Chronic Negative Mood Affects Internal Representations Of Negative Facial Expressions – An Internet Study

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Abstract

Facial expressions are an important source of information in social interactions, as they effectively communicate someone's emotional state. Not surprisingly, the human visual system is highly specialized in processing facial expressions. Interestingly, processing of facial expressions is influenced by the emotional state of the observer: in a negative mood, observers are more sensitive to negative emotional expression than when they are in a positive mood, and vice versa. Here, we investigated the effects of chronic negative mood on perception of facial expressions by means of an online reverse correlation paradigm. We administered a depression questionnaire assessing chronic negative mood over the last two weeks. We constructed a classification image for negative emotion for each participant by means of an online reverse correlation task, which were rated for intensity of expression by an independent group of observers. Here we found a strong correlation between chronic mood and intensity of expression of the internal representation: the more negative chronic mood, the less intense the negative expression of the internal representation. This experiment corroborates earlier findings that the perception of facial expression is affected by an observer's mood, and that this effect may be the result of altered top-down internal representations of facial expression. Equally importantly, though, our results demonstrate the feasibility of applying a reverse correlation paradigm via the Internet, opening up the possibility for large-sample studies using this technique.

Keywords: mood, perception, visual representations

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The human visual system is particularly sensitive to displays of emotion: facial expressions and body language are processed quickly, and accurately, to some extent in specialized areas of the brain (Vuilleumier and Pourtois, 2007). There is ample evidence that the processing of emotional expressions is highly automatic, and even occurs in absence of conscious awareness: patients with damage to the early visual cortex can nevertheless correctly guess emotional facial expressions and body language, a phenomenon called affective blindsight (De Gelder, Vroomen, Pourtois & Weiskrantz, 1999; Tamietto & De Gelder, 2007; Tamietto & De Gelder, 2010). This ability for unconscious emotion recognition is also present in normal observers (e.g. Whalen et al., 1999; Jolij and Lamme, 2005), suggesting that the perception of emotion occurs in an automatic, bottom-up fashion. These results corroborate the idea that the human visual system may be ‘hard-wired’ to recognize emotional expressions (Ekman, 1987).

Neuroimaging studies suggest that this ‘hard-wired’ emotion circuit involves a fast subcortical route including the amygdala that is primarily driven by the low-frequency components of visual input, which is most informative about emotional expressions (Whalen et al., 1998; Kilgore and Yurgelun-Todd, Tamietto and De Gelder, 2010; Vuilleumier et al., 2003). This circuit is believed to play an important role in priming behavioural responses, or in the allocation of attention towards emotional information (Pourtois & Vuilleumier, 2006). An important assumption of this view on processing emotional expressions is that there are ‘fixed’ and hard-wired mental representations of emotional expressions.

However, emotion perception is not independent of top-down influences. In particular the emotional state of an observer affects the processing of emotional stimuli. In a negative mood, observers are better in recognizing negative faces than positive faces and vice versa (Bouhuys, Bloem & Groothuis, 1995; Niedenthal & Setterlund, 1994; Jolij and Meurs, 2011). These results may be attributed to effects of attention: in a negative mood, a negative stimulus may simply draw more attention than a positive stimulus after it has been recognized and vice versa. This mood-congruency effect is not only present in experimentally induced positive or negative mood. Interestingly, patients suffering from depression or anxiety disorders show a similar bias in perceiving negative expressions of emotion: in general, these patients are more sensitive to negative emotional expressions, and tend to rate neutral facial expressions as negative (Joormann, Levens & Gotlib, 2011; Demenescu, Kortekaas, Den Boer & Aleman, 2010).

