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Acutely induced anxiety increases negative interpretations of events in a closed-circuit television monitoring task

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In two experiments we measured the effects of 7.5% CO_2 inhalation on the interpretation of video footage recorded on closed circuit television (CCTV). As predicted, inhalation of 7.5% CO_2 was associated with increases in physiological and subjective correlates of anxiety compared with inhalation of medical air (placebo). Importantly, when in the 7.5% CO_2 condition, participants reported the increased presence of suspicious activity compared with placebo (Experiment 1), a finding that was replicated and extended (Experiment 2) with no concomitant increase in the reporting of the presence of positive activity. These findings support previous work on interpretative bias in anxiety but are novel in terms of how the anxiety was elicited, the nature of the interpretative bias, and the ecological validity of the task.

Keywords: Emotions; Monitoring; Response bias.

Our subjective experience of the world is to some extent governed by the way in which we interpret ambiguous information. For example, the explanation for why a person is seen running down a busy street might be benign (e.g., they are trying to catch a bus) or more sinister (e.g., they are escaping the scene of a crime). The tendency to give ambiguous information a negative or threatening interpretation is central to various cognitive models of anxiety (Mogg & Bradley, 1998; Ouimet, Gawronski, & Dozois, 2009; Williams, Mathews, & MacLeod, 1996). Indeed, biases in the interpretation of ambiguous information are considered to be common features of most emotional disorders (Mathews & MacLeod, 2005). This is true for both offline measures of

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interpretative bias (where judgements are made regarding past or future ambiguous events), and online measures (where judgements of responses are made at the time when the ambiguous information is present). These biases may contribute to the maintenance of emotional disorders such as anxiety by negatively biasing the interpretation of emotionally salient (or potentially salient) events (Mathews & MacLeod, 2002).

The majority of data in this field, however, are derived from studies in which participants were identified as being either high or low in anxiety prior to the experiment (Blanchette & Richards, 2010). One problem with this approach is loss of experimental control: anxiety is often highly comorbid with other emotional states such as depression (Mogg & Bradley, 1998), so that the unique contribution of anxiety is difficult to ascertain. More importantly, classifying individuals as high or low in anxiety carries difficulties associated with self-report measures of mood. Some individuals who report low levels of anxiety on self-report measures demonstrate physiological responses typical of high levels of anxiety, indicating presentation bias (Weinberger, Schwartz, & Davidson, 1979). It may be possible to identify and exclude these individuals from subsequent analyses, but this is imperfect. Perhaps most importantly, it can be difficult to dissociate the effects of state (i.e., current) and trait (i.e., dispositional) anxiety, given that the two are highly correlated, despite theoretical models attributing distinct roles to the effects of state and trait anxiety on cognition (Mathews & Mackintosh, 1998).

Recently, however, a number of studies have shown clear effects of state anxiety on cognition, using the inhalation of air enriched with 7.5% carbon dioxide (CO_2) to experimentally induce anxiety. This technique offers the important advantage of a within-subjects comparison (Cooper et al., 2011; Garner et al., 2011)—inhalation of 7.5% CO_2 is known to robustly increase self-reported anxiety and autonomic arousal, and therefore provides an experimental model of anxiety in healthy humans (Bailey, Argyropoulos, Kendrick, & Nutt, 2005). Evidence that acute benzodiazepines and selective serotonin reuptake inhibitors, drugs which reduce anxiety in patients with generalised anxiety disorder, attenuate subjective response to 7.5% challenge in healthy volunteers further validates the inhalation of 7.5% CO_2 as a model of anxiety in humans (Bailey, Argyropoulos, Lightman, & Nutt, 2003; Bailey, Kendrick, Diaper, Potokar, & Nutt, 2007; Bailey, Papadopoulos, Seddon, & Nutt, 2009). We have used this technique in a number of studies (Cooper et al., 2011; Garner et al., 2011), and recently shown that state anxiety induced by the inhalation of 7.5% CO_2 increases vigilance to threat, and reduces threat inhibition on an emotional antisaccade task using negatively valenced stimuli (Garner et al., 2011). One goal of the current study was therefore to measure the effects of experimentally induced state anxiety, using the 7.5% CO_2 inhalation technique, on the interpretation of ambiguous information.

However, many tasks used in the anxiety literature lack ecological validity, so that the extent to which these findings generalise to naturalistic settings remains uncertain. Typical studies require participants to undertake a lexical decision task in which they, for example, hear a homophone (e.g., bruise/brews) and are asked to spell the word (Blanchette & Richards, 2010). A second goal of this current study was therefore to measure the impact of state anxiety on the interpretation of ambiguity using a task with improved ecological validity over earlier studies. Here we report data from two experiments using a closed-circuit television (CCTV) monitoring task. This is analogous to, for example, control-room environments where operators are required to monitor and interpret real-time complex social information and engage in an alerting response when potentially suspicious or negative behaviour is detected. This is arguably a more ecologically valid model of naturalistic information processing than has been used previously. We hypothesised that participants would be more likely to report the presence of suspicious behaviour during 7.5% CO_2 inhalation compared with air inhalation.

