Changing mothers' perception of infant emotion:
A pilot study

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Abstract

Cognitive Bias Modification (CBM) techniques, which experimentally retrain abnormal processing of affective stimuli, are becoming established for various psychiatric disorders. Such techniques have not yet been applied to maternal processing of infant emotion, which is affected by various psychiatric disorders.

Materials and Methods

In a preliminary study, mothers of children under 3 years old (n = 32) were recruited and randomly allocated to one of three training exercises, aiming either to increase or decrease their threshold of perceiving distress in a morphed continuum of 15 infant facial images. Differences between pre- and post- training threshold were analysed between and within subjects.

Results

Compared to baseline thresholds, the threshold for perceiving infant distress decreased in the lowered threshold group (mean difference -1.7 95% confidence intervals (CI) -3.1, -0.3 p=0.02), increased in the raised threshold group (1.3, 95% CI 0.6, 2.1 p<0.01), and was unchanged in the control group (0.1, 95% CI -0.8, 1.1 p=0.80). Between group differences were similarly robust in regression models, and were not attenuated by potential confounders.

Conclusions

The findings suggest that it is possible to change the threshold at which mothers perceive ambiguous infant faces as distressed, either to increase or decrease sensitivity to distress. This small study was intended to provide proof of concept (i.e. that it is possible to alter a mother's perception of infant distress.) Questions remain as to whether the effects persist, have an impact on maternal behaviour, and could be used in at-risk samples to improve maternal and child outcomes.

Key Words

Cognitive Bias Modification, Maternal Depression, Maternal Responsiveness

Key Points:

- Maternal mental illness is associated with altered maternal sensitivity to infant distress.
- Altered maternal sensitivity may mediate the association between mental illness and adverse child outcomes.
- Maternal sensitivity does not improve following recovery from psychiatric disorder such as postpartum depression.

- This study shows that Cognitive Bias Modification techniques can alter the threshold for perceiving infant distress– both decreasing and increasing sensitivity to infant distress.
- Such techniques may be a novel way of altering maternal sensitivity to improve maternal-child relationships and child outcomes.
- Potential clinical applications include perinatal depression, schizophrenia and autism, but further research is needed.

Introduction

Maternal responses to infant distress are a fundamental part of the mother-infant relationship (Bell and Ainswort.Md 1972). Maternal responsiveness, characterised by prompt and appropriate responses to infant signals (Bohlin et al. 1989), is positively associated with cognitive, emotional and behavioural child outcomes. (Leerkes and Burney 2007; Pearson et al. 2011) Understanding the cognitive processes underpinning maternal responsiveness may help to develop strategies for improving maternal responses in mothers who have difficulties interacting with their infants.

Sensitive maternal responses to infant distress are likely to be facilitated by adaptive neurocognitive processing of infant emotion. (Pearson et al. 2010; Strathearn et al. 2009)Altered neurocognitive processing of infant emotion has been identified in various psychiatric conditions, and may have implications for maternal sensitivity in mothers affected by these conditions. In mothers with depression, studies suggest that depressed mother's interpret infant emotion differently to non-depressed mothers. Stein and colleagues (Stein et al. 2010) showed that depressed mothers judged distressed infant faces more negatively than non-depressed mothers. Arteche and colleagues (Arteche et al. 2011) showed that depressed mothers were less sensitive towards happy infant faces. The attentional bias towards distressed infant faces that is seen in non-depressed mothers during pregnancy also appears to be reduced in depression. (Pearson et al. 2010)However, measurement of autonomic activity, including blood pressure responses to distressed infant faces (Pearson et al. 2012), suggests that depressed women may actually be more sensitive to this stimulus, but actively disengage. This hypothesis is supported by behavioural studies, in which depressed mothers appear to actively avoid infant distress during observed mother-infant interactions. (Field 2010; Murray and Cooper 1996) It is possible that depressed mothers disengage from distressed infant faces to avoid their own emotional reaction to such stimuli. This explanation is supported by neuroimaging studies, which suggests that less sensitive and more depressed mothers have a blunted neural response towards infant distress in reward/motivation areas, (Swain et al. 2007)and increased activation in neural structures involved in negative affect (Strathearn, Fonagy, Amico, & Montague, 2009; Laurent & Ablow, 2012). Evidence from outside of the perinatal period also suggests that depression is associated with cognitive biases towards negative emotion (Mathews and MacLeod 2005) and increased neural responses to negative emotion in the amygdala and anterior cingulate. (Drevets 2003)

