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MATTER in emotion research: Spanish standardization of an affective image set

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Abstract

Pictures with affective content have been widely used in the scientific study of emotions, from two main perspectives: on the one hand, dimensional theories claiming that affective experiences can be described according to a few fundamental dimensions such as valence and arousal, and on the other hand, discrete-category theories proposing the presence of a number of basic and universal emotions. Although it has been demonstrated that these two approaches are not mutually exclusive, the existing standardized affective picture databases have been created from the dimensional perspective, which has led to important gaps for research focused on discrete emotions. The present work introduces MATTER, a new database comprising 540 pictures depicting disgusting, fearful, neutral, erotic, mirthful and incongruent content, which provides normative values (total $N = 368$, mean = 120.47 ratings/picture) in valence and arousal dimensions, as well as in discrete affective (disgust, fear, erotica and mirth) and cognitive (incongruence and interest) features. A tentative classification into discrete categories is presented, and the physical properties of each picture are reported. Our findings suggest that MATTER constitutes a modern and suitable set of affective images including, for the first time, both mirth- and incongruence-related pictures. Additionally, it will enable the examination of affective and cognitive processes in fear/disgust and humor/incongruence fields.

Keywords Picture database · Affective ratings · Disgust · Fear · Neutral · Erotic · Mirth · Incongruence · Humor

Introduction

The presentation of static pictures has been used for decades to elicit emotions in psychological research settings. There are specific features that have made this method the most widely employed for emotion induction and regulation. Photographs can depict a broad range of semantic content and may be standardized, enabling good experimental control in terms of intensity or duration, thus making them suitable for use in multiple diverse research topics and designs, from subliminal emotional modulation (Ruiz-Padial & Vila, 2007) to moral cognition (Moll, Zahn, Oliveira-Souza, Krueger, & Grafman, 2005). In addition, a considerable number of studies have provided experimental evidence based on varied measures, such as behavioral (e.g. reaction time) or multiple physiological responses (e.g. autonomic correlates or event-related potentials). The capacity of the pictures to produce emotional states is well established in thousands of studies, and seems to be far superior even to video clips (Uhrig et al., 2016).

Although a plausible strategy might be to create a custom-made set of pictures according to the goal of each specific research project, this approach might be biased by the researcher's ideas and thus could hamper comparisons across studies, in addition to consuming too much time. When possible, it seems preferable to use an already standardized affective pictorial database. To this end, the International Affective Picture System (IAPS) was developed in the Center for the Study of Emotions and Attention (CSEA-NIMH, University of Florida, USA) in 1995, and since then, many other affective picture databases have been provided to the scientific community. The IAPS was the first set of pictures validated for research purposes, and it has had an important impact on the

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experimental study of emotions, serving as a standard in the field for decades. The IAPS contains more than 1000 color photographs depicting real-life aspects and situations with standardized norms in three dimensions (affective valence, arousal and dominance) obtained in different countries around the world (e.g. Deák, Csenki, & Révész, 2010; Lasaitis, Ribeiro, Freire, & Bueno, 2008; Moltó et al., 1999; Silva, 2011; Soares et al., 2015; Verschuere, Crombez, & Koster, 2001). Although the IAPS remains widely cited, there are some reasons for the emergence of additional standardized picture sets: (1) the intensive use of the IAPS stimuli in the same lab may produce a loss, in part, of its emotional power; (2) the range of situations represented by the IAPS pictures is wide, but the number of available stimuli within the same topic is too small to design studies with an elevated number of trials; (3) most of the pictures are over one or two decades old, so their quality is poor or they are outdated and unsuitable for the contemporary generation. Some of these limitations have been addressed by the construction of new sets of pictures, such as EmoPics (Wessa et al., 2010), the Geneva affective picture database (GAPED; Dan-Glauser & Scherer, 2011), Nencki affective picture system (NAPS; Marchewka, Żurawski, Jednoróg, & Grabowska, 2014), EmoMadrid emotional pictures database (Carretié, Tapia, López-Martín, & Albert, 2019), or the Open Affective Standardized Image Set (OASIS; Kurdi, Lozano, & Banaji, 2017), among others.

In addition, it should be mentioned that all these picture sets (i.e., IAPS, EmoPics, GAPED, NAPS, EmoMadrid and OASIS) have been specifically standardized according to the dimensional model of emotion, so they typically offer normative data in terms of affective valence (ranging from negative to positive) and arousal (ranging from relaxing to activating), but neglect the categorical model of emotions, which proposes the presence of a number of basic and universal emotions such as happiness, anger, fear, disgust and sadness (Ekman, Friesen, & Ellsworth, 1982). It has been demonstrated that these two approaches are not mutually exclusive, and there is at least an integrative model of emotion (Lang & Bradley, 2010) according to which discrete emotions would be organized in a subordinated way around affective valence and arousal as two basic dimensions. In fact, some affective word databases have been normed from both dimensional and discrete perspectives of emotion (Ferré, Guasch, Martínez-García, Fraga, & Hinojosa, 2017; Fraga, Guasch, Haro, Padrón, & Ferré, 2018; Stadthagen-González, Ferré, Pérez-Sánchez, Imbault, & Hinojosa, 2018).

In an attempt to overcome this situation, Mikels et al., (2005), for example, tried to classify 390 pictures from the IAPS (203 negative and 187 positive) into disgust, fear, sadness, amusement, awe, contentment and excitement categories. There were 263 out of the 390 stimuli that did not fit into any of those categories and were labeled "blended" or "undifferentiated." Two main limitations should be noted regarding that study. Firstly, the authors did not include erotic pictures, and secondly, the disadvantages of the IAPS described above are still applicable (e.g., poor photographic quality and outdated images). On the other hand, Riegel et al. (2016) classified 368 out of 510 pictures from the NAPS into happiness, anger, fear, sadness, disgust and surprise categories (the remaining 142 pictures were again classified as blended or undifferentiated). However, the authors also did not include erotic pictures. Finally, there are additional picture databases focused on specific emotions such as disgust (Haberkamp, Glombiewski, Schmidt, & Barke, 2017) or fear (Michałowski et al., 2017), as well as specific topics such as food (Blechert, Meule, Busch, & Ohla, 2014; Miccoli et al., 2016), alcohol (Billieux et al., 2011) or smoking (Khazaal, Zullino, & Billieux, 2012). Indeed, the number of standardized sets of pictures for emotion research has grown exponentially in recent years, but important gaps still exist and need attention.

