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Facial expression to emotional stimuli in non-psychotic disorders: A systematic review and meta-analysis

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Highlights

- Facial expressivity is altered in patients with non-psychotic mental disorders
- High summary effect for decreased positive facial expression in anorexia nervosa
- Longitudinal studies are needed regarding trait vs. state influences
- Emotion induction and coding methods need validation and standardization

Abstract

Facial expression of emotion is crucial to social interaction and emotion regulation; therefore, altered facial expressivity can be a contributing factor in social isolation, difficulties with emotion regulation and a target for therapy. This article provides a systematic review and meta-analysis of the literature on automatic emotional facial expression in people with non-psychotic disorders compared to healthy comparison groups. Studies in the review used an emotionally salient visual induction method, and reported on automatic facial expression in response to congruent stimuli.

A total of 39 studies show alterations in emotional facial expression across all included disorders, except anxiety disorders. In depression, decreases in facial expression are mainly evident for positive affect. In eating disorders, a meta-analysis showed decreased facial expressivity in response to positive and negative stimuli. Studies in autism partially support generally decreased facial expressivity in this group.

The data included in this review point towards decreased facial emotional expressivity in individuals with different non-psychotic disorders. This is the first review to synthesise facial expression studies across clinical disorders.

Keywords: facial expression; emotion regulation; anxiety; obsessive-compulsive; eating disorders; borderline personality disorder; depression; autism.

1. Introduction

Facial expressions have a culturally invariant basis in how they are performed and perceived (Darwin, 1872; Ekman and Friesen, 1971). Developmental studies support this idea (Reissland et al., 2011; Rinn, 1984) as well as studies which have shown that children born deaf and blind display facial expressions such as anger and smiles in circumstances that would be plausible occasions for the corresponding emotion (Eibl-Eibesfeldt, 1989).

Cultural and developmental studies suggest that all humans have the same facial musculature and move them in a similar way under similar circumstances, denoting facial expression as a behavioural phenotype (Schmidt and Cohn, 2001). However, within this phenotype there is individual and group variation in people's ability and tendency to produce facial expressions based on factors such as culture (Chentsova-Dutton et al., 2007; Jack et al., 2012), age (Chapell, 1997), gender (Chaplin and Aldao, 2013; Hess et al., 2000), and psychopathology (e.g. Bylsma et al., 2008; Fagundo et al., 2013; Kring and Moran, 2008; Rosenthal et al., 2008).

This broad repertoire of invariant emotional facial expressions is crucial for emotional communication, social connectedness and rapport (Schmidt and Cohn, 2001). For example, facial mimicry of emotion, which is the visible or non-visible use of facial musculature by an observer to match the facial gestures in another person's expression (Hess and Bourgeois, 2010), often occurs at an unconscious level and seems to be related to enhancing levels of empathy between recipients

(Nummenmaa et al., 2012). This can have important implications for effective and efficient communication.

To convey or communicate emotion is a key function of facial expression, but there are other theories, for example concerning regulation of emotion (facial feedback theory; e.g. Davis et al., 2010); social motives (Fridlund, 1994); dimensions of affect (Russell and Fernandez-Dols, 1997) and indications of direction of attention (Rutter, 1987). It has been argued that none of these theories alone is right and that the essence of facial function is hard to distil into a single theory (Parkinson, 2005); however, clearly facial expression is an important function in these processes.

Altered emotionality, social cognition and difficulties in interpersonal functioning are an integral part of many mental disorders (e.g. Aldao et al., 2010; Bylsma et al., 2008; Oldershaw et al., 2011; Tchanturia et al., 2013). Decreased emotion recognition abilities were found in a broad range of mental disorders (Kret and Ploeger, 2015), and research has shown that voluntary and involuntary facial expression of emotions plays a key role in the recognition of others' emotions (Künecke et al., 2014; Schneider et al., 2013; Sel et al., 2015). This process has been referred to as "embodiment of emotions", meaning that the perceiver simulates the emotion on a motor, somatosensory and affective level and thus deduces its meaning and reward value (Niedenthal et al., 2010; Zajonc et al., 1989). Therefore, the exploration of the nature and prevalence of facial expression alterations in mental disorders as compared to healthy control groups is a useful line of enquiry in order to better understand the mechanisms underlying difficulties in the recognition of emotions and in the emotion regulation process in general.

There are different methods for assessing facial expressions in a standardized way. One possibility is the use of electromyography (EMG), which assesses electrical activity of facial muscles, whereby corrugator supercilii (frowning), levator labii (disgust) and zygomaticus major (smiling) are the muscles of interest often assessed in emotion research (Dimberg, 1990; Sato et al., 2008; Whitton et al., 2014). Another method is coding systems to identify specific facial movements, which are then categorized into emotional expressions. The most commonly used and validated coding systems are the Facial Action Coding System (FACS; Ekman and Friesen, 2003) with its special version for emotional expressions (EMFACS; Ekman and Friesen, 1978), the Facial Expression Coding System (FACES; Kring and Sloan, 2007) and the Emotional Expressive Behaviour Coding System (EEB; Gross and Levenson, 1993).

A front runner in respect of published studies in emotional expressivity in mental disorders is the psychosis field. A review of emotional responding, including facial expression in schizophrenia summarised 62 studies (Kring and Moran, 2008). Using a wide range of elicitation techniques, these studies showed that individuals with schizophrenia display less observable expressiveness in positive and negative emotion than individuals without schizophrenia. This has a number of interpersonal drawbacks. For example, people with schizophrenia, who are least expressive, show the poorest interpersonal relationships and poorest adjustment at home and in other social domains (Bellack et al., 1990).

Attenuated emotion expression has been observed among people with schizophrenia both on and off medication and cannot be explained by a neuromotor deficit, as electromyography recordings have shown congruent responses to stimuli (Kring and Moran, 2008). Kring and Moran suggest that patients with schizophrenia have a different threshold for producing observable displays and do so only when stimuli are of sufficient intensity (Kring and Moran, 2008). Only a few studies have looked at trait related factors and there seems to be a bias towards attenuated expression in people in remission from the illness and those at risk (Mattes et al., 1995; Walker et al., 1993).

Furthermore, a meta-analysis of emotion responses including facial expressions has been undertaken in depression (Bylsma et al., 2008). This included seven studies which measured facial expressivity using either EMG or observational coding in response to stimuli including pictures or film clips. The key findings were that people with major depressive disorder demonstrated reduced emotional reactivity to both positive and negative valenced stimuli, with the larger reduction for positive stimuli (medium effect size (ES) d=.53) than for negative stimuli (small ES d=.25) (Bylsma et al., 2008).

Very little is known about emotional expressivity in psychiatric disorders other than schizophrenia or depression. The main aims of the present review were (1) to synthesize the evidence from empirical studies exploring emotional facial expression in individuals with non-psychotic mental disorders in order to identify alterations in comparison to healthy control groups (2) to examine possible similarities and differences across disorders and (3) to assess whether facial emotion expression is related to state or trait factors.

2. Method

This review follows the guidelines in the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses; Liberati et al., 2009; Moher et al., 2009), which was developed to improve the standard of reporting of systematic reviews and meta-analyses.

2.1. Eligibility Criteria

The article focuses on automatic facial expressions elicited by emotional and social stimulus material as the main outcome. Since facial expression to neutral stimuli and incongruent responses are very rarely observed, the review concentrates on congruent responses to positive and negative emotions.

For inclusion in this review, studies were required to fulfil the following criteria: 1) a healthy control group had to be present, 2) the clinical group was diagnosed according to DSM criteria, 3) there were a minimum of 10 people in each group, 4) participants could be adolescent or adult, 5) the stimulus material to elicit facial expressions elicited positive and/or negative emotions and had to be a visual induction method, 6) the primary outcome measure was congruent automatic facial emotional expression as measured by EMG activity (zygomaticus to positive stimuli; corrugator supercilii or levator labii superioris activity to negative stimuli) or observation [e.g. through FACES (Kring and Sloan, 2007), FACS (Ekman and Friesen, 2003), EMFACS (Ekman and Friesen, 1978) or other (e.g. automated) emotion coding programs], and 7) the study was reported in English in a peer reviewed journal.

The criterion for inclusion for meta-analysis was the use of a visual emotion induction method clearly distinguishable into positive or negative valence and the availability of means and standard deviations for the main outcomes, separated for positive and negative emotions.

2.2. Search Strategy

The following electronic databases were searched: Embase, Medline/PubMed and PsychInfo. The search covered the period from 1962 to January 2016. This start date was chosen as the empirical study of facial expression began in 1962 with the publication of books on emotion by Tomkins and by Plutchik (Russell and Fernandez-Dols, 1997).

The following search terms were used ($ denotes truncation): Facial express$ OR emotion express$ OR emotion response$ OR non verbal behave$ OR facial behav$ OR EMFACS OR facial action coding system AND clinical OR mood OR mental OR psych$ OR borderline personality disorder OR post traumatic stress OR PTSD OR anxiety OR addiction OR anorex$ OR bulimi$ OR binge eating OR obsessive$ OR bipolar OR autis$ OR personality$ OR depression OR psychosis OR schizoph$.

2.3. Study Selection

Two authors (HD and IW) screened all titles and abstracts in the electronic databases. The abstracts of potentially eligible articles were saved to an electronic reference manager. Bibliographic references from these articles were systematically searched. Eligible records then had a full text screening by two reviewers (HD and IW) and were promoted to the next stage of the process by categorising as ‘yes’, ‘no’ or ‘maybe’. The next stage was to have a consensus meeting and to call in external opinions as to whether any ‘maybe’ records should be included in the review. From each included study, information on participants (clinical group, number of participants, age, medication status), elicitation method, coding method, outcome measure and ES was extracted by the shared first authors (HD and IW) and summarized in a table. In order to control for bias caused by the inclusion of multiple reports of the same study, authors were contacted in cases where an overlap of the sample was suspected.

2.4. Risk of bias and quality assessment

The Newcastle-Ottawa Quality Assessment Tool (Wells et al., 2014) for case control studies was applied to assess for the quality of the studies, in particular risk of bias. This tool has been used in previous studies, shows content validity and inter-rater reliability. Selection bias is assessed on four items and thus can receive a total score of 4 (definition and representativeness of cases and controls), comparability between groups is scored with a maximum of two points (depending on group matching and/or adjustments) and validity of the exposure procedure is assessed by the use of three items (ascertainment of exposure, same method for cases and controls, no-response rate). In addition to this scale, studies were rated according to the presence of a power calculation (one point if reported) and the reporting of statistical parameters necessary for meta-analysis, receiving two points if means and standard deviations were available and one point if only the ES was reported.

2.5. Data Synthesis

Due to the heterogeneous nature of the groups and methodologies in some areas and to missing statistical parameters in others it was not feasible to undertake a quantitative meta-analysis approach in most of the diagnostic categories. For one diagnostic subcategory (eating disorders (ED)), it was possible to meta-analyse the existing data; one analyses was conducted for positive emotions and one for negative emotions. Results of all studies were summarized in a table as well as being qualitatively reviewed (IW, JL, KT and HD).

2.6. Statistical Data Analysis

Where possible, Cohen's *d* ES were calculated based on means and standard deviations. If these were not reported in the published article, corresponding authors were contacted by e-mail (IW) with the request to provide these data. In case of lack of response/unavailability of the data, ES estimations were based on the reported *t*- or *F*-statistic, when possible. ES can be interpreted as: negligible (≥−0.15 and >0.15), small (≥0.15 and >0.40), medium (≥0.40 and >0.75), large (≥0.75 and >1.10), very large (≥1.10 and >1.45) and huge (≥1.45).

Meta-analysis was based on a random effects model and computed with Stata 11.0 (Stata Corporation, College Station, TX, USA) with the user-contributed commands metan (Bradburn et al., 1998), metabias, metatrim (Steichen, 1998) and metareg (Sharp, 1998). Cohen's *d* ES and 95% confidence intervals (CI) were calculated. Assessment of consistency was done by assessing the I^2-value as an index of heterogeneity, as it is a more powerful measure for a small number of studies than Cochran's Q test (Higgins et al., 2003). The I^2 index of heterogeneity goes from 0% to 100%, indicating low (25%), moderate (50%) and high (75%) heterogeneity. When heterogeneity was moderate or high, meta-regressions for related variables such as age, depression and anxiety were calculated as an attempt to explain the inconsistency. To assess for a possible publication bias, funnel plots were visually inspected and Egger's tests (Egger et al., 1997) were calculated.

3. Results

3.1. Risk of bias

The results of the quality assessment are shown in Table 1. No studies were excluded post-hoc based on quality. This is most likely related to the strict inclusion and exclusion criteria of this review (e.g. studies which did not have a healthy control group or not clearly defined cases were excluded beforehand). It is nevertheless noted that very few studies conducted a power analyses; therefore, the possibility that some effects were not detected due to insufficient power has to be considered when interpreting the results of this systematic review.

Insert Table 1 about here

3.2. Main study findings

A total of 39 articles (35 independent samples) were included in this review, results are shown in Table 2. Twenty-three of these studies were identified through electronic database searching and the remainder through scanning of reference lists. Figure 1 shows a flow chart of the study selection process as recommended by Moher et al. (2009). During the search, systematic reviews of emotional responding (which included facial expression) in depression (Bylsma et al., 2008) and borderline personality disorder (BPD) (Rosenthal et al., 2008) were identified. Inclusion criteria were different to the current review; therefore, studies meeting the criteria of the present review were included into the following data synthesis.

-------FIGURE 1 HERE--------

As a result of the final selection of studies included in the review, the following clinical groups were represented: post-traumatic stress disorder (PTSD; *n*=4), generalised anxiety disorder (GAD; *n*=1), social phobia (*n*=1), obsessive-compulsive disorder (OCD; *n*=3), depression (*n*=7), bipolar disorder (*n*=1), ED (*n*=11), BPD (*n*=4), autism spectrum disorders (ASD; *n*=6) and disruptive behaviour disorder

(DBD; *n*=1). There were no studies including patients diagnosed to the remaining categories of mental disorders, such as attention-deficit hyperactivity disorder, substance abuse, somatoform disorders, sleep disorders, or personality disorders other than BPD.

3.2.1. Evocation and coding methods

The included studies utilised different methods to evoke emotional response and different measures to record the facial expressions. With regard to the method used to evoke emotion, ten studies used pictures, 24 studies used film clips (all clinical groups), three studies used social interaction (PTSD, anxiety, BPD) and two studies used a video game (ED). Twelve of the studies used EMG to record facial expression, three studies used automated emotion recognition techniques and the remainder utilised an observational coding technique, of these twelve used FACS/ EMFACS, nine FACES and two EEB.