In a recent study we have put forward evidence that the effects of mood on perception may be the result of an altered process of matching visual input with mental representations of emotion, and not so much of attention (Jolij and Meurs, 2011). Apart from a benefit in detecting mood-congruent stimuli in a face detection task, we found that when observers made false alarms (i.e., they reported a face whilst no face was present), the reported emotional expression was strongly influenced by their mood. Several electrophysiological and neuroimaging studies have linked false alarms to (erroneous) top-down signals from higher cortical areas to lower visual areas, or putting it differently, mapping mental representations on visual input (Zhang et al., 2008; Jolij and Lamme, 2010; Jolij, Meurs and Haitel, 2011; Smith, Gosselin & Schyns, 2012). This may suggest that mood congruency effects in emotion perception not only reflect changes in attention allocation, but also a change in the mental representations of emotional expressions themselves. Indeed, recent studies seem to suggest that the supposedly hard-wired mental representations of emotion may not be as hard-wired as previously thought, and are influenced by, for example, culture (Jack, Blais, Scheepers, Schyns & Caldara, 2009; Jack, Garrod, Yu, Calada & Schyns, 2012). We may have 'hard-wired' circuitry to detect emotions rapidly and unconsciously, but classification of emotional expressions appears to be guided by so-called top-down representations that can be learnt, and may therefore be influenced by external factors, such as mood, or culture.

Here we have investigated the effects of chronic mood on mental representations of negative emotional expressions in an online study. By not carrying out these studies in the lab, but via the internet we were able to recruit a large number of participants, which allowed us to adopt an individual differences approach in studying mental representations of negative emotional expression. To visualize mental representations of negative expressions, we adapted the reverse correlation paradigms used by Mangini and Biederman (2002) and Dotsch, Wigboldus, Langner & Van Knippenberg (2008) for online use. We assessed feelings of depression over the past two weeks of 82 participants and afterwards let them do a reverse correlation task, in which they had to select the most negative looking face from two side-by-side presented neutral faces with superimposed noise for 100 trials. Adding noise adds random features to the faces, which in some cases will make the faces appear more negative. By averaging all images that have been chosen as the saddest of the pair of faces, the features that make a face look negative will stand out in the resulting average image, the so-called classification image. It is important to realize that this classification image does not reflect a threshold for detecting negative emotion (i.e., faces that look more negative than the classification image are classified as negative by the participant). Rather, this classification image may be interpreted as the internal representation or 'mental prototype' an observer has of negative emotion. The intensity of the expression in the resulting classification images, as rated by an independent group of observers (n=105), significantly correlated with feelings of depression, but negatively: more depressed participants had a less intense mental representation of negative emotional expression, which means they are more inclined to classify a neutral face as 'negative'.

These results support the idea that mood may affect the mental representation of emotional expression, rather than inducing an attention bias towards mood-congruent stimuli. However, equally importantly, our study demonstrates that reverse correlation tasks can be successfully adapted for use via the internet. Obviously, the individual classification images are not as convincing and sharp as those obtained in laboratory studies, but the ability to sample large populations with relative ease makes up for this, opening up new alleys for reverse correlating mental representations on a larger scale.

Methods

Ethics statement

This study has been approved by the local ethics committee ('Ethische Commissie Psychologie van het Heymans Instituut voor Psychologisch Onderzoek'). Before starting the questionnaires, participants were presented an informed consent, and had to explicitly agree with participating before continuing the questionnaire. All participants were completely debriefed on the purpose of the experiment after finishing the respective questionnaires.

Participants

Participants were psychology students who participated in exchange for course credit. 82 participants (31 women, mean age 29.3 (*SD*=11.0) years) filled out the depression questionnaire and did the reverse correlation experiment – we will refer to this group as the 'experimental group'. An independent group of 105 participants (77 women, mean age 20.17 (*SD* 1.90) years) rated the classification images.

Materials and procedure

Questionnaire software. We used two packaged to present questionnaires via the internet: eXamine (CAMeRA, Amsterdam, NL) for the experimental group (IDS-SR and reverse correlation) and the Qualtrics.com Research Suite (Qualtrics, USA) for the image rating questionnaire. The reason for using two different packages is an organizational one – the institution switched its online questionnaire system between the two experiments.

Participants accessed the questionnaires via a protected link within the Sona Subject Pool Management System (Sona Systems Ltd., Tallinn, Estonia) of the University of Groningen to prevent external participants from filling out the questionnaires.

Assessment of depressive feelings. To assess the mood of participants in the image creation stage, we used the Inventory of Depressive Symptoms Self-Rated (IDS-SR; Drieling, Schärer, & Langosch (2007)). The IDS-SR is a depression scale consisting of 30 multiple choice questions with four alternatives. Participants were asked to indicate the best fitting answer, concerning amongst others their mood, sleep patterns, eating behaviour and body functions within the last seven days. Answers could indicate a lack of typical depressive symptoms or different stages of depressive behaviour. The questionnaire was conducted in Dutch.

