Looking on the bright side reduces worry in pregnancy: training interpretations in pregnant women

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Looking on the bright side reduces worry in pregnancy: training interpretations in pregnant women

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**RUNNING HEAD:** TRAINING POSITIVE INTERPRETATIONS IN PREGNANT WORRIERS

**Keywords:** perinatal mental health, worry, interpretation bias, cognitive bias mediation (CBM), pregnancy, anxiety

**Highlights**
- Modification of interpretation bias in pregnant women with high levels of worry was examined.
- Participants received interpretation bias training or an active control condition.
- Training led to less negative interpretations and fewer negative thought intrusions.
- Modifying negative interpretation bias in pregnant women may have clinical utility.

**Statement of conclusions**
Computerised training to reduce negative interpretation during pregnancy is effective. This paves the way for longer-term interventions to reduce anxiety and worry in pregnant women.
Abstract

Background
Recent evidence suggests that anxiety is more common than depression in the perinatal period, however there are few interventions available to treat perinatal anxiety. Targeting specific processes that maintain anxiety, such as worry, may be one potentially promising way to reduce anxiety in this period. Given evidence that negative interpretation bias maintains worry, we tested whether interpretation bias could be modified, and whether this in turn would lead to less negative thought (i.e., worry) intrusions, in pregnant women with high levels of worry.

Method
Participants (N = 47, at least 16 weeks gestation) were randomly assigned to either an interpretation modification condition (CBM-I) which involved training in accessing positive meanings of emotionally ambiguous scenarios, or an active control condition in which the scenarios remained ambiguous and unresolved.

Results
Relative to the control condition, participants in the CBM-I condition generated significantly more positive interpretations and experienced significantly less negative thought intrusions.

Conclusions
Our findings indicate that worry is a modifiable risk factor during pregnancy, and that it is possible to induce a positive interpretation bias in pregnant women experiencing high levels of worry. Although preliminary, our findings speak to exciting clinical possibilities for the treatment of worry and the prevention of perinatal anxiety.
Introduction

The perinatal period, the time from conception to 12 months post birth (Austin, Highet, & Expert Working Group, 2017), is a time of significant change and adjustment. It often brings new pressures and stressors which, combined with hormonal fluctuations, can leave women vulnerable to mental health problems. Women are at a higher risk of developing a serious mental illness during the first month postpartum than at any other point in their lives (Stewart et al., 2003), and are also at risk for relapse or recurrence of a pre-existing mental health problem. Perinatal mental health problems are associated with negative outcomes for both mother and baby; for example, poor foetal development (DiPietro et al., 2002), low birth weight (Hedegaard et al., 1993), and greater risk of behavioural, psychological and developmental problems (Stein et al., 2014; O’Connor et al., 2002).

Until relatively recently, most research on perinatal mental health has focused on postnatal depression, with other conditions overlooked (Goodman, Watson & Stubbs, 2016; Howard et al., 2014). In particular, perinatal anxiety has tended to be ignored in favour of depression, despite evidence that anxiety disorders are more prevalent than depression in pregnancy and postpartum (Fairbrother et al., 2016). This is particularly the case in the treatment outcome literature. In a recent systematic review, Loughnan et al. (2018) identified only one randomised controlled trial evaluating a treatment for perinatal anxiety. With prevalence rates of up to 8.5% (Goodman et al., 2016), and in light of evidence that maternal prenatal anxiety is associated with a twofold increase in the risk of a child developing psychological disorders (O’Donnell et al., 2014), there is a clear need to develop effective, evidence-based approaches to treat perinatal anxiety.

One promising approach may be to target modifiable psychological processes that maintain anxiety symptoms and their consequences, such as repetitive negative thinking (RNT). RNT refers to types of thinking which are pathological, perseverative and difficult to
control (Samtani & Moulds, 2017); for example, worry and rumination. Worry is a form of RNT that is predominantly verbal, difficult to control and involves entertaining potential negative outcomes for future situations (Borkovec 1994; Hayes et al., 2010). Rumination is another form of RNT, and primarily involves focusing on events in the past, as well as one’s perceived personal inadequacies, current mood/symptoms and their causes and consequences (Nolen-Hoeksema, 1991; Hirsch et al. 2020). Both of these forms of RNT are experienced as unwanted negative intrusive thoughts that come to mind unbidden, and capture attention such that it is difficult to shift focus away from the thought. Worry is a form of RNT that is predominantly verbal, difficult to control and involves entertaining potential negative outcomes for future situations (Borkovec 1994; Hayes et al., 2010). Moulds et al. (2018) proposed that RNT could be an important factor to target in interventions to improve perinatal distress. In keeping with this, a recent study of pregnant women (Hirsch, Meeten et al., 2020) demonstrated that worry and RNT more generally was associated with increased levels of perinatal anxiety and depression. The predictive role of worry in the development and maintenance of anxiety is well-established, and recent research has indicated that this may similarly apply in the perinatal context. For example, Schmidt et al. (2016) reported that levels of worry in the first four months of pregnancy predicted anxiety and depression symptoms in the third trimester.