--------TABLE 2 HERE-------

3.2.2. Anxiety Disorders:

3.2.2.1. Post-Traumatic Stress Disorder (PTSD)

Four studies were retrieved for PTSD. Three of these used emotional pictures or film clips to induce emotion and did not find group differences of negative expressivity to negative stimuli or positive expressivity to positive stimuli (Carlson et al., 1997; Litz et al., 2000; Orsillo et al., 2004). One of these studies used disorder specific stimuli (combat related pictures in war veterans; Carlson et al., 1997); results were comparable to those studies using generic emotional stimuli (Litz et al., 2000, Orsillo et al., 2004). The one study using a social interaction to evoke emotion found less positive and more negative facial expressions in PTSD patients compared to HC, with large to very large ES (*d*=.97-1.59) (Kirsch and Brunnhuber, 2007).

3.2.2.2. Obsessive Compulsive Disorder (OCD)

Three studies found reduced facial expressivity in patients with OCD in response to film clips with positive versus negative valence. Two of them reported one total score for congruent emotional expression to negative and positive stimuli (Bersani et al., 2013; Valeriani et al., 2015); therefore, it is not known if blunted facial expression was due to negative or positive valence or both. The third study used only positive stimulus material, showing that OCD patients express positive emotions less frequently and with decreased velocity than HC (Mergl et al., 2003). ES ranged from medium (*d* = .62) to huge (*d* = 3.09), evidencing robustness of these results.

3.2.2.3. Other Anxiety Disorders

Two studies were retrieved which included clinically anxious groups (Baker and Edelmann, 2002; Hubert and De Jong-Meyer, 1990). These found no significant differences regarding automatic facial expression of congruent emotions in response to emotional film clips or a social interaction paradigm.

3.2.3. Mood Disorders

3.2.3.1. Depression

Seven studies in depression were found to fulfil our inclusion criteria; three of these had been included in the meta-analysis by Bylsma (2008). Six of these studies used film clips to induce emotions (Berenbaum and Oltmanns, 1992; Chentsova-Dutton et al., 2007; Renneberg et al., 2005; Rottenberg et al., 2005, 2002; Tsai et al., 2003) and one used emotional pictures (Sloan et al., 2001). Renneberg et al. (2005) was the only study to use EMG, the others used an observational coding system in order to assess emotional expression.

Regarding positive emotions, four studies (Berenbaum and Oltmanns, 1992; Renneberg et al., 2005; Sloan et al., 2001; Tsai et al., 2003) found fewer facial expressions in the clinical group for at least one of the outcome variables, with ES ranging from d=.8 to d=3.6. One study found more positive expressions in depressed patients compared to HC with a medium effect (Rottenberg et al., 2005) and two studies found no effects of group on expression of positive emotions (Chentsova-Dutton et al., 2007; Rottenberg et al., 2002). Regarding negative emotions, one study found that the depressed group expressed less facial emotions than HC with a medium ES (d=.71) (Renneberg et al., 2005), but the other six studies found no significant effects of depression on facial expression of negative emotions.

A group of individuals recovered from depression did not show any significant difference in emotional expression to positive or negative stimuli when compared to patients with acute depression or HC (Rottenberg et al., 2005).

Chentsova-Dutton et al. (2007) compared facial expressivity of depressed and non-depressed people of European American (EA) and Asian Americans of East Asian (AA) descent. Depressed EAs showed a pattern of diminished reactivity (likelihood of crying) to the sad film compared to non-depressed participants. In contrast, depressed AAs showed a pattern of heightened emotional reactivity compared to non-depressed participants. This suggests that there is cultural specificity of altered facial expression in depression.

3.2.3.2. Bipolar Disorder

The one study in bipolar disorder (Bersani et al., 2013) used film clips to induce emotions and the FACS coding system. Results are reported as a global score of congruent expressivity and show blunted affect in patients with bipolar disorder compared to HC.

3.2.4. Eating Disorders (ED)

Eleven studies were retrieved in ED which investigated facial expression. In anorexia nervosa (AN) *n*=6; bulimia nervosa (BN) *n*=1; AN/BN *n*=4 (Cardi et al., 2015, 2014; Claes et al., 2012; Dapelo et al., 2015; Davies et al., 2013, 2011; Lang et al., 2016; Rhind et al., 2014; Soussignan et al., 2011, 2010; Tárrega et al., 2014).

Seven of these studies used similar emotion elicitation methods and outcome measures, more precisely they used either pictures or film clips reliably evoking either positive or negative emotions and they used one of the two most common coding systems (FACS or FACES) in order to measure positive and negative facial emotional expressions. While five of these studies used pretested segments of movies (Dapelo et al., 2015; Davies et al., 2013, 2011; Lang et al., 2016; Rhind et al., 2014), two used film clips of humans displaying facial expressions (Cardi et al., 2015, 2014). Two of these studies were excluded from the meta-analysis because they had overlapping samples (Cardi et al., 2014; Davies et al., 2011) and one article included two samples, one with adolescents and the other with adults (Lang et al., 2016). One study focused specifically on the expression of positive emotions (Dapelo et al., 2015), comparing Duchenne-smiles (real smiles) and Non-Duchenne-smiles (social smiles). Results were similar for both outcome measures, but since Duchenne-smiles are considered a more authentic expression of positive emotion, these outcome values were included in the meta-analysis. This resulted in six ES for quantitative synthesis for positive emotions and five for negative emotions (Dapelo et al. (2015) analysed positive emotions only).

Meta-analytic results for positive expression showed a large and significant summary effect for reduced facial expression in patients with AN when compared to HC (ES -1.01; CI -1.50, -0.52). Heterogeneity was high (I^2 = 80.7%) and significant (p<.001); therefore, meta-regression analyses including the factors anxiety, depression and age were conducted. For positive expression, results showed that anxiety (residual I^2 = 79.57%; adj. R^2 = -0.3%; p = .38) and age (residual I^2 = 82.18%; adj. R^2 = -23.35%; p = .77) did not explain a significant amount of between-studies variance, but depression reduced heterogeneity to I^2 = 12.35% (adj. R^2 = 100%; p <.05). There was no evidence of publication bias when inspecting the funnel plot or according to Egger's test (t = .80; p = .47).

A meta-analysis including studies on negative emotions shows reduced expressivity in the clinical group for negative emotions as well, with medium ES (ES = -.58; 95% CI -1.09, -0.07). Heterogeneity was high (I^2 = 82.6%) and significant (p<.001). Meta-regressions for negative expressivity showed that age (residual I^2 = 86.22%; adj. R^2 = -41.03%; p = .38) and anxiety (residual I^2 = 69.53%; adj. R^2 = 22.72%; p = .86) did not explain heterogeneity, depression accounted for R^2 = 100% of between studies variance, which reduced I^2 to 0%. There was no evidence of publication bias when inspecting the funnel plot or according to Egger's test (t = .45; p = .69).

The remaining four studies in ED (Claes et al., 2012; Soussignan et al., 2011, 2010; Tárrega et al., 2014) used different methodologies. In Soussignan et al. (2010), participants were shown pictures of food preceded by different subliminal faces expressing emotions (including happiness, disgust, fear and neutral). Facial response of participants was measured both by EMG and observational coding. The authors found reduced positive facial expression in the AN group in both EMG recording (*d*=0.8) and observational coding (*d*=0.8). For negative expression there was no main effect on neither of the outcome measures. However, increased muscle tension of the corrugator muscle was demonstrated when subliminal 'fear faces' were shown prior to the food pictures (*d*=0.9). Soussignan et al. (2011) also used food stimuli in comparison to non-food stimuli with comparative hedonic value and measured EMG response of zygomaticus and corrugator activity. There was a stronger zygomatic reaction in HC compared to AN to both kinds of stimuli (*d*=.64) with no main effects found for corrugator activity.

The studies by Claes and colleagues (2012) and Tárrega and colleagues (2014) were conducted in the same laboratory, measuring facial expression of joy and anger through an automatic emotion detection software, during a video game (Playmancer) designed for emotion regulation training. Unfortunately, the stimulus valence is not obvious; or rather, it cannot be defined exactly what was going on in the game in the moment a specific emotion was displayed; therefore, it was not possible to include these studies into the quantitative synthesis. Interestingly, the results of the first study show that AN patients expressed less anger than HC during the game (*d*=1.0), the BN group did not differ from HC (although there was a trend in the same direction) and there were no differences for the expression of joy. The second study (Tárrega et al., 2014) increased the power of the BN sample and found significantly more expression of joy (*d*=8.9) and less expression of anger (*d*=53.5) in BN patients compared to controls.

There were two studies in ED including a recovered group. Davies et al. (2013) found that individuals recovered from AN had more expression of positive emotions than acute AN patients (*d*=1.1), while these groups did not differ in the expression of negative emotions. The recovered AN group was comparable to the HC group on both negative and positive expression of emotion. A recovery from altered emotional expression after remission from BN was also found by Tárrega et al. (2014), the recovered group being more similar to HC than the BN group, although they still had significantly less expression of anger.

3.2.5. Borderline Personality Disorder (BPD)

A systematic review of emotional responses, which included two studies exploring facial expression, had previously been undertaken in BPD (Rosenthal et al., 2008). The two studies described in the review used positive and negative pictures and films to elicit emotion and EMG and observational coding to measure outcomes (Herpertz et al., 2001; Renneberg et al., 2005), respectively. Both studies reported an attenuation of positive and negative facial expression in BPD groups.

Subsequent to Rosenthal’s review (2008) two further studies were retrieved in BPD (Matzke et al., 2014; Staebler et al., 2011). Matzke and colleagues (2014) used a design similar to the above-mentioned studies (emotional pictures) and EMG to measure emotional expression. They found no group differences for zygomaticus activity during positive emotions, but for negative emotions corrugator activity was increased during pictures displaying disgust, anger and sadness, but not during fear evoking pictures. Activity of the levator labii (muscle of the upper lip, related to disgust) did not differ between groups. Staebler et al. (2011) used a social interaction paradigm inducing social exclusion. Consistent with Herpertz et al. (2001) and Renneberg et al. (2005), an attenuation of positive facial expression was observed (d=0.9); however, there was an increase in negative expression (d=0.7), in keeping with the findings by Matzke and colleagues (2014). Reasons for these increases in negative facial expression are outlined in the discussion.

3.2.6. Autism Spectrum Disorders (ASD)

Six studies were identified comparing facial expression in people with ASD to typically developing individuals (TD) (Grossman et al., 2013; Mathersul et al., 2013; McIntosh et al., 2006; Rozga et al., 2013; Stel et al., 2008; Yoshimura et al., 2014).

The studies by McIntosh et al. (2006) and Mathersul et al. (2014) used pictures to induce emotions, the other four studies used emotional film clips. Three studies used EMG as a measure of emotional expression (Mathersul et al., 2013; McIntosh et al., 2006; Rozga et al., 2013) and three used observation through FACS/FACES (Yoshimura et al., 2014) or specifically developed scales (Grossman et al., 2013; Stel et al., 2008).

Two studies reported global scores for expression of congruent emotions, one found less expression in ASD with a large ES (*d*=0.8) (McIntosh et al., 2006) and one found no significant group differences (Grossman et al., 2013). Regarding positive expression, two studies found very large ES (*d*=1.15-1.34) for a reduction of facial expression in ASD compared to TD (Stel et al., 2008; Yoshimura et al., 2014), but two studies found no group differences (Mathersul et al., 2013; Rozga et al., 2013). This may partly be explained by the elicitation method, since Yoshimura and colleagues (2014) found that the effect was only significant for dynamic stimuli, but not for static ones. Mathersul et al. (2013) used pictures and Rozga et al. (2013) used film clips, but also of relatively small duration (< 2 seconds of length).

Three studies reported results on facial expression in response to negative stimuli. There seemed to be a trend towards lower values in ASD than TD (Mathersul et al., 2013; Rozga et al., 2013; Yoshimura et al., 2014), but only two studies reported significant differences with medium ES (*d*= .5 - .78) and each only in one of their two outcome measures (Rozga et al., 2013; Yoshimura et al., 2014).

3.2.7. Disruptive Behaviour Disorder (DBD)

One study assessing emotion expressivity in people with DBD was identified (De Wied et al., 2012). It used film clips to induce positive and negative emotions. Facial expression was measured by EMG. Results show that adolescents with DPD have less facial expression of positive and negative emotions compared to healthy peers, although this may be moderated by unemotional traits and dependent on the specific emotion, since the differences were only significant for sadness, but not for anger.

3.3. Manipulation and validity checks

Five studies reported voluntary facial expression of participants and most of the studies assessed subjective experience of emotions. Although it is beyond the focus of this review to look at these outcomes, both are important for a deeper understanding of the causes and meanings of altered facial expressivity and are therefore shortly summarized hereafter.

None of the five studies reporting on voluntary movement or explicit mimicry of facial expressions found significant differences between clinical (OCD, depression, ASD) and control groups; therefore, facial expression differences are unlikely to be attributable to problems in facial muscle movement.

Regarding self-report of positive vs. negative emotions experienced during exposure to positive vs. negative stimuli, of the 21 studies reporting this outcome, most reported that there were no group differences for subjective experience of emotions (twelve for positive and eleven for negative emotions). Conversely, eight studies reported more self-reported negative emotions during negative stimulus exposure in clinical groups and six studies reported less subjective experience of positive emotions during positive stimuli in clinical groups.

Some studies in ED also coded the frequency of looking away and found that AN patients looked away more often during a negative (sad) film (Davies et al., 2013; Lang et al., 2016) or during negative and positive films of adults expressing emotions (Cardi et al., 2015), but they did not differ in frequency of looking away during a film of infants' facial expressions; one of the possible explanation for this was that patients found it hard to identify infants' facial expressions (Cardi et al., 2014).

4. Discussion

The aims of the current review were to analyse differences between individuals with a non-psychotic disorder and control participants in the automatic, stimulus-related facial expression of emotions. Since the importance of facial expression for the recognition of others' emotions has been shown (Künecke et al., 2014; Sel et al., 2015), a lack of automatic facial emotional expressivity in patient groups could be an explanation for shortcomings in social interaction (e.g. Harrison et al., 2014; Jeung and Herpertz, 2014; Lavelle et al., 2014; Tchanturia et al., 2013). To investigate this assumption, it is important to first answer the question whether individuals with psychological disorders have altered facial expressions of emotions when compared to controls.

The results show that there are alterations in emotional facial expression in DSM non-psychotic Axis I and II disorders in the acute phase of the illness. The review highlights that, although compared to the large body of research on this topic in schizophrenia (Kring and Moran, 2008), research of facial expression in non-psychotic mental disorders is in its infancy; however, it has notably grown in recent years.

