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A Database of Morphed Facial Expressions of Emotions

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Abstract

The objective of the database was to develop a set of face images, varying in emotional intensity and valence using a morphing procedure. The faces were chosen from existing databases and included one identity shown in the three expressions (neutral, negative and positive). These were rated on valence and arousal in an initial rating study. Two categories of emotional direction were then created using morphing software: one contained all identities morphed from neutral towards their corresponding negative expression. The other contained the same identities morphed towards their positive expression. A movie file was created for all images, comprising the full morphing sequence. Still images were extracted from each movie file, creating specified intermediates in the morphing sequence for each identity and category, corresponding to increasing intensity (0%, 25%, 50%, 75% 100%) of emotion. The second rating study assessed valence and arousal on these intensity levels for these intermediate images.

Keywords: *Facial expression, Emotion, Morphing*

A Database of Morphed Facial Expressions of Emotion

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Emotions interact in various ways with cognitive processes such as memory and attention. For instance, previous research suggests that emotional information can modulate memory by enhancing perception and attention (see Phelps, 2004; Vuilleumier, 2005; LaBar and Cabeza, 2006; McGaugh, 2004 for reviews). In an attempt to broaden the understanding of how emotional information influences memory performance, laboratory studies frequently employ varying types of stimuli with emotional content, e.g. emotional words. Facial expressions of emotion are commonly used since they are the most potent emotionally relevant stimuli that we respond to (see Oatley and Jenkins, 1992; Adolphs, 2002a; Haxby, Hoffman & Gobbini, 2002 for review).

The basic facial emotions i.e. fear, anger, disgust, sadness, and happiness (Ekman and Friesen, 1975) are described and divided by means of two emotional dimensions: valence and arousal (e.g. see Russell, 1980, for review see Kensinger, 2004). Valence signifies whether the emotion is pleasurable or aversive, allowing different types of the basic emotions to belong to the same valence type. Arousal signifies the level of intensity of the emotional activation that is evoked (Bradley and Lang, 2000). The two dimensions are commonly assessed in rating studies where participants rate their subjective experience of viewing the stimuli with emotional content (e.g. emotional expressions in faces), mapping their experience to a graded scale (e.g. high arousal to low arousal) pre-set by the researcher.

The objective of the present database is to provide researchers with a larger pool of standardized facial images to be used in empirical investigations into how changes in emotional expressions can influence cognitive processes. It comprises standardized still images, each expressing three different facial expressions of emotion, rated on arousal and valence in an initial rating study. Using a morphing program, movie files for each identity has been created, generating two categories of emotional direction. The files originate from a neutral expression and progresses towards a negative and a positive, respectively. The progression begins at 0% emotion (i.e. 100% neutral) and terminates at 100% emotion (negative and positive). From these movie files for each identity and category intermediate still images has been extracted creating different levels of emotional intensity, rated on arousal and valence in a second rating study.

Method

Participants

All images included in the database underwent two separate rating procedures, assessing ratings of valence and arousal. Rating 1, on which the subsequent morphing processed was based, consisted of 17 undergraduate students (8 fem; mean age 25 years) at Lund University. They received two scratch tickets for their participation. The resulting morphing images were rated in a second rating study conducted at Lund university campus. It consisted of 120 new students (63 fem; mean age 23,38 years, 57 males; mean age 24.15 years) and a scratch ticket was given for participating.

Material

355 faces (coloured frontal view images) were selected from five separate databases that offered each identity in three different facial expressions: the NimStim database (NSTM: Tottenham, Tanaka, Leon, McCarry, Nurse, Hare, et al., 2009), the Radboud Faces Database (RAFD: Langner, Dotsch, Bijlstra, Wigboldus, Hawk, & van Knippenberg, 2010), the Amsterdam Dynamic Facial Expression database (ADFES: van der Schalk, Hawk, Fischer, &

Doosje, 2011), the database of facial expressions in young, middle-aged, and older women and men (FACES: Ebner, Riediger & Lindeberger, 2010) and The Karolinska Directed Emotional Faces Database (KDEF: Lundqvist, Flykt, & Öhman, 1998). Identity was selected in three versions, displaying a neutral, fearful and a happy expression.

Of the 355 images were 164 females and 191 males. The ages varied from old, middle-aged to young (106 young, 29 middle aged and 29 old females, while there was 127 young, 34 middle aged and 30 old men).

