59$, $p = .11$, $\eta^2 = .01$. The interaction between sex and sounds' valence for the arousal dimension was also significant, $F(1, 330) = 4.47$, $p < .05$, $\eta^2 = .02$, as well as the marginally significant interaction observed for the valence dimension, $F(1, 330) = 2.95$, $p = .08$, $\eta^2 = .01$. The results observed with the first and second MANOVAs were consistent. Therefore, in spite of the discrepancy in the number of males and females in the adaptation of the IADS-2 to EP, the sex differences observed are reliable. The normative values obtained with the total sample (N=300) will thus be considered in the subsequent analyses.

The *post-hoc Scheffé* contrasts for the main effect of sounds' valence showed, as expected, that pleasant sounds were assessed more positively than unpleasant sounds ($p < .001$). Also, in line with the abovementioned findings, unpleasant sounds were assessed as significantly more arousing than pleasant sounds ($p < .001$), and additionally with significantly lower dominance ratings ($p < .001$). These findings confirm the previously reported asymmetry between valence and arousal for pleasant and unpleasant stimuli (e.g., Bradley & Lang, 2000; Bradley et al., 2001a, 2007b; Soares et al., 2012), as well as the fact that unpleasant stimuli tend to elicit subjective feelings of lower control (see LeDoux, 1996).

Furthermore the interaction between sex and sounds' valence for the arousal affective dimension revealed, as illustrated in Figure 4, that unpleasant sounds (i.e. scored below 5 in valence) were assessed as more arousing by females than by males ($p < .05$). However, pleasant sounds (i.e. scored above 5 in valence), especially erotic sounds (e.g., 200, 201, 202, 215), tended to be assessed as more arousing by males than by females. These findings of a *negativity bias* in the way EP females rated IADS-2 sounds and a tendency for a *positivity* *bias* in the way EP males rated the same sounds, confirm in the IADS-2 Portuguese adaptation a pattern that has been found in previous studies (e.g., Bradley et al., 2001b; Gohier et al., 2011; Lithari et al., 2010; Schirmer et al., 2002, 2005). For example, Bradley and Lang (2007b) found that while 30% of females assessed IAPS unpleasant pictures as more arousing (and only 15% assessed pleasant pictures as more arousing), 40% of males assessed IAPS pleasant pictures as more arousing (and only 15% assessed unpleasant pictures as more arousing).

<INSERT FIGURE 4>

It is also worth reemphasizing that within the category of pleasant stimuli, erotic sounds have a ‘special’ status. Additionally, research has also demonstrated that the mechanisms associated with the processing of erotic stimuli seem to be distinct in males and females, with males showing higher peripheral physiological activation (e.g., Bradley et al., 2001b), and also higher activation of limbic structures (e.g., Karama et. al., 2012; Phelps, 2006; Royet et al., 2000) in response to erotic stimuli relative to females. Males also show lower inhibitory control (e.g., Pessoa, 2009; Yu et al., 2012) in tasks involving the previous presentation of erotic stimuli. Our findings are consistent with this evidence.

Moreover, the marginally significant interaction between sex and sounds’ valence for the valence affective dimension showed that females tend to use more extreme scores when rating IADS stimuli, i.e., they tend to assess unpleasant sounds not only as more negative than males, but also pleasant sounds as more positive than males. These findings support our hypothesis and show that, as in previous studies (e.g., Bradley et al., 2001b; Lithari et al., 2010; Schirmer, et al., 2002, 2005; Soares et al., 2012), Portuguese females tend to show a higher emotional reactivity in response to affective sounds than males.

However, the finding that sex's influence on sound ratings was better captured when the two systems of appetitive *vs.* defensive motivation were considered separately points to the need to attend to both systems of motivational mobilization when exploring sex differences. In line with existing studies (e.g., Bradley et al., 2001a; Lithari et al., 2010; Schirmer et al., 2002, 2005), sex differences were more pronounced for the defensive system. The fact that Portuguese females revealed more emotional reactivity towards negative sounds than males may be explained by a complex interaction between underlying biological processes and social and cultural responses. However, as mentioned by Lithari et al. (2010), an evolutionary account may also explain this finding: the more rapid and stronger response of women to potentially dangerous stimuli (i.e., unpleasant and high arousing stimuli) may have been useful for the effective nurturing of their offspring. The same kind of argument has been also proposed more recently to justify the differential processing associated with erotic stimuli within the category of positively valenced stimuli. Similarly to high-arousing negative stimuli, the reaction to erotic-type positive stimuli seems to reflect an important selection mechanism, given that these stimuli convey information that is of equal relevance for survival: procreation (see Briggs & Martin, 2009; Sakaki, Niki, & Mather, 2012).