4.1. Alterations in facial expression within and across clinical groups

The evidence from studies in PTSD summarized in this review does not suggest altered facial expression in response to emotional stimuli in individuals with this diagnosis. It is of note that patients with PTSD nevertheless show problems in the recognition of emotional expressions (Kret and Ploeger, 2015), which suggests that this patient group may have problems in some domains of social emotional interaction, i.e. in deciphering socially significant emotional signals in others, but that they are as competent as healthy individuals when communicating their own emotions through facial expressions. However, earlier studies (Davis et al., 1996; Pitman et al., 1987; Shalev et al., 1993) using trauma-related imagery had found increased expressivity in patients compared to controls. Therefore, it can be concluded that individuals suffering from PTSD have ‘heightened’ facial expression in response to stimuli related to their trauma, but not in general to emotional stimuli. There might be some alteration during social interaction, but this has to be consolidated by further studies.

Although there were not enough studies in OCD to conduct a meta-analysis, the present results support the hypothesis of blunted facial emotional expressivity in patients with OCD, which were found to be comparable to patients with schizophrenia with regard to facial expression of emotions (Valeriani et al., 2015).

In other anxiety disorders, the evidence is quite limited; there were only two studies reporting no differences between healthy controls and patients with generalised anxiety disorder or social phobia/clinical anxiety. More studies are needed to better understand emotional processing in anxiety disorders, and to distinguish processes related to disorder-related and general emotional stimuli.

Findings from studies of depression, ED and BPD mostly show a general attenuation in facial expression. In depression and BPD this particularly manifests in attenuation of positive expression. One hypothesis for this result in depression was explored in a study by Reed et al. (2007). The authors examined whether the attenuated response to positive stimuli was related to how depressed people appraise emotional stimuli (based on research which suggests that appraisals of emotional stimuli may be different to non-depressed individuals). The study explored ‘dynamic’ facial expression to positive stimuli, thus looking at patterns of response (e.g. does a frown follow a smile?) rather than simply counting each expression. Results showed that depressed people were more likely to show affect-related shifts in expression in response to the positive film clip, specifically initial smiles were followed by negative affect-related expressions. As anhedonia, which is associated with lowered motivation to engage in pleasurable events, is a prominent feature of the illness (Rottenberg and Vaughan, 2008), this response pattern is unsurprising. Depression and anhedonia are common features in AN (Davis and Woodside, 2002; Harrison et al., 2014; Hudson et al., 2007; Tchanturia et al., 2012) and in BPD (Marissen et al., 2012).

Regarding ED, the main conclusion of the meta-analysis for facial expression in adult patients with AN is that diminished positive facial expression can be seen as a robust finding (ES = -.59; CI -1.21, 0.03). Negative emotions are also diminished (ES = -.58; CI -1.09, -0.07) although results are less strong. For adolescent AN patients, and for BN and binge eating disorder more research is needed in order to examine whether there is an effect of psychopathology on facial emotional expression (see Figures 2 and 3). Depression is an important influencing factor which should be controlled for in future studies.

In some of the studies of people with ED in this review (Cardi et al., 2015; Davies et al., 2011; Lang et al., 2016) depression was shown to be negatively associated with positive facial expression, whereas it did not correlate with the attenuation of negative expression or looking away. Attenuating negative facial expression or looking away may be explained as a way of regulating threatening or indeed any social interaction (Oltmanns and Gibbs, 1995). For example, studies have shown that people with AN report that they perceive the expression of negative emotion as unacceptable and believe that it should not be expressed for fear of being criticized and/or rejected (Hambrook et al., 2011; Oldershaw et al., 2015). This is supported by an fMRI study reporting that AN patients may react over-sensitively to social rejection (Via et al., 2015). The expressive suppression of emotions might then be further amplified by the patients being unclear of their proper emotion and its adequacy, having less emotional clarity and general problems in emotion regulation (Wolz et al., 2015). Recent research further suggests that AN patients also have problems in deliberate facial expression of emotions, seen in less accuracy when posing and imitating facial emotions, and underlining their difficulties to convey emotional meaning (Dapelo et al., 2016).

In contrast to the above results in ED, one study reported increased facial expression of joy in patients with BN (Tárrega et al., 2014), which may be explained by the nature of the evocation method and the capacity of patients to inhibit or avoid negative emotions and to increase positive emotions, in order to obtain social reward.

The finding of attenuated facial expression in BPD is more unexpected, as dysregulated emotion manifesting in high sensitivity to emotional stimuli and strong emotional reactivity, is a central feature of the disorder (Herpertz et al., 2001; Renneberg et al., 2005). One explanation for attenuated expression is that these individuals may have learned to hide their facial expressions as negative emotional expressions were ignored or punished in the social contexts they were raised in (Linehan, 1993). Applying Fridlund's theory (Fridlund, 1994) of facial expression as a communication of intention, a neutral face could be a way of making oneself invisible by suggesting 'I do not wish to take part in this interaction' and may be an attempt to reduce threat, as showing signs of emotion leaves the person vulnerable if the emotion displayed is not reciprocated or dismissed by others as invalid or inappropriate.

Conversely, Staebler and colleagues (2011) found conflicting findings in BPD compared to the other BPD studies in the review. They employed a social interaction task inducing social exclusion. Although an attenuation of positive facial expression was observed, there was in fact an increase in negative expression as well as 'blends' of emotions (the expressions of at least two facial expressions at the same time), indicating an asynchrony of facial expression in BPD rather than a general attenuation. Another study, using pictures of faces to induce emotions, did not find differences in positive expression, but supported a heightened response to negative stimuli (Matzke et al., 2014). Since pictures of facial expressions are more similar to a real social interaction than emotional scenes used in the former two studies, it is possible that the theme elicited more intense emotional reactions in patients with BPD than the negative but 'non-disorder' stimuli used in the other two investigations of facial expression in BPD. Alternatively, a social situation task may just be more ecologically valid and thus more engaging. Clearly there is some way to go in untangling the effects of social context on display of facial expression.

The research questions have been different for the ASD studies thus making it difficult to draw comparisons with the other studies in this review. Although many studies in ASD explicitly addressed whether deficits were in automatic versus voluntary emotional mimicry, this review focused on automatic facial expression and only these results were summarized. Mimicry (doing what others do) often occurs at an unconscious level thus enabling smooth and effective interactions, aiding emotion recognition and creating empathy between people (e.g. Stel et al., 2008) – although a recent study questions the place of emotion mimicry in emotion recognition (Rives Bogart and Matsumoto, 2010). It seems that in ASD, alterations in facial expressivity are related more to automatic than voluntary processes as participants could mimic facial expressions if instructed to. Automatic expression was found to be decreased with medium to very large ES (d=.5 to 1.34) in some of the studies, but in others no group differences were found. Insignificant results may be explained by small sample sizes (none of the studies reported a power analysis) or by the nature of the stimulus material (social vs. emotional scenes).

Research in autism suggests that imitation may involve two different processes, one comprising 'an affective mechanism modulating social exchanges' and the second 'a more executively constructed cognitively mediated intentional imitation system'. It is suggested that people with ASD rely on the second (McIntosh et al., 2006). Difficulties with automatic emotional mimicry may mediate the ability to empathise, something which has been shown to be lowered in ASD (Baron-Cohen and Wheelwright, 2004; Kret and Ploeger, 2015).

4.2. Effects of medication on facial expression alterations

It is important to determine whether attenuation of expression (observed in OCD, depression, ED, BPD and ASD) is a symptom of the disorder or a side effect of medication. For example, akinesia (neuromotor dysfunction) is one of the most common side effects of neuroleptic medication (Blanchard and Neale, 1992). However, in schizophrenia the expressive deficit does not appear to be associated with medication status (Kring and Moran, 2008). In this review, only a few studies listed medication status, or included only participants not taking medication. Eighteen studies reported medication status, but only a limited number of studies looked at effects of medications. In three studies (Chentsova-Dutton et al., 2007; Renneberg et al., 2005; Staebler et al., 2011), no differences were found between people taking medication and those who were not. In one study, groups did differ as a function of medication status; therefore, this factor was included as a covariate, but did not notably change the results (De Wied et al., 2012).

4.3. Trait related alterations

Three studies in this review addressed state and trait related factors of facial expressivity by including a recovered (not acutely ill) sample (Davies et al., 2013; Rottenberg et al., 2005; Tárrega et al., 2014). The studies by Davies and colleagues (2013) and by Tárrega and colleagues (2014) found an intermediate profile in recovered individuals between people with current ED (AN and BN, respectively) and controls. The third study in depression (Rottenberg et al., 2005) showed no differences between the recovered and the healthy group for both positive and negative expressivity. In schizophrenia, only a few studies have looked at trait related factors and there seems to be a bias towards attenuated expression in people in remission from the illness and those at risk (Mattes et al., 1995; Walker et al., 1993). To conclude, therefore, studies which have addressed the issue of trait alterations in facial expression in ED and depression have found evidence for facial expression improvement in recovered groups. However, longitudinal studies are needed to clarify state/trait influences of facial expressivity in people with axis I and II disorders.

4.4. Limitations

4.4.1. Limitations at review level

This review focussed on congruent facial expression; therefore, some of the outcomes available in the literature – such as mixed or incongruent facial expressions – were not included into data synthesis. Moreover, we were unable to conduct a global meta-analysis including different mental disorders due to the lack of statistical parameters in some studies.

4.4.2. Limitations at study/outcome level

Cultural and educational background, age, gender and medication may have an important influence on facial emotional expression. Most of the studies reported at least some of these variables, but statistic tests of mean differences may not be enough to control for the influence and there were very few studies to use well matched groups.

Finally, many of the studies did not report means and standard deviations, which is crucial for doing an exact calculation of a summary effect size. Furthermore, some studies analysed positive and negative expressions as one common effect, which probably blurs the results, since the pattern of reactivity in clinical groups has been found to differ between positive versus negative stimuli. Therefore, results should be reported as separate values, where possible.

4.4.3. Limitations of the literature

Aside from the limited number of studies, one of the major limitations of the literature in this review is the heterogeneity of methodologies across studies. This is in part due to the wide ranging methods available to elicit emotion but also due to the range of theories which drive research questions in this area of study. A wide variety of stimuli was used ranging from pictures and films to social interaction and within each of these there was variability. For example, across studies different pictures and films were used. This may result in differences in the salience of stimuli e.g. in the degree of sadness induced by different stimuli or trauma related stimuli compared to generic affective stimuli.

With regard to assessment methods, it is important to bear in mind the possible differences depending on the technique. Only one of the studies included in this review used a combination of both EMG and manual coding and showed that alterations were consistent across coding methods (Soussignan et al., 2010). Finally, the review aimed to investigate whether alterations are related to trait factors; however, there is a complete absence of studies which have addressed state and trait questions using longitudinal groups.

4.5. Clinical Implications

Emotional facial expressions contribute to the regulation of both social interactions and individual emotion regulation (Butler et al., 2003; Davis et al., 2010; Gross and

Levenson, 1997, 1993). Therefore, alterations can have negative consequences for the individual and their social functioning (Tchanturia et al., 2015a).

Attenuated facial expression can have negative social consequences as emotional responses or typical communicatory signals are not available to others (Srivastava et al., 2009). This could cause therapeutic difficulties because obvious markers of emotion are not available (Buhl, 2002). Suppression or avoidance of emotion is suggested to lead to a rebound effect whereby the emotion becomes increasingly more intense (Gross and John, 2003). Expressive suppression of emotions leads to decreased sensitivity in recognizing facial expressions, while deliberate mimicry increases this capacity (Schneider et al., 2013).

Emotional constraint or suppression has been associated with heightened depressive symptoms primarily, but also symptoms of anxiety (Barr et al., 2008); therefore, there are important health benefits to enabling patients to express how they feel. Furthermore, attenuated facial expression may not be representative of the felt experience. For example, in schizophrenia, AN, BN and BPD, although facial expression is attenuated, experiences of emotion have been shown to be comparable or stronger than in healthy controls (Dapelo et al., 2015; Davies et al., 2013; Kring and Moran, 2008; Tárrega et al., 2014). Therefore, the expected responses in social interactions may not be given, for example, the evocation of sympathy and distress, thus perpetuating further negative effects. Interventions that help patients better match their expressions with their subjective emotion may have positive effects on intra- and inter- personal adjustment (Davies et al., 2012; Money et al., 2011; Schmidt et al., 2015, 2012; Tchanturia et al., 2015b, 2014).

4.6. Research Implications

The review highlights the patchiness of elicitation methodologies used, and the need for replication of methods within and across disorders. As already mentioned in the limitations section, one crucial point in research on facial expression is that the outcome is strongly dependent on two factors: the stimuli used to evoke emotions and the assessment methods. To develop a full picture of facial emotional expression in healthy and in clinical populations and its impact on emotion recognition and regulation, additional studies will be needed which combine different methods and compare these. For example, there are not always consistencies between EMG and manual coding results. In the schizophrenia literature, where facial expression has been studied extensively, discontinuances have been shown between outcomes in EMG and manual coding results. Although people with schizophrenia are less outwardly expressive than people without schizophrenia as shown through observable studies, their facial muscles are still responding in a way that is consistent with the valence (positive, negative) of the stimuli, as shown through studies using EMG (Kring and Elis, 2013). It is suggested that this difference may be in part related to medication effects and/or social skills deficits, motivation and effort (Kring and Elis, 2013). However, further studies need to be undertaken to understand these differences. Particularly it would be beneficial if studies used both EMG and observational methods in the same group for measuring facial expression as this could reveal discontinuities and consistencies in the transition from covert to overt expressions (Cacioppo et al., 1992). A few studies which have done so e.g in people experiencing pain (Karmann et al., 2015) and in this review looking at facial expression in eating disorders (Soussignan et al. 2010) found consistency in results in EMG activity and manual coding results.

Going beyond these conventional methods, automatic coding systems could be helpful to improve reliability, validity and comparability of results, yielding a more detailed coding of intensity, duration and fine-grained variety of facial movements (Ahn et al., 2003), and additionally alleviating the time consuming nature of manual coding. Automatic face analysis systems based on the FACS coding system use automatic face recognition for an evaluation and more detailed analyses of facial movements and have been found to be highly reliable (Girard et al., 2014a; Mohammadi et al., 2015; Tian et al., 2001). Although these techniques have been available for years, they are only recently finding their way into clinical research (Hamm et al., 2011; Wu et al., 2014). A study with participants having different degrees of depression and following these individuals over time used both automatic and manual coding and found comparable and consistent results (Girard et al., 2013).