Standardization

Using Adobe Photoshop CS6, all the original images were cropped to display only the frontal view excluding shoulders and clothes of the person. Removal of additional information (e.g. earrings) not pertaining to the facial expression was attained using a black ellipse placed around each face (see Fig. 1). All identities were then standardized with respect to size (500 x 500) and colour (grey scale), background (black) and contrast. All files were renamed from their original file name from their original database (see Appendix 1 and 2).

Figure 1.

Illustration of an identity shown in 100% neutral, (far left) 100% fear and 100% happiness (far right), assessed in Rating 1.

Morphing

After standardizing the images they underwent a morphing procedure. This referrers to a computer animation technique by which a face was smoothly transformed from one expression another expression, increasing the level of emotional intensity in the face (see Fig 2). To attain the alteration of emotional expression progressing from 0% emotion and terminating at 100% emotion, Morph Age Express (version 4.1.3) was used. The morphing program produces images that are intermediates, generating a continuous series of images of the face. This process involves computations on the pixels, i.e. the smallest component of digital images. One manipulation is to align two faces in terms of their corresponding features and then simply to change the luminance values of the pixels between the two images to generate a fade that interpolates grey scale values of the basic pixels. Another manipulation is to preserve the luminance value of the pixels and instead alter the pixel positions to “wrap” one image into another. The current database combines the two methods of manipulation. Two faces of the same identity expressing different emotions were “morphed” into one another by simultaneously changing their pixel luminance and wrapping their pixel position (see e.g. Adolphs, 2002b). This process thus generated continuous, physically linear changes in each face creating different thresholds of emotional intensity.

The creation of the intermediate images produced by the program entailed several steps: for each identity, its neutral expression was first morphed with its corresponding negative face. Thereafter it was morphed with its corresponding positive face, thus creating two morph versions for each identity. This gave us a total of 710 files (355x2 versions) that were saved in the movie format (.mov). From the movie files we extracted a total of 10 still images for each identity. Five of these comprised the negative category (0%, 25%, 50%, 75% and 100%) and five comprised the positive category (see Appendix 3).

