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

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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 ($N = 49$, 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 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 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 given 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 of future situations (Borkovec 1994; Hayes et al., 2010). Rumination 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). Both 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. 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 showing 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 benign manner (see Appendix A for an example scenario). Evidence indicates 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 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 where 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 (Hirsch, Krahé, Whyte, Bridge, et al. 2020). These findings prompt the clinically interesting possibility that CBM-I can be used as a potential intervention for anxiety.

To determine whether CBM-I can help reduce worry and anxiety via a web-based platform with no face-to-face contact with researchers during assessment or training, 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 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 convenient for pregnant women, and thus has scope to be more readily integrated into daily life.

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: https://osf.io/ye84g/. See Appendix B for registered information.

Participants

Forty-nine women with high levels of self-reported worry (scoring ≥ 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 and were invited via email to take part in the study. Sixty-three of these responded and were offered a testing date. Of these, 49 participants completed the study, while six were found to be ineligible on the day of testing due to their Penn State Worry Questionnaire score (Meyer et al., 1990) being below cut off, seven withdrew before attending and one session was 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,

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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 ≥ 56.

S.D = 6.82). Twelve participants had one child and two participants had two children. The

other 35 participants were pregnant with their first child.

Table 1

Mean demographic and statistics characteristics and questionnaires (standard deviation in

parenthesis)

| | CBM-I | Control | *t(45)* | *p* |
	N= 23	N= 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 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. Recruitment and testing ended prematurely after testing 49 participants (two participants were excluded due to performance on the Recognition Test) 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 α = .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 α = .94 in current sample). Perinatal depression was assessed with the Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden, & Sagowsky, 1987: Cronbach's α = .84). General depressed mood was assessed using the Patient Health Questionnaire 9 (PHQ-9, Kroenke & Spitzer, 2002; Cronbach's α = .84) and 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[2].

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 instructed to silently worry about this topic as they normally would for five minutes.

Interpretation assessment task - Recognition Test (*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, 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 by subtracting the mean ratings for negative targets from the mean ratings for positive targets. Higher scores 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

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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.

focus task. Next, they were instructed to engage in worry about a current worry topic for five minutes, 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 (12 computerised tones) throughout the task; at each 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 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 a 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 was 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 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[3] significantly predicted post-training positivity index score, ($b = 0.54$, $SE = .19$, $p = .007$, 95% 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% 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 ($M = 2.61$, $SD = 1.85$).

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

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[3] 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 ($p = .02$).

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. Given 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 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). However, 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., reductions in RNT at one-month follow-up; Hirsch et al., 2018; Hirsch, Krahé, Whyte, Bridge, et al. 2020). Future research employing 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 potential 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 research 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 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

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

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

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

(Molina & Borkovec, 1994)….

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.

Appendix A

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

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Appendix A

1. **Cognitive Bias Modification for Interpretation (CBM-I; Hirsch et al. 2009; Hirsch, Krahé, Whyte, Bridge, et al. 2020)**

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 are 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'*).

Example scenario: You are getting a piece of work back from your supervisor today. When working on it, you were very busy with other tasks but spent as much time on it as you could manage. When you read your supervisor's feedback, you understand that your work was fine.

Comprehension question: Is your supervisor pleased with your work?

Answer: Yes

2. Interpretation assessment task - Recognition Task (Hirsch et al., 2018; adapted from Mathews & Mackintosh, 2000)

<u>Example Scenario</u>

Title: The car park

It is late at night and you are in a multi-storey car park trying to find your car. You have been looking for about ten minutes and still cannot find it. You hear a noise behind you and see a shadow of

Som_th_ng [something].