Other psychiatric conditions such as autism and schizophrenia have also been associated with reduced maternal sensitivity. (Riordan et al. 1999; Wan et al. 2007) Although specific imaging studies in mothers with these conditions are lacking, some of the clinical features of these conditions- such as reduced empathy and processing of emotion- may explain the difficulties reported in mother-infant interactions in observational studies of affected women. (Hadjikhani et al. 2006; Riordan et al. 1999; Wan et al. 2007) Indeed, fMRI studies of autism (Hadjikhani et al. 2006) outside of pregnancy show reduced neural activity in regions overlapping with those for maternal sensitivity, such as the cingulate and insular cortices. (Bernhardt and Singer 2012; Hadjikhani et al. 2006)

Although maternal sensitivity appears to be affected in several psychiatric disorders, studies suggest that treatment of the underlying mental illness often does not improve mother-infant interactions or child outcomes. (Forman DR 2007; Murray et al. 2003; Wan et al. 2008) As maternal sensitivity is thought to mediate the association between maternal mental health and poor child outcomes (Leerkes and Burney 2007; Pearson et al. 2013); Pearson et al. (2011)., interventions directed at improving maternal sensitivity are vital for reducing the inter-generational transmission of mental illness. (Wan et al. 2008) There is some evidence that interventions directly tackling maternal sensitivity do improve mother-infant interactions (Stein et al. 2014). However, such interventions can be costly and time-intensive for mothers and health care providers.

Cognitive Bias Modification (CBM) techniques, which experimentally retrain abnormal processing of affective stimuli, are becoming established for various psychiatric disorders. An increasing evidence base suggests that it is possible to modify individual's perception of emotional stimuli, using CBM techniques (Hallion and Ruscio 2011; Penton-Voak et al. 2012). For example, the threshold at which an individual categorises a face of an ambiguous emotion (along a continuum of morphed faces ranging from happy to sad) can be modified by providing feedback based on their baseline threshold. If subjects are repeatedly informed that the ambiguous stimuli they judge as negative is in fact positive, their threshold for perceiving negative emotion can be increased. Penton-Voak and colleages (2012) have used CBM techniques to raise the threshold at which depressed subjects perceived (adult) faces as sad, (Penton-Voak et al. 2012) and the threshold for detecting anger in a group of adolescents at risk of anti-social behaviour (Penton-Voak et al. 2013).

To our knowledge, CBM has not yet been applied to maternal processing of infant emotion. If CBM proves to be successful in recalibrating maternal sensitivity to infant distress, this could have therapeutic potential for use in a range of psychiatric conditions, as well as in mentally well mothers who struggle to interpret an appropriate response to their infant cues. Examples of potential applications might be to increase maternal sensitivity in mothers with an abnormally high threshold for perceiving infant distress, such as those with autistic traits or schizophrenia with reduced social cognition. Conversely, it could be used in depressed mothers with a negative emotional bias to increase tolerance to infant distress, in order to facilitate engagement with interaction rather than avoidance.

In the current study we applied this technique to mothers' perception of infant faces in order to investigate whether it is possible to change the threshold at which mothers perceive an ambiguous infant face as distressed. If this is possible it could, in the future, be used to facilitate more positive interactions with infant distress where this is disrupted by maternal mental illness.

Materials and Methods

Participants

Mothers were recruited from the University of Bristol School of Social and Community Medicine staff email lists, including those who were currently on maternity leave. Participants were eligible if they a child under 3 years, and were not undergoing any treatment for a psychiatric condition. All participants gave informed consent to take part. Testing took place either in a private room at The University of Bristol, or at the participant's own home. Participants were randomly assigned through computer generated block randomization to one of three groups: either to raise their threshold of perceiving infant distress (increase tolerance), to lower their threshold (increase sensitivity) or to remain the same (control group). As a double blind randomised design, both participant and experimenter were blinded to group allocation. Prior to testing, the participants completed a questionnaire to elicit social demographic information, and the Beck Depression Inventory (Beck et al. 1996) to measure symptoms of depression.