Reverse correlation task. For the reverse correlation task, participants had to choose which of two side-by-side presented faces looked saddest to them. Each face pair consisted of one face with sinusoid patches added to the base face image, whilst the other was the base face minus the sinusoid patches (see Dotsch et al., 2008, for full details). The base face was the average neutral male face taken from the Averaged Karolinska Directed Emotional faces Database (Lundquist & Litton, 1998). In total participants rated 100 face pairs. The noise parameters of all faces that a participant classified as 'saddest' were averaged, and per participant a classification image was computed on basis of these parameters, representing that participant's mental representation of a sad face (Dotsch et al., 2008). All participants were shown the same images; hence any differences in the resulting classification images cannot be attributed to random differences in the Gaussian noise. Face stimuli and classification images were generated using Matlab R2010a (The MathWorks Inc., Natick, USA).

Image rating task. The 82 classification images of the experimental group were subsequently imported into a new questionnaire, which was filled out by the rating group. Per face, the raters had to indicate using a slider whether a face looked happy (0) or sad (100). Faces were presented in random order, and the initial position of the slider was randomized per face to prevent response bias or fatigue effects.

Data analysis

Data collection for both experiments was terminated exactly two weeks after publishing the respective experiment on the Sona Subject Pool Management system. The dependent variable of interest is the Spearman correlation between the mood of the participants in the experimental group and the emotional expression of their classification image of a sad face, as rated by the rating group. To compute the rating of emotion, we averaged the scores given to each classification image over all raters. To compute the final Spearman correlation, a total of six outliers on mood and emotional expression were removed. Outliers were defined as data points that deviated more than 2 SD from the means of either variable of interest. Correlations were computed using SPSS version 20 (IBM Inc., Armonk, NY).

Results

Five data points have been identified as outliers, and were removed prior to analysis. The results show a weak but significant monotonic relation between mood and emotional expression: Spearman's rho = -.286, df = 75, p = .012, 95% CI [-.482 -.063] (rho = -.255; df = 80; p = .022, 95% CI [-.450 -.037], with outliers included). See figure 1.

Discussion

Using an internet-based survey, we obtained classification images representing the mental representations of negative emotional expression of a large sample of participants, and had these classification images rated by an independent group of observers. We found a significant correlation between chronic mood of the participants who did the reverse correlation experiment, and the subsequent ratings of the classification images by independent observers: the more depressed the participant, the less negative his or her classification image was rated. In other words, the mental representation of negative emotional expression is less negative for more depressed participants, and the more depressed an observer is, the more likely that observer is to classify a relatively neutral facial expression as 'negative'. However, it is important to note that the effect we observe here is not likely to be the result of a criterion shift for detecting negative emotion, that is: participants had to compare two faces side-by-side, and pick the most negative of the two. A criterion shift in detecting negative emotion would not affected the outcome of this side-by-side comparison – participants would have still picked the most negative face of the two. Instead, we observe that the mental representation of negative emotion is less intense in more depressed participants: if a happy participant imagines a negative face, it will look really negative, whereas if a depressed participant imagines a negative face, its expression will be rather neutral.

These results are in line with earlier work on the relation between mood and emotion perception. Niedenthal and Setterlund (1994), for example, found that participants in a negative mood had a lower threshold for classifying a face as negative when they had to judge a face morphing from happy to angry, and Bouhuys, Bloem & Groothuis (1992) reported a bias towards classifying ambiguous facial expressions as negative if an observer is in a negative mood. We have put forward evidence that this increased sensitivity to mood-congruent stimuli may be the result of altered top-down processing: not only does mood increase sensitivity to mood-congruent stimuli, we also found an increase in mood-congruent false alarms in an emotional face detection task (Jolij and Meurs, 2011). False alarms in that context have been associated with top-down processing, or, in other words, matching a mental representation or template with actual perceptual input (Bar, 2003; Gosselin and Schyns, 2000; Jolij, Meurs & Haitel, 2011; Raizada and Grossberg, 2003; Zhang et al,. 2008).