Question: Did you find your car right away? (Correct answer: no)

In the second phase, participants are presented with a scenario title and four statements in random order, and then asked to indicate how similar each statement was 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 of 1 (*very different in meaning*) to 4 (*very similar in meaning*). For example, for the carpark scenario:

- You see a security person approaching to help you (positive target)

- You see someone coming towards you looking threatening (negative target)

- You see some money on the floor and pick it up (positive foil)

- You see that you have forgotten your ticket and will have to pay a fine (negative foil)

Appendix B

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

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Pre-registered protocol

Title:
Cognitive Bias Modification for Interpretation (CBM-I) to reduce worry in pregnant women

Authors:
Colette Hirsch, Calum Gordon

Research Questions:
This experiment is designed to answer two questions:

1) Can a single session of cognitive bias modification for interpretation (CBM-I) promote more positive interpretations, compared to an active control condition, in pregnant women?

2) If a more benign interpretation bias is found after CBM-I training, does this lead to fewer negative thought intrusions, compared to an active control condition?

Hypotheses:
Our hypotheses are directional.

Hypothesis 1: We predict that CBM-I, relative to the control condition, will increase positive interpretations following the single session intervention.

Hypothesis 2: We predict that CBM-I, relative to the control condition, will be associated with fewer self-reported negative intrusions on a Breathing Focus task

Sampling Plan
Existing data:
Registration prior to the creation of data

Explanation of existing data:
There is no existing data for this study

Data collection procedures:
Participants will be recruited via the internet e.g., through adverts on social media platforms (e.g., Facebook), and classified advert websites (e.g. Gumtree). Advertisement opportunities will also be sought with local, pregnancy relevant groups, such as antenatal classes, and in local mother & baby shops. Participants will receive an incentive of £25 for taking part in the research.

Participants (aged 18 or over) will be eligible to participate in the study if they are 22-28 weeks pregnant, and have not previous experienced a stillbirth. Since we are looking to recruit high worriers for this study, participants will need to have a score on the Penn State Worry Questionnaire (PSWQ) >61 at screening. This same questionnaire will be administered 24hrs before the scheduled testing session, and participants will be screened again, with scores needing to be >56 for further eligibility. Given the study involves reading words and listening to scenarios, participants will need to be fluent in reading and listening to English, and have normal, or corrected to normal, vision and hearing.

Potential participants who indicate their interest in response to our adverts will be contacted, and sent a brief screening questionnaire to assess for the above criteria. Those who are deemed eligible will be scheduled for testing. To ensure that we are only testing high-worriers, participants will be resent the PSWQ to be completed online within 24hrs of their scheduled appointment. Any participants who have fallen below cut-off at this point will be deemed ineligible and will be offered £5 in vouchers as a thank you for their time thus far. In the same survey, participants will also complete a number of

other questionnaires, including the Perinatal Anxiety Screening Scale, Edinburgh Depression Scale, Repetitive Negative Thinking Questionnaire-10, Ruminative Response Subscale, Generalised Anxiety Disorder 7-item scale, and Patient Health Questionnaire, as well as a number of demographic questions, such as number of children and relationship status.

Eligible participants will attend a lab session and be randomly allocated to either the CBM-I or control condition. If a participant is in the CBM-I condition, they will complete a short imagery practice , whilst those in the control condition will complete a filler task. After this, participants will be asked to identify a recent worry and worry about this for 5 mins, before completing either the CBM-I or Control training. Following CBM-I/control training, participants will do a short filler task, before completing the recognition test, assessing interpretation bias. Participants will then run through a short CBM-I or Control booster training, before completing a Breathing Focus task designed to measure negative intrusions. Participants will also fill in 2 mood rating forms across the testing session.

The study is anticipated to run between December 2018 and December 2019.

Sample size:
Our projected number of participants is 60

Sample size rationale:
The project sample size of 60 is based on power 0.8 and alpha 0.05, using effect sizes from research on the breathing focus task in post-modification assessment (Hayes et al., 2010; Hirsch et al., 2009), which is 24 participants per group. Another 6 participants are added to each group as it is unclear whether effects will be as evident in this population

Stopping rule:
N/A

Variables
Manipulated variables:
We will manipulate interpretation bias by training one group (those in the CBM-I condition) to make more positive interpretations using a scenario-based cognitive bias modification paradigm (see Krahé, Mathews, Whyte, & Hirsch, 2016; Hirsch et al., under review).