Therefore, the differences observed between males and females in the Portuguese adaptation of the IADS-2 suggest that these should be taken into account in the selection of sound stimuli when conducting research on affective processing with EP participants, especially if stimuli with negative valence are planned to be used.

3. Cultural differences in EP ratings of IADS-2 stimuli

In order to explore cross-cultural differences in IADS ratings we considered the four standardizations that reported normative ratings for IADS stimuli: the American version of the IADS-2 (USA - Bradley & Lang, 2007a), the two Spanish versions (SP_1 - Redondo et al., 2008; and SP_2 - Fernández-Abascal et al., 2008) and the ratings obtained in the European Portuguese (EP) version. Given the existence of two Spanish adaptations published in the same year and the fact that they considered a distinct number of sounds and a distinct sample, we decided to integrate both standardizations in the analysis. The version of Redondo et al. (2008) considers the 111 sounds of the IADS original version (Bradley & Lang, 1999a) that were rated by a sample of 159 college students but it provides only normative ratings for the global sample irrespective of sex. The second Spanish adaptation published by Fernández-Abascal et al. (2008) presents the normative ratings of 110 sounds of the original IADS version (Bradley & Lang, 1999a) rated by a wide sample of college students (1,136 females and 580 males), but contrary to Redondo et al. (2008), it presents normative ratings not only for the global sample but also for males and females separately.

Figure 5 illustrates the distribution of the mean values of IADS ratings in terms of the bidimensional affective space of valence and arousal for the American standardization (USA), the two Spanish adaptations (SP_1 and SP_2) and the European Portuguese (EP) adaptation presented in this work.

<INSERT FIGURE 5>

The distribution of valence and arousal ratings presented in Figure 5 indicates a great overlap in the four standardizations, with all revealing the expected boomerang-shape. In any of the presented standardizations, the quadratic relationship between valence and arousal was higher and captured more variance (USA: r=.64; R^2=.72, p < .001; SP_1: r=.69; R^2=.46, p < .001; SP_2: r=.83; R^2=.70, p < .001; EP: r=.85; R^2=.72, p < .001) than their corresponding pairwise linear correlations (USA: r= -.44; R^2=.19, p < .001; SP_1: r= -.46; R^2=.21, p < .001; SP_2: r= -.75; R^2=.56, p < .001; EP: r= -.79; R^2=.62, p < .001) (see Note 1).

The similarities in findings observed in the four standardizations may also be observed in Table 2 that presents the results for *Pearson* correlations between the ratings obtained in the European Portuguese (EP), American English (USA) and Spanish (SP_1 and SP_2) languages in each of the three affective dimensions. It is important to note that in the correlational analysis of the EP-USA standardizations we considered the 167 sounds of IADS-2, while in the correlational analysis of EP-SP_1, we considered only 106 sounds that are common in both standardizations, and in the correlational analysis of EP-SP_2, we considered those 105 sounds that are common in both standardizations. In the specific case of SP_1, we only considered correlations for the global sample, as mentioned above.

<INSERT TABLE 2>

All correlations were positive and highly significant ($p < .001$ in all comparisons) (see Note 2). It is worth noting that these correlations reveal stability not only in the global sample but also in the subsamples of males and females separately. This suggests that IADS stimuli evoke similar emotional responses in individuals from different countries and cultures.

In order to explore with more detail the cross-cultural differences observed for each of the three affective dimensions of the IADS sounds' ratings in the four standardizations, we conducted a MANOVA with IADS standardization (EP, USA, SP_1, SP_2) and sample type (global sample, female subsample, male subsample) as between-subjects factors and the affective dimensions of valence, arousal and dominance as dependent variables. For this analysis we have only considered the global sample of the Spanish standardization published by Redondo et al. (2008). Table 3 presents means, standard deviations and range scores for each of the affective dimensions under analysis for the global sample, and for the subsamples of females and males separately.