One key cognitive process proposed to contribute to pathological worry is negative interpretation bias: the transdiagnostic tendency to perceive ambiguous information or events as threatening or negative (Hirsch & Mathews, 2012; Hirsch et al., 2016). Krahé et al. (2019) found that greater levels of negative interpretation were associated with increased worry. Similarly, Hirsch, Meeten et al. (2020) demonstrated that higher levels of both worry and anxiety in pregnant women are associated with more negative interpretation bias. These findings speak to the clinically related possibility that modifying interpretation bias may
reduce worry. One experimental methodology that has shown promise in this regard is cognitive bias modification for interpretation (CBM-I).

The goal of CBM-I is to facilitate consistent generation of positive interpretations of ambiguous information (where the interpretation could be positive or threatening) via repeated computerised practice. Specifically, participants listen to ambiguous scenarios, with ambiguity being resolved by the final word in a positive manner (e.g., ‘Your boss sends you an email asking you to call them so they can discuss your work with you. When you ring them, they tell you that you that your recent work has been excellent (terrible).’). In previous single session CBM-I studies, participants have been presented with up to 90 scenarios (e.g., Hirsch et al., 2009) disambiguated in a benign manner.

There is evidence that a single session of CBM-I can modify interpretation bias and in turn reduce worry in high worriers (Hirsch et al., 2009; Feng et al., 2020), as well as those with generalised anxiety disorder (GAD) (Hayes et al., 2010). In another GAD sample, Hirsch et al. (2018) demonstrated that multi-session positive CBM-I training (first session completed in the lab, remaining sessions online) resulted in a more positive interpretation bias and reduced worry and anxiety one month later compared to an active control condition. More recently, community participants with high levels of RNT (worry and/or rumination) completed an enhanced version of CBM-I in which participants were instructed to generate positive resolutions to ambiguous scenarios (rather than be presented with a positive resolution) for half of the scenarios, in order to aid generalisation and engagement. Participants were also instructed to generate positive images of the outcome for each scenario. This led to more positive interpretation bias, fewer negative interpretations, and lower levels of RNT, anxiety and depression, relative to a control condition in which ambiguity was unresolved and participants did not generate positive imagery (Hirsch, Krahé,
Whyte, Bridge, et al. (2020). These findings prompt the clinically interesting possibility that interpretation bias training can be adapted as a potential intervention for anxiety.

To determine whether CBM-I can help reduce worry and anxiety via a fully web-based platform which involved no face-to-face contact with researchers during assessment or training (or control sessions), we conducted a study with a sample of individuals with GAD with or without comorbid major depressive disorder (Hirsch, Krahé, Whyte, Krzyzanowski, et al., 2020). Training was highly effective at reducing negative interpretations over the intervention period compared to the control condition. Importantly, reductions in worry, rumination, anxiety and depression were evident at three-months follow-up. Furthermore, effects were mediated by changes in interpretation bias. These findings raise the possibility of CBM-I forming a low-intensity intervention for pregnant women at risk of escalating levels of anxiety or depression due to heightened RNT. As an online intervention, it could be completed at a location and time that are convenient for pregnant women, and thus has scope to be more readily integrated into daily life compared to traditional face-to-face interventions.

The possibility that CBM-I may have utility in facilitating a more positive interpretation bias in pregnant women who engage in high levels of worry remains untested.

Given that pregnant women who worry have a more negative interpretation bias (Hirsch, Meeten et al., 2020), and the proposal that targeting RNT, such as worry, in pregnancy may have the potential to prevent and treat postpartum anxiety (Moulds et al., 2018), testing whether CBM-I can shift interpretive bias in pregnant high worriers represents a logical first step. Accordingly, we recruited pregnant women with self-reported high levels of worry who were randomly allocated to either (i) CBM-I (i.e., interpretation training enhanced with positive imagery and self-generation) or (ii) control (no resolution of ambiguity nor positive imagery) conditions. We hypothesised that participants in the CBM-I condition would generate more positive interpretations and thus demonstrate a positive interpretation bias.
compared to those in the control condition. We also hypothesised that participants in the
CBM-I condition would experience fewer negative thought intrusions (indicative of worry)
during a behavioural worry task in which they were instructed to focus on their breathing,
relative to participants in the control condition.

Method

Study registration
The study was registered on Open Science Framework with number https://osf.io/ye84g/.

Participants
Forty-nine women with high levels of self-reported worry (scoring $\geq 56^1$ on the Penn
State Worry Questionnaire cf. Hayes, Hirsch, & Mathews, 2010) completed the study and 47
women completed useable data (see Table 1 for demographic information). Participants were
required to be sixteen or more weeks pregnant, fluent in English, with normal or corrected
vision and hearing, and have no history of either stillbirth or three or more miscarriages.
Participation involved attending a session in the lab, and participants were reimbursed £25
for taking part.