With regard to stimuli, many studies have used the International Affective Picture System (Lang et al., 2005) set , which is a validated battery of emotional and neutral pictures. Attempts at standardising film clips have been made (e.g. Rottenberg et al., 2007) and should be referred to in future studies. Going beyond this type of 2D-stimuli, the review also highlights how ecological methods, such as social interaction, can produce results which differ from less ecological methods e.g. pictures (e.g. Kirsch and Brunnhuber, 2007; Staebler et al., 2011). Although social interaction paradigms come with problems of standardisation, and can increase the number of dependent variables, some novel virtual reality methods are being used (e.g. Cyberball, see Staebler et al., 2011) and could provide alternatives to “real-life”, less standardised paradigms. Future studies using virtual reality paradigms for emotion elicitation are therefore recommended to create ecologically valid and standardized social situations and thus increase generalizability of results and transferability. Virtual environment systems have advanced to a great extent in the last few years, becoming less expensive, more user-friendly and more reliable (Parsons, 2015). Therefore, these paradigms can be seen as a useful method to induce emotions and produce “life-like” social interaction, creating a higher feeling of “presence” as compared to traditional stimuli such as film clips or pictures and thus increasing the intensity of the evoked emotion (Riva et al., 2007). 3D interactive virtual reality thereby enhances this feeling of “presence” compared to 2D paradigms due to higher immersion, but there are also other associated factors that may influence the participants’ “presence” such as movement and spatial distribution (Kober et al., 2012; Wilson et al., 2015).

In these paradigms, factors such as gaze direction and mutual eye contact could be systematically varied to study their effect in social interaction and differences between clinical and non clinical groups in this respect (Marschner et al., 2015; Soussignan et al., 2013). Multidimensional systems such as the Empathy Enhancing Virtual Evolving Environment (Jackson et al., 2015) could be used to create specific emotional situations and at the same time measure emotional reactions on different levels (i.e. facial expression, psychophysiology, gaze dynamics) in a standardized manner. Additionally, virtual environment systems can be used to give real time feedback to patients on their emotional responses and thus to have the capacity to train immediately some emotion regulation skills (Fernandez-Aranda et al., 2012), as shown in recently published research with impulse related disorders (Fernandez-Aranda et al., 2015; Tárrega et al., 2015).

Another important factor on stimulus level is if it depicts emotional scenes or facial expressions, where participants’ expression may rather be mimicry than really felt emotions. Results of the meta-analyses nevertheless point out that both could have a comparable effect, since one of the included studies (Cardi et al., 2015) used facial expressions for emotion elicitation and the others used emotional scenes. Cardi and colleagues study (2015) supported the outcomes from the other studies regarding group differences in emotional expression.

In terms of future directions, researchers in this area should also consider whether they wish to look at general affect or discrete emotions. An example of why this is an issue comes from two studies in AN (Davies et al., 2011; Soussignan et al., 2010), where it is debatable whether attenuated expression may be related to specific emotions or general negative affect. Thus using a range of discrete emotion elicitation methods or a coding system which accounts for coding discrete emotions (e.g. EMFACS, automated systems) could resolve this issue. Furthermore, future studies should look at the effects of pathology relevant stimuli (e.g. food in eating disorders, phobia-related cues in anxiety) in order to compare the effects of general emotional processing versus emotional processing related to disorder specific material. One study in this review (Soussignan et al., 2011), which compared general and specific stimuli, points towards a generally flat emotional expressivity in AN patients, but this finding needs to be corroborated by further studies and expanded to other diagnoses.

The research summarized in this work is not exhaustive with regard to non-verbal expression of emotions; future work has to bring clarity to other related functions and its relationship to facial expression. A recent article postulates the importance of including more subtle affective signals (e.g. gaze direction or blushing, pupil dilation), which go beyond muscular reactions and may be less susceptible to top-down regulation, into research on facial emotional expression (Kret, 2015). Gaze dynamics for example are not only an indicator of emotional involvement versus avoidance, but are also important to inform on attentional allocation and thus identify the environmental cues that shape emotion evocation and facial expression; therefore, eye tracking methods should be included in future research on facial expression of emotions. Gaze dynamics might reveal whether alterations in facial expressivity in psychiatric patients are due to patients focussing on different information or cues (e.g. not focusing on most informative/ emotional parts of a scene) than healthy controls, or if these findings may be rather explained by emotional numbing regardless of attentional biases or avoidance. In social situations for instance, direct eye contact is a vital social signal which entices others into social interaction (Theeuwes and Van Der Stigchel, 2006) and also is important for the embodiment of emotions (Niedenthal et al., 2010). However, the use of another's face to obtain social and emotional information may vary in clinical populations (Cipolli et al., 1989; Watson, 2010) and, additionally, direct eye contact seems to have differing effects on emotional reactions (Wieser et al., 2009), which could influence facial expressivity.

Furthermore, other channels of expression like body posture and body contact should also be taken into account (App et al., 2011). It is possible that patients with less facial expression display their emotions through other channels. Regarding the rebound effect of emotional suppression, physiological parameters should be used in combination with measures of facial expression in order to investigate the physiological cost of expressive suppression of facial emotion (Fagundo et al., 2014).

4.7. Conclusions

In conclusion, this review has shown that facial expression of emotion is altered in people with mental health problems with broad similarities across certain clinical groups. There is tentative support for recovered individuals having a facial expression profile more similar to non clinical controls; however, longitudinal studies are required to understand whether alterations in facial expression are a trait vulnerability factor to mental disorders or rather a state of the illness. Given the multiple functions of facial expression, altered expression in clinical disorders can be explained from as many different standpoints. For example, the impact of social presence could be a particularly useful line of enquiry in untangling causes of disrupted expression in disorders such as BPD and AN. With regard to future directions relating to research methods, emotion elicitation and coding methods need standardisation (e.g. Girard et al., 2014; Rottenberg et al., 2007) to make comparison within and between groups more reliable.

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Figure Captions

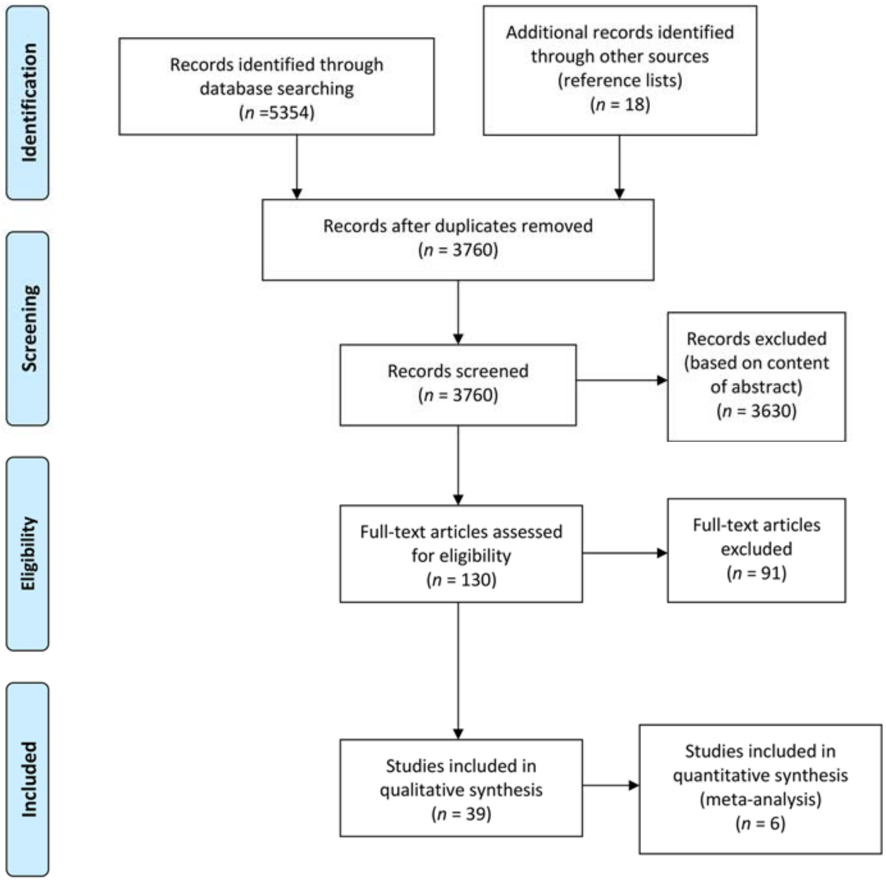


Figure 1. PRISMA flow chart of study selection process (Moher et al., 2009).

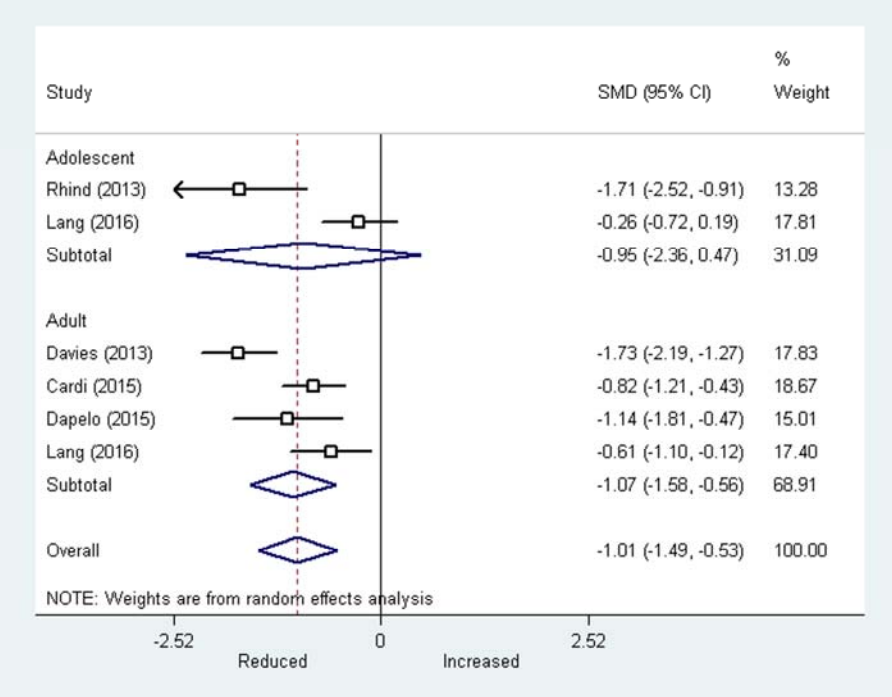
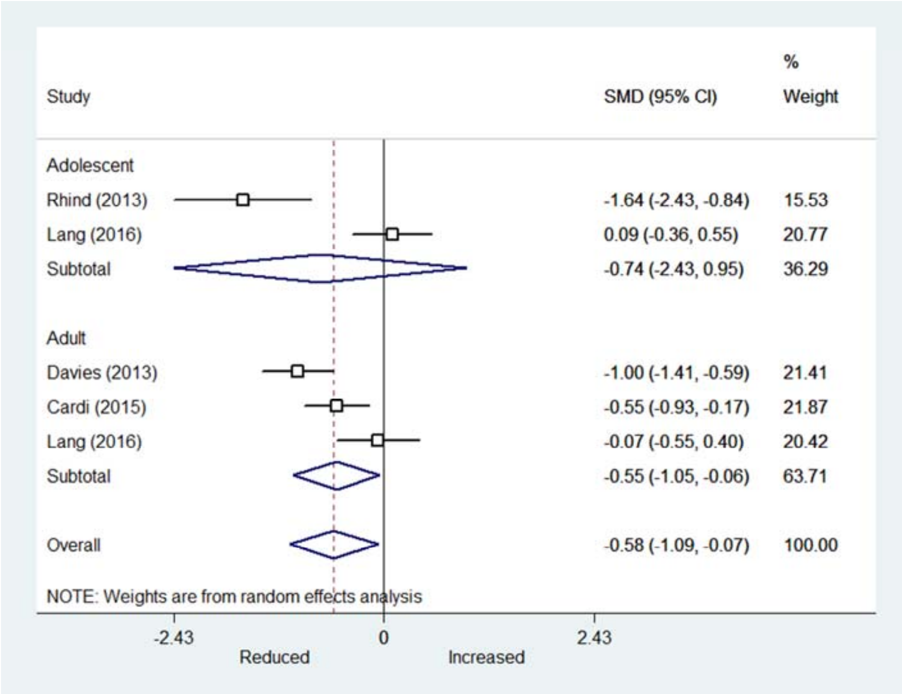


Figure 2. Forest plot of the meta-analysis for facial emotional expression in response to positive affect in patients with AN.


Study
SMD (95% CI)
% Weight
Adolescent
Rhind (2013)
-1.64 (-2.43, -0.84)
15.53
Lang (2016)
0.09 (-0.36, 0.55)
20.77
Subtotal
-0.74 (-2.43, 0.95)
36.29
Adult
Davies (2013)
-1.00 (-1.41, -0.59)
21.41
Cardi (2015)
-0.55 (-0.93, -0.17)
21.87
Lang (2016)
-0.07 (-0.55, 0.40)
20.42
Subtotal
-0.55 (-1.05, -0.06)
63.71
Overall
-0.58 (-1.09, -0.07)
100.00
NOTE: Weights are from random effects analysis
-2.43
0
2.43
Reduced
Increased

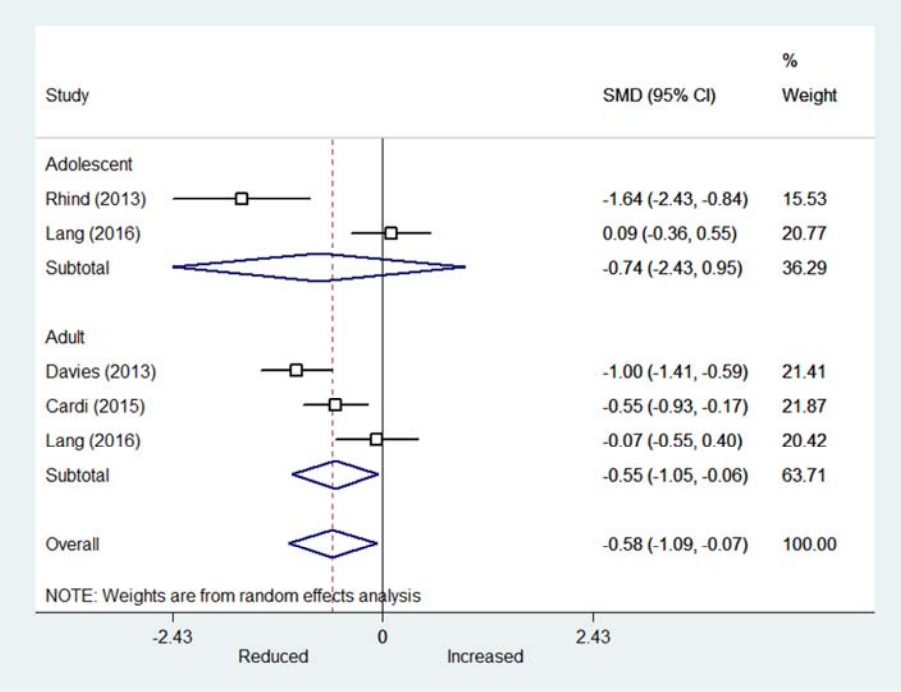


Figure 3. Forest plot of the meta-analysis for facial emotional expression in response to negative affect in patients with AN.