Thus, the amount of research on various discrete emotions has increased in the last few years, but pictures covering some specific topics are scarce. This is the case with experiments comparing physiological responses to disgust and fear stimuli, a topic that has emerged as an important volume of literature within the last 10 years (e.g., Carretié, Ruiz-Padial, López-Martín, & Albert, 2011; Ruiz-Padial, Mendoza Medialdea, Reyes del Paso, & Thayer, 2018; Schienle, Schäfer, Stark, Walter, & Vaitl, 2005; Stark et al., 2007; van Hooff, Devue, Vieweg, & Theeuwes, 2013; Xu et al., 2016). Only pictures from IAPS and NAPS have been classified according to the discrete emotions they evoke (Mikels et al., 2005; Riegel et al., 2016); however, the number of pictures categorized as disgust- or fear-eliciting is too small (12 fear/31 disgust in IAPS and 11 fear/51 disgust in NAPS). In addition, although some standardized sets of stimuli focusing on disgust-related (Haberkamp et al., 2017) and fear-related pictures (Michałowski et al., 2017) have recently been developed, their normative ratings are not comparable with each other, and fear pictures have not been rated on a disgust scale.

In the opposite extreme of the dimension of affective valence, several discrete positive emotions, including amusement, love, contentment, surprise or happiness, are often included in the diverse lists made from the discrete perspective (e.g., Arnold, 1960; Ekman et al., 1982; Fredrickson, 2013; Oatley & Johnson-laird, 1987; Plutchik, 1980). There is a clear imbalance in all taxonomies between the number of positive and negative emotions. Besides the lower number of positive emotions, there is a significant lack of consensus on the specific positive emotions proposed, which is also evident in the completely different positive categories that emerged from the classifications by Mikel et al., (2005) and Riegel et al. (2016). Shiota et al. (2017) tried to overcome this by proposing a hierarchical model that differentiates between eight discrete positive emotions (liking/pleasure, contentment,

pride, sexual desire, attachment love, nurturant love, amusement, awe) that would emerge from a common ancestor (enthusiasm), mediating adaptive management of fitness-critical resources. Even though Shiota and colleagues' proposal represents a step forward and recognizes the relevance of differentiating between discrete positive emotions, the lack of consensus on the proposed specific categories is still evident. Besides the gap that experimental research on discrete positive emotions has suffered, what it may also call into question is their universality versus their dependency upon individual and cultural differences. One factor that may have contributed to this lacuna in the positive emotion field is that it is difficult or even impossible in many cases to prompt these emotions through standardized pictures. Indeed, the elicitation of most of those positive emotions requires stimuli with a clear self-reference component that must be personalized for each participant or even by definition, as in the case of surprise, the stimuli have to be original. Mirth is an important positive emotion suitable for elicitation by standardized pictures, and is receiving increased attention in scientific research contexts, but it has not been included in any of the taxonomies of discrete emotions. Specifically, mirth has been defined as "the distinctive emotion that is elicited by the perception of humor" (Martin, 2007). The stimuli used to provoke mirth in experimental settings are strips, cartoons, jokes, video clips or comedies. All these stimuli are composed of at least two components with the capacity to create a context that will be solved in an unexpected and funny way. It is hard to find a static photograph of a real scene that evokes, by itself, a humor response. Perhaps this is the reason that, according to visual inspection, none of the existing sets of standardized pictures contain mirth-evoking stimuli or ratings on the mirth of their pictures. Incongruity resolution theory (Suls, 1972) is one of the most influential at this time, guiding most current research on the neural processes associated with humor. Despite the lack of consensus on whether the incongruity needs to be resolved (Shultz, 1974; Suls, 1972), or whether the resolution of the incongruity plays a minimal role (Martin, 2007; McGraw & Warren, 2010), there is majority consensus that some kind of incongruity is necessary to elicit humor. From this perspective, the stimuli must be mirthful while also containing an incongruence component in order to prompt an emotion of mirth.

The aim of the present study was to develop a new database of pictures useful for research on disgust/fear and mirth/incongruity fields, assessed on the basis of both target discrete emotions, and valence and arousal dimensions. To this end, pictures related to four emotional (disgust, fear, mirth and erotica) and two neutral categories (congruent and incongruent) were collected. The rationale for selecting these specific categories is that *mirth-evoking pictures* have not been included in any prior databases, even though humor research is an emerging area within positive psychology that claims validated instruments for its scientific study. *Incongruent* but not mirthful pictures will help in designing new experiments that would enable testing of the incongruity theory, acting as control for the cognitive component of mirth. In turn, *erotic pictures* are evaluated as highly pleasant and arousing stimuli, being therefore an excellent control for the affective component of mirth. Moreover, erotic pictures have been rated very differently by men and women participants, a phenomenon which has been somehow related to inherent disgust properties in this specific category (Bradley, Costa, & Lang, 2015). To avoid a response bias to the positive extreme of valence dimension, two of the more widely investigated negative emotions have been included: *disgust* and *fear*. In this way, we also aimed to complement prior literature with comparable norms for these two negative discrete emotions. Finally, we included a *neutral* (congruent) category as control condition for the rest of the categories, which is especially relevant for the cognitive component of incongruent pictures. Consequently, this new database provides comparable norms that would certainly facilitate the design of further studies on mirth and on disgust/fear.

Method

Stimuli selection

The database comprises 540 images selected according to the authors' criteria so that six categories were equally represented: disgusting, fearful, mirthful, incongruent, erotic and neutral (90 pictures per category). All the mirthful and incongruent pictures were selected from the internet, and the rest of the images were chosen from either the internet or other existing sets. Thus, the final sample of stimuli comprised pictures extracted from the IAPS ($N = 96$: 21 disgusting, 22 erotic, 34 fearful, 19 neutral), NAPS ($N = 75$: 14 disgusting, 40 erotic, 15 fearful, 6 neutral), EmoMadrid ($N = 91$: 27 disgusting, 9 erotic, 17 fearful, 38 neutral), the Set of Fear Inducing Pictures (SFIP; $N = 18$: 1 disgusting, 1 fearful, 16 neutral), GAPED ($N = 16$: 5 fearful, 11 neutral) and the internet ($N = 244$: 27 disgusting, 19 erotic, 18 fearful, 90 mirthful, 90 incongruent). Text and comments included in some of the pictures selected from the internet were removed to leave only the pictorial aspects. All pictures were resized to 1024×768 pixels, and black borders were added when necessary to obtain this specific size. The stimuli from IAPS, NAPS, EmoMadrid and GAPED are available from the original authors. The identification of the exact pictures selected from those databases, as well as from the rest of the stimuli included in MATTER, is available at www4.ujaen.es/~erpadial/ for research to noncommercial use.