Individuals who expressed interest in the study were sent a screening questionnaire
via Qualtrics, an online data acquisition platform. One hundred and sixty three women
completed the screening questionnaire, of whom 64 did not meet the inclusion criteria.
Ninety nine respondents were eligible to take part in the study on the basis of their responses
and were invited via email to take part in the study. Sixty-three of these responded to the

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1 In a sample of individuals diagnosed with GAD, a PSWQ score of 56 was one standard
deviation below the mean (Molina & Borkovec, 1994) and is commonly used as a cut-off in
research (Feng et al. 2020; Hirsch, Perman et al. 2015). Accordingly, we classified
participants as high worriers if their PSWQ score was $\geq 56$. 

email and were offered a testing date. Of these, 49 participants completed the study, while 6 were found to be ineligible on the day of testing due to their score on Penn State Worry Questionnaire (Meyer et al., 1990; PSWQ) being below cut off, 7 withdrew before attending the testing session and one had the session cancelled due to the COVID-19 pandemic. Two participants’ data was not included in the study as their responses to the Recognition Test Comprehension Questions indicated they had either not understood or not engaged with the task. The final sample of 47 participants were aged between 22 and 42 years (M = 32.89, S.D = 4.69), and ranged between 16 and 39 weeks pregnant (M = 27.64, S.D = 6.82). Twelve participants had one child already, and two participants had two children. The other 35 participants were pregnant with their first child.

Table 1

|                | CBM-I   | Control | t(45) | p    |
|----------------|---------|---------|-------|------|
| **N**          | 23      | 24      |       |      |
| **Age**        | 33.35 (4.78) | 32.46 (4.65) | 0.65  | 0.52 |
| **Weeks of gestation** | 26.96 (7.10) | 28.29 (6.62) | 0.67  | 0.51 |
| **PSWQ**       | 64.30 (5.67) | 66.13 (5.66) | 1.10  | 0.28 |
| **RTQT**       | 39.70 (10.63) | 40.67 (7.01) | 0.37  | 0.71 |
| **PASS**       | 43.09 (15.83) | 47.54 (17.87) | 0.90  | 0.37 |
| **EDPS**       | 11.87 (3.55) | 14.21 (5.37) | 1.76  | 0.09 |
| **PHQ-9**      | 8.87 (3.88) | 11.00 (6.09) | 1.42  | 0.16 |
| **GAD-7**      | 8.52 (4.12) | 11.42 (5.36) | 2.07  | 0.04 |
| **RRS**        | 54.48 (13.30) | 52.63 (13.54) | 0.47  | 0.64 |
Note. CBM-I = cognitive bias modification for interpretation; Weeks of gestation = number of weeks pregnant at time of testing; PSWQ = Penn State Worry Questionnaire, RTQT = Trait Repetitive Thinking Questionnaire, PASS = Perinatal Anxiety Screening Scale, EPDS = Edinburgh Postnatal Depression Scale, GAD7 = Generalised Anxiety Disorder Questionnaire, PHQ9 = Patient Health Questionnaire, RRS = Ruminative Response Scale.

Sample size

An a-priori power calculation with an alpha of .05 and power of .80 was computed in GPower. The effect size was determined by a recent study examining the effects of interpretation bias manipulation on the Recognition Test (Feng et al., 2020). Projected sample size was 26 per condition. As we did not know whether pregnancy would influence the capacity to modify interpretation bias, we elected to increase the planned number of participants recruited per condition to 30. However, due to the COVID-19 pandemic in 2020, face-to-face testing was ultimately prohibited. Accordingly, we ceased recruitment and testing prematurely, after testing 49 participants. Of these, two participants were excluded on the basis of poor performance on the recognition test comprehension questions, resulting in final samples of $n = 23$ and $n = 24$ in the CBM-I and control conditions, respectively.

Measures & Materials

Questionnaires

Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990). The PSWQ consists of 16 statements related to worry (e.g., My worries overwhelm me) which are rated from 1 (not at all typical of me) to 5 (very typical of me). The PSWQ has high internal consistency (present sample Cronbach’s $\alpha = .70$), convergent and criterion validity (Hayes et al., 2010), and good test-retest reliability (Meyer et al., 1990).

Other standardised questionnaires. Perinatal anxiety was assessed using the Perinatal Anxiety Screening Scale (PASS; Somerville et al., 2014; Cronbach’s $\alpha = .94$ in current sample). Perinatal depression was assessed with the Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden, & Sagowsky, 1987: Cronbach’s $\alpha = .84$). General depressed mood was
assessed using the Patient Health Questionnaire 9 (PHQ-9, Kroenke & Spitzer, 2002; Cronbach’s α = .84) and general anxiety symptoms using the Generalized Anxiety Disorder 7-item scale (GAD-7; Spitzer et al., 2006; Cronbach’s α = .87). Trait RNT was assessed with the Repetitive Thinking Questionnaire (RTQ-T [trait]; McEvoy, Tribodeau, & Asmundson, 2014; Cronbach’s α = .90). Ruminative Response Scale (RRS; Nolen-Hoeksema & Morrow, 1991; Cronbach’s α = .93) was used to assess depressive rumination.