<INSERT TABLE 3>

The MANOVA analysis showed a main effect of the IADS standardization in the affective dimensions of valence, $F(3, 1413) = 3.55$, $p < .05$, $\eta^2 = .01$, arousal, $F(3, 1413) = 4.35$, $p < .01$, $\eta^2 = .01$, and dominance, $F(3, 1413) = 6.53$, $p < .001$, $\eta^2 = .02$, and a main effect of sample type in the dominance dimension, $F(2, 1413) = 3.29$, $p < .05$, $\eta^2 = .01$. No interaction reached statistical significance ($p > .05$).

The *post-hoc Scheffé* contrasts for the main effect of the IADS standardization revealed that, even though the EP participants were not statistically different from American participants in the affective dimensions of valence, arousal and dominance, they differed from Spanish participants of the SP_1 standardization, revealing lower scores in the affective dimension of arousal ($p < .001$).

It is worth noting that Spanish participants of the SP_1 standardization rated the IADS sounds with lower valence scores when compared with participants of any of the other standardizations, although these differences only reached statistical significance when compared with participants of the SP_2 ($p < .05$) and USA ($p < .05$) standardizations. In the arousal dimension, Spanish participants of the SP_1 standardization also differed from the participants of all the other standardizations, rating IADS sounds with higher arousal scores. These differences were statistically significant not only for the comparison with EP as already mentioned ($p < .001$), but additionally with SP_2 ($p < .001$). Finally, in the dominance dimension, the Spanish participants of the SP_1 standardization rated the IADS sounds with lower dominance scores than any other standardization, although these differences only reached statistical significance when compared with the SP_2 standardization ($p <.001$). The

MANOVA analysis also showed a main effect of sample type, revealing that in all the IADS standardizations males rated sound stimuli with higher dominance levels when compared with females (p <.05), or even when compared with the ratings of the global sample (p < .05).

Together these findings demonstrated similarities in the ratings obtained in the four standardizations of the IADS considered in this analysis. The only significant cross-cultural difference was with the Spanish standardization conducted by Redondo et al. (2008). The reduced sample size of the Redondo et al. standardization and the associated limitations may account for the differences observed.

Contrary to the hypothesis that geographic and cultural similarities between Portugal and Spain would lead to a greater similarity in the IADS ratings between the EP-SP standardizations than between the EP-USA standardizations, as previously observed for ratings of affective words (Soares et al., 2012), our results suggest that sounds may be less sensitive to cultural influences when compared with words. In fact, although research on the cross-cultural differences in ratings of emotional sounds is scarce, a study of emotion recognition from vocal expressions conducted with participants from nine countries by Scherer, Banse and Wallbott (2001) showed that, irrespective of cultural and linguistic origin, participants were able to identify the vocally portrayed emotions with a high degree of accuracy. Since sounds carry emotional cues embedded in a continuously acoustic stream that are relatively independent of semantic content (based on the dynamic interplay of F_0, intensity and duration – see Juslin & Laukka, 2003; Schirmer & Kotz, 2006), it is possible that their affective salience and meaning are accessed more automatically than in stimuli that are semantically mediated such as words (Scherer et al., 1984). Therefore, affective sounds may be more useful for the development of cross-linguistic studies and for the comparison of findings from studies on affective processing involving distinct research teams, countries and cultures, avoiding the linguistic confounds that the use of words may imply (Sauter & Eimer, 2010; Scherer et al., 1984).

CONCLUSION

In this study, we aimed at adapting the IADS-2 database (Bradley & Lang, 2007a) to the EP context. The use of standardized stimuli is needed to effectively support current research on affective processing. Our results indicate that the IADS-2 is a valid and useful digitized sounds database for the study of emotions in a European Portuguese context, allowing the comparability of results with other international studies that used the same database. Similarly to what was observed both for affective pictures (Lang et al., 1999, 2008) and words (Bradley & Lang, 1999b; Soares et al., 2012), the results of the EP adaptation of IADS-2 confirm that the affective responses to sounds are organized around two motivational systems that regulate emotion expression (Bradley & Lang, 2000; Bradley et al., 2001a).