Participants

Initially, 409 university students from different degrees and universities (University of Jaén, University of Granada, University Jaume I, University Rey Juan Carlos) participated in the study, and were rewarded with course credit for their participation. A preliminary data analysis showed that many participants did not rate a high number of pictures, or rated some properties with scores completely opposite those given by the overall sample. For each participant, we calculated the number of responses that were either too high or too low in relation to the average for each feature and each picture, according to a two-standard-deviations criterion. For the analysis reported here, those participants who had more than 288 (20%) irregular scores (blank and/or out of range) out of the overall 1440 scores were excluded. According to this criteria, 41 participants were removed, leaving a final sample of 368 participants ($N = 135$ rated the pictures included in Set 1; $N = 109$ rated Set 2; and $N = 124$ rated Set 3). In addition, the men/women ratio was controlled to obtain a minimum of 1:2. In total, 132 men and 236 women participated in the study (details on gender and age of the participants that rated each set can be found in Table 1). Preliminary *t* tests calculated for age differences between genders did not show significant effects for any of the three sets of pictures (see Table 1). The Research Ethics Committee of the University of Jaén approved the experimental protocol, and written informed consent was obtained from all participants prior to the study.

Procedure

The whole database (540 pictures) was divided into three sets of 180 pictures each (30 from each emotional category). For each set of pictures, four orders of presentation were semi-randomly created, with the constraint that no more than two stimuli in one category were presented in succession. Each picture was presented on a full screen for one second (see Fig. 1 for a schematic representation of a typical trial). In a prior pilot study, it was observed that with practice, participants became familiar with the procedure and began to respond faster. Therefore, in the final procedure we decided to set 26 seconds (for the first 15 pictures) and 15 seconds (for all other images) as the maximum time to evaluate each picture in paper-and-pencil form, including the rating scales for the eight properties: two emotional aspects according to the dimensional perspective (valence and arousal), four emotional features according to the categorical perspective of emotions (disgust, fear, erotic and mirth), and two cognitive attributes (incongruence and interest). In all cases, the scale ranged from 1 to 9, where 1 meant unpleasant, relaxing, not disgusting, not fearful, not erotic, not mirthful, not incongruent and not interesting at all, whereas 9 meant highly pleasant, arousing, very disgusting, very fearful, very erotic, very mirthful, very incongruent and very interesting (for valence, arousal, disgust, fear, erotica, mirth, incongruence and interest, respectively). One second before the presentation of each picture, a tone was presented as a warning signal for participants to look at the screen in order to not miss any picture. All the ratings were collected in group sessions, with a maximum of 30 participants who received instructions, making sure that the meaning of the rating scales and the procedure was understood. The study began with three test trials, followed by the 180 pictures of one of the three sets, presented in 12 blocks of 15 pictures each, according to four randomization orders. Each block was followed by a nine-second break in order to avoid participant fatigue. The overall task lasted for a maximum of one hour. After completing the experimental session, participants were thanked and received the corresponding course credit.

Table 1 Number, gender and age (mean and standard deviation) of the participants who rated every set of images, and *t* values for age comparisons between genders

		N	Mean age (SD)	Ratio (women/men)	*t* Values (*p* values)*
IMAGE SET 1	Women	88	20.87 (2.51)		
	Men	47	21.51 (2.47)		
	Total	135	21.09 (2.51)	1.87	−1.41 (0.16)
IMAGE SET 2	Women	70	20.41 (1.94)		
	Men	39	21.44 (3.38)		
	Total	109	20.78 (2.58)	1.79	−1.73 (0.09)
IMAGE SET 3	Women	78	21.03 (3.24)		
	Men	46	21.98 (3.09)		
	Total	124	21.38 (3.21)	1.70	−1.60 (0.11)

*Equal variances (non-significant Levene test) were assumed

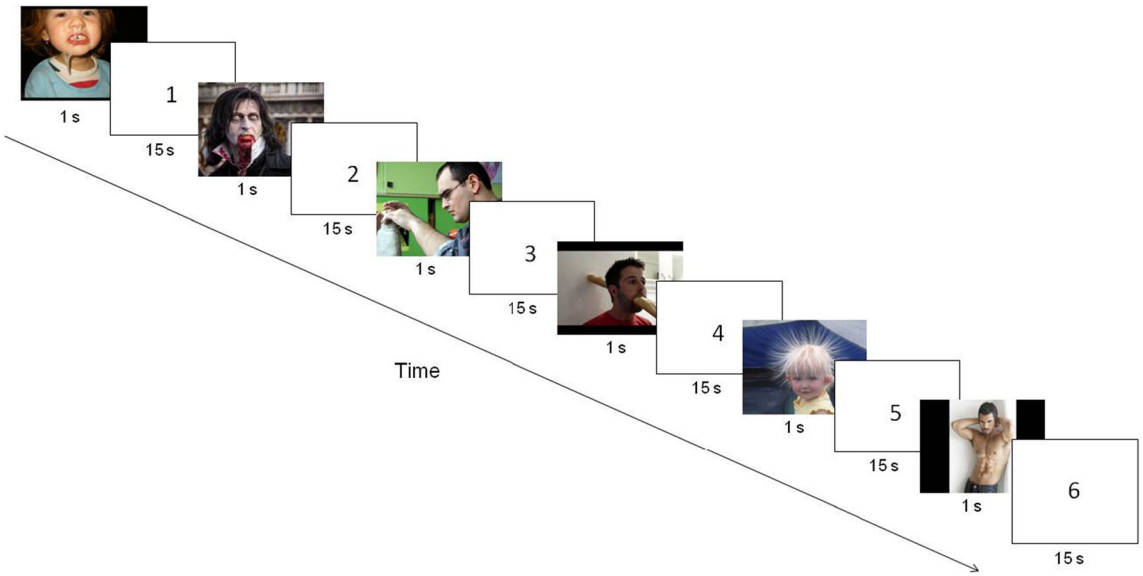

Fig 1 Schematic representation of a trial. Examples of pictures belonging to each category (disgust, fear, neutral, incongruence, mirth and erotica) are included. s = seconds

Results

Ratings

Ratings from 120.47 participants on average were collected for each picture (132.35 for pictures in Set 1, 107.13 in Set 2, 121.92 in Set 3). Mean and standard deviation for the ratings in valence, arousal, disgust, fear, mirth, erotica, interest and incongruence were calculated for each individual picture for the overall sample, and for men and women separately. Data may be helpful for researchers in selecting stimulus material, and can be found in Table S1 (supplementary material available at www4.ujaen.es/~erpadial/).