EXPERIMENT 1

Methods and materials

Design and overview. The experiment consisted of a repeated-measures design, with Gas (air, CO_2) as the within-subjects factor. The order of gas inhalation was counterbalanced across participants.

Participants. Healthy volunteers were recruited from the staff and students of the University of Bristol and from a participant database. Exclusion criteria were history of psychiatric disorder or drug dependence (excluding caffeine), assessed using a structured interview by a trained researcher, based on the Mini-International Neuropsychiatric Interview (MINI; Sheehan et al., 1998). Blood pressure ($<$140/90 mmHg), heart rate (50–90 bpm) and body mass index (BMI; 18–28 kg/m^2) were required to be within the normal range. Prior to the study, participants were asked to refrain from alcohol for 36 hours, from smoking for 12 hours (daily smokers were excluded) and from caffeine after midnight. Participants were reimbursed £20 for their time at the end of testing. The study was reviewed and approved by the Faculty of Science Research Ethics Committee.

Gas mixtures. The gas mixtures used were CO_2 7.5%/O_2 21%/N 71.5% and medical air (O_2 21%). These were administered to participants using a mask (Hans Rudolph, Kansas City, MO, USA), which was attached to a 500 L bag with tubing. Gas was administered single-blind.

Physiological assessment. Participants were tested for alcohol and carbon monoxide levels in exhaled breath using the Alcohawk PT400 (Q3 Innovations, Independence, IA, USA) and the Bedfont Micro Smokerlyser (Bedfont Scientific Ltd, Maidstone, UK), respectively. Blood pressure was recorded using the OMRON M6 Comfort Digital Blood Pressure Monitor (OMRON Healthcare Ltd, Milton Keynes, UK). Urine samples were collected to test for the presence of barbiturates, benzodiazepines, opiates, tetrahydrocannabinol (THC), methamphetamine, amphetamine and cocaine, and to test for pregnancy in female participants (Surescreen Diagnostics Ltd, Derby, UK).

Questionnaires. Participants completed the State-Trait Anxiety Inventory State (STAI-S) and Trait (STAI-T) subscales (Spielberger, 1983), Anxiety Sensitivity Inventory (ASI; Reiss, Peterson, Gursky, & McNally, 1986), Positive and Negative Affect Schedule positive (PANAS-P) and negative (PANAS-N) subscales (Watson, Clark, & Tellegen, 1988) and visual analogue scales (VAS) for alert, sedated, fearful, relaxed, anxious, happy, feel like leaving, tense, nervous, worried and stressed, on a scale from 0 (*Not at all*) to 100 (*The most ever*). Participants also completed the Eysenck Personality Questionnaire – Revised (EPQ-R; H. J. Eysenck & Eysenck, 1991) at the end of testing.

Stimuli. Video clips consisted of 18 one-minute clips obtained from a database of video clips from six cameras placed around Manchester, UK, city centre (Howard, Gilchrist, Troscianko, Behera, & Hogg, 2009). We chose three clips from each of the six camera locations to show a range of typical urban street scenes. Although these videos were obtained from real CCTV, they contained no criminal or threatening activities. Presentation of these clips was split into three blocks: block 1 (baseline), block 2 (first inhalation) and block 3 (second inhalation). Six clips (one from each camera location) were randomly chosen for the baseline condition. The remaining clips were assigned to blocks 2 and 3, so that every camera location appeared once in each block. One additional clip was presented to each participant during a practice session at the start of testing. The allocation of clips to the various blocks and the order of videos within each block were presented in pseudo-random order. The videos were 180 mm × 150 mm in size, and a black box measuring 60 mm × 20 mm was placed over the time-stamp on the recording, which was otherwise visible in the bottom right-hand corner.

Procedure. Participants completed a telephone interview before attending the testing session, in order to ascertain likely eligibility for the study. On the day of testing, participants completed the consent procedure, and then completed further screening procedures, including exhaled breath and urine testing, assessment of blood pressure, heart rate, height and weight, and completion of the screening interview. Eligible participants then completed the STAI-S, STAI-T, ASI, PANAS-P, PANAS-N and VAS measures prior to the first inhalation. Inhalations of air and CO_2 each lasted twenty minutes, during which time participants watched and rated the activity in the videos. Participants also completed a second behavioural task (results not reported here), and the order of tasks during each inhalation was counterbalanced across participants and held constant within participants. Inhalations were separated by 30 minutes of rest, and the order of air and CO_2 was counterbalanced across participants. Throughout the study, an experimenter remained within close proximity of the gas cylinders to ensure the bag was adequately full at all times. Participants sat with their back to the gas cylinders. Immediately after each inhalation, blood pressure and heart rate were recorded while the participant remained seated, and the STAI-S, PANAS and VAS were then completed. The effects of CO_2 inhalation are mediated via blood pH, which buffers very rapidly. Therefore, while anxiety induced by the inhalation is sustained during inhalation, it declines very rapidly on inhalation of normal air. Participants were therefore asked to indicate how they felt *during the inhalation* when completing the questionnaire measures.