Moreover, our findings revealed that males and females react differently to affective sounds and illustrate the importance of taking sex differences into account during the investigation of emotional processing. Therefore, the use of norms derived from the adaptation of the IADS to EP for males and females separately is needed to avoid confounding effects when doing research on auditory affective processing.

Finally, the cross-cultural analyses revealed a strong stability in the results obtained for the three affective dimensions in the EP, American (Bradley & Lang, 2007a) and Spanish (Fernández-Abascal et al., 2008; Redondo et al., 2008) standardizations, suggesting that sounds are less sensitive to cultural influences. Also because of the underlying minimal influence of linguistic processing, IADS stimuli may represent an ideal option when conducting cross-cultural studies on affective processing.

However, even though no pronounced differences were found when comparing the four standardizations, it is important to note that research on auditory affective processing conducted in an EP context should use the normative values for the EP adaptation of the IADS-2. In spite of the similarities observed, the ratings for the EP, American and Spanish standardizations are not exactly the same. Therefore, the norms reported in this study can better fit the socio-cultural characteristics of the Portuguese population. Additionally, and contrary to what was observed in the other standardizations, the sex differences observed in the EP standardization of the IADS-2 strongly points to the need for researchers to use sex-adjusted norms in the development of studies within an EP context.

The use of the norms provided in this paper can enable researchers to better control their experimental stimuli, compare results across studies, and combine the stimuli with other normatively rated stimuli for the EP population such as words (Soares et al., 2012). Therefore, the EP adaptation of the IADS-2 has the potential of becoming a useful tool for the development and internationalization of Portuguese research on affective auditory processing, both at unisensory and multisensory levels.

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Notes:

1. Even though the authors of the USA, SP_1 and SP_2 standardizations present values of linear and quadratic correlations between valence and arousal (although in the SP_2 standardization only linear correlation values were presented), the values presented in this paper were re-calculated based on the normative ratings included in their studies, since the comparison that we report in this work is with the second and not with the first edition of the IADS, as in those studies.
2. Although the authors of the Spanish standardizations (SP_1 and SP_2) presented *Pearson* correlations values between the affective ratings of Spanish and USA, the values presented in this work were re-calculated based on the normative ratings included in their studies, given that in the Spanish standardizations the authors considered the norms of the first edition of IADS and not the second edition as in this work.

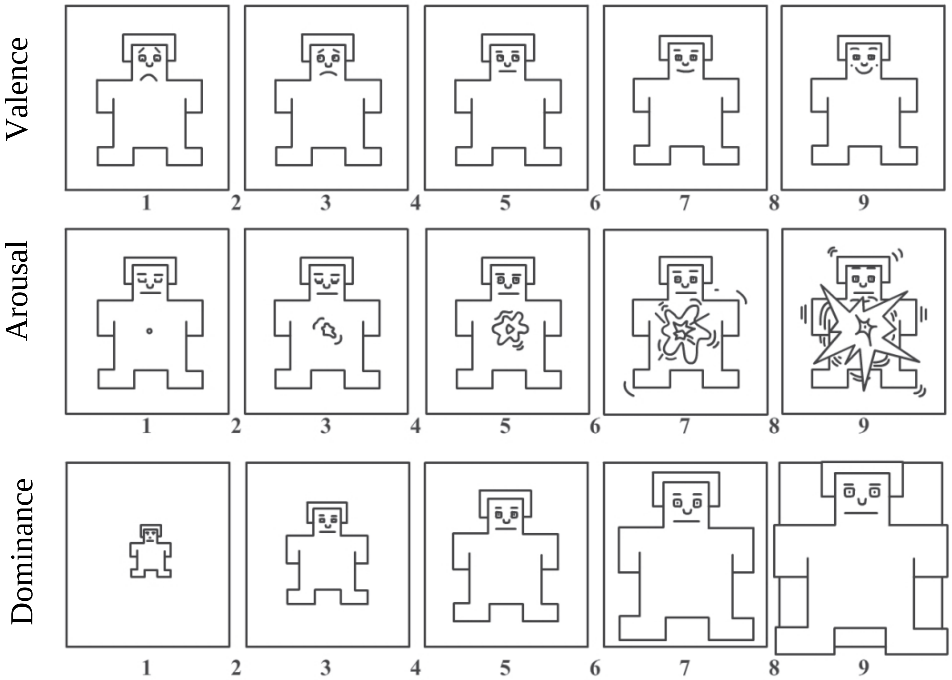

Figure 1. Self-Assessment Manikin (SAM) for valence, arousal, and dominance. The five graphical figures and the spaces between each define a nine-point scale used.