Classification into discrete categories

The pictures included in the study were selected as belonging to the following discrete categories: disgust, fear, mirth, incongruence, erotica and neutral. In order to investigate the categorical structure of the selected set of pictures based on the empirical data, the same procedure used by Mikels et al., (2005) was applied to identify images that elicit one discrete emotion more than other emotions. Thus, means for the ratings in the five characteristics (disgust, fear, erotica, mirth and incongruence) related to the quality of the discrete emotions that constituted the main aim of the current study were calculated individually for each image. Although incongruence is not an affective feature and represents a cognitive rather than an emotional category, in order to improve the readability of the present section it will be treated as one more emotional category. A 90% confidence interval (CI) was constructed around each mean, and it was used to determine the category membership of every individual picture such that if the mean for one characteristic was higher than the means for all other ratings, and if the CI for that characteristic did not overlap with the CIs for the other four ratings, it was classified within a single discrete category. If two, three or four means were higher than the rest, and if the CIs of those means overlapped only with each other, the image was categorized as blended. Finally, if all five CIs overlapped, such an image was classified as undifferentiated.

According to this procedure, pictures were classified into one of the following categories: disgust, fear, erotica, mirth, incongruence, blended or undifferentiated. However, the initial selection of pictures also considered the inclusion of neutral images. It has been difficult to find an objective criterion to classify pictures as neutral. To our knowledge, only two studies have applied a similar design as that of the current study, by classifying emotional pictures into discrete categories and also collecting ratings on dimensional aspects (valence and arousal). Whereas Mikels et al., (2005) worked with negative and positive but not with neutral pictures, Riegel et al. (2016) classified pictures as neutral following a dimensional criteria (valence values ranging from 4 to 6), but according to a discrete criteria, the same set of pictures was divided into eight categories that did not include a neutral one (happiness, anger, sadness, fear, disgust, surprise, blended and undifferentiated). Therefore, none of the previous studies has considered neutral pictures as a discrete category of its own for comparison of discrete emotional images, as we expect to do here. To consider pictures as neutral in the current set of data, the same dimensional criteria used by Riegel et al. (2016) were applied to pictures so that they met two conditions: they did not elicit a single discrete emotion, and the mixed emotion elicited was of low intensity. Thus, blended or undifferentiated pictures with mean values lower than 4 in

Table 2 Discrete categories and number of pictures included in each one after applying CI and conservative methods of classification

		Disgust	Fear	Mirth	Incongruence	Erotica	Neutral	Blended	Undifferentiated
Set 1	*CI*	33	17	26	30	28	17	29	
	Conservative	22	3	11	10	16			
Set 2	*CI*	33	13	28	29	29	18	29	1
	Conservative	19	2	6	9	22			
Set 3	*CI*	33	16	33	27	28	22	21	
	Conservative	20	4	13	7	19			
TOTAL	*CI*	99	46	87	86	85	57	79	1
	Conservative	61	9	30	26	57			

the elicited target emotions, and whose valence ratings ranged between 4 and 6, were classified as neutral. Accordingly, overlapping between neutral and other discrete categories was avoided.

The results of this analysis yielded eight categories: disgusting, fearful, mirthful, incongruent, erotica, neutral, blended and undifferentiated. As can be observed in Table 2, in most of the discrete categories the *N*s are around 30 in every image set except for fearful and neutral pictures, where the *N*s are lower. Moreover, a new category of blended pictures emerged, not considered in the original design. As described before, pictures were considered blended when they could not be classified within a single category and received similar ratings in two, three or four discrete features. This means that the label "blended" may cover pictures depicting very different content (see Table 3).

The visual inspection of the pictures included in each discrete category (disgust, fear, mirth, incongruence, erotica and neutral) generated doubts about the efficiency of the CI procedure for classifying some images. Indeed, after applying the CI method to the current ratings, some pictures selected from other datasets as belonging to one specific category were classified into a different one here (for example, neutral pictures in NAPS resulted as disgusting or mirthful pictures in the current data). Similar confusion applied for pictures classified as neutral that had clear erotic or mirthful content.

Hence, although the CI-based procedure seems to be the preferred method for classifying pictures into discrete categories according to the literature, both Mikel et al. (2005) and Riegel et al. (2016) referred to alternative methods based on the mean ratings: (1) a liberal criterion that assigns to each discrete category those pictures that received the higher mean rating in that particular discrete emotion compared to the other emotions, and (2) a conservative method that assigns to a discrete category those pictures whose mean rating in one specific emotion was more than one standard deviation higher than the ratings for the other discrete emotions. Despite none of these mean-based methods being suitable for identifying potentially neutral pictures (since scores in a "neutral" scale were not collected), the conservative method was applied to the current data to complement the classification made following the CI method. The number of images assigned to each discrete category through the conservative procedure was smaller compared to the CI method (see Table 2), especially for fear-eliciting pictures, which were reduced by (80.44%), followed by incongruent (69.77%), mirthful (65.52%), disgusting (38.38%) and erotic (32.94%) pictures. In addition, this procedure does not allow one to classify pictures as neutral but eliminates the problem of the classification of images into erroneous categories.