Ethics

All participants were treated in accordance to the British Psychological Society ethics guidelines. Ethics approval for the study was obtained from the University of Bristol Faculty of Science Ethics Committee. Participants gave written informed consent prior to undertaking the experiment, and confirmed their ongoing consent to use their data by counter signing following completion. They were then given a debriefing form that explained the aims of the study and were given a chance to ask any questions.

Stimuli

Prototypical happy and distressed composite images were generated using established techniques (Tiddeman et al. 2001) from 10 individual baby images faces showing a happy facial expression, and 10 babies showing a distressed expression. The original image database and methods are described in further detail by Kringelbach et al (Kringelbach et al. 2008). These prototypical composite images were used as endpoints to generate a linear morph sequence that consisted of images that changed incrementally from unambiguously happy to unambiguously sad, with emotionally ambiguous images in the middle. We created a sequence with 15 equally spaced images for use as experimental stimuli (see figure 1).

Procedures

Each session consisted of three phases: Baseline, Train and Test. The baseline and test phases consisted of 45 trials, in which each of the stimuli from the morph sequence was presented three times. Images were presented, in random order, for 150 ms, preceded by a fixation cross (1500-2500 ms, randomly jittered). Stimulus presentation was followed by a mask of visual noise (150 ms), and then a prompt asking the participant to respond (a judgement of happy or sad).

Within participants, classification responses to morph continua tend to shift monotonically from one expression response to the other across the continuum presented (Young et al. 1997). Therefore, a simple estimate of the balance points pre- and post-training can be derived by counting the number of happy responses as a proportion of the total number of trials.

Each trial in the training phase was similar to a trial in the baseline and test phases with respect to inter-trial interval and stimuli presentation, but with the addition of feedback subsequent to the participant's response. In the control condition, feedback was based on the participant's baseline balance point. Responses were classified as 'correct' if the participant identified images below the original balance point image as happy, and above it as sad, and otherwise were classified as 'incorrect'. Feedback was a message saying 'Correct / Incorrect! That face was happy / distressed'. In the raised threshold condition, feedback was again based on the participant's baseline balance point, but the 'correct' classification was shifted two morph steps towards the distressed end of the continuum, so that the two images nearest the balance point that the participant would previously have classified as sad at baseline were considered happy when providing feedback. Conversely, in the lowered threshold condition, the 'correct' classification was shifted 2 morphed steps towards the happy end of the continuum, so that the two images nearest to the participant's baseline threshold that they would have previously considered happy, were considered as distressed when providing feedback. The structure of the training blocks was designed to present more training trials with ambiguous expression, than unambiguous expression. Thus, images 1-2 (unambiguously happy) and 14-15 (unambiguously sad) were presented once in each training block, images 3-5 and 11-13 were presented twice in each training block, and images 6-10 were presented three times in each training block, giving 31 trials per training block in total. Participants completed six blocks.

Statistical Analysis

Analysis was undertaken using STATA 13.

The change in threshold for detecting distress was compared within-subjects over time and between groups according to condition. Between group comparison used a linear regression model specifying the group allocation as a categorical variable. Subsequent analysis specified BDI score, maternal age, socioeconomic status and baseline threshold as confounding variables. We also used regression analysis to see whether a mother's baseline threshold for perceiving distress was associated with depressive symptoms on the BDI. The within-subject comparison used paired means tests to investigate before and after thresholds for each subject. The study was explorative at this stage and inferential statistics should be interpreted cautiously. However, to give an indication of statistical power , we calculated that we had 80% power to detect a minimum within-subject standardised difference of 0.6 (approximately corresponding to a 1.2 frame shift or larger).