In keeping with Hirsch et al. (under review), the CBM-I training will involve listening to some ambiguous scenarios over headphones. Participants are either presented with positive outcomes for a scenario and asked to generate a vivid mental image of it (50% of trials), or are asked to generate their own positive outcome and vividly imagine it (50% of trials). Pre CBM-I training, participants will be given some practice in generating mental images. After each scenario, participants will be asked a comprehension question, which reinforces the intended positive interpretation.

The control group will complete a training that is similar in content, but does not generate or reinforce positive outcomes. Participants will be presented with ambiguous scenarios, but the ambiguity will remain unresolved. As a result, interpretation bias should remain unchanged for this group. They will also be asked comprehension questions. Instead of the imagery practice, participants in the control condition will complete a neutral filler task (watching a video on an unrelated subject and answering questions about it) before taking part in the scenario-based training.

Measured variables:
Describe each variable that you will measure. This will include outcome measures, as well as any predictors or covariates that you will measure. You do not need to include any variables that you plan on collecting if they are not going to be included in the confirmatory analyses of this study.

Appendix B

Interpretation bias measures

Interpretation bias will be assessed using a Recognition Test (Mathews & Mackintosh, 2000). This involves reading a series of ambiguous descriptions in which the ambiguity is not resolved. Some of these materials present ambiguous situations in everyday life where one could worry, and some present ambiguous situations that someone might encounter during pregnancy. Subsequent recognition ratings of possible interpretations will test which interpretations participants generated (i.e. positive or negative). During the encoding phase, 21 ambiguous descriptions of situations will be presented, and participants will be asked a comprehension question. During the recognition phase to assess interpretations, a list of different possible interpretations will be presented, and participants are required to rate from 1 (very different in meaning) to 4 (very similar in meaning) as to how related the meaning is to the original scenario.

Primary symptom measures of worry, RNT and anxiety

In The Breathing Focus task (adapted from: Hirsch, Hayes, & Mathews, 2009), participants will be asked to worry for five minutes, and then focus on their breathing for five minutes. During this focusing period, 12 audio cues, presented at random intervals, will prompt participants to indicate whether they are focusing on breathing or they have thought intrusions that are positive, negative or neutral. At the end of the breathing focus period, participants will complete brief mood rating scales and rate their level of focus. The number of intrusions during breathing focus period will be calculated. An expanded descriptions component will be used, where participants will be asked to expand on any intrusions sampled during the Breathing Focus task. These will be audio recorded (full anonymity maintained, verbal consent to be included in recording) and will be rated for valence content by a raters who are blind to the research question.

Participants will also complete mood ratings after the first worry induction (pre-CBM-I), and before the recognition test (post-CBM-I)

The following Standardised self-report questionnaires will be delivered before the session: Perinatal Anxiety Screening Scale (PASS; Somerville et al., 2014) - measures anxiety symptoms throughout the perinatal period; Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden, & Sagovsky, 1987) - indexes symptoms of perinatal and postnatal depression; Repetitive Thinking Questionnaire-10 (RTQ-10; McEvoy, Mahoney, & Moulds, 2010) – a transdiagnostic validated measure of the tendency to engage in RNT. Penn State Worry Questionnaire will assess trait worry (Meyer, Miller, Metzger, & Borkovec, 1993); while depressive rumination will be assessed by Response Style Questionnaire Ruminative Response Subscale (RRS; Butler, & Nolen-Hoeksema, 1994). Generalized Anxiety Disorder 7-item scale (GAD-7; Spitzer, Kroenke, Williams, & Löwe, 2006) - screens and measures severity of GAD; Patient Health Questionnaire (PHQ-9; Kroenke, Spitzer, & Williams, 2001) - screens and measures severity of depression.

Indices:
If any measurements are going to be combined into an index (or even a mean), what measures will you use and how will they be combined? Include either a formula or a precise description of your method. If your are using a more complicated statistical method to combine measures (e.g. a factor analysis), you can note that here but describe the exact method in the analysis plan section.
Total scores will be calculated for all self-report questionnaires described above. The outcome variable of the recognition test is an index of mean similarity ratings for positive targets minus mean similarity ratings for negative targets (as in Hirsch et al., 2018).