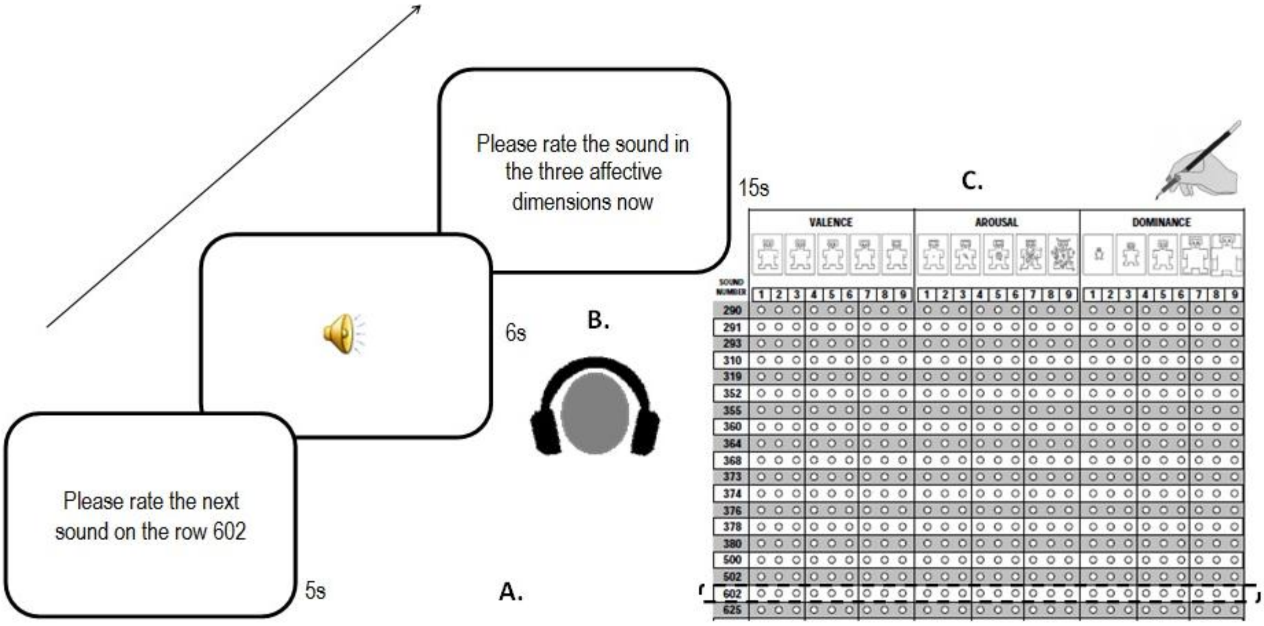

Figure 2. Example of an experimental trial following the procedure adopted for ratings of valence, arousal and dominance of IADS stimuli.

A. The participant reads the instruction: "*Please rate the next sound in line number 602*" and identifies the row that corresponds to that number (602) in the response sheet (5 seconds); B. The participant listens to the sound corresponding to the presented number through headphones (6 seconds); and C. The participant reads the instruction: "*Please rate the sound in the three affective dimensions now*" and rates the sound that (s)he has just listened in the three affective dimensions (valence, arousal and dominance) using the SAM scale in the response sheet (15 seconds). This procedure was repeated for each of the sounds that were included in an experimental block.