Tasks

Worry induction. Participants identified a current worry topic (related to their pregnancy or other aspects of their life) and were asked a series of questions to prime salient features. They were then instructed to silently worry about this topic as they normally would for five minutes.

Interpretation assessment task - Recognition Task (Hirsch et al., 2018; adapted from Mathews & Mackintosh, 2000). The first phase of this task requires participants to read a series of ambiguous scenarios. The last word of each scenario (which leaves the ambiguity unresolved) is presented as a word fragment, and participants are instructed to fill in the first missing letter of that word. Next, participants complete a comprehension question (yes/no) about the scenario (see Appendix A for example). In the second phase, participants are presented with a scenario title and four statements in random order, then indicate how similar each statement is to the meaning of the original scenario. The statements include one positive target (in keeping with the positive interpretation of the original scenario), one negative target, and one positive and one negative foil unrelated to the scenario meaning. Participants rate each statement on a scale from 1 (very different in meaning) to 4 (very similar in meaning). Interpretation bias is assessed by calculating a positivity index, which is calculated

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2 VAS mood ratings were also taken during the study, but were not available for analysis due to the university being closed because of COVID-19.
by subtracting the mean ratings for negative targets from the mean ratings for positive targets. Higher scores therefore indicate a more positive interpretation bias.

**Breathing Focus Task (Feng et al., 2020; adapted from Ruscio & Borkovec, 2004).**

In the version of the task employed in this study, participants first practiced the breathing focus task. Next, they were instructed to engage in worry about a current worry topic for five minutes, and then completed a five-minute breathing focus task. During this task, participants were instructed to focus on their breathing. They were given a series of prompts (i.e., 12 computerised tones) throughout the task; each time they heard a prompt, participants were asked to indicate if they were focusing on their breathing as instructed, or if their mind had wandered to another topic (i.e., they were experiencing a thought intrusion). If the latter, participants were asked to indicate the valence of the intrusion (i.e., positive, negative or neutral). Negative thought intrusions are interpreted to be indicative of worry, as per previous CBM-I studies (e.g., Feng et al., 2020).

**CBM-I condition**

**Imagery Practise Task - adapted from Holmes et al. (2006) and used in Hirsch et al. 2019; Feng, et al. 2020.** Participants in the CBM-I condition completed an online imagery practice task to help them generate vivid and positive mental images, and to instruct them on how to hold them in mind (see Feng et al., 2020).

**Cognitive Bias Modification for Interpretation (CBM-I).** CBM-I is an online, scenario-based task that requires participants to listen (over headphones) to 40 scenarios which present common worry-related situations that are initially emotionally ambiguous. Participants in the active condition were provided with a positive resolution (i.e. ending) of the ambiguous scenario for 20 trials, and instructed to generate their own positive resolution for the 20 remaining trials. Participants are instructed to use mental imagery to vividly picture the resolution. After each scenario, participants are presented with a ‘Yes/No’ comprehension
question, designed to emphasise the desired interpretation of the scenario. They then receive feedback (‘correct/incorrect’) on these answers. Participants then rate the positivity of the scenario, on a scale of 0 (‘not at all’) to 100 (‘extremely’) (see Appendix A for example).

**Control condition**

*Filler Task.* The Feng et al. (2019) filler task used to match the time taken to complete the imagery training in the CBM-I condition.

*Sham Training.* Similar to CBM-I training, participants listened to 50 ambiguous worry-related scenarios over headphones. An increased number of trials was required to match the duration of CBM-I training. In this condition ambiguity remained unresolved, and participants were not instructed to generate particular outcomes. Participants completed comprehension questions without feedback, thus allowing for either positive or negative interpretations without correction.

**Procedure**

Participants completed the PSWQ online within the 24 hours prior to the experimental testing session, to ensure that they still met study eligibility criteria. Before coming into the lab, participants were randomly allocated to the CBM-I or control condition on the basis of an allocation by an independent researcher. They then completed the study tasks associated with their allocated condition. See Figure 1. for an overview of the study procedure.

**Results**

*Questionnaire measures for CBM-I and Control conditions*

See Table 1 for means of questionnaire measures and statistics for participants included in the analysis. The only significant between-condition difference to emerge was for GAD-7; such that participants in the control condition reported higher anxiety. Importantly, however, we note that the conditions did not differ on the PASS, – i.e., a measure of perinatal
anxiety specifically (rather than a measure of general anxiety developed for non-pregnant populations).

**Assessing the impact of CBM-I on interpretation bias (Hypothesis 1)**

To examine the effect of condition on interpretation bias, we conducted a regression analysis with mean positivity index score as the dependent variable. Condition significantly predicted post-training positivity index score, \( b = 0.54, SE = 0.19, p = .007, 95\% \text{ CIs} [0.16, 0.92] \). The mean positivity index was higher for the CBM-I \((M = 0.35, SD = 0.64)\) than the control \((M = 0.19, SD = 0.65)\) condition, confirming that CBM-I was effective in facilitating a positive interpretation bias.