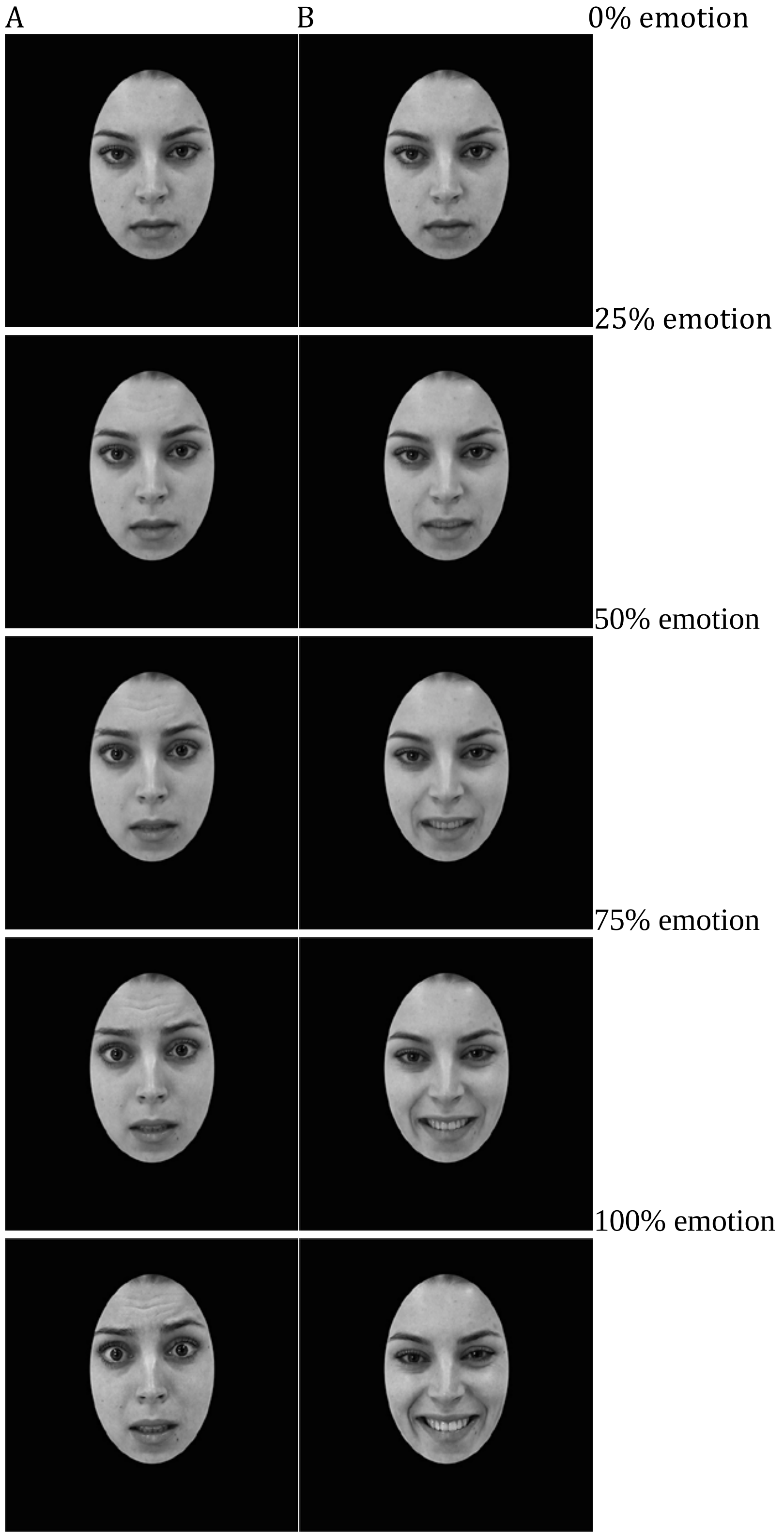

Figure 2.

Illustration of how the emotional direction (horizontally) progresses from neutral to fear and from neutral to happy. The images were rendered from the five seconds movie file created by the morphing software. The example shows the five (out of 120) intermediate versions corresponding to degrees of emotional intensity (0%, 25%, 50%, 75%, 100%) rated on arousal and valence (see Table 1), assessed in Rating 3.

Rating procedures

Rating 1

Participants appraised a total of 1065 selected faces. This collection was made up of 355 different identities, each identity expressing a 100% neutral face, a 100% negative (fear) expression and a 100% positive (happy) face. The presentation of the stimuli was randomised. Participants were informed that they would be viewing a series of faces, that each identity would appear randomised in three different expressions and that each expression had to be appraised on valence and arousal. The task was to rate each face (appearing in three versions) on arousal and valence, matching their subjective experience of the face at the moment of encounter, with the following pre-set scale. The presentation of the stimuli was self-phased and participants responded by using marked response keys.

Rating 2

Participants appraised the morphed files based on the first rating study. The morphing process had formed three still images for each identity and for both emotional categories, creating the following thresholds for both categories: for Negative: 25% negative/75% neutral, 50% negative/50% neutral, 75% negative/25% neutral, and Positive: 25% positive /75% neutral, 50% positive /50% neutral and 75% positive/25% neutral.

To avoid within-subject repetition effects for each stimulus identity the 120 participants were randomly assigned to six different rating groups (N=20 per group). The presentation of stimuli was randomised on a trial-by-trial basis. Each group appraised all identities on the two dimensions of emotion, but each participant only appraised one of the six intermediate versions created by the morphing program for each identity. This design allowed all versions and all identities to be assessed but only one intensity version of each identity for each participant. Response procedure, rating instructions and scales in Rating 2 was identical to Rating 1.

Results

The valence and arousal scores from each rating study (Rating 1 was conducted on 0 % emotion (i.e. 100% neutral) and 100% emotion. Rating 2 was conducted on 25%, 50% and 75% positive/negative emotion) were first calculated separately and then compared against each within each category other in the second rating study (i.e. 100% neutral (Rating 1) compared to 25% negative (Rating 2)). Repeated measures ANOVAs with factors of Emotional Arousal and Emotional Valence (for negative, positive and neutral) and Intensity Levels (0%, 25%, 50%, 75% and 100%) were conducted and significant effects were followed up with *t*-tests (dependent and independent *t*-tests).

Rating 1.

Levels of intensity within an emotional category

Table 1 illustrates mean, standard error and standard deviation values for both emotional categories and all the intensity levels as assessed in Rating 1 and 2. Appendix 2 illustrates the 355 individual rating levels of arousal and valence, assessed in Rating 1.

Table 1. Emotional Face Characteristic (intensity level and emotional direction) assessed in Rating 1 and 2.