Table 1. Assessment of bias and study quality of included studies.

Study	Selection	Compar-ability	Exposure	Data availability	Power-Analysis
PTSD					
Carlson (1997)	♦♦♦		♦♦♦	♦♦	
Litz (2000)	♦♦		♦♦♦	♦♦	
Orsillo (2004)	♦♦♦♦		♦♦♦	♦♦	
Kirsch (2007)	♦♦♦	♦♦	♦♦♦	♦♦	
OCD					
Mergl (2003)	♦♦	♦	♦♦♦	♦♦	
Bersani (2012)	♦	♦	♦♦	♦♦	
Valeriani (2015)	♦♦		♦♦	♦♦	
Other AD					
Hubert (1990)	♦	♦♦	♦♦♦		
Baker (2002)	♦♦♦		♦♦♦	♦♦	
MD					
Berenbaum (1992)	♦♦♦	♦	♦♦♦	♦♦	
Sloan (2001)	♦	♦♦	♦♦♦	♦	
Rottenberg (2002)	♦♦♦		♦♦♦		
Tsai (2003)	♦	♦	♦♦		
Rottenberg (2005)	♦♦♦♦		♦♦♦	♦♦	
Renneberg (2005)	♦♦♦	♦♦	♦♦♦	♦♦	
Chentsova-Dutton (2007)	♦♦♦	♦	♦♦		
Bersani (2013)	♦	♦♦	♦♦	♦♦	
ED					
Soussignan (2010)	♦♦	♦	♦♦♦	♦	
Soussignan (2011)	♦♦	♦	♦♦♦	♦	
Davies (2011)	♦♦♦♦	♦♦	♦♦♦	♦♦	♦
Claes (2012)	♦♦		♦♦♦	♦♦	
Davies (2013)	♦♦♦♦	♦♦	♦♦♦	♦♦	♦
Rhind (2013)	♦♦	♦♦	♦♦	♦♦	♦
Tárrega (2014)	♦	♦	♦♦♦	♦♦	
Cardi (2014)	♦♦		♦♦	♦♦	
Cardi (2015)	♦♦		♦♦	♦♦	
Dapelo (2015)	♦♦		♦♦♦	♦♦	♦
Lang (2016)	♦♦♦	♦♦	♦♦	♦♦	
BPD					
Herpertz (2001)	♦♦♦	♦♦	♦♦♦		
Renneberg (2005)	♦♦♦	♦♦	♦♦♦	♦♦	
Staebler (2011)	♦♦♦	♦♦	♦♦♦	♦	
Matzke (2014)	♦♦♦	♦♦	♦♦♦		
ASD					
McIntosh (2006)	♦♦	♦♦	♦♦♦		
Stel (2008)	♦♦♦	♦♦	♦♦♦	♦♦	
Grossman (2013)	♦♦♦		♦♦	♦♦	
Mathersul (2013)	♦♦♦		♦♦		
Rozga (2013)	♦♦♦		♦♦	♦♦	
Yoshimura (2014)	♦♦	♦♦	♦♦♦	♦♦	
DBD					
De Wied (2012)	♦♦♦	♦♦	♦♦♦	♦	

AD = Anxiety Disorders; ASD = Autism Spectrum Disorder; BPD = Borderline Personality Disorder; DBD = Disruptive Behaviour Disorder; ED = Eating Disorders; MD = Mood Disorders; OCD = Obsessive Compulsive Disorder; PTSD = Post-Traumatic-Stress Disorder
Newcastle-Ottawa Quality Assessment Tool (Wells et al., 2014): one point is given each for definition and representativeness of cases and controls, respectively (selection bias, total of 4), matched groups, adjustments between groups (comparability, total of 2), validity and ascertainment of exposure procedure, same method for cases and controls, low no-response rate (exposure, total of 3). Additionally, one point is given for: the presence of a power calculation, availability of means and standard deviations, availability of effect size.

Table 2. Summary of studies included into the systematic review of emotional facial expression in non-psychotic DSM Axis I and II disorders.

Authors[1]	Clinical Group	Number of participants	Age in years Mean (SD)	Psychoactive Medication (N per group)	Emotion Elicitation Method	Coding Method	Outcome Measure	Result and Effect Size (magnitude)
Post-Traumatic Stress Disorder								
Carlson (1997)	PTSD (war veterans)	PTSD: 10 HC: 10	PTSD & HC 49.4	Not monitored	Pictures[2]	EMG	Negative (corrugator)[3]	NS 0.66[++]
Litz (2000)	PTSD (war veterans)	PTSD: 32 HC: 29	PTSD: 49.5 (2.8) HC: 52.3 (5.3)	Not reported	Pictures[4]	EMG	Positive (zygomaticus)[5] Negative (corrugator)	NS .06[+-] NS .08[+-]
Orsillo (2004)	PTSD (sexual trauma)	PTSD: 18 HC: 17	PTSD & HC: 35.4 (14.1)	Not reported	Film clips[6]	FACES	Positive expression[7] - Amusement film - Contentment film Negative expression - Sadness film - Fear film - Anger film	 NS 0.59[++] NS 0.36[+-] NS 0.45[++] NS 0.11[+-] NS 0.26[+-]
Kirsch (2007)	PTSD (sexual trauma)	PTSD:15 HC: 15	PTSD: 44.9 HC: 46.7	Not reported	Social interaction[8]	EMFACS	Positive expression - Duchenne smiles - Non-Duchenne smiles Negative expression (anger)	 PTSD<HC 1.59 PTSD<HC 1.23 PTSD>HC 0.97
Obsessive Compulsive Disorder								
Mergl (2003)	OCD	OCD: 34 HC: 34	OCD: 35.8 (11.5) HC: 37.5 (13.1)	OCD (at baseline): 0 HC: 0	Film clips[9]	Kinematical analysis and video-recording	Positive (laughing)[10] 1. Frequency 2. Initial velocity - left eye - right eye - left angle of the mouth - right angle of the mouth	 OCD < HC 1.17 OCD < HC .68 OCD < HC .62 OCD < HC .74 OCD < HC .62
Bersani (2012)	OCD	OCD: 10 HC: 10	OCD: 40.22 (13.49) HC: 40.20 (10.49)	OCD: min 7 HC: 0	Film clips[11]	FACS	Congruent emotional expression[12]	OCD < HC 2.45
Valeriani (2015)	OCD	OCD: 10 MildOCD: 11 HC: 15	OCD: 40.61 (6.21) MildOCD: 37.77 (8.21) HC: 41.71 (12.53)	Not reported	Film clips[13]	FACS	Congruent emotional expression[12]	OCD < HC 3.09 MildOCD < HC 2.74
Other Anxiety Disorders								

Hubert (1990)	Generalized Anxiety Disorder	GAD: 12 HC: 12	GAD & HC: 30	GAD: 0 HC: 0	Film clips[14]	EMG	1. Positive film clip 2. Negative film clip	NS[*+-] NS [*+-]
Baker (2002)	Social Phobia and Clinical anxiety	CA:10 SP: 10 HC: 10	CA: 48.3 (11.4) SP: 42.3 (12.2) HC: 50.9 (8.0)	Not reported	Social[15] interaction	Observation	Positive (relative amount of time spent smiling)	SP vs HC NS .05[+-] CA vs HC NS .25[++]

Authors[1]	Clinical Group	Number of participants	Age in years Mean (SD)	Psychoactive Medication (N per group)	Emotion Elicitation Method	Coding Method	Outcome Measure	Result and Effect Size
Mood Disorders								
Berenbaum (1992)	Depression	DPN: 17 HC: 20	DPN: 38.9 (11.3) HC: 36.1 (10.8)	DPN: 6 HC: 0	Film clips[16]	EMFACS	Positive expression[17] Negative expression[17]	DPN < HC .91 NS .17[+-]
Sloan (2001)	Depression	DPN: 20 HC: 20	DPN: 40.4 (9.2) HC: 42.5 (6.0)	DPN: 20 HC: not reported	Pictures[18]	FACES	Positive expression[19] - Frequency - Intensity Negative expression - Frequency - Intensity	 DPN < HC 3.63 DPN < HC 2.66 NS .25[++] NS .23[++]
Rottenberg (2002)	Depressions	DPN: 72 HC: 33	DPN: 33.4 (10.5) HC: 32.3 (11.7)	DPN: 31 HC: 0	Film clips[20]	EEB	Positive expression[21] Negative expression	NS[*+-] NS[*+-]
Tsai (2003)	Depression	DPN: 12 HC: 10	DPN & HC: 28.28 (7.45)	Not reported	Films clips[22]	FACS	Positive expression[23] - Duchenne smile - Non-Duchenne smile Negative expression	 NS[*+-] DPN < HC 1.09 NS[*+-]
Rottenberg (2005)	Depression	DPN: 19 RecDPN: 22 HC: 26	DPN: 35.7 (7.5) RecDPN: 33.7 (9.3) HC: 33.6 (10.7)	DPN: 6 RecDPN: 7 HC: 0	Film clips[24]	EMG	Positive (zygomaticus)[25] Negative (corrugator)	DPN > HC .72 RecDPNvsHC NS .57[--] DPNvsRecDPN NS .12[+-] DPN vs HC NS .24[--] RecDPN vs HC NS .37[--] DPN vs RecDPN NS.16[+-]
Renneberg (2005)	Depression	DPN: 27 HC: 30	DPN: 39.1 (8.0) HC: 28.3 (8.6)	Not reported.	Film clips[26]	EMFACS	Positive expression[27] - Frequency (happiness) - Frequency (surprise) - Intensity Negative expression (frequency)	DPN < HC .73 DPN < HC .8[a] NS .1[a +-] DPN < HC .82[a] DPN < HC .87[a]
Chentsova-Dutton (2007)	Depression	DPN: 27 HC: 29	DPN EA: 28.7 (8.4) DPN AA: 26.8 (9.1) HC EA: 32.0 (9.8) HC AA: 26.3 (4.9)	DPN: 12 HC: 0	Film clips[28]	EEB	Positive expression[29] Negative expression - Likelihood of crying	NS[*++] NS[*+-] DPN EA < HC OR .34 DPN AA > HC OR 6.5
Bersani (2013)	Bipolar Disorder	BD: 15 HC: 15	BD: 48.13 (10.60) HC: 41.80 (12.50)	BD: 15	Film clips[30]	FACS	Congruent emotional expression[31]	BD < HC 1.84

Authors[1]	Clinical Group	Number of participants	Age in years Mean (SD)	Psychoactive Medication (N per group)	Emotion Elicitation Method	Coding Method	Outcome Measure	Result and Effect Size
Eating Disorders								
Soussignan	AN	AN: 16	AN: 26.6 ± 7.3	AN: 0	Pictures[32]	EMG &	Positive[33]	
(2010)		HC: 25	HC: 24.6 ± 6.0	HC: 0		FACS	- Zygomaticus	AN < HC .78
							- Smiles	AN < HC .78
							Negative	
							- Corrugator	NS[*–]
							- Expression	NS[*+–]
Soussignan	AN	AN: 17	AN: 26.5 ± 7.1	AN: 0	Pictures[34]	EMG	Positive (zygomaticus)[35]	
(2011)		HC: 27	HC: 24.7 ± 6.1	HC: 0			- Food	AN < HC .64[a]
							- Objects	AN < HC .78[a]
							Negative (corrugator)	
							- Food	NS[*–]
							- Objects	NS[*+–]
Eating Disorders (continued)								
Davies (2011)	AN	AN: 30	AN 24.5 (19-33.5)	Not reported	Film clips[36]	FACES	Positive expression	AN<HC 1.78
		HC: 34	HC 23 (19-31.5)				Negative expression[37]	AN<HC .99
Claes (2012)	AN	AN: 11	AN: 32.5 (9.7)	Not reported	Videogame[38]	Facial	Expression of joy[39]	AN vs. HC NS .22[++]
	BN	BN: 12	BN: 29.2 (10.5)			Recognition		BN vs. HC NS .16[–]
		HC: 11	HC: 28.1 (5.1)			software	Expression of anger	AN < HC 1.02
								BN vs. HC NS .92[++]
Davies (2013)	AN	AN: 49[38]	AN: 25.9 (6.8)	AN: 19	Film clips[36]	FACES	Positive expression	AN < HC 1.72
	RecAN	RecAN: 21	RecAN: 28.4 (8.7)	RecAN: 4				AN < RecAN 1.10
		HC: 53	HC: 26.4 (8.4)	HC: 0				RecAN vs HC NS .50[++]
							Negative expression[41]	AN < HC 1.13
								AN vs RecAN .46[++]
								RecAN vs HC .61[++]
Rhind (2013)	AN	AN: 16	AN: 14.75 (1.65)	Not reported	Film clips[42]	FACES	Positive expression[43]	AN < HC 1.7
		HC: 17	HC: 14.41 (1.28)				Negative expression	AN < HC 1.6
Tárrega (2014)	BN	BN: 22[42]	BN: 28.9 (7.8)	Not reported	Videogame[38]	Facial	Expression of joy	BN > HC 8.96
	RecBN	RecBN: 22	RecBN: 27.2 (8.6)			Recognition		RecBN vs HC NS 1.13[++]
		HC: 19	HC: 29.4 (8.1)			software		BN > RecBN 10.26
							Expression of anger[45]	BN < HC 53.54
								RecBN < HC 29.08
								BN < RecBN 27.18
Cardi (2014)	AN	AN: 49	AN: 28.2 (10)	AN: 26	Pictures[46]	FACES	Positive expression[47]	ED < HC .79
	BN	BN: 16	BN: 23.4 (5.7)	BN: 9			Negative expression	
		HC: 73	HC: 26.4 (7.8)	HC: N/A			- Sadness	NS .2[++]
							- Frustration	NS .1[++]
Cardi (2015)	AN	AN: 49[48]	AN: 28.2 (10)	AN: 26	Film clips[49]	FACES	Positive expression[50]	ED < HC .8