The resulting categorical classification for each image by both methods is included in Table S1 of the supplementary material. The mean values in valence and arousal for each discrete category according to the CI and the conservative method are shown in Tables 4 and 5, respectively. Figure 2 represents the pictures classified according to the CI (a) and the conservative method (b), respectively, according to the affective space formed by their averaged valence and arousal

Table 3 Combinations of different emotional content included under the label "blended" and number of blended pictures in each combination

	M & I	D & F	D & I	D & I & F	D & I & M	F & I	E & M & I	TOTAL
Set 1	17	6	1	1		2	2	29
Set 2	11	10	2	5	1			29
Set 3	10	9		1		1		21
TOTAL	38	25	3	7	1	3	2	79

**Note*: D = disgusting, E = erotic, F = fearful, M = mirthful, I = incongruent

Table 4 Mean values (and standard deviations) in valence and arousal dimensions for pictures included in each discrete category according to the CI method

		Disgust	Fear	Mirth	Incongruence	Erotica	Neutral	Blended	Undifferentiated
Valence	*Set 1*	2.548 (1.64) (Range: 1.48–4.28)	3.351 (1.89) (Range: 2.20–5.98)	5.766 (1.58) (Range: 4.54–7.45)	4.571 (1.56) (Range: 2.65–5.74)	5.924 (1.72) (Range: 4.77–6.78)	5.225 (1.21) (Range: 4.30–5.90)	4.658 (2.16) (Range: 1.80–6.95)	-
	Set 2	2.556 (1.72) (Range: 1.44–4.16)	3.524 (1.87) (Range: 1.86–5.68)	5.923 (1.72) (Range: 3.99-7.23)	4.723 (1.58) (Range: 3.15–6.18)	6.140 (1.75) (Range: 4.99–7)	5.277 (1.21) (Range: 4.93–5.99)	3.861 (2.11) (Range: 1.84–6.43)	6.048 (1.64)
	Set 3	2.121 (1.47) (Range: 1.61-4.97)	3.619 (1.99) (Range: 2.43–6.39)	5.886 (1.69) (Range: 4.37–7.37)	4.838 (1.46) (Range: 2.79–5.72)	5.928 (1.80) (Range: 4.32–6.85)	5.208 (1.41) (Range: 4.05–5.89)	3.976 (2.02) (Range: 2.05–6.16)	-
	TOTAL	2.549 (1.68) (Range: 1.44–4.97)	3.487 (1.92) (Range: 1.86–6.39)	5.857 (1.66) (Range: 3.99–7.45)	4.701 (1.54) (Range: 2.65–6.18)	5.991 (1.75) (Range: 4.32–7)	5.233 (1.29) (Range: 4.05–5.99)	4.214 (2.14) (Range: 1.80–6.95)	6.048 (1.64)
Arousal	Set 1	6.111 (1.47) (Range: 4.57–7.24)	6.703 (1.47) (Range: 5.99–7.55)	5.218 (1.50) (Range: 4.08–6.16)	5.384 (1.35) (Range: 4.50–6.40)	5.893 (1.58) (Range: 5.09–6.61)	4.762 (1.31) (Range: 3.93–5.53)	5.360 (1.85) (Range: 3.31–6.90)	-
	Set 2	6.080 (1.55) (Range: 5.29–6.87)	6.703 (1.55) (Range: 5.99–7.50)	5.108 (1.64) (Range: 3.64-5.94)	5.253 (1.33) (Range: 4.40–6.08)	5.959 (1.76) (Range: 4.88–6.58)	4.823 (1.37) (Range: 3.93–5.71)	5.816 (1.74) (Range: 3.44–6.97)	3.798 (1.73)
	Set 3	6.112 (1.60) (Range: 4.99–7.11)	6.535 (1.64) (Range: 4.55–6.94)	5.019 (1.66) (Range: 3.17–5.72)	5.167 (1.36) (Range: 4.72–6.47)	6.061 (1.69) (Range: 5.06–6.82)	4.734 (1.51) (Range: 4.08–6.55)	5.947 (1.63) (Range: 3.91–7.09)	-
	TOTAL	6.102 (1.54) (Range: 4.57–7.24)	6.645 (1.55) (Range: 4.5–7.55)	5.109 (1.61) (Range: 3.17–6.16)	5.2276 (1.35) (Range: 4.40–6.47)	5.969 (1.67) (Range: 4.88–6.82)	4.768 (1.41) (Range: 3.93–6.55)	5.667 (1.78) (Range: 3.31–7.09)	3.798 (1.73)

Table 5 Mean values (and standard deviations) in valence and arousal dimensions for pictures included in each discrete category according to the conservative method

		Disgust	Fear	Mirth	Incongruence	Erotica
Valence	*Set 1*	2.303 (1.48) (Range: 1.48–3.01)	4.276 (2.15) (Range: 3.19–5.98)	5.677 (1.65) (Range: 4.63–7.45)	4.749 (1.68) (Range: 3.55–5.74)	6.115 (1.73) (Range: 5.43–6.78)
	Set 2	2.118 (1.47) (Range: 1.44–3.07)	2.858 (1.58) (Range: 2.61–3.11)	6.506 (1.61) (Range: 5.33–7.23)	4.646 (1.66) (Range: 3.56–5.60)	6.417 (1.66) (Range: 5.14–7)
	Set 3	2.186 (1.49) (Range: 1.61–2.72)	3.614 (1.98) (Range: 2.94–4.57)	6.318 (1.64) (Range: 5.24–7.28)	4.972 (1.32) (Range: 4.59–5.66)	6.335 (1.67) (Range: 5.56–6.85)
	TOTAL	2.215 (1.48) (Range: 1.44–3.07)	3.705 (2.04) (Range: 2.61–5.98)	6.217 (1.65) (Range: 4.63–7.45)	4.781 (1.58) (Range: 3.55–5.74)	6.295 (1.69) (Range: 5.14–7)
Arousal	*Set 1*	6.166 (1.45) (Range: 5.59–6.74)	6.950 (1.57) (Range: 6.60–7.55)	5.330 (1.54) (Range: 5.02–5.61)	5.388 (1.45) (Range: 4.89–6.21)	6.175 (1.62) (Range: 5.11–6.61)
	Set 2	6.256 (1.59) (Range: 5.42–6.87)	7.206 (1.45) (Range: 6.96–7.45)	5.196 (167) (Range: 4.82–5.62)	5.267 (1.30) (Range: 4.88–5.64)	6.08 (1.81) (Range: 4.88–6.58)
	Set 3	6.165 (1.56) (Range: 5.49–6.84)	6.840 (1.53) (Range: 6.67–6.94)	5.096 (1.74) (Range: 4.43–5.67)	5.147 (1.34) (Range: 4.77–5.72)	6.233 (1.78) (Range: 5.06–6.82)
	TOTAL	6.190 (1.53) (Range: 5.42–6.87)	6.951 (1.54) (Range: 6.60–7.55)	5.205 (1.66) (Range: 4.43–5.67)	5.275 (1.37) (Range: 4.77–6.21)	6.162 (1.75) (Range: 4.88–6.82)