		Category 1	*Category 2*
		Neutral to Negative	Neutral to Positive
	% *Emotional Intensity*	Mean (SEM) SD	Mean (SEM) SD
Arousal			
Rating1	0%	3.83 (.48) 1.98	3.83 (.48) 1.98
Rating2	25%	3.51 (.13) 1.44	3.35 (.12) 1.35
Rating2	50%	4.49 (.13) 1.41	4.08 (.12) 1.36
Rating2	75%	5.12 (.15) 1.65	4.95 (.15) 1.63
Rating1	100%	6.44 (.29) 1.18	6.35 (.27) 1.11
Valence			
Rating 1	0%	-.46 (.08) .35	-.46 (.08) 0.35
Rating 2	25%	-.57 (.04) .48	-.02 (.04) 0.47
Rating 2	50%	-1.54 (.08) .82	1.17 (.09) 1.03
Rating 2	75%	-2.04 (.10) 1.04	2.12 (.10) 1.12
Rating 1	100%	-2.11 (.18) .74	2.03 (.16) 0.64

Note: Rating 1: Values range from 1 (low arousal) to 9 (high arousal). Valence ranges from -4 (very negative) to +4 (very positive). Rating 2: Arousal values range from 1 (very low arousal) to 9 (Very high arousal). Valence values ranges from -4 (very positive) to +4 (very negative).

Arousal

A repeated measures ANOVA of arousal revealed a main effect of Emotion ($F(2, 15)=20.41$, $p=<.001$, $n^2=.73$). Follow-up paired sample *t*-tests showed that differences in arousal were found between negative and neutral (*t*(16)=4.38, *p*=<.001), and between positive and neutral face (*t*(16)=5.80, *p*=<.001). No difference was found between negative and positive arousal (*t*(16)=.38, *p*=.71).

Table 2. A-D**.** Illustrations of the conditions of comparison

Rating	Type	Emotional Conditions	*P*
A: Rating 1			
	Arousal		
		100% Negative vs. 0% emotion	**
		100% Positive vs. 0% emotion	**
		100% Negative vs. 100% Positive	.71
	Valence		
		100% Negative vs. 0% emotion	**
		100% Positive vs. 0% emotion	**
		100% Negative vs. 100% Positive	**
B: Rating 2 within emotional category			
	Arousal		
		25% Negative vs. 50% Negative	**
		25% Negative vs. 75% Negative	**
		50% Negative vs. 75% Negative	**
		25% Positive vs. 50% Positive	**
		25% Positive vs. 75% Positive	**
		50% Positive vs.75% Positive	**
	Valence		
		25% Negative vs. 50% Negative	**
		25% Negative vs. 75% Negative	*
		50% Negative vs. 75% Negative	**
		25% Positive vs. 50% Positive	**
		25% Positive vs. 75% Positive	**
		50% Positive vs. 75% Positive	**

C: *Rating 1 + 2 within emotional categories*		
Arousal		
	0% emotion vs. 25% Negative	.41
	75% Negative vs. 100% Negative	*
	0% emotion vs. 25% Positive	.20
	75% Positive vs. 100% Positive	**
Valence		
	0% emotion vs. 25% Negative	.36
	75% Negative vs. 100% Negative	.78
	0% emotion vs. 25% Positive	**
	75% Positive vs. 100% Positive	.76
D: *Rating 2 between emotional categories*		
Arousal		
	25% Negative vs. 25% Positive	**
	50% Negative vs. 50% Positive	**
	75% Negative vs. 75% Positive	.09
Valence		
	25% Negative vs. 25% Positive	**
	50% Negative vs. 50% Positive	**
	75% Negative vs. 75% Positive	**

** *p*-value <.001 * *p*-value <.05

Valence

A repeated measures ANOVA of valence revealed a main effect of Emotion ($F(2,15)=98.27$, $p=<.001$, $\eta^2=.93$). Follow-up paired sample *t*-tests indicated that negative faces differed significantly from neutral ($t(16)=-7.90$, $p=<.001$), as did positive from neutral ($t(16)=-13.56$ $p=<.001$), and negative compared to positive ($t(16)=-13.50$, $p=<.001$).

Rating 2

Next we investigated whether the intermediate images created by the morph program, e.g. the different thresholds of emotional intensity (i.e. 25%, 50% and 75%) in facial expressions were comparable across the intensity levels within each emotional category. Table 2 illustrates significant effects within and across emotional categories as well as between and within Rating 1 and 2. Appendix 2 illustrates the individual ratings (for each image) of arousal and valence, on the different thresholds of emotional intensity for each identity and category.