	BN	BN: 16	BN: 23.4 (5.7)	BN: 9			Negative expression	
		HC: 73	HC: 26.4 (7.8)	HC: N/A			- Sadness	ED < HC .2
							- Anger	ED < HC .52
Dapelo (2015)	AN	AN: 20	AN: 28.85 (9.75)	AN: 12	Film clips[51]	FACS	Duchenne Smile[52]	
	BN	BN: 20	BN: 26.85 (6.75)	BN: 5			- Duration	AN < HC 1.13
		HC: 20	HC: 26.40 (7.60)	HC: 0				BN vs HC NS .78[++]
							- Intensity	AN < HC 1.6
								BN vs HC .36[++]
							Non-Duchenne Smile	
							- Duration	AN < HC 1.32
								BN < HC .92
							- Intensity	AN < HC 1.67
								BN vs HC NS .85[++]
Lang (2016)	AN	AN: 36	AN: 26.03 (6.82)	Not reported	Film clips[36]	FACES	Positive expression[53]	NS .26[++]
		HC: 38	HC: 24.79 (7.08)				Negative expression	NS .09[+-]
		AN: 30	AN: 15.08 (1.79)				Positive expression	AN < HC .61
		HC: 38	HC: 15.05 (1.93)				Negative expression	NS .07[+-]

Authors[1]	Clinical Group	Number of participants	Age in years Mean (SD)	Psychoactive Medication (N per group)	Emotion Elicitation Method	Coding Method	Outcome Measure	Result and Effect Size
Borderline Personality Disorder								
Herpertz (2001)	BPD (criminal offenders)	BPD: 18 HC: 24	BPD: 33.3 (6.9) HC: 32.5 (10.8)	BPD: 0 HC: 0	Pictures[54]	EMG	Negative (corrugator)[55]	BPD < HC[*]
Renneberg (2005)	BPD	BPD: 30 HC: 30	BPD: 28.5 (9.1) HC: 28.3 (8.6)	Not reported	Film clips[26]	EMFACS	Positive expression[27]	BPD < HC .64
							- Frequency (happiness)	NS .45[a++]
							- Frequency (surprise)	BPD < HC .93[a]
							- Intensity	NS .45[a++]
							Negative expression (frequency)	BPD < HC .71
Staebler (2011)	BPD	BPD: 35 HC: 33	BPD: 27.9 (8.3) HC: 27.9 (8.6)	BPD: 23 HC: 0	Social Interaction[56]	EMFACS	Positive expression[57]	BPD<HC 0.92
							Negative expression	BPD>HC 0.74
Matzke (2014)	BPD	BPD: 28 HC: 28	BPD: 24.93 (5.81) HC: 24.81 (5.40)	BPD: 0 HC: 0	Pictures[58]	EMG	Positive (zyogamaticus)[59]	NS[*]
							Negative (corrugator)	
							- Anger	BPD > HC .7[a]
							- Sadness	BPD > HC .69[a]
							- Disgust	BPD > HC .49[a]
							- Fear	NS[*]
							Negative (levator labii)	NS[*]
Autism Spectrum Disorder								
McIntosh (2006)	ASD	ASD:14 HC: 14	ASD: 27 (13.8) HC: 24 (8.6)	Not reported	Pictures[60]	EMG	Congruent facial expressions[61]	ASD < HC .82 [a]
Stel (2008)	ASD	ASD: 23 HC: 21	ASD: 14.6 (0.6) HC: 15.7 (0.4)	Not reported	Films clip[62]	Observation	Positive expression[63]	ASD < HC 1.34
Grossman (2013)	ASD	ASD: 14	ASD: 13.1 (3.4)	Not reported	Film clips[64]	Observation	Congruent expressions[65]	NS .39

		HC: 12	HC: 15 (3.6)				Intensity of expression	NS .67
Mathersul (2013)	ASD	ASD: 18	ASD: 36.7 (17.1)	Not reported	Pictures[66]	EMG	Positive (zygomaticus)[67]	NS[*+-]
		HC: 18	HC: 44.6 (15.5)				Negative (corrugator)	NS[*++]
Rozga (2013)	ASD	ASD: 17	ASD: 16.6 (9.2)	Not reported	Film clips[68]	EMG	Positive (zygomaticus)[69]	NS .24[++]
		HC: 17	HC: 15.2 (5.4)				Negative (corrugator)	
							- Anger	NS .47[++]
							- Fear	ASD < HC .50
Yoshimura (2014)	ASD	ASD: 15	ASD: 26.2 (6.9)	ASD: 0	Film clips[70]	FACS &	Positive expressions[71]	
		HC: 15	HC: 24.1 (4.0)	HC: 0		FACES	- Dynamic	ASD < HC .81
							- Static	NS .19[++]
							Negative expressions	
							- Dynamic	ASD < HC 1.02
							- Static	NS .00[+-]
Disruptive Behaviour Disorder								
De Wied (2012)	DBD	DBD/CU+: 14	DBD/CU+: 13.93 (1.17)	DBD: 14	Film clips[72]	EMG	Positive (zygomaticus)[73]	DBD/CU- < HC .73
		DBD/CU-: 17	DBD/CU-: 13.29 (0.85)	HC: 0				DBD/CU+ vs. HC NS .5
		HC: 32	HC: 13.75 (0.76)				Negative (corrugator)	
							- Sadness	DBD/CU+ < HC .48
								DBD/CU- < HC .52
							- Anger	NS .07[a+-]

NS: non-significant; results in bold indicate significant differences between groups.
* indicates that mean/standard deviations or f statistic were unobtainable to calculate effect size.
[a] The effect size is an approximation of the real effect size, calculated through the “Practical Meta-Analysis Effect Size Calculator” by David B. Wilson
++ indicates a trend to more facial expression in the HC group; -- indicates a trend to less facial expression in the HC group; +- indicates where the direction of the effect is unclear.

AA: Asian Americans of East Asian descent; AN: Anorexia Nervosa; ASD: Autism Spectrum Disorder; BPD:Borderline Personality Disorder; CA: Clinical Anxiety; CU: callous unemotional traits; DBD: Disruptive Behaviour Disorder; DPN: Depression; EA: East Asians; EEB: Emotional Expressive Behavior Coding System (Gross & Levenson, 1993); EMFACS: Emotional Facial Action Coding System (Ekman & Friesen, 1978); EMG: Electromyography; FACS: Facial Action Coding System (Ekman & Friesen, 2003); FACES: Facial expression coding system (Kring & Sloan, 2007); GAD: Generalised anxiety disorder; HC: Healthy Control; IAPS: International Affective Picture System (Lang, Bradley & Cuthbert, 1999); OCD: Obsessive Compulsive Disorder; OR: Odds Ratio; PTSD: Post Traumatic Stress Disorder; Rec: Recovered; SP: Social phobia.

[1] First authors stated only.
[2] 15 combat-related and 15 neutral pictures
[3] PTSD patients had significantly higher values than HC on a subjective measure of distress.
[4] Positive, negative and neutral IAPS pictures, 8/category. Trauma related and neutral priming videos were shown prior to pictures. The results shown are based on the neutrally primed blocks.
[5] Groups did not differ in subjective ratings of valence or arousal. The combat prime increased corrugator activity to negative stimuli in both groups similarly.
[6] The Money Pit (amusement; 4:31m), The Champ (sadness; 2:44m), Cat’s Eye (fear; 1:42m), Cry Freedom (anger; 2:36m), waves breaking on a beach (contentment; 1:04m)
[7] PTSD patients had significantly higher values than HC on a subjective measure of negative feelings towards all of the film clips and of positive feelings towards the anger and fear film clips.
[8] Participants were filmed during a psychodynamic interview.
[9] Mr. Bean (amusement; max. 9m).
[10] Groups did not differ in voluntary facial movement or subjective ratings of amusement.
[11] MGM introduction (neutral; 0:10m), When Harry met Sally (amusement; 2:35m), The Shining (fear; 1:22m), Capricorn one (surprise; 0:49m), Cry Freedom (anger; 2:36m), The Champ (sadness; 2:51m), Pink Flamingos (disgust; 0:30m), Roberto Benigni and Massimo Troisi video interview (amusement; 1:30m)
[12] Facial expression values are not reported separately for positive and negative emotions. OCD patients had significantly lower values than HC on a subjective measure of emotions. Bersani 2012: OCD patients did not differ significantly on emotional measures when compared to a group of patients with schizophrenia.
[13] Color Bars (neutral; 0:08m), When Harry met Sally (amusement; 2:35m), The silence of the lambs (fear; 3:29m), Sea of love (surprise; 0:09m), Cry Freedom (anger; 2:36m), The Champ (sadness; 2:51m), Pink Flamingos (disgust; 0:30m)
[14] Indiana Jones (Anxiety/disgust; 9m) and Peanuts cartoon (Joy; 9m)
[15] 9 minute talk with a confederate of the experimenters.
[16] Chinatown/Marathon Man (negative), The Godfather (negative), Bill Cosby: Himself (positive), Alt Baba Bunny (positive), all films had a length between 2:47m and 3:32m.
[17] Groups did not differ in voluntary facial movement or subjective ratings of happiness and disgust. Patients with depression did not differ in negative emotional expression from a group of patients with non-blunted schizophrenia, but showed less positive emotions these patients.
[18] Positive (happiness and contentment), negative (sadness and disgust) and neutral IAPS pictures, 16/category.
[19] Depressed patients rated positive pictures as less pleasant and less arousing than the HC group, groups did not differ in their rating of negative pictures. Neutral slides did not elicit notable facial expressions.
[20] Landscape (neutral; 3m), airplane turbulence (fear; 2:20m),. boy mourning father (sadness, 2:50m), slapstick comedy (amusement; 2m).
[21] Depressed patients reported more sadness and less amusement during neutral and amusing films, but there were no differences for the fear or sadness films.
[22] Two sad (one human; 3:35m, one animal; 2m), two amusing film clips (one human; 4:07m, one animal; 1:12m), neutral (colour sticks; 1m)
[23] Groups did not differ significantly in self-report of emotional experience.

[24] Landscape (neutral; 3m), airplane turbulence (fear; 2:20m), boy mourning father (sadness, 2:50m), boy with family (happiness; 3:57m). The study also used idiographic stimuli, but for comparability here only data to these normative clips is reported.
[25] Reported is the difference score of change between neutral and emotional pictures. The DPN group reported less happiness and more sadness in response to all stimuli than the HC and RecDPN groups.
[26] Cry Freedom (negative), French Kiss (positive).
[27] Depressed patients did not differ significantly in facial expression of negative and positive emotion from patients with BPD (63% also had a comorbid depression). Medication status had no effect on the outcome.
[28] Natural scenery (neutral; 3m), The Champ (sadness; 2:50m), Mr. Bean (amusement; 2m), shown in this order.
[29] EA depressed patients reported significantly less sadness to the negative film than HC, AA depressed patients did not differ from HC. There were no group differences in the subjective ratings of the positive film clip. Medication did not have any effect on emotional reactivity for either of the groups.
[30] Color Bars (neutral; 1:30m), When Harry met Sally (amusement; 2:35m), The Shining (fear; 1:22m), Capricorn One (surprise; 0:49m), Cry Freedom (anger; 2:36m), The Champ (sadness; 2:51m), Pink Flamingos (disgust; 0:30m), Roberto Benigni and Massimo (amusement; 1:30m).
[31] Facial expression values are not reported separately for positive and negative emotions. Patients with BD showed significantly more congruent emotion expressions than schizophrenia patients. BD patients had significantly lower values than HC on a subjective measure of emotions.
[32] 32 IAPS pictures of food. The pictures were preceded by subliminal emotional and neutral face primes, results shown are based on the main effects of group regarding facial expression. Participants were tested in a hungry and in a satiated state, results show main effects of facial expression.
[33] AN patients reported significantly less hedonic liking in response to food pictures than HC in both states and lower wanting in the hunger state. For emotional primes, only fear induced more corrugator activity in AN compared to HC (in the hunger state only), for zygomaticus activity, smiles and negative expression there was no priming effect.
[34] 6 food and 6 object pictures matched for hedonic rating. There were no differences between AN patients and HC in the subjective rating of the pictures.
[35] Participants were tested once in a hungry state and once in a satiated state, the table shows main effects. There was an interaction effect for food pictures in corrugator activity in that patients had higher activity than HC during the hungry state only. Also, for the time window between 400 and 600ms post stimulus, AN patients had less corrugator activity for picture stimuli.
[36] Four Weddings and A Funeral (amusement; 2m), Shadowlands (sadness; 2m), waves (neutral; 2m).
[37] AN patients looked away significantly more often than HC during the negative film, for the positive film there was no difference in frequency of looking away. AN patients reported significantly less positive affect in response to the positive film clip than HC, groups did not differ for ratings of the negative film clip.
[38] Playmancer video game designed to train emotion regulation, set on an island and consisting of three mini-games including different challenges. Emotions are coded during the game, but the stimulus valence is not clearly assignable to the coded expressions.
[39] AN and BN patients did not differ significantly, but AN patients tended to express less. BN patients self-reported significantly more state anger than HC, there were no differences in anger between HC and AN.
[40] One part of the patients of the AN group was included in Davies (2011).
[3941] During the negative film AN patients looked away significantly more often than HC and RecAN (which did not differ), for the positive film there was no difference in frequency of looking away. AN patients reported significantly less positive affect in response to the positive film clip than HC, RecAN did not differ significantly from neither of both groups, groups did not differ for ratings of the negative film clip.
[42] The Bare Necessities from the Jungle Book (amusement), The Death of Mufasa from Lion King (sadness), ocean waves (neutral).
[43] Groups did not differ in subjective ratings of positive and negative effect in response to the according film clips.
[44] One part of the patients of the BN and of the HC groups was included in Claes (2012).
[45] BN patients self-reported significantly more state anger than HC and than RecBN, RecBN reported more anger than HC.
[46] Four film clips (1m each) showing infants displaying discrete emotions: happiness, sadness, anger and neutrality.
[47] AN and BN groups did not differ significantly on the main outcome measures, wherefore they were pooled into one ED group. Groups did not differ in frequency of looking away. AN patients reported more negative emotions in response to sad film clips, groups did not differ in subjective emotion ratings of the other film clips.
[48] Same sample as included in Cardi (2014)
[49] Four film clips (1m each) showing adults displaying discrete emotions: happiness, sadness, anger and neutrality.