Design Plan
Study Type:
Experiment - A researcher randomly assigns treatments to study subjects, this includes field or lab experiments. This is also known as an intervention experiment and includes randomized controlled trials.

Appendix B

Blinding:
Participants will be blind to which condition they have been assigned

Study design:
Describe your study design. Examples include two-group, factorial, randomized block, and repeated measures. Is it a between (unpaired), within-subject (paired), or mixed design? Describe any counterbalancing required. Typical study designs for observation studies include cohort, cross sectional, and case-control studies.
This study will employ a two-group, between-subjects design. The between-subjects factor is condition (2 levels: CBM-I, control).

Randomisation:
If you are doing a randomized study, how will you randomize, and at what level?
We will randomise which of the two conditions (CBM-I or control) participants are allocated to, by means of a random allocation sequence. Allocation concealment will be implemented so that experimenters are not aware of which condition the next participant will be assigned to.

Analysis Plan
Statistical Models:
What statistical model will you use to test each hypothesis? Please include the type of model (e.g. ANOVA, multiple regression, SEM, etc) and the specification of the model (this includes each variable that will be included as predictors, outcomes, or covariates). Please specify any interactions that will be tested and remember that any test not included here must be noted as an exploratory test in your final article.
Regression analyses (with bootstrapped standard errors in the event of non-normally distributed data) will be used to test the hypothesis that the CBM-I condition will make more positive interpretations post-training than the control condition. The predictor variable will be condition (CBM-I, control), the outcome variable will be interpretation bias post training. The same type of analysis will be used to test the hypothesis that the number of reported negative intrusions will be lower in the CBM-I vs. control analysis after completing the training program. T-tests will be carried out to determine if the groups differed on accuracy of comprehension questions.

Transformations
If you plan on transforming, centering, recoding the data, or will require a coding scheme for categorical variables, please describe that process.
The variable 'condition' (two levels: CBM-I, control) will be dummy-coded for analyses.

Follow-up analyses
If not specified previously, will you be conducting any confirmatory analyses to follow up on effects in your statistical model, such as subgroup analyses, pairwise or complex contrasts, or follow-up tests from interactions? Remember that any analyses not specified in this research plan must be noted as exploratory.
..

Inference criteria
What criteria will you use to make inferences? Please describe the information you'll use (e.g. specify the p-values, Bayes factors, specific model fit indices), as well as cut-off criterion, where appropriate. Will you be using one or two tailed tests for each of your analyses? If you are comparing multiple conditions or testing multiple hypotheses, will you account for this?
The critical p value will be set at .05. Two-tailed tests will be used.

Data exclusion
How will you determine which data points or samples (if any) to exclude from your analyses? How will outliers be handled?
Participants will be excluded from certain analyses if there are technical issues (e.g., data is not recorded), or if they fail to follow instructions correctly or their response accuracy falls below certain thresholds (2.5 SD below the mean). Outliers will be examined and may be excluded; skewed data will be handled by implementing bootstrapping, which does not place distributional assumptions on the data.

Appendix B

Missing data
How will you deal with incomplete or missing data?
While missing data is unlikely, any measures with missing data will be prorated.

Exploratory analysis
If you plan to explore your data set to look for unexpected differences or relationships, you may describe those tests here. An exploratory test is any test where a prediction is not made up front, or there are multiple possible tests that you are going to use. A statistically significant finding in an exploratory test is a great way to form a new confirmatory hypothesis, which could be registered at a later time.

…

Figure 1. *Overview of study procedure*

24 hours prior to testing

Participants complete PSWQ

Paid £5 for no longer meeting study criteria

Study begins

Random allocation to condition

CBM-I

CONTROL

Imagery practice task

Filler task

CBM-I practice task

Sham training task

Worry induction

First mood rating scale

CBM-I task

Sham training task

Second mood rating scale

Recognition task

CBM-I booster (10-trials)

Sham training booster

Breathing Focus Task

Debrief and payment