**Assessing the impact of CBM-I on negative thought intrusions (Hypothesis 2)**

To examine the effect of condition on negative thought intrusions, we conducted a bootstrapped (due to non-normality of data) regression analysis with number of negative thought intrusions from the breathing focus task as the dependent variable. Condition significantly predicted post-training positivity index score \( (b = -1.11, SE = .45, p = .02, 95\% \text{ CIs} [-1.96, -0.28]) \). Consistent with the hypothesis, participants in the CBM-I condition reported significantly fewer intrusions \((M = 1.50, SD = 1.01)\) than did those in the control condition \((M = 2.61, SD = 1.85)\).

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As GAD7 scores were significantly different at baseline we re-ran the regression analysis with mean centred GAD7 scores and an interaction variable of (mean centred) GAD7 and condition. Neither GAD7 scores \((p = .67)\) or the interaction term \((p = .54)\) were significant predictors in the model. Condition remained a significant predictor \((p = .02)\).
Figure 1  *Overview of study procedure*

1. Participants complete PSWQ

2. Paid £5 for no longer meeting study criteria

3. Random allocation to condition

4. 24 hours prior to testing

**Study begins**

| CBM-I | CONTROL |
|-------|---------|
| Imagery practice task | Filler task |

1. CBM-I practice task | Sham training task

2. Worry induction

3. First mood rating scale

4. CBM-I task | Sham training task

5. Second mood rating scale

6. Recognition task

7. CBM-I booster (10-trials) | Sham training booster

8. Breathing Focus Task

9. Debrief and payment
Discussion

In this first study of interpretation training in pregnant worriers, we successfully induced a positive interpretation bias using CBM-I. Consistent with Hirsch et al. (2009) and Feng et al. (2019), participants in the CBM-I condition reported fewer negative thought intrusions relative to the control condition, supporting a causal role for interpretation bias in maintaining worry in pregnant women. As the first study to employ CBM-I to test questions about interpretation bias and worry in pregnant women, our results extend the CBM literature in important ways. First, on a methodological note, they demonstrate the applicability and effectiveness of CBM-I in the perinatal context. Second, they confirm that interpretation bias maintains worry in pregnant women. Whilst this relationship is well-established in the broader literature (Hirsch et al., 2009; Feng et al., 2019; Hirsch, Krahé, Whyte, Bridge, et al., 2020), given the unique and multi-faceted circumstances and changes (e.g., biological, cognitive) which characterise the perinatal period, our results are theoretically important in confirming this link in a perinatal sample.

Third, by indicating that worry is a modifiable psychological risk factor in pregnancy, our findings have clinical promise. As noted earlier, the treatment of perinatal anxiety has received limited research attention. Further, the treatments that have been developed are primarily generic such that they are comprised of standard CBT techniques, including challenging cognitions by generating alternative interpretations (e.g., Forsell et al., 2017; see Moulds et al., 2018). In contrast, CBM-I seeks to enhance access to positive interpretations in a more direct, automatic way. Our findings suggest that developing novel approaches which draw on experimental findings and directly target factors have been identified to maintain anxiety (e.g., worry) to potentially supplement existing treatment approaches may be a promising future clinical direction.
Moreover, our findings speak to the issue of prevention. In light of growing evidence that antenatal RNT predicts perinatal mental health problems (de Jong et al., 2016; Schmidt et al., 2016), the prospect of reducing worry in pregnant women by targeting interpretation bias represents an exciting possibility for preventing postpartum anxiety. Topper et al. (2017) found that a preventive intervention which targeted RNT reduced the onset of depression and anxiety 12 months later. Our finding that antenatal worry is a modifiable risk factor similarly raises the possibility that an intervention targeting worry may also have utility in preventing subsequent mental health problems in the postnatal period.

We acknowledge some limitations and suggest future research directions. First, while single-session CBM experiments critically advance understanding of theoretical mechanisms, they do not provide sufficient evidence regarding the sustained consequences of targeting interpretation bias in this way (Hirsch et al., 2018). That said, we note that recent studies using multiple CBM-I sessions (e.g., 10 internet-delivered sessions) have reported encouraging preliminary evidence of the longevity of effects (i.e., improved mood, reductions in RNT at one-month follow-up; Hirsch et al., 2018; Hirsch, Krahé, Whyte, Bridge, et al. 2020). Future research which employs multiple sessions with an extended follow-up period is needed before conclusions can be drawn about potential clinical benefit and preventive utility in the perinatal context. Second, we did not gather detailed information about previous numbers of miscarriages or complications in participants’ current (or any previous) pregnancy, leaving it unknown whether our findings generalise to pregnant women who have experienced pregnancy loss or complications in participants’ current (or any previous) pregnancy.