[50] AN and BN groups did not differ significantly on the main outcome measures, wherefore they were pooled into one ED group. Participants with ED looked away more frequently than HC in response to both of the films. Groups did not differ in subjective ratings of positive and negative emotions experienced during the film clips.
[51] Waves (neutral; 0:30m), Four Weddings and A Funeral (amusement; 2m).
[52] Groups did not differ in subjective ratings of positive mood in response to the positive film clip. AN patients had significantly lower values than BN in duration and intensity of duchenne smiles and in intensity (but not duration) of non-duchenne smiles.
[53] AN patients looked away significantly more often than HC during the negative film, for the positive film there was no difference in frequency of looking away. AN patients reported significantly more negative emotions during the negative and the positive film clip than HC, groups did not differ for ratings of the positive film clip.
[54] Positive, negative and neutral IAPS pictures, 8/category.
[55] The outcome is measured as corrugator activity change from neutral to unpleasant pictures. BPD patients did not differ from a group of psychopaths in negative stimulus evoked corrugator activity. Groups did not differ in self-report ratings of valence and arousal in response to the pictures.
[56] Participants facial expressions were observed when playing Cyberball, a virtual ball-tossing game that reliably induces social exclusion.
[57] Compared to HC and to an objective measure, BPD patients felt more excluded while playing the game, they also reported more self-focused negative and less positive emotions (independent from playing) and more increase in other focused negative emotions after being excluded. Depression and medication did not significantly change outcomes.
[58] NimStim Face Stimulus set: 5 male and 5 female faces depicting happiness, sadness, anger, surprise, disgust, fear, 10/category morphed into dynamic facial expressions.
[59] BPD patients did not differ from HC in recognition of facial expressions, nor on subjective intensity ratings of the pictures.
[60] Pictures depicting angry and happy facial expressions, 8/category.
[61] Results are not reported separately for positive and negative stimuli. Groups did not differ in voluntary mimicry of facial expressions.
[62] Student talking about his adventures (amusement; 5m).
[63] Groups did not differ in voluntary mimicry of facial expressions. Facial expression during the video correlated with reported emotion experience in HC, but not in ASD.
[64] Four videotaped stories told by “Safari Bob”, depicting happy, fearful, angry and positive surprise emotions (0:25-0:32m).
[65] Results were not reported separately for positive and negative emotions.
[66] Positive, negative and neutral IAPS pictures, 18/category.
[67] Groups did not differ in subjective ratings of valence and arousal in response to the pictures.
[68] Actors depicting sentences in angry, fearful, or happy valence, 8/category (0.9-2s).
[69] Groups did not differ in an emotion recognition task.
[70] Male and female faces displaying facial expressions, dynamic (evolving from neutral to angry and neutral to happy expressions) vs. static (1.5s).
[71] Results for FACS and FACES coding were comparable, effect sizes are shown for FACES data since it seemed to be the more conservative measure. Groups did not differ in voluntary mimicry of facial expressions.
[72] Boys and girls in everyday situations creating sadness, anger and happiness, 2/category (2:04m-2:37m).
[73] Medication had a significant effect on the outcome and was therefore entered as covariate. Groups did not differ in an emotion recognition task. The high CU group reported less empathy in response to the films than the low CU and the HC groups, which did not differ. DBD groups did not differ in facial expressivity.

Table 2. Summary of studies included into the systematic review of emotional facial expression in non-psychotic DSM Axis I and II disorders.

Authors[1]	Clinical Group	Number of participants	Age in years Mean (SD)	Psychoactive Medication (N per group)	Emotion Elicitation Method	Coding Method	Outcome Measure	Result and Effect Size (magnitude)
Post-Traumatic Stress Disorder								
Carlson (1997)	PTSD (war veterans)	PTSD: 10 HC: 10	PTSD & HC 49.4	Not monitored	Pictures[2]	EMG	Negative (corrugator)[3]	NS 0.66^{++}
Litz (2000)	PTSD (war veterans)	PTSD: 32 HC: 29	PTSD: 49.5 (2.8) HC: 52.3 (5.3)	Not reported	Pictures[4]	EMG	Positive (zygomaticus)[5] Negative (corrugator)	NS .06^{+-} NS .08^{+-}
Orsillo (2004)	PTSD (sexual trauma)	PTSD: 18 HC: 17	PTSD & HC: 35.4 (14.1)	Not reported	Film clips[6]	FACES	Positive expression[7] - Amusement film - Contentment film Negative expression - Sadness film - Fear film - Anger film	 NS 0.59^{++} NS 0.36^{+-} NS 0.45^{++} NS 0.11^{+-} NS 0.26^{+-}
Kirsch (2007)	PTSD (sexual trauma)	PTSD:15 HC: 15	PTSD: 44.9 HC: 46.7	Not reported	Social interaction[8]	EMFACS	Positive expression - Duchenne smiles - Non-Duchenne smiles Negative expression (anger)	 PTSD<HC 1.59 PTSD<HC 1.23 PTSD>HC 0.97
Obsessive Compulsive Disorder								
Mergl (2003)	OCD	OCD: 34 HC: 34	OCD: 35.8 (11.5) HC: 37.5 (13.1)	OCD (at baseline): 0 HC: 0	Film clips[9]	Kinematical analysis and video-recording	Positive (laughing)[10] 1. Frequency 2. Initial velocity - left eye - right eye - left angle of the mouth - right angle of the mouth	 OCD < HC 1.17 OCD < HC .68 OCD < HC .62 OCD < HC .74 OCD < HC .62
Bersani (2012)	OCD	OCD: 10 HC: 10	OCD: 40.22 (13.49) HC: 40.20 (10.49)	OCD: min 7 HC: 0	Film clips[11]	FACS	Congruent emotional expression[12]	OCD < HC 2.45
Valeriani (2015)	OCD	OCD: 10 MildOCD: 11 HC: 15	OCD: 40.61 (6.21) MildOCD: 37.77 (8.21) HC: 41.71 (12.53)	Not reported	Film clips[13]	FACS	Congruent emotional expression[12]	OCD < HC 3.09 MildOCD < HC 2.74
Other Anxiety Disorders								
Hubert (1990)	Generalized Anxiety Disorder	GAD: 12 HC: 12	GAD & HC: 30	GAD: 0 HC: 0	Film clips[14]	EMG	1. Positive film clip 2. Negative film clip	NS^{*+-} NS $^{*+-}$
Baker (2002)	Social Phobia	CA:10	CA: 48.3 (11.4)	Not reported	Social[15]	Observation	Positive (relative amount of time	SP vs HC NS .05^{+-}

and Clinical anxiety	SP: 10 HC: 10	SP: 42.3 (12.2) HC: 50.9 (8.0)	interaction	spent smiling)	CA vs HC NS .25[++]

Authors[1]	Clinical Group	Number of participants	Age in years Mean (SD)	Psychoactive Medication (N per group)	Emotion Elicitation Method	Coding Method	Outcome Measure	Result and Effect Size
Mood Disorders								
Berenbaum (1992)	Depression	DPN: 17 HC: 20	DPN: 38.9 (11.3) HC: 36.1 (10.8)	DPN: 6 HC: 0	Film clips[16]	EMFACS	Positive expression[17] Negative expression[17]	DPN < HC .91 NS .17[+-]
Sloan (2001)	Depression	DPN: 20 HC: 20	DPN: 40.4 (9.2) HC: 42.5 (6.0)	DPN: 20 HC: not reported	Pictures[18]	FACES	Positive expression[19] - Frequency - Intensity Negative expression - Frequency - Intensity	 DPN < HC 3.63 DPN < HC 2.66 NS .25[++] NS .23[++]
Rottenberg (2002)	Depressions	DPN: 72 HC: 33	DPN: 33.4 (10.5) HC: 32.3 (11.7)	DPN: 31 HC: 0	Film clips[20]	EEB	Positive expression[21] Negative expression	NS[*+-] NS[*+-]
Tsai (2003)	Depression	DPN: 12 HC: 10	DPN & HC: 28.28 (7.45)	Not reported	Films clips[22]	FACS	Positive expression[23] - Duchenne smile - Non-Duchenne smile Negative expression	 NS[*+-] DPN < HC 1.09 NS[*+-]
Rottenberg (2005)	Depression	DPN: 19 RecDPN: 22 HC: 26	DPN: 35.7 (7.5) RecDPN: 33.7 (9.3) HC: 33.6 (10.7)	DPN: 6 RecDPN: 7 HC: 0	Film clips[24]	EMG	Positive (zygomaticus)[25] Negative (corrugator)	DPN > HC .72 RecDPNvsHC NS .57[--] DPNvsRecDPN NS .12[+-] DPN vs HC NS .24[--] RecDPN vs HC NS .37[--] DPN vs RecDPN NS.16[+-]
Renneberg (2005)	Depression	DPN: 27 HC: 30	DPN: 39.1 (8.0) HC: 28.3 (8.6)	Not reported.	Film clips[26]	EMFACS	Positive expression[27] - Frequency (happiness) - Frequency (surprise) - Intensity Negative expression (frequency)	DPN < HC .73 DPN < HC .8[a] NS .1[a +-] DPN < HC .82[a] DPN < HC .87[a]
Chentsova-Dutton (2007)	Depression	DPN: 27 HC: 29	DPN EA: 28.7 (8.4) DPN AA: 26.8 (9.1) HC EA: 32.0 (9.8) HC AA: 26.3 (4.9)	DPN: 12 HC: 0	Film clips[28]	EEB	Positive expression[29] Negative expression - Likelihood of crying	NS[*++] NS[*+-] DPN EA < HC OR .34 DPN AA > HC OR 6.5
Bersani (2013)	Bipolar Disorder	BD: 15 HC: 15	BD: 48.13 (10.60) HC: 41.80 (12.50)	BD: 15	Film clips[30]	FACS	Congruent emotional expression[31]	BD < HC 1.84
Eating Disorders								
Soussignan (2010)	AN	AN: 16 HC: 25	AN: 26.6 ± 7.3 HC: 24.6 ± 6.0	AN: 0 HC: 0	Pictures[32]	EMG & FACS	Positive[33] - Zygomaticus - Smiles Negative	 AN < HC .78 AN < HC .78

							- Corrugator	NS[*--]
							- Expression	NS[*+-]
Soussignan (2011)	AN	AN: 17 HC: 27	AN: 26.5 ± 7.1 HC: 24.7 ± 6.1	AN: 0 HC: 0	Pictures[34]	EMG	Positive (zygomaticus)[35]	
							- Food	AN < HC .64[a]
							- Objects	AN < HC .78[a]
							Negative (corrugator)	
							- Food	NS[*--]
							- Objects	NS[*+-]

Authors[1]	Clinical Group	Number of participants	Age in years Mean (SD)	Psychoactive Medication (N per group)	Emotion Elicitation Method	Coding Method	Outcome Measure	Result and Effect Size
Eating Disorders (continued)								
Davies (2011)	AN	AN: 30 HC: 34	AN 24.5 (19-33.5) HC 23 (19-31.5)	Not reported	Film clips[36]	FACES	Positive expression Negative expression[37]	AN<HC 1.78 AN<HC .99
Claes (2012)	AN BN	AN: 11 BN: 12 HC: 11	AN: 32.5 (9.7) BN: 29.2 (10.5) HC: 28.1 (5.1)	Not reported	Videogame[38]	Facial Recognition software	Expression of joy[39] Expression of anger	AN vs. HC NS .22[++] BN vs. HC NS .16[--] AN < HC 1.02 BN vs. HC NS .92[++]
Davies (2013)	AN RecAN	AN: 49[38] RecAN: 21 HC: 53	AN: 25.9 (6.8) RecAN: 28.4 (8.7) HC: 26.4 (8.4)	AN: 19 RecAN: 4 HC: 0	Film clips[36]	FACES	Positive expression Negative expression[41]	AN < HC 1.72 AN < RecAN 1.10 RecAN vs HC NS .50[++] AN < HC 1.13 AN vs RecAN .46[++] RecAN vs HC .61[++]
Rhind (2013)	AN	AN: 16 HC: 17	AN: 14.75 (1.65) HC: 14.41 (1.28)	Not reported	Film clips[42]	FACES	Positive expression[43] Negative expression	AN < HC 1.7 AN < HC 1.6
Tárrega (2014)	BN RecBN	BN: 22[42] RecBN: 22 HC: 19	BN: 28.9 (7.8) RecBN: 27.2 (8.6) HC: 29.4 (8.1)	Not reported	Videogame[38]	Facial Recognition software	Expression of joy Expression of anger[45]	BN > HC 8.96 RecBN vs HC NS 1.13[++] BN > RecBN 10.26 BN < HC 53.54 RecBN < HC 29.08 BN < RecBN 27.18
Cardi (2014)	AN BN	AN: 49 BN: 16 HC: 73	AN: 28.2 (10) BN: 23.4 (5.7) HC: 26.4 (7.8)	AN: 26 BN: 9 HC: N/A	Pictures[46]	FACES	Positive expression[47] Negative expression - Sadness - Frustration	ED < HC .79 NS .2[++] NS .1[++]
Cardi (2015)	AN BN	AN: 49[48] BN: 16 HC: 73	AN: 28.2 (10) BN: 23.4 (5.7) HC: 26.4 (7.8)	AN: 26 BN: 9 HC: N/A	Film clips[49]	FACES	Positive expression[50] Negative expression - Sadness - Anger	ED < HC .8 ED < HC .2 ED < HC .52
Dapelo (2015)	AN BN	AN: 20 BN: 20	AN: 28.85 (9.75) BN: 26.85 (6.75)	AN: 12 BN: 5	Film clips[51]	FACS	Duchenne Smile[52] - Duration	 AN < HC 1.13