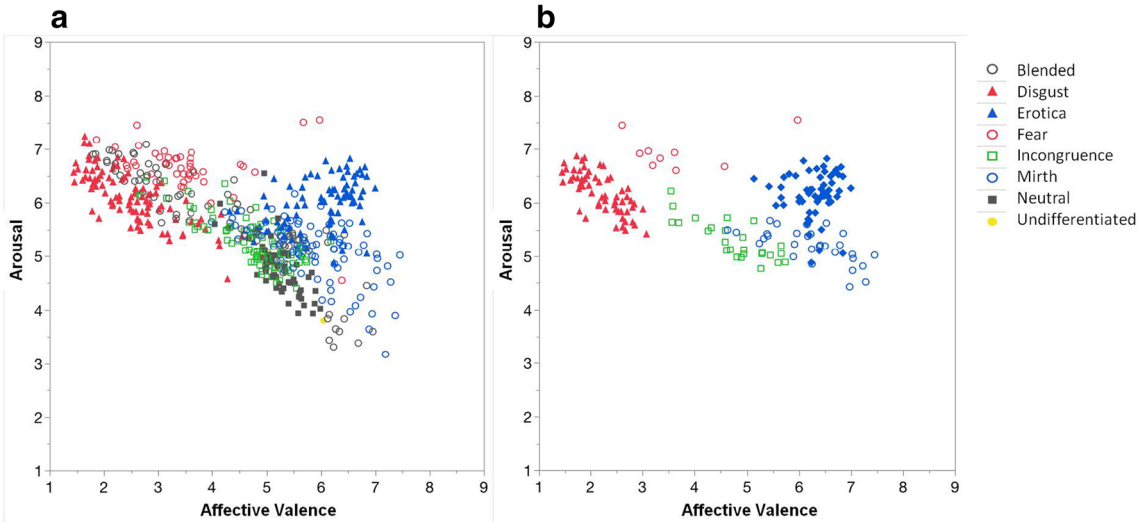

Fig. 2 Pictures in the affective space formed by their averaged valence and arousal ratings, classified according to the **a** CI and **b** conservative methods

ratings. After comparing the two classifications, the conservative method seemed too strict and resulted in too few pictures per category, with a remarkable reduction in fearful images, and importantly, it did not allow us to create a neutral category.

Reliability

The internal consistency of participant evaluations was estimated by calculating split-half reliability scores (Wierzba et al., 2015). To this end, participants were numbered according to their order of participation, and each sample that evaluated one of the three sets of pictures was split into two groups (i.e., odd vs. even participant numbers). The average ratings for valence, arousal, disgust, fear, erotica, mirth, incongruence and interest were then calculated separately for each image and within each participant group. Finally, Pearson correlations among these average ratings were calculated for the two groups of participants of each sample. All correlations were significant ($p < 0.001$), and Spearman-Brown-corrected reliability scores were high for the three sets of pictures (valence: $r = 0.995$, $r = 0.994$, $r = 0.988$; arousal: $r = 0.989$, $r = 0.976$, $r = 0.977$; disgust: $r = 0.996$, $r = 0.996$, $r = 0.992$; fear: $r = 0.994$, $r = 0.997$, $r = 0.957$; erotica: $r = 0.998$, $r = 1$, $r = 1$; mirth: $r = 0.997$, $r = 0.996$, $r = 0.993$; incongruence: $r = 0.993$, $r = 0.992$, $r = 0.992$; interest, $r = 0.982$, $r = 0.986$, $r = 0.972$; for Sets 1, 2 and 3, respectively).

Gender differences

The effect of gender on the picture ratings was explored by calculating the mean of valence, arousal, disgust, fear, mirth, erotica, incongruence and interest ratings for each image broken down by gender (see Table S1). The mean, standard deviation and range of the ratings in these eight features are presented in Table 6 for the overall sample and for men and women separately.

Correlations were applied and the results showed that assessments by men and women were highly positively correlated for all the features measured in this study (valence ($r = 0.925$), arousal ($r = 0.88$), disgust ($r = 0.976$), fear ($r = 0.973$), mirth ($r = 0.969$), erotica ($r = 0.911$), incongruence ($r = 0.969$), interest ($r = 0.755$), all $ps < 0.001$).

As in previous studies, the distribution of the emotional pictures in the bidimensional affective space was similar between men and women (see Figure 3). Likewise, the results regarding the quadratic correlation between valence and arousal for both men ($r = 0.565$, $p < .001$) and women ($r = 0.629$, $p < .001$), although slightly lower, were comparable to other emotional pictures adapted to Spanish samples (for example, Moltó et al. (1999) reported .61 and .65 for men and women, respectively).

Table 6 Mean values (and standard deviations) for the eight features evaluated for the whole sample and for men and women separately

	Men	Woomen	All participants
Valence	4.757 (2.00)	4.479 (2.18)	4.578 (2.12)
Arousal	5.604 (1.65)	5.643 (1.67)	5.629 (1.66)
Disgust	2.284 (2.30)	2.567 (2.65)	2.466 (2.53)
Fear	1.723 (1.71)	1.945 (2.09)	1.865 (1.97)
Mirth	2.665 (2.47)	2.463 (2.46)	2.536 (2.47)
Erotica	1.777 (2.01)	1.763 (1.99)	1.768 (1.99)
Incongruence	2.916 (2.68)	2.926 (2.78)	2.922 (2.75)
Interest	3.627 (2.50)	3.040 (2.43)	3.251 (2.47)

*Ranges were 1–9 for all ratings in all participants and for men and women separately