Third, we did not assess interpretation bias or the presence of negative intrusions pre-training, and thus do not know whether groups differed at the outset. However, participants were randomised to condition by a researcher outside of the study team, making these
possible explanations for the results unlikely. Fourth, randomisation led to differences in anxiety (GAD-7) between groups. Finally, due to COVID-19 pandemic ruling out completion of data collection, the number of participants was slightly below that recommended in the original sample size calculation.

Our findings raise interesting possibilities for future research. In a recent fully web-based study, Hirsch, Krahé, Whyte, Krzyzanowski, et al. (2020) reported that CBM-I led to reductions in depression and anxiety, as well as worry and rumination, in participants with GAD with or without comorbid depression. The effects persisted to 3-month follow-up, and notably, were mediated by changes in interpretation bias. These results raise the exciting possibility that CBM-I could form a low intensity intervention to treat or prevent anxiety and worry, with potential for application in the perinatal context. Further, given evidence that CBM-I may be effective in modifying interpretation bias in the context of a range of mental health conditions (e.g., depression, Hirsch et al., 2018; eating disorders, Turton et al., 2018; social anxiety, Stevens et al., 2018), another potentially fruitful research direction could be to investigate the effectiveness of CBM-I for other perinatal psychological symptoms, beyond anxiety.

In sum, this study is the first to evaluate the effectiveness of single session CBM-I for reducing worry in pregnant women. Our findings provide empirical support for interpretive bias as a mechanism underlying antenatal worry, and thus indicate that worry is a modifiable risk factor during pregnancy. Future investigations with a broader sample warrant investigation (where the current sample were from South London and had not experienced three or more miscarriages) to determine if the findings generalise to a more heterogenous sample. Furthermore, future research with pregnant women diagnosed with GAD is needed to confirm that these results are generalisable to treatment-seeking, clinical samples. Nonetheless, given evidence that worry early in pregnancy predicts later anxiety, these data
represent an important first step in investigating whether CBM-I holds promise as a therapeutic approach to address perinatal mental health problems.
References

Austin, M.P., Highet, N. & Expert Working Group (2017). Mental health care in the perinatal period: Australian clinical practice guideline, *Melbourne: Centre of Perinatal Excellence.*

Borkovec, T. D. (1994). The nature, functions, and origins of worry. In G. C. L. Davey & F. Tallis (Eds.), *Worrying: Perspectives on Theory, Assessment and Treatment* (pp. 5-33). Oxford, England: John Wiley and Sons.

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of postnatal depression: development of the 10-item Edinburgh Postnatal Depression Scale. *The British Journal of Psychiatry, 150,* 782-786. [https://doi.org/10.1192/bjp.150.6.782](https://doi.org/10.1192/bjp.150.6.782)

de Boer, M. R., Waterlander, W. E., Kuijper, L. D., Steenhuis, I. H., & Twisk, J. W. (2015). Testing for baseline differences in randomized controlled trials: an unhealthy research behavior that is hard to eradicate. *International Journal of Behavioral Nutrition and Physical Activity, 12,* 4. [https://doi.org/10.1186/s12966-015-0162-z](https://doi.org/10.1186/s12966-015-0162-z)

DeJong, H., Fox, E., & Stein, A. (2016). Rumination and postnatal depression: A systematic review and a cognitive model. *Behaviour Research and Therapy, 82,* 38-49. [https://doi.org/10.1016/j.brat.2016.05.003](https://doi.org/10.1016/j.brat.2016.05.003)

DiPietro, J.A., Hilton, S.C., Hawkins, M., Costigan, K.A. & Pressman, E.K. (2002). Maternal
stress and affect influence foetal neurobehavioral development. *Developmental Psychology, 38*, 659-668. https://doi.org/10.1037/0012-1649.38.5.659

Fairbrother, N., Janssen, P., Antony, M. M., Tucker, E., & Young, A. H. (2016). Perinatal anxiety disorder prevalence and incidence. *Journal of Affective Disorders, 200*, 148-155. https://doi.org/10.1016/j.jad.2015.12.082

Feng, Y. C., Krahé, C., Sumich, A., Meeten, F., Lau, J. Y., & Hirsch, C. R. (2019). Using event-related potential and behavioural evidence to understand interpretation bias in relation to worry. *Biological Psychology, 148*, 107746. https://doi.org/10.1016/j.biopsycho.2019.107746

Feng, Y. C., Krahé, C., Meeten, F., Sumich, A., Mok, C. M., & Hirsch, C. R. (2020). Impact of imagery-enhanced interpretation training on offline and online interpretations in worry. *Behaviour Research and Therapy, 124*, 103497. https://doi.org/10.1016/j.brat.2019.103497

Forsell, E., Bendix, M., Hollandare, F., von Schultz, B.S., Nasiell, J., Blomdahl-Wetterholm, M., Eriksson, C., Kvarned, S., van der Linden, J.L., Söderberg, E., Jokinen, J., Wide, K. & Kaldo, V. (2017). Internet delivered cognitive behavior therapy for antenatal depression: A randomised controlled trial. *Journal of Affective Disorders, 221*, 56-64. https://doi.org/10.1016/j.jad.2017.06.013