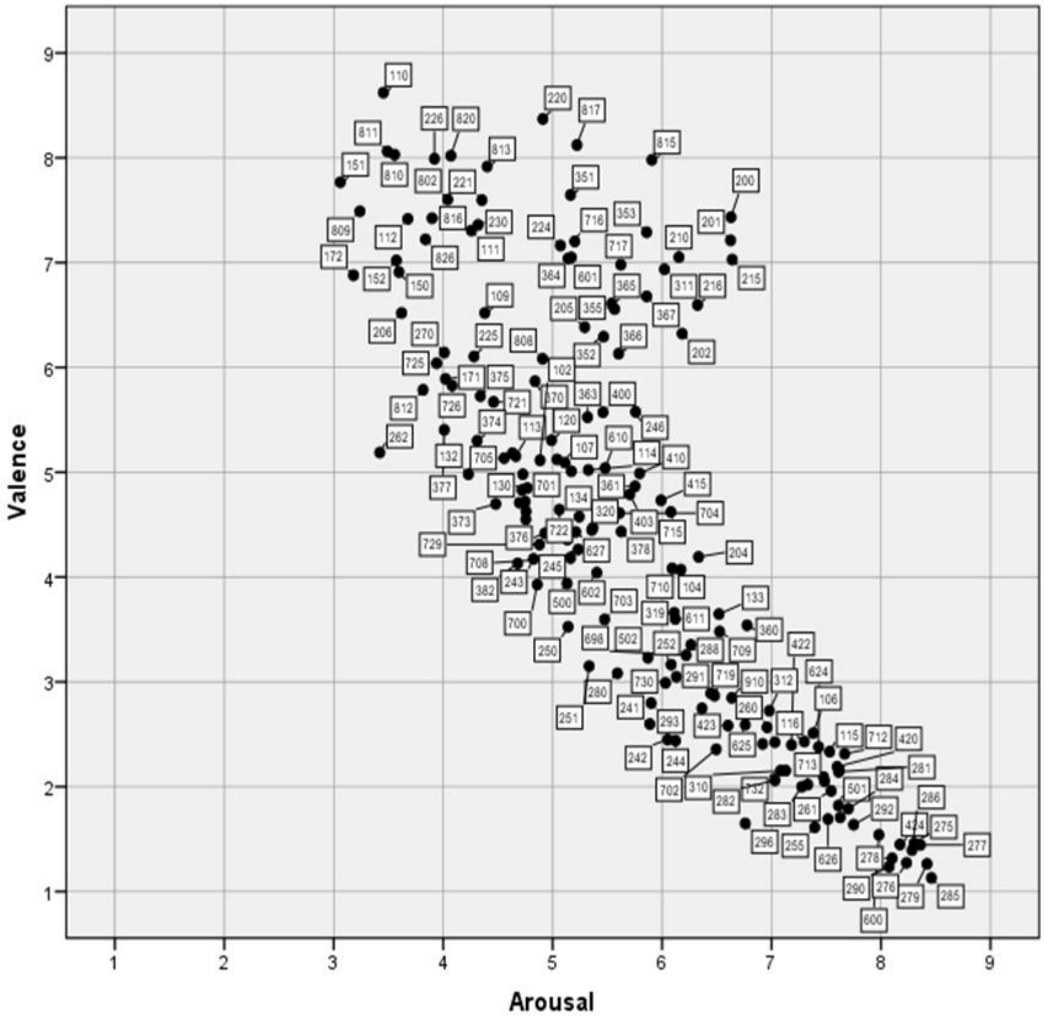

Figure 3. Distribution of mean values for the 167 sounds of the EP adaptation of the IADS-2 in the valence and arousal affective dimensions.