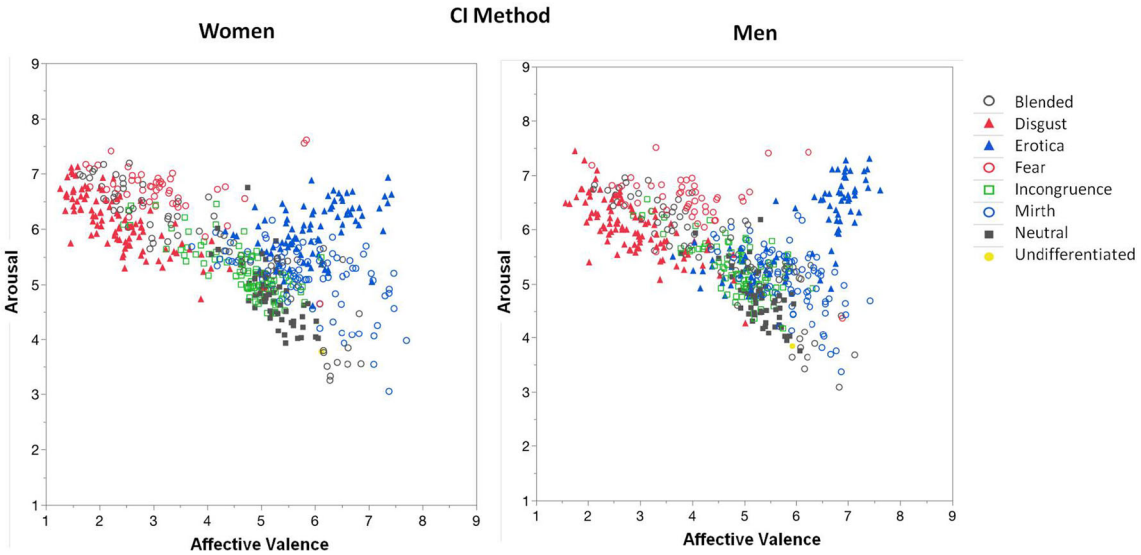

Fig. 3 Pictures in the affective space formed by their averaged valence and arousal ratings (classified according to the CI method), for women and men separately

Physical properties of images

The luminance, contrast, mean channel values in CIE 1976 L*a*b color space, spatial frequency in nine different bands, and size of each image were also calculated and are listed in Table S1 (supplementary material available at www4.ujaen.es/~erpadial/).

Luminance was defined as the average pixel value, and contrast was defined as the standard deviation across all pixels of the grayscale image (as, for example, in Haberkamp et al., 2017, and in Marchewka et al., 2014). Mean channel values in CIE 1976 L*a*b color spaces were obtained by converting RGB values to color space values and computing the mean of each channel. As CIE 1976 L*a*b is a color-opponent space, it approximates characteristics of the human visual system ,with the L* dimension corresponding to lightness (range: 0–100) and two color-opponent dimensions corresponding to green (negative values)–red (positive values) range in the a* dimension, and to blue (negative values)–yellow (positive values) range in the b* dimension (Marchewka et al., 2014). These physical properties of each image were computed with the ImageJ program (version 1.52a; Rasband, Rasband & Image, 1997–2018). JPEG size has been proposed to be a good index of the overall complexity of an image, since it correlates with subjective measures of image complexity (Donderi, 2006). With respect to spatial frequency, spectral energies were computed for nine frequency bands (768-384 pixels/cycle or p/c, 384-192 p/c, 192-96 p/c, 96-48 p/c, 48-24 p/c, 24-12 p/c, 12-6 p/c, 6-3 p/c and residuals) within each picture, including the black margins that some of them needed in the vertical or the horizontal dimension to fit the 1024 × 768 pixel format. Analyses were carried out following the procedure described by Delplanque et al., (2007), in which the gray 709 option was selected (see also Carretié et al., 2019). The JPEG size of the color images was determined with a compression quality setting of 80% using the FastStone Photo Resizer (version 3.9; https://www.faststone.org/) for JPEG compression.

Discussion

The current study presents MATTER, a database of pictures depicting disgusting, fearful, erotic, mirthful and incongruent content. All the pictures have been normed in valence and arousal dimensions, as well as in discrete emotional (disgust, fear, erotica and mirth) and cognitive (incongruence and interest) features. Furthermore, MATTER is also the first database that includes mirth- and incongruence-related pictures, thus enabling the design of future controlled studies in the humor research field, especially relevant for incongruity resolution theory. Additionally, the physical properties of each picture are reported in order to provide complementary information that can aid in the selection of images for future research designs. Finally, around half of the included pictures (45.18%) were not selected from existing databases, being carefully chosen to adjust to contemporary canons and avoid outdated images.

All these factors render MATTER a modern and suitable set of affective images that allows researchers to examine both affective and cognitive components in different important scientific fields of discrete emotion research, such as fear/disgust and humor/incongruence. Notably, in the current database, subjective ratings in four discrete emotions (disgust, fear, erotica and mirth) and two affective dimensions (valence and arousal) are provided for each picture, with the aim of

allowing researchers to simultaneously select the stimuli according to both discrete and dimensional perspectives.

A classification of all pictures into one of the six categories considered in our original design (disgust, fear, erotica, mirth, incongruence and neutral) was carried out based on the CI method, according to the mean scores assigned to each stimulus in five features: the four target emotions (disgust, fear, erotica, mirth) and the cognitive attribute of incongruence. The results revealed a number of pictures belonging to each discrete category in accordance with the initial design of the study (N = around 30 pictures for each category in each image set) for disgust, mirth, incongruence and erotica categories. However, the Ns for fear and neutral categories were lower than expected. As a consequence, a new category of *blended* emotions (including pictures with diverse affective content) strongly emerged. The most frequent content in the blended category was a mixture of mirth and incongruence (48.10 %), followed by a mixture of fear and disgust (31.65 %). The rest of the blended subcategories included a small number of pictures and comprised different combinations that always contained a mixture of incongruence and other emotional categories.

The high number of images experienced as equally incongruence- and mirth- eliciting seems to indicate the relevance of incongruence for humor (in line with incongruity resolution theory) and positions MATTER as a useful tool that will allow researchers to investigate the role of incongruence in inducing mirth based on the selection of pure mirthful, pure incongruent and mixed mirthful/incongruent pictures. The relevance of cognitive factors may not be limited to incongruence and humor. Existing literature has shown important differences between positive and negative emotions in their relationship with several cognitive processes (Madan, Scott, & Kensinger, 2019; Zinchenko, Obermeier, Kanske, Schröger, & Kotz, 2017). Since the adaptive functions of all positive emotions—not just mirth—are linked to facilitating the management of and response to opportunities, and not to immediate threat for survival, they might involve a more complex cognitive processing of the environment compared to negative stimuli. However, these are questions that future research will have to address.