Goodman, J.H., Watson, G.R. & Stubbs, B. (2016). Anxiety disorders in postpartum
women: a systematic review and meta-analysis. *Journal of Affective Disorders, 203*, 292-331. https://doi.org/10.1016/j.jad.2016.05.033

Hayes, S., Hirsch, C.R., Krebs, G. & Mathews, A. (2010). The effects of modifying interpretation bias on worry in generalized anxiety disorder. *Behaviour Research and Therapy, 48*, 171-178. https://doi.org/10.1016/j.brat.2009.10.006

Hayes, S., Hirsch, C.R., & Mathews, A. (2010). Facilitating a benign attention bias reduces negative thought intrusions. *Journal of Abnormal Psychology, 119*, 235-240. https://doi.org/10.1037/a0018264

Hedegaard, M., Henriksen, T.B., Sabroe, S. & Secher, N.J (1993). Psychological distress in pregnancy and preterm delivery. *British Journal of Medicine, 307*, 234-239. https://doi.org/10.1016/0020-7292(94)90149-X

Hirsch, C.R., Hayes, S. & Mathews, A. (2009). Looking on the bright side: accessing benign meanings reduces worry. *Journal of Abnormal Psychology, 118*, 44. https://doi.org/10.1037/a0013473

Hirsch, C.R., Krahé, C., Whyte, J., Loizou, S., Bridge, L., Norton, S. & Mathews, A. (2018). Interpretation training to target repetitive negative thinking in generalized anxiety disorder and depression. *Journal of Consulting and Clinical Psychology, 86*, 1017-1030. https://doi.org/10.1037/ccp0000310

Hirsch, C. R., Krahé, C., Whyte, J., Bridge, L., Loizou, S., Norton, S., & Mathews, A. (2020).
Effects of modifying interpretation bias on transdiagnostic repetitive negative thinking. *Journal of Consulting and Clinical Psychology, 88*, 226. 

https://doi.org/10.1037/ccp0000455

Hirsch, C. R., Krahé, C., Whyte, J., Krzyzanowski, H., Meeten, F., Norton, S., & Mathews, A. (2020). Internet-Delivered Interpretation Training Reduces Worry and Anxiety in Individuals with Generalized Anxiety Disorder: A Randomized Controlled Experiment. Manuscript submitted for publication.

Hirsch, C.R. & Mathews, A. (2012). A cognitive model of pathological worry. *Behaviour Research and Therapy, 50*, 636-646. https://doi.org/10.1016/j.brat.2012.06.007

Hirsch, C.R., Meeten, F., Gordon, C., Newby, J., Bick, D., & Moulds, M. (2020). Repetitive Negative Thinking and Interpretation Bias in Pregnancy. (Manuscript submitted for publication).

Hirsch, C.R., Meeten, F., Krahé, C. & Reeder, C. (2016). Resolving ambiguity in emotional disorders: The nature and role of interpretation biases. *Annual Review of Clinical Psychology, 12*, 281-305. https://doi.org/10.1146/annurev-clinpsy-021815-093436

Hirsch, C. R., Perman, G., Hayes, S., Eagleson, C., & Mathews, A. (2015). Delineating the role of negative verbal thinking in promoting worry, perceived threat, and anxiety. *Clinical Psychological Science, 3*, 637–647.
Holmes, E. A., Mathews, A., Dalgleish, T., & Mackintosh, B. (2006). Positive interpretation training: Effects of mental imagery versus verbal training on positive mood. *Behavior Therapy, 37*, 237-247.

Howard, L.M., Megnin-Viggars, O., Symington, I. & Pilling, S. (2014). Antenatal and postnatal mental health: summary of updated NICE guidance. *British Journal of Medicine, 349*, 7394. https://doi.org/10.1136/bmj.g7394

Howard, L.M., Molyneaux, E., Dennis, C., Rochat, T., Stein, A. & Milgrom, J. (2014). Non-psychotic mental disorders in the perinatal period. *The Lancet, 384*, 1775-1788. https://doi.org/10.1016/S0140-6736(14)61276-9

Krahé, C., Whyte, J., Bridge, L., Loizou, S., & Hirsch, C. R. (2019). Are different forms of repetitive negative thinking associated with interpretation bias in generalized anxiety disorder and depression? *Clinical Psychological Science, 7*, 969-981. https://doi.org/10.1177/2167702619851808

Kroenke, K., & Spitzer, R. L. (2002). The PHQ-9: a new depression diagnostic and severity measure. *Psychiatric Annals, 32*, 509-515. https://doi.org/10.3928/0048-5713-20020901-06