Authors[1]	Clinical Group	Number of participants	Age in years Mean (SD)	Psychoactive Medication (N per group)	Emotion Elicitation Method	Coding Method	Outcome Measure	Result and Effect Size
		HC: 20	HC: 26.40 (7.60)	HC: 0				BN vs HC NS .78[++]
							- Intensity	AN < HC 1.6 BN vs HC .36[++]
							Non-Duchenne Smile	
							- Duration	AN < HC 1.32 BN < HC .92
							- Intensity	AN < HC 1.67 BN vs HC NS .85[++]
Lang (2016)	AN	AN: 36 HC: 38 AN: 30 HC: 38	AN: 26.03 (6.82) HC: 24.79 (7.08) AN: 15.08 (1.79) HC: 15.05 (1.93)	Not reported	Film clips[36]	FACES	Positive expression[53] Negative expression Positive expression Negative expression	NS .26[++] NS .09[+-] AN < HC .61 NS .07[+-]
Borderline Personality Disorder								
Herpertz (2001)	BPD (criminal offenders)	BPD: 18 HC: 24	BPD: 33.3 (6.9) HC: 32.5 (10.8)	BPD: 0 HC: 0	Pictures[54]	EMG	Negative (corrugator)[55]	BPD < HC[*]
Renneberg (2005)	BPD	BPD: 30 HC: 30	BPD: 28.5 (9.1) HC: 28.3 (8.6)	Not reported	Film clips[26]	EMFACS	Positive expression[27]	BPD < HC .64
							- Frequency (happiness)	NS .45[a++]
							- Frequency (surprise)	BPD < HC .93[a]
							- Intensity	NS .45[a++]
							Negative expression (frequency)	BPD < HC .71
Staebler (2011)	BPD	BPD: 35 HC: 33	BPD: 27.9 (8.3) HC: 27.9 (8.6)	BPD: 23 HC: 0	Social Interaction[56]	EMFACS	Positive expression[57] Negative expression	BPD<HC 0.92 BPD>HC 0.74
Matzke (2014)	BPD	BPD: 28 HC: 28	BPD: 24.93 (5.81) HC: 24.81 (5.40)	BPD: 0 HC: 0	Pictures[58]	EMG	Positive (zyogamaticus)[59] Negative (corrugator)	NS[*]
							- Anger	BPD > HC .7[a]
							- Sadness	BPD > HC .69[a]
							- Disgust	BPD > HC .49[a]
							- Fear	NS[*]
							Negative (levator labii)	NS[*]
Autism Spectrum Disorder								
McIntosh (2006)	ASD	ASD:14 HC: 14	ASD: 27 (13.8) HC: 24 (8.6)	Not reported	Pictures[60]	EMG	Congruent facial expressions[61]	ASD < HC .82 [a]
Stel (2008)	ASD	ASD: 23 HC: 21	ASD: 14.6 (0.6) HC: 15.7 (0.4)	Not reported	Films clip[62]	Observation	Positive expression[63]	ASD < HC 1.34
Grossman (2013)	ASD	ASD: 14 HC: 12	ASD: 13.1 (3.4) HC: 15 (3.6)	Not reported	Film clips[64]	Observation	Congruent expressions[65] Intensity of expression	NS .39 NS .67
Mathersul (2013)	ASD	ASD: 18 HC: 18	ASD: 36.7 (17.1) HC: 44.6 (15.5)	Not reported	Pictures[66]	EMG	Positive (zygomaticus)[67] Negative (corrugator)	NS[*+-] NS[*++]
Rozga (2013)	ASD	ASD: 17 HC: 17	ASD: 16.6 (9.2) HC: 15.2 (5.4)	Not reported	Film clips[68]	EMG	Positive (zygomaticus)[69] Negative (corrugator)	NS .24[++]

							- Anger	NS .47[++]
							- Fear	ASD < HC .50
Yoshimura (2014)	ASD	ASD: 15 HC: 15	ASD: 26.2 (6.9) HC: 24.1 (4.0)	ASD: 0 HC: 0	Film clips[70]	FACS & FACES	Positive expressions[71]	
							- Dynamic	ASD < HC .81
							- Static	NS .19[++]
							Negative expressions	
							- Dynamic	ASD < HC 1.02
							- Static	NS .00[+−]
Disruptive Behaviour Disorder								
De Wied (2012)	DBD	DBD/CU+: 14 DBD/CU-: 17 HC: 32	DBD/CU+: 13.93 (1.17) DBD/CU-: 13.29 (0.85) HC: 13.75 (0.76)	DBD: 14 HC: 0	Film clips[72]	EMG	Positive (zygomaticus)[73]	DBD/CU- < HC .73 DBD/CU+ vs. HC NS .5
							Negative (corrugator)	
							- Sadness	DBD/CU+ < HC .48 DBD/CU- < HC .52
							- Anger	NS .07[a+-]

NS: non-significant; results in bold indicate significant differences between groups.
* indicates that mean/standard deviations or f statistic were unobtainable to calculate effect size.
[a] The effect size is an approximation of the real effect size, calculated through the "Practical Meta-Analysis Effect Size Calculator" by David B. Wilson
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[2] 15 combat-related and 15 neutral pictures
[3] PTSD patients had significantly higher values than HC on a subjective measure of distress.
[4] Positive, negative and neutral IAPS pictures, 8/category. Trauma related and neutral priming videos were shown prior to pictures. The results shown are based on the neutrally primed blocks.
[5] Groups did not differ in subjective ratings of valence or arousal. The combat prime increased corrugator activity to negative stimuli in both groups similarly.
[6] The Money Pit (amusement; 4:31m), The Champ (sadness; 2:44m), Cat's Eye (fear; 1:42m), Cry Freedom (anger; 2:36m), waves breaking on a beach (contentment; 1:04m)
[7] PTSD patients had significantly higher values than HC on a subjective measure of negative feelings towards all of the film clips and of positive feelings towards the anger and fear film clips.
[8] Participants were filmed during a psychodynamic interview.
[9] Mr. Bean (amusement; max. 9m).
[10] Groups did not differ in voluntary facial movement or subjective ratings of amusement.
[11] MGM introduction (neutral; 0:10m), When Harry met Sally (amusement; 2:35m), The Shining (fear; 1:22m), Capricorn one (surprise; 0:49m), Cry Freedom (anger; 2:36m), The Champ (sadness; 2:51m), Pink Flamingos (disgust; 0:30m), Roberto Benigni and Massimo Troisi video interview (amusement; 1:30m)
[12] Facial expression values are not reported separately for positive and negative emotions. OCD patients had significantly lower values than HC on a subjective measure of emotions. Bersani 2012: OCD patients did not differ significantly on emotional measures when compared to a group of patients with schizophrenia.
[13] Color Bars (neutral; 0:08m), When Harry met Sally (amusement; 2:35m), The silence of the lambs (fear; 3:29m), Sea of love (surprise; 0:09m), Cry Freedom (anger; 2:36m), The Champ (sadness; 2:51m), Pink Flamingos (disgust; 0:30m)
[14] Indiana Jones (Anxiety/disgust; 9m) and Peanuts cartoon (Joy; 9m)
[15] 9 minute talk with a confederate of the experimenters.
[16] Chinatown/Marathon Man (negative), The Godfather (negative), Bill Cosby: Himself (positive), Alt Baba Bunny (positive), all films had a length between 2:47m and 3:32m.
[17] Groups did not differ in voluntary facial movement or subjective ratings of happiness and disgust. Patients with depression did not differ in negative emotional expression from a group of patients with non-blunted schizophrenia, but showed less positive emotions these patients.
[18] Positive (happiness and contentment), negative (sadness and disgust) and neutral IAPS pictures, 16/category.
[19] Depressed patients rated positive pictures as less pleasant and less arousing than the HC group, groups did not differ in their rating of negative pictures. Neutral slides did not elicit notable facial expressions.
[20] Landscape (neutral; 3m), airplane turbulence (fear; 2:20m),. boy mourning father (sadness, 2:50m), slapstick comedy (amusement; 2m).
[21] Depressed patients reported more sadness and less amusement during neutral and amusing films, but there were no differences for the fear or sadness films.
[22] Two sad (one human; 3:35m, one animal; 2m), two amusing film clips (one human; 4:07m, one animal; 1:12m), neutral (colour sticks; 1m)
[23] Groups did not differ significantly in self-report of emotional experience.

[24] Landscape (neutral; 3m), airplane turbulence (fear; 2:20m), boy mourning father (sadness, 2:50m), boy with family (happiness; 3:57m). The study also used idiographic stimuli, but for comparability here only data to these normative clips is reported.
[25] Reported is the difference score of change between neutral and emotional pictures. The DPN group reported less happiness and more sadness in response to all stimuli than the HC and RecDPN groups.
[26] Cry Freedom (negative), French Kiss (positive).
[27] Depressed patients did not differ significantly in facial expression of negative and positive emotion from patients with BPD (63% also had a comorbid depression). Medication status had no effect on the outcome.
[28] Natural scenery (neutral; 3m), The Champ (sadness; 2:50m), Mr. Bean (amusement; 2m), shown in this order.
[29] EA depressed patients reported significantly less sadness to the negative film than HC, AA depressed patients did not differ from HC. There were no group differences in the subjective ratings of the positive film clip. Medication did not have any effect on emotional reactivity for either of the groups.
[30] Color Bars (neutral; 1:30m), When Harry met Sally (amusement; 2:35m), The Shining (fear; 1:22m), Capricorn One (surprise; 0:49m), Cry Freedom (anger; 2:36m), The Champ (sadness; 2:51m), Pink Flamingos (disgust; 0:30m), Roberto Benigni and Massimo (amusement; 1:30m).
[31] Facial expression values are not reported separately for positive and negative emotions. Patients with BD showed significantly more congruent emotion expressions than schizophrenia patients. BD patients had significantly lower values than HC on a subjective measure of emotions.
[32] 32 IAPS pictures of food. The pictures were preceded by subliminal emotional and neutral face primes, results shown are based on the main effects of group regarding facial expression. Participants were tested in a hungry and in a satiated state, results show main effects of facial expression.
[33] AN patients reported significantly less hedonic liking in response to food pictures than HC in both states and lower wanting in the hunger state. For emotional primes, only fear induced more corrugator activity in AN compared to HC (in the hunger state only), for zygomaticus activity, smiles and negative expression there was no priming effect.
[34] 6 food and 6 object pictures matched for hedonic rating. There were no differences between AN patients and HC in the subjective rating of the pictures.
[35] Participants were tested once in a hungry state and once in a satiated state, the table shows main effects. There was an interaction effect for food pictures in corrugator activity in that patients had higher activity than HC during the hungry state only. Also, for the time window between 400 and 600ms post stimulus, AN patients had less corrugator activity for picture stimuli.
[36] Four Weddings and A Funeral (amusement; 2m), Shadowlands (sadness; 2m), waves (neutral; 2m).
[37] AN patients looked away significantly more often than HC during the negative film, for the positive film there was no difference in frequency of looking away. AN patients reported significantly less positive affect in response to the positive film clip than HC, groups did not differ for ratings of the negative film clip.
[38] Playmancer video game designed to train emotion regulation, set on an island and consisting of three mini-games including different challenges. Emotions are coded during the game, but the stimulus valence is not clearly assignable to the coded expressions.
[39] AN and BN patients did not differ significantly, but AN patients tended to express less. BN patients self-reported significantly more state anger than HC, there were no differences in anger between HC and AN.
[40] One part of the patients of the AN group was included in Davies (2011).
[3941] During the negative film AN patients looked away significantly more often than HC and RecAN (which did not differ), for the positive film there was no difference in frequency of looking away. AN patients reported significantly less positive affect in response to the positive film clip than HC, RecAN did not differ significantly from neither of both groups, groups did not differ for ratings of the negative film clip.
[42] The Bare Necessities from the Jungle Book (amusement), The Death of Mufasa from Lion King (sadness), ocean waves (neutral).
[43] Groups did not differ in subjective ratings of positive and negative effect in response to the according film clips.
[44]One part of the patients of the BN and of the HC groups was included in Claes (2012).
[45] BN patients self-reported significantly more state anger than HC and than RecBN, RecBN reported more anger than HC.
[46] Four film clips (1m each) showing infants displaying discrete emotions: happiness, sadness, anger and neutrality.
[47] AN and BN groups did not differ significantly on the main outcome measures, wherefore they were pooled into one ED group. Groups did not differ in frequency of looking away. AN patients reported more negative emotions in response to sad film clips, groups did not differ in subjective emotion ratings of the other film clips.
[48] Same sample as included in Cardi (2014)
[49] Four film clips (1m each) showing adults displaying discrete emotions: happiness, sadness, anger and neutrality.

[50] AN and BN groups did not differ significantly on the main outcome measures, wherefore they were pooled into one ED group. Participants with ED looked away more frequently than HC in response to both of the films. Groups did not differ in subjective ratings of positive and negative emotions experienced during the film clips.
[51] Waves (neutral; 0:30m), Four Weddings and A Funeral (amusement; 2m).
[52] Groups did not differ in subjective ratings of positive mood in response to the positive film clip. AN patients had significantly lower values than BN in duration and intensity of duchenne smiles and in intensity (but not duration) of non-duchenne smiles.
[53] AN patients looked away significantly more often than HC during the negative film, for the positive film there was no difference in frequency of looking away. AN patients reported significantly more negative emotions during the negative and the positive film clip than HC, groups did not differ for ratings of the positive film clip.
[54] Positive, negative and neutral IAPS pictures, 8/category.
[55] The outcome is measured as corrugator activity change from neutral to unpleasant pictures. BPD patients did not differ from a group of psychopaths in negative stimulus evoked corrugator activity. Groups did not differ in self-report ratings of valence and arousal in response to the pictures.
[56] Participants facial expressions were observed when playing Cyberball, a virtual ball-tossing game that reliably induces social exclusion.
[57] Compared to HC and to an objective measure, BPD patients felt more excluded while playing the game, they also reported more self-focused negative and less positive emotions (independent from playing) and more increase in other focused negative emotions after being excluded. Depression and medication did not significantly change outcomes.
[58] NimStim Face Stimulus set: 5 male and 5 female faces depicting happiness, sadness, anger, surprise, disgust, fear, 10/category morphed into dynamic facial expressions.
[59] BPD patients did not differ from HC in recognition of facial expressions, nor on subjective intensity ratings of the pictures.
[60] Pictures depicting angry and happy facial expressions, 8/category.
[61] Results are not reported separately for positive and negative stimuli. Groups did not differ in voluntary mimicry of facial expressions.
[62] Student talking about his adventures (amusement; 5m).
[63] Groups did not differ in voluntary mimicry of facial expressions. Facial expression during the video correlated with reported emotion experience in HC, but not in ASD.
[64] Four videotaped stories told by "Safari Bob", depicting happy, fearful, angry and positive surprise emotions (0:25-0:32m).
[65] Results were not reported separately for positive and negative emotions.
[66] Positive, negative and neutral IAPS pictures, 18/category.
[67] Groups did not differ in subjective ratings of valence and arousal in response to the pictures.
[68] Actors depicting sentences in angry, fearful, or happy valence, 8/category (0.9-2s).
[69] Groups did not differ in an emotion recognition task.
[70] Male and female faces displaying facial expressions, dynamic (evolving from neutral to angry and neutral to happy expressions) vs. static (1.5s).
[71] Results for FACS and FACES coding were comparable, effect sizes are shown for FACES data since it seemed to be the more conservative measure. Groups did not differ in voluntary mimicry of facial expressions.
[72] Boys and girls in everyday situations creating sadness, anger and happiness, 2/category (2:04m-2:37m).
[73] Medication had a significant effect on the outcome and was therefore entered as covariate. Groups did not differ in an emotion recognition task. The high CU group reported less empathy in response to the films than the low CU and the HC groups, which did not differ. DBD groups did not differ in facial expressivity.