Arousal

Negative Category. A repeated measures ANOVA of arousal revealed a main effect on Emotion ($F(2,118)=78.43$, $p=<.001$, $\eta^2=.57$) across the intensity levels. Follow-up paired sample *t*-tests indicated a significant effect between all intensity levels: between 25% and 50% negative arousal ($t(119)=-10.47$, $p=<.001$), between 25% and 75% negative arousal ($t(119)=-12.06$, $p=<.001$) as well as between 50% and 75% negative arousal ($t(119)=-12.13$, $p=<.001$).

Positive Category. A repeated measure ANOVA on positive arousal revealed a main effect on Emotion ($F(2,118)=101.83$, $p=<.001$, $\eta^2=.63$) across the intensity levels. Follow up paired sample *t*-tests indicated a significant effect between all intensity levels: between 25% and 50% ($t(119)=-8.63$, $p=<.001$) positive arousal, between 25% and 75% ($t(119)=-13.29$, $p=<.001$) positive arousal, as well as between 50% and 75% ($t(119)=-13.40$, $p=<.001$) positive arousal.

Valence

Negative Category. A repeated measure ANOVA on negative valence revealed a main effect of Emotion ($F(2,118)=174.29$, $p=<.001$, $\eta^2=.75$) across the intensity levels. Follow up paired sample *t*-tests indicated that the difference was found between 25% and 50% negative valence ($t(119)=16.90$, $p=<.001$), between 25% and 75% negative valence ($t(119)=18.70$, $p=.03$), as well as between 50% and 75% negative valence ($t(119)=15.29$, $p=<.001$).

Positive Category. A repeated measure ANOVA of valence also revealed a significant effect of Emotion ($F(2,118)=327.36$, $p=<.001$, $\eta^2=.85$) across the intensity levels within the positive category. Follow up paired sample *t*-tests showed a significant difference between all levels: between 25% and 50% positive valence (*t*(119)=-16.50, *p*=<.001), between 25% and 75% positive valence (*t*(119)=-24.15, *p*=<.001) as well as between 50% and 75% positive valence (*t*(119)=-21.22, *p*=<.001).

Rating 1 and 2: Level of intensity within the emotional categories between rating 1 and 2

To apprehend how 0% emotion (i.e.100% neutral) related to 25% and how 75% related to 100%, independent sample *t*-tests were conducted, comparing Rating 1 to Rating 2 (see Table 1 and 2).

Arousal and Valence

Negative Category. 0% emotional arousal showed a non-significant difference with 25% negative arousal (*t*(135)=.83, *p*=.41). A significant difference was found for 75 % negative arousal compared to 100% negative arousal (*t*(135)=3.19, *p*=<.005). In terms of valence, a non-significant difference was found between 0% negative valence compared to 25% negative valence (*t*(135)=.91, *p*=.36). A non-significant effect was also found between 75 % negative and 100% negative valence (*t*(135)=-.28, *p*=.78).

Positive Category. Independent sample *t*-tests revealed a non-significant effect comparing 0% and 25% positive arousal (*t*(135)=1.29, *p*=.20). A significant difference was found for arousal between 75 % positive and 100% positive arousal (*t*(135)=3.45, *p*=<.001). Independent sample *t*-tests showed a significant effect on positive valence comparing 0% to 25% positive valence (*t*(135)=-3.74, *p*=<.001). A non-significant effect was found for 75% to 100% positive valence (*t*(135)=-.31, *p*=.76).

Rating 2: Level of intensity across emotional categories

Next we investigate whether the intermediate images created by the morph program were comparable across the two emotional categories in terms of arousal and valence (see Table 1 and 2).

Arousal

A repeated measures ANOVA of arousal ratings, comparing the intensity levels (25%, 50% and 75%) for the two categories (negative and positive), revealed a main effect ($F(5,115)=46.17$, $p=<.001$, $\eta^2=.67$). Follow up paired sample *t*-tests showed a significant difference between 25% negative and 25% positive arousal ($t(119)=3.36$, $p=<.001$), as well as between 50% negative and 50% positive arousal ($t(119)=5.07$, $p=<.001$). There was no significant difference in arousal level between 75% negative and 75% positive arousal ($t(119)=1.71$, $p=.09$).

Valence

A repeated measures ANOVA of valence ratings, comparing 25%, 50% and 75% negative valence to the same intensity intervals of positive valence, revealed a main effect ($F(5,115)=128.45$, $p=<.001$, $\eta^2=.85$). Follow up paired sample *t*-tests revealed a significant difference between 25% negative and 25% positive valence ($t(119)=-12.51$, $p=<.001$), between.50% negative and 50% positive ($t(119)=-19.00$, $p=<.001$) as well as between 75% negative and 75% positive ($t(119)=-22.80$, $p=<.001$).