A recent study by Smith, Gosselin and Schyns (2012) puts forward evidence that similar processes play a role in reverse correlation tasks, as we used here: they found that in a reverse correlation task, noise images that were classified by participants as containing a signal evoked a negative posterior brain potential around 200 ms post stimulus onset, that is often reported in association with re-entrant processing (Jolij, Scholte, Van Gaal, Hodgson & Lamme, 2011; Jolij, Meurs, and Haitel, 2011). We may speculate that in a typical reverse correlation task, participants scan the noise images for features that match their internal representation of whatever attribute they are classifying. Finding such weak features may be indexed by the N2, the evoked potential component mentioned above – the N2 is believed to reflect re-entrant processing, which is according to many theories of vision a crucial component for 'vision with scrutiny' – finding the minute details one is looking for (Ahissar and Hochstein, 2002).

However, do such processes also play a role in normal perception (or rather, in other tasks than the rather artificial reverse correlation task we used here)? Several studies have linked problems in perceptual processing of details, for example in autism, in particular to deficits in top-down processing (Loth, Gómez & Happé, 2010; Vandenbroucke, Scholte, Van Engeland, Lamme & Kemner, 2008). Moreover, a recent TMS study demonstrated that recognition of natural scenes is impaired when top-down processing is interrupted by means of a strong magnetic field (Camprodon, Zohary, Brodbeck & Pascual-Leone, 2009). Together, such findings do suggest that the process we tap in to using reverse correlation tasks is indeed a type of top-down processing in which a mental representation is mapped back on to visual input. Of course, such a process could be interpreted as attention, albeit a purely perceptual enhancement rather than a more 'cognitive' form of attention operating at a later decision making stage (eg. Roelfsema, Lamme & Spekreijse, 1998).

It should be noted, though, that there is a caveat: contrary to earlier studies using reverse correlation paradigms, here we look at emotional state differences between observers. In particular, this means we cannot exclude the possibility that negative mood is the result of a criterion shift towards categorizing faces as 'negative', rather than altering mental representations of negative emotion. The noise-convoluted faces we presented may have not been symmetrical in terms of emotional content: that is, even though on an overall brightness basis the pairs of faces we presented were balanced, this does not mean the emotional expressions or features of emotional expression were balanced. In some trials, the difference in emotional content may have been quite symmetric (that is, one face looks very negative, the other very positive), but in others it may not have been. The reverse correlation method we used here does not allow for precise control over the exact parameters that make up the expressions to be tested. Therefore we cannot exclude the possibility that negative emotional state of the observer may have shown an interaction with specific emotional content of the faces. It could be that a negative mood has a larger effect on detection of weak emotional features than on detection of extremely negative features, for example, and thus biases the classification image towards a more neutral expression.

However, if we accept our results do reflect representation rather than bias, our present results would indicate that the perceptual bias toward interpreting facial expressions as negative depressed individuals show is the result of a chronically altered mental representation of facial expression. Several influential theories of depression, such as Beck's cognitive model (1984), suggest that depression biases cognitive processes towards negative events, and that treating depression should focus on removing this bias, for example by means of cognitive behavioural therapy. Our results suggest that the effects of depression may even extend to processing stages preceding explicit cognition, that is, at the perceptual level. An interesting, yet speculative, idea would be to investigate the effects of a perceptual training on biases towards negative emotional expression in depressed individuals. Obviously, before undertaking such studies the present result would need to be confirmed in a more traditional laboratory setting, and to validate claims about the neural correlates of what is going on during reverse correlation tasks, neurophysiological measures such as EEG or fMRI should be taken into account.

On a final note, our results show the feasibility of running reverse correlation tasks via the Internet. Online studies are becoming increasingly popular, and data collection via the internet has become a viable and useful alternative for laboratory studies (Buhrmester et al,. 2011). Reverse correlation tasks, however, have thus far not been used in an online fashion: typically, the tasks require a lot of time and effort, and a large number of trials per participant. Here we show that the number of trials per participant can be decreased by such an amount that online administration of a reverse correlation task becomes feasible. Although the individual results are not as clean and crisp as those obtained in the lab, the sheer amount of data one can collect from many individuals makes up for this. Given that our study is largely a conceptual replication of earlier findings, it is encouraging that the data we collected online shows the expected pattern of results and validates the online use of reverse correlation tasks. Moreover, using large samples via the Internet, for example via Amazon's Mechanical Turk (http://www.mturk.com), opens up exciting possibility to validate research findings in larger samples than the typical first year undergraduate pools used in psychological research as we did here – think of large scale cross-cultural studies, but also studies in populations with specific psychopathologies for example.