Results

Demographic Variables

Participant characteristics are summarised in Table 1. A total of 32 mothers were recruited to the study, ages ranging from 23-41 years (median age 34 years). Computer registration of results failed for 4 of the participants, leaving 28 women with complete data for analysis. All of the participants were of European ancestry, and by nature of the selection process a large proportion of the sample population were from higher socioeconomic positions. Although participants were randomly assigned to groups, there were some chance differences between characteristics of the group participants. The participants in the increased threshold group were younger than control and lowered threshold groups, and also were from lower socioeconomic class. The median BDI score was similar between groups.

Baseline and Post Threshold Training

The mean baseline threshold for perceiving distress was frame 7 (s.d. 1.9) and was similar between groups, (see Table 2).

Within-subject changes in each group

The change in perception of infant distress within each group was in the expected direction: increasing in the raised threshold group (1.3 frames (95% CI 0.6, 2.1) $p<0.01$), decreasing in the lowered threshold group (-1.7 frames (95% CI -3.1, -0.3) $p=0.02$) and was unchanged in the control group (0.1 frames (95% CI -0.8, 1.1) $p=0.80$).

Between subject difference in change

Table 3 shows the results for the linear regression models. Compared to controls, the threshold for perceiving infant distress decreased in the lowered threshold group both before (-1.8, 95% CI –0.2,-3.4 $p=0.03$), and after adjusting for potential confounders (-2.1, 95% CI-0.6,-3.7 $p=0.01$). Conversely, the threshold increased in the raised threshold group (1.2, 95% CI 0.1 to 2.4, $p=0.04$), and (1.6, 95% CI 3.3, 0.02 $p=0.05$) after adjustment.

We did not find any association between depressive symptoms and baseline threshold for perceiving distress (p=0.71), or change in threshold (p=0.71) in this group.

Discussion and Conclusion

The findings from this study suggest that it is possible to modify maternal perception of infant emotion either to or decrease the threshold for perceiving infant distress. Strengths of this study include the novelty of this concept, the double-blind randomised design, and its timeliness in the literature given the increasing public awareness of the importance of maternal mental illness (Howard et al. 2014a; Howard et al. 2014b; Stein et al. 2014). Although evidence suggests that interventions to directly target maternal sensitivity are required, alongside those to reduce maternal mental illness, the evidence base in this area is limited to intensive psycho-education programmes, which may not be accessible or desirable for many at-risk mothers. Once more developed, using cognitive bias modification techniques to improve maternal sensitivity may provide a cheaper and more accessible alternative.

As this was a small study in healthy volunteers, further research is required to confirm the findings in larger samples, including in mothers with mental illness. Previous studies using CBM have suggested that the change in perception is temporary, and return to the baseline occurs within a short period of time. Further research should therefore establish how frequently the task would need to be repeated if a therapeutic intervention were to be considered.

Our data did not support previous literature suggesting that depressive symptoms affected the perception of infant distress; however, the sample size was small, and depressive symptoms were of low prevalence and severity among the participants. The small sample size also resulted in some differences between baseline group characteristics. Despite these differences, the training had the intended effect on thresholds to perceive infant distress, suggesting the effectiveness of the training was unlikely to have been impacted by these differences. Furthermore, the association was maintained when these characteristics when included in the regression analysis as confounding factors. A further limitation is that the participants were recruited from University staff, meaning the sample is not representative of mothers in the general population. However, the aim of the current study was to provide proof of principle (i.e. that it is possible to transiently change mothers' perceptions of infant distress). Future studies are needed to address the feasibility of this approach to wider populations of mothers, including those with mental illness.

One important aspect of future research would be to establish whether the change in perception induced by the CBM training translates into meaningful changes in maternal behaviour towards their own infants, or to improvements in maternal-child relationship, depressive symptoms or perceived stress. We hypothesize that reducing the threshold at which an infant is perceived to be distressed may facilitate positive interactions in mothers who struggle with empathic interactions, which may in turn increase the satisfaction with their relationship. Conversely, mothers with overly sensitive responses to infant distress may benefit from increasing the threshold for these distress signals. In these mothers, increasing the threshold for perceiving distress may prevent them from becoming overwhelmed by frequent perceived low-level distress (which may actually be misinterpreted ambiguous emotion.) Reducing the frequent perception of low level distress or misinterpreted ambiguous emotion, may release some emotional capacity to provide appropriate infant interactions when necessary - thus facilitating engagement rather than avoidance when the infant is distressed.