The emergence of a rather large additional number of images prompting a blurred disgust/fear emotion, along with a scarce number of "pure fear" eliciting pictures suggests two complementary hypotheses regarding the basic emotion of fear. One interpretation that has received attention in recent years would be that disgust has a strong participation in certain situations often labeled as fear-related (Knowles, Jessup, & Olatunji, 2019). Whereas it is frequently stated that fear is one of the most investigated negative emotions, the term "fear" is avoided in many publications on the topic (with terms such as "negative emotions", "threat" or "anxiety" being typically preferred). Many other studies have focused on phobic fear, which involve other components such as anxiety (e.g., social phobia) or disgust (e.g., spider, snake or blood-injection-injury phobias), in addition to the pure emotion of fear. Another plausible explanation is that it is especially difficult to prompt genuine fear in a safe context such as a laboratory setting. In this vein, Gross and Levenson (1995) reported decades ago that fear was one of the most difficult emotions to provoke viewing film clips. The scarce number of pictures classified as fearful in the current study, much like in Riegel et al.'s (2016), seems consistent with this idea. One factor that may contribute to the difficulty in inducing fear in safe contexts could be the strong role of motion in threatening stimuli as it occurs when a predator is approaching (Courtney, Dawson, Schell, Iyer, & Parsons, 2010). However, motion may be less relevant for inducing other negative emotions that are less dependent on danger proximity (e.g., disgust), or for eliciting positive emotions (e.g., mirth relying on a hilarious situation). Nonetheless, this is an open question that should be further explored in future research.

Similarly, the classification of pictures as neutral has generally not been addressed in previous research. Thus, neutral stimuli are supposed to elicit low emotional arousal (do not provoke intense negative or positive emotions) and medium arousal (do not elicit extremely relaxing or arousing states), being therefore considered as a control condition in most studies focused on emotion induction and regulation. Previous pictorial databases that include neutral scenes have used a priori dimensional criteria (Dan-Glauser & Scherer, 2011; Haberkamp et al., 2017; Michałowski et al., 2017), but do not subsequently verify whether these neutral pictures could be considered as such according to the subjective evaluations collected in their studies. Only Riegel et al. (2016) used the valence ratings from their participants to classify pictures as neutral according to the dimensional perspective (in which pictures are classified as negative, neutral or positive). However, they did not include a neutral category among the discrete categories, so when comparing both dimensional and discrete classifications, an important overlap could emerge. It is usually assumed that neutral pictures score in the mid-range of the hedonic valence scale. In our opinion, such a criterion is not only nonspecific, but it may also cover a wide and heterogeneous range of semantic content that is not necessarily neutral in terms of affect. In this regard, Haberkamp et al. (2017) found a mean valence score of 7.30 for neutral pictures, whereas Michałowski et al. (2017) reported a mean value of 6.14 (both in scales ranging from 1 = very negative/unpleasant to 9 = very positive/pleasant, with 5 = neutral). In addition, it is worth noting that neutral stimuli have not traditionally been the focus of interest in emotion research, but rather a mere control condition. However, the specific neutral stimuli used to compare with target categories can be decisive in a scientific scenario. In this sense, we expect that our study (both the methodology for classifying the pictures

and the neutral stimuli included in MATTER) can be regarded as a relevant contribution to the study of human emotions.

Finally, it should be considered that our stimulus classifications were made according to the CI procedure, since it has been the preferred method in past research. Nonetheless, neither of the two methods used here for classifying the pictures into discrete emotional categories is free of limitations. Whereas one seems a bit relaxed, the other seems too strict. The results from both classifications are offered in this work, so that the researchers can decide which one better fits their own goals. Moreover, as data are available for each image across all ratings, alternative methods can be used to classify pictures into the discrete categories presented here. Similarly, the pictures could be selected simply based on their mean scores in the features or dimensions of interest.

In line with previous findings (Haberkamp et al., 2017; Kurdi et al., 2017), subjective ratings of men and women were highly correlated for all affective measures. However, these results differ from those reported in a Spanish population by Moltó et al. (1999) and Vila et al., (2001), as higher arousal ratings were found for women than for men. On other hand, Redondo, Fraga, Padrón, and Comesaña (2007) also obtained strong correlations between men and women for both valence and arousal ratings in their Spanish adaptation of the ANEW (Affective Norms for English Words), replicating the gender differences previously found for pictures (Moltó et al., 1999; Vila et al., 2001). Indeed, findings regarding gender differences in subjective valence and arousal ratings in samples from other countries are mixed. While no gender differences were reported in several studies (e.g., Billieux et al., 2011; Khazaal et al., 2012; Kurdi et al., 2017), other works found a main gender effect in either valence (Bradley et al., 2001; Haberkamp et al., 2017; Miccoli et al., 2016) or arousal ratings (Bradley, Codispoti, Sabatinelli, & Lang, 2001). In order to understand what may contribute to these inconsistencies, variables such as the specific content of the pictures could be explored. Data from MATTER would enable the analysis of gender differences in pictures belonging to different discrete emotional categories, as well as providing the ability to explore the contribution of other specific features (beyond valence and arousal). Further research could address this relevant issue, which is beyond the scope of the current research.

Nevertheless, our study has certain limitations that should be addressed in future investigations. On the one hand, there are a considerable number of outliers, probably due to the elevated number of pictures rated by each participant and the short period of time to rate each picture in eight different features. Despite this limitation, our design was similar to prior studies in terms of the number of pictures per session (Carretié et al., 2019; Dan-Glauser & Scherer, 2011), and even other studies including higher numbers of pictures per session (Marchewka et al., 2014). However, these factors certainly must be considered because of their plausible influence on fatigue, the decision process or simply the commission of errors. On the other hand, the sexual orientation of participants should have been requested, since it could be relevant for the ultimate statistical analysis and interpretation of findings concerning erotic images, as stated in previous works (Wierzba et al., 2015). Finally, we must acknowledge that our experimental sample was quite homogeneous in some demographic variables (such as age and education), which might limit the generalization of the current results. Although this limitation would also involve previous works providing sets of affective pictures for either basic or clinical research purposes, it can be turned into a methodological advantage in terms of experimental rigor. Nevertheless, future research will have to explore in greater detail the existence of gender differences (for example in the classification into discrete categories), in addition to plausible age and cross-cultural differences with other Spanish-speaking countries, in order to guarantee the generalization of the current results. Likewise, MATTER could be considered as a dynamic database that might be expanded in the near future by adding new images in order to broaden the spectrum of discrete emotions currently covered.

Despite the above limitations and methodological improvements that could be implemented over time, we should emphasize that MATTER adds to the current literature. Indeed, it constitutes a pictorial database comprising a wide number of fearful, disgusting, neutral, erotic, mirthful and incongruent images normed for the first time considering both dimensional and discrete perspectives simultaneously, in addition to cognitive features, therefore opening new avenues for experimental designs.

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Author notes The data used for this article (ratings and physical properties of each image) is available as online Supplementary material.

Declarations

Conflict of interest The authors declare no conflict of interest.

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