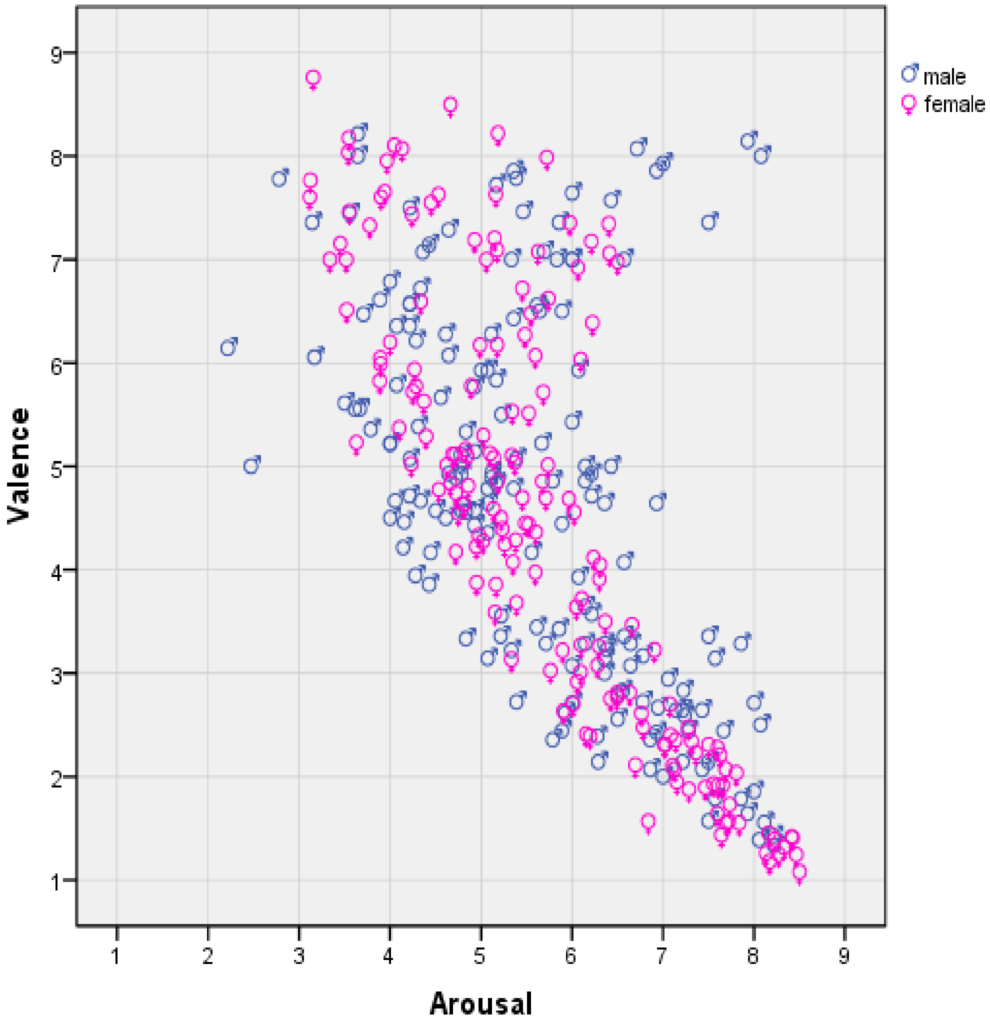

Figure 4. Distribution of mean values for the 167 sounds of the EP adaptation of the IADS-2 in the valence and arousal affective dimensions for males and females separately.