Discussion

The database comprises 355 standardized images of unknown identities, each expressing three different facial expressions of emotion (see Fig. 1). By constructing movie files of the morphed characteristics in these identities, three intermediate still images for each identity and emotional category were extracted at specified time points constructing a total of 10 images per identity. The intermediate images were created using an automated procedure, corresponding to five thresholds of emotional intensity for each valence (see Fig. 2). All thresholds within each emotional category underwent two assessment procedures (Rating 1 and 2), in which subjects rated each image on arousal and valence (see Table 1-2, Appendix 1-3).

The design allowed us to appraise the ability to judge different levels of emotional intensity as a function of valence and arousal in facial expressions. In doing so we were able to investigate if the positive and negative facial expressions were equally positive and negative as compared with neutral, and to validate our manipulation constructed by the morphing process, assuring that the threshold of 50% emotion in physical terms actually implied 50% experienced intensity.

In terms of detecting the different emotional levels in arousal, our data indicated that for both negative and positive an increase from 0 to 25% went undetected by the participants. For both emotional categories all other intensity levels of arousal were detectable. In terms of valence, the data indicated that the participants only detected an increase in positive valence from 0-25 %, an effect absent for negative valence. For both emotional categories however, an increase from 75-100 % valence went undetected. To clarify the inability to detect an increase from 0-25% arousal in both categories (see Table 2C), galvanic skin response may be a useful technique. The fact that participants are able to detect an increase from 75-100% arousal for both the negative and positive category (see Table 2C), an effect absent for 75-100% valence is in line with the notion that arousal is a critical factor to the emotional enhancement effect often found in declarative memory studies (e.g. for review see Cahill and McGaugh, 1998).

Our data on intensity ratings within each emotional category may also be explained by participant's competency to grade their experience upon viewing the face. For instance, while participants may be able to detect changes produced by the gradual transition across the early thresholds, they may be unable to appropriately map it on to the pre-set grading rating scale we offer to log their responses. Thus, when asking them to map their experienced arousal that they feel upon viewing the face, there may be no equivalent response alternative. One alternate way to assure that the transitional changes using the morphing software succeeded is simply to ask participants to place the five images ranging from 0% to 100% emotion in the order of preference, for instance according to perceptual arousal level they experience. Such type of mapping of their response is less restrained and thus may be easier to perform.

When comparing all intermediate intensity levels across the two emotional categories (see Table 2D), our data indicated that it is first at the 75-100% threshold that negative and positive facial expressions exhibit equal arousal levels. This may imply that a change towards increasing negative arousal (as compared to increasing positive arousal) is detected with heightened sensitivity until the intensity levels cross the 75% threshold. While this is partly supported by research demonstrating that different types of facial emotions are detected with different perceptual sensitivities, it contradicts research showing that positive facial emotion are given perceptual priority (e.g. Maher, Ekström & Chen, 2014). Our results are however in line with a wide range of research showing that viewing negative emotional stimuli automatically elicit defensive reactions and facilitates visual perception and attention (see e.g. Mather & Sutherland, 2011; Phelps, 2006, for reviews; Öhman, Flykt, & Esteves, 2001). It may also be explained by the ambiguity in the transitional changes at this time points is perceptually difficult to see and even more to match with our rating scale.

Important facts to consider are that morphing one emotional face expression into another may generate intermediates that are never actually observed as facial expression in real life. Also, the rate of change of the transition of one expression into the other may not map linearly onto the rate at which one in real life perceived changes of emotion from one category into another (e.g. Adolphs, 2002b). Yet in parallel, the fact that we do perceive dynamic faces more often than static ones simultaneously highlights the importance of this database providing intermediate images of the transition of emotional face characteristics. Furthermore while the results presented above are based on the collected results from the two rating studies, the current database allows the possibility to derive each image specific ratings. Thus, by using the provided appendix (1-3) future researchers can extract a subset of images according to their needs.

A major problem in research using emotional facial expressions as stimuli is the lack of large standardized set of still images containing the same identity expressing different emotions and especially with varying emotional intensity level varies. The present database was therefore formed in an attempt to provide such larger pool of still images and it is our hope that this can be used for empirical research on emotion and how emotion interacts with cognition.

Acknowledgements

To access and locate each faces original database and its corresponding ratings in Ratings as provided by Appendix 1 to 3, use the following link: Appendix (Excel)

All the images and movie files can be provided upon verified approval from the original database (please refer to the the databases in the Reference list).

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