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Figure 1

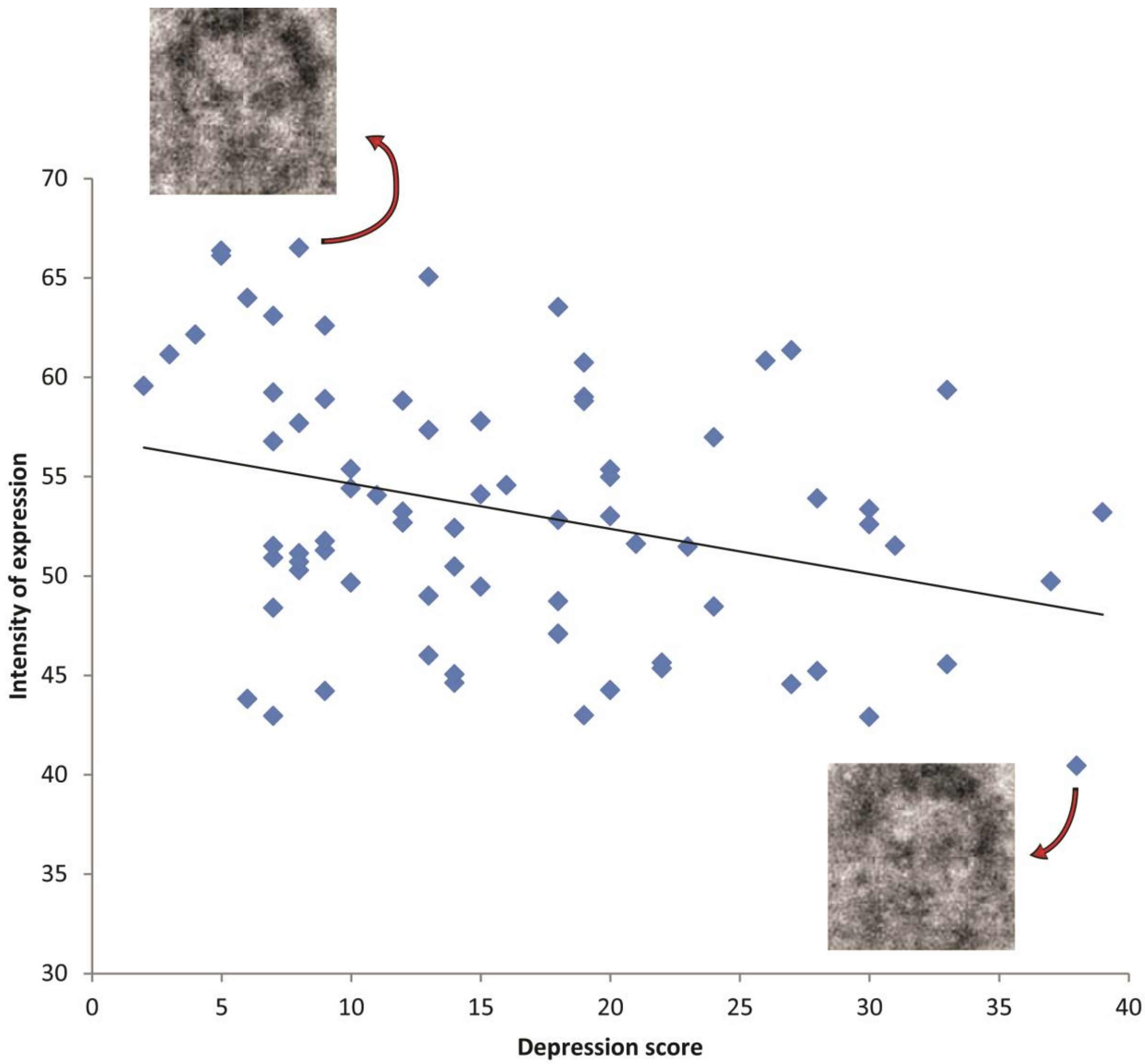

Figure 1. **Scatterplot of intensity of emotional expression by depression score.** Images shown are two representative classification images, one of a participant with a low depression score and one of a high-scoring participant.