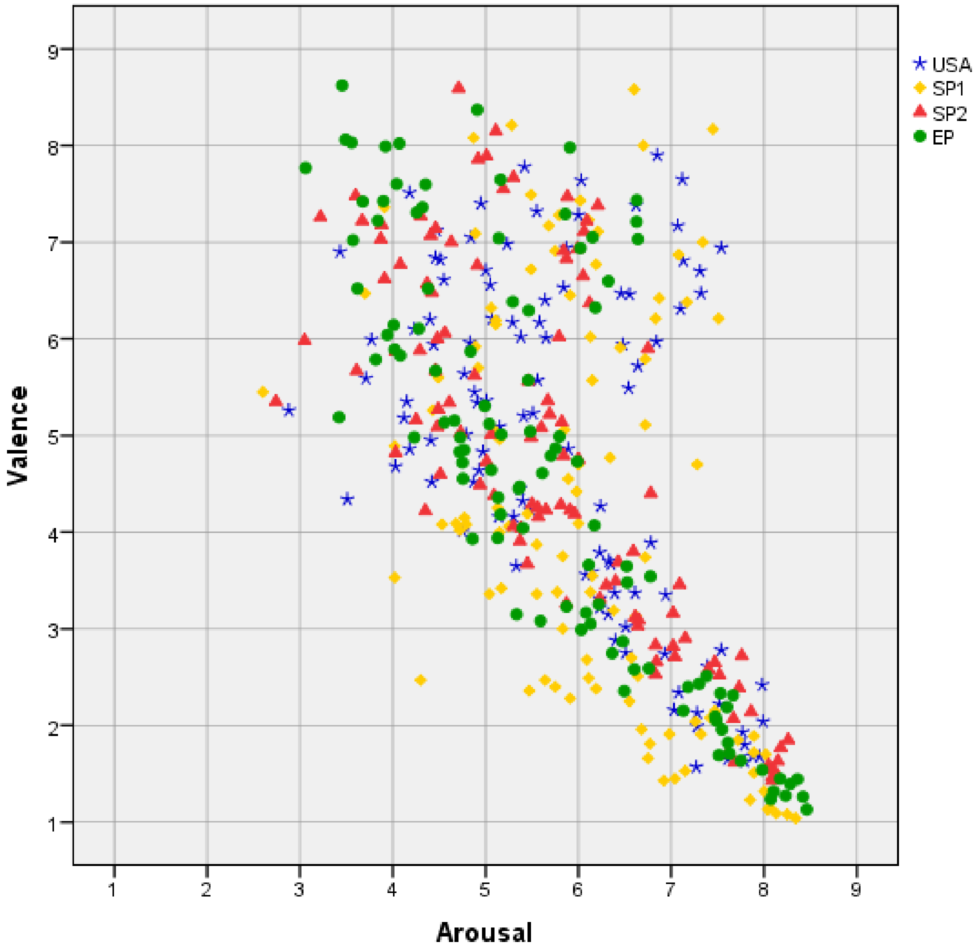

Figure 5. Distribution of mean values of IADS sounds ratings for valence and arousal affective dimensions in the American (USA; Bradley & Lang, 2007a), SP_1 (Redondo et al., 2008), SP_2 (Fernández-Abascal et al., 2008) and EP versions.

Table 1. *Means (M), Standard Deviations (SD) and range values of the 167 sound ratings of the EP adaptation of the IADS-2 for females and males in three affective dimensions.*

Affective dimensions	Females			Males		
	M	*SD*	*Range*	*M*	*SD*	*Range*
Valence	4.52	2.09	7.68	4.69	1.86	6.88
Arousal	5.73	1.35	5.38	5.64	1.34	6.01
Dominance	4.78	1.53	5.84	4.98	1.41	5.64

Table 2. *Linear correlations between European Portuguese (EP), American (USA - Bradley & Lang, 2007a) and Spanish (SP_1 – Redondo et al., 2008; SP_2 - Fernández-Abascal et al., 2008) IADS-2 sound ratings in the three affective dimensions for all subjects, and for females and males separately.*

Affective dimensions	All subjects			Females		Males	
	USA	SP_1	SP_2	USA	SP_2	USA	SP_2
Valence	.93**	.94**	.95**	.93**	.94**	.91**	.95**
Arousal	.80**	.78**	.89**	.79**	.88**	.82**	.85**
Dominance	.92**	.93**	.93**	.92**	.92**	.88**	.88**

** $p < .001$

Table 3. *Mean, Standard Deviations (SD) and range for the European Portuguese (EP), American (USA – Bradley & Lang, 2007a), and Spanish (SP_1 – Redondo et al., 2008; SP_2 - Fernández-Abascal et al., 2008) IADS sound ratings in the three affective dimensions for the global sample, and for females and males separately.*

Standardizations	sample	Valence *M*	Valence *SD*	Valence *range*	Arousal *M*	Arousal *SD*	Arousal *range*	Dominance *M*	Dominance *SD*	Dominance *range*
EP	*all*	4.55	2.04	7.49	5.71	1.32	5.40	4.82	1.50	5.60
	females	4.52	2.09	7.68	5.73	1.35	5.38	4.78	1.53	5.84
	males	4.69	1.86	6.88	5.64	1.34	6.01	4.98	1.41	5.64
USA	*all*	4.78	1.76	6.33	5.84	1.16	5.28	4.71	1.17	4.57
	females	4.72	1.92	6.77	5.89	1.20	5.70	4.59	1.28	5.26
	males	4.88	1.59	6.12	5.78	1.14	5.01	4.88	1.07	4.80
SP_1	*all*	4.18	2.14	7.54	6.17	1.19	5.74	4.51	1.39	5.22
SP_2	*all*	4.82	1.89	7.16	5.71	1.33	5.52	5.07	1.36	5.05
	females	4.80	1.90	7.22	5.76	1.34	5.56	5.01	1.38	5.14
	males	4.86	1.86	6.88	5.57	1.27	5.35	5.21	1.28	4.92

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