Loughnan, S. A., Wallace, M., Joubert, A. E., Haskelberg, H., Andrews, G., & Newby, J. M. (2018). A systematic review of psychological treatments for clinical anxiety during the perinatal period. *Archives of Women's Mental Health, 21*, 481-490. https://doi.org/10.1007/s00737-018-0812-7
Mathews, A. & Mackintosh, B. (2000). Induced emotional interpretation bias and anxiety, *Journal of Abnormal Psychology*, 109, 602-615. https://doi.org/10.1037/0021-843X.109.4.602

McEvoy, P. M., Thibodeau, M. A., & Asmundson, G. J. (2014). Trait repetitive negative thinking: A brief transdiagnostic assessment. *Journal of Experimental Psychopathology*, 5, 1-17. https://doi.org/10.5127/jep.037813

Meyer, T.J., Miller, M.L., Metzger, R.L. & Borkovec, T.D. (1990). Development and validation of the Penn State Worry Questionnaire. *Behaviour Research and Therapy*, 28, 487-495. https://doi.org/10.1016/0005-7967(90)90135-6

Moulds, M.L., Black, M.J., Newby, J.M. & Hirsch, C.R. (2018). Repetitive negative thinking and its role in perinatal mental health. *Psychopathology*, 51, 161-166. https://doi.org/10.1159/000488114

O’Connor, T.G., Heron, J., Glover, V. & Alspac Study Team (2002). Antenatal anxiety predicts child behavioral/emotional problems independently of postnatal depression. *Journal of the American Academy of Child and Adolescent Psychiatry*, 41, 1470-1477. https://doi.org/10.1097/00004583-200212000-00019

O'Donnell, K. J., Glover, V., Barker, E. D., & O'Connor, T. G. (2014). The persisting effect of
maternal mood in pregnancy on childhood psychopathology. *Development and Psychopathology, 26*, 393-403. https://doi.org/10.1017/S0954579414000029

Ruscio, A.M. & Borkovec, T.D. (2004). Experience and appraisal of worry among high worriers with and without generalized anxiety disorder. *Behaviour Research and Therapy, 42*, 1469-1482. https://doi.org/10.1016/j.brat.2003.10.007

Samtani, S., & Moulds, M. L. (2017). Assessing maladaptive repetitive thought in clinical disorders: A critical review of existing measures. *Clinical Psychology Review, 53*, 14–28. DOI: 10.1016/j.cpr.2017.01.007

Schmidt, D., Seehagen, S., Vocks, S., Schneider, S. & Teismann, T. (2016). Predictive importance of antenatal depressive rumination and worrying for maternal–foetal attachment and maternal well-being. *Cognitive Therapy and Research, 40*, 565-576. https://doi.org/10.1007/s10608-016-9759-z

Somerville, S., Dedman, K., Hagan, R., Oxnam, E., Wettinger, M., Byrne, S., Coo, S., Doherty, D. & Page, A. C. (2014). The perinatal anxiety screening scale: development and preliminary validation. *Archives of Women's Mental Health, 17*, 443-454. https://doi.org/10.1007/s00737-014-0425-8

Spitzer, R. L., Kroenke, K., Williams, J. B., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: the GAD-7. *Archives of Internal Medicine, 166*, 1092-1097. https://doi.org/10.1001/archinte.166.10.1092
Stein, A., Pearson, R.M., Goodman, S.H., Rapa, E., Rahman, A., McCallum, M., Howard, L.M. & Pariante, C.M. (2014). Effects of perinatal mental disorders on the foetus and child. *The Lancet, 384*, 1800-1819. https://doi.org/10.1016/S0140-6736(14)61277-0

Stevens, E.S., Behar, E. & Jendrusina, A.A. (2018). Enhancing the efficacy of cognitive bias modification for social anxiety. *Behavior Therapy. 49*, 995-1007. https://doi.org/10.1016/j.beth.2018.02.004

Stewart, D.E., Robertson, E., Dennis, C., Grace, S.L. and Wallington, T. (2003). Postpartum depression: Literature review of risk factors and interventions. *Toronto: University Health Network Women’s Health Program for Toronto Public Health*. URL: https://www.who.int/mental_health/prevention/suicide/lit_review_postpartum_depression.pdf

Topper, M., Emmelkamp, P.M., Watkins, E. & Ehring, T. (2017). Prevention of anxiety disorders and depression by targeting excessive worry and rumination in adolescents and young adults: A randomized controlled trial. *Behaviour Research and Therapy, 90*, 123-136. https://doi.org/10.1016/j.brat.2016.12.015

Turton, R., Cardi, V., Treasure, J. & Hirsch, C.R. (2018). Modifying a negative interpretation bias for ambiguous social scenarios that depict the risk of rejection in women with anorexia nervosa. *Journal of Affective Disorders, 227*, 705-712. https://doi.org/10.1016/j.jad.2017.11.089

Williams, A.D. & Grisham, J.R. (2013). Cognitive Bias Modification (CBM) of obsessive
compulsive beliefs. *BMC Psychiatry, 13*, 256. https://doi.org/10.1186/1471-244X-13-256.