Another important area for future research is whether there are any adverse effects mothers undergoing more intense and enduring forms of CBM. Maternal responses to infant distress have slowly evolved over millennia, and adaptation of these cognitive biases may have unintended consequences. Potential adverse effects should be carefully considered and evaluated, and suitable subgroups selected to minimise any potential harms.

Although it is too soon to establish whether CBM training is suitable for use as intervention in mothers with mental illness, it may be a valuable tool for future research into maternal perception of emotion in mental illness, and whether changing maternal perception of emotion effects the maternal-child relationship, or maternal stress levels. Further research is needed to develop CBM and its potential use in the perinatal period.

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Figures

Table 1

Characteristics of Participants

	Lowered threshold	Control group	Raised threshold
N, (%)	10 (31%)	12 (38%)	10 (31%)
Age, years (range)	35.3 (30-41)	34.3 (28-41)	31.7 (23-37)
Socioeconomic Status, n (%)			
1 (highest)	8 (67%)	7 (70%)	1 (10%)
2	2 (16.5%)	3 (30%)	4 (40%)
3	2 (16.5%)	0 (0%)	4 (40%)
4 (lowest)	0 (0%)	0 (0%)	1 (10%)

Median BDI (IQR)	6.5 (4-10)	7 (5-8)	7 (2-10)

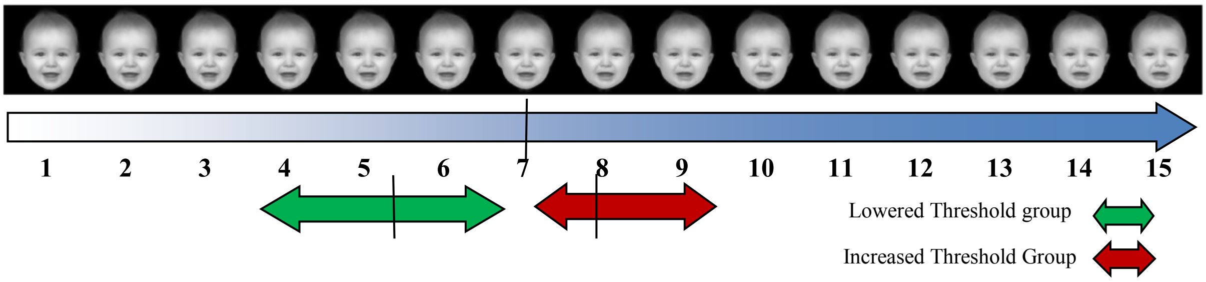
Table 2: Within subject comparison of thresholds for perceiving infant distress pre- and post- training

Group	**N**	**Baseline (s.d.)**	**Post-training**	**Change**
Lowered threshold	10	7.0 (2.1)	5.3 (1.6)	-1.7 (95% CI -3.1, -0.3) p=0.02
Control	9	7.4 (1.6)	7.5 (2.4)	0.1 (95% CI -0.8, 1.1) p=0.80
Raised threshold	9	6.6 (1.9)	7.9 (1.5)	1.3 (95% CI 0.6, 2.1) p<0.01

Table 3: Between subject comparison of thresholds for perceiving infant distress pre- and post- training compared to the control group using linear regression, before and after adjusting for potential confounding factors

Group	**Difference between Pre-and Post- training threshold** (95% confidence intervals and p-value)	
	Unadjusted	Adjusted for maternal age, socioeconomic status, baseline threshold and BDI
Lowered threshold	-1.8 (-0.2, -3.4), p=0.03	-2.1 (95% CI -0.6,-3.7) p=0.01
Raised threshold	1.2 (0.1, 2.4), p=0.04	1.6 (95% CI 3.3, 0.02) p=0.05

Figure 1:Morphed facial images showing continuum gradually increasing distress from frame 1 (happy) to frame 15 (distressed). Baseline threshold shown in upper image, with the shift in perception of distress each group shown below.



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