Participants were instructed to watch the videos, which they were told depicted real everyday scenes of a city centre. They were asked to make a continuous judgement about the suspiciousness of the behaviour shown in the scenes. To do this, they were asked to use a joystick to constantly indicate the current level of perceived suspicious behaviour. They were told that if they perceived the events at a given moment to be very suspicious, they should move the joystick fully forwards for the duration of the suspicious events. They were told that whenever they perceived the scene as not at all suspicious, they should apply no force at all on the joystick. They were instructed that the joystick was sensitive to every tiny division in between these two extreme positions, and that they could respond with judgements by holding the joystick at any of the intermediate positions. They were told to keep their hand on the joystick at all times during the videos, and that the joystick position would be recorded constantly. Videos were presented using a standard laptop computer and the joystick position was recorded at 100 Hz with 5,000-degree precision of ratings throughout the presentation of videos. Each participant was given a one-minute practice video at the start of the experiment, followed by the baseline block. They then completed the same task with inhalation of medical air and CO_2, with order of gas presentation counterbalanced across participants.

When the inhalations were complete participants completed the EPQ-R. Final measures of blood pressure and heart rate were taken 25 min after the end of the last inhalation to ensure the participant was fit to leave. Participants were then thanked and reimbursed £20 before leaving. The experimenter gave each participant a follow-up telephone call the next day to ensure they had not experienced any adverse effects from the CO_2.

Statistical analysis. We excluded the first one second of joystick responses for each of the one-minute video presentations to allow participants time to evaluate the scene. For each participant, we calculated a mean joystick rating assigned to each video by taking the mean of the ratings at each time sample (100 Hz sampling rate). For each participant, we then calculated the mean rating under each inhalation condition using the means for each of the six videos in that condition.

A repeated-measures analysis of variance (ANOVA), with Gas (air, CO_2) as a within-subjects factor was the primary method of analysis. Order (air-first, CO_2-first) was included as a between-subjects factor, and removed if it did not modify the results. Paired samples t-tests were conducted for STAI-S, PANAS-P, PANAS-N, heart rate and blood pressure data. All data were analysed using SPSS 16.0 (SPSS Inc., Chicago, IL, USA). Exact p-values are reported throughout.

Results

Characteristics of participants. Participants ($n = 25$; 70% female) were aged 21.52 years on average ($SD = 2.97$ years), had an EPQ-R Neuroticism score of 7.76 ($SD = 3.60$), a STAI-T score of 33.20 ($SD = 6.34$), and an ASI score of 13.88 ($SD = 6.62$). At baseline, participants had, on average, an STAI-S score of 30.04 ($SD = 6.22$), a PANAS-P score of 28.60 ($SD = 6.47$) and a PANAS-N score of 11.52 ($SD = 2.06$).

Cardiovascular and subjective data. A series of paired-samples t-tests of cardiovascular data did not indicate any effects of CO_2 inhalation, compared with air, on systolic, $t(24) = -1.63$, $p = .12$, $\eta^2 = .10$, or diastolic, $t(24) = -1.12$, $p = .27$, $\eta^2 = .05$, blood pressure, but higher heart rate in the CO_2 condition compared with the air condition, $t(24) = -2.52$, $p = .019$, $\eta^2 = .21$. For questionnaire data, STAI-S, $t(24) = -4.34$, $p < .001$, $\eta^2 = .44$, and PANAS-N, $t(24) = -2.79$, $p = .010$, $\eta^2 = .14$, scores were higher in the CO_2 condition compared with the air condition, and there was a trend in the opposite direction for PANAS-P scores, $t(24) = 1.93$, $p = .065$, $\eta^2 = .25$. These data are presented in Table 1. Ratings of VAS fearful, relaxed, anxious, feel like leaving, tense, nervous, worried and stress also increased, while ratings of VAS happy decreased, ps $< .02$, η^2s $> .20$. There were no effects on ratings of VAS alert or sedated, ps $> .50$, η^2s $< .20$.

CCTV rating data. Repeated-measures ANOVA of CCTV data, with Gas (air, CO_2) as a within-subjects factor indicated a trend in the predicted direction towards greater mean ratings of suspicious behaviour, $F(1, 24) = 3.32$, $p = .081$, $\eta^2 = .12$, during the CO_2 inhalation compared with the air inhalation. The order term was non-significant and was removed from the model. These results are presented in Figure 1.

Discussion

In Experiment 1, we found some evidence that participants rated the scenes as more suspicious under inhalation of CO_2 than inhalation of air, although this did not achieve statistical significance. This suggests that state anxiety causes evaluations of everyday scenes to be more negative than they would otherwise have been, possibly by biasing attention towards the most negative aspects of the scenes. Critically, this does not appear to be due to changes in subjective non-specific arousal, given the lack of effect of CO_2 inhalation on ratings of alert and sedated, although we did observe effects on heart rate consistent with the autonomic arousal known to be associated with elevated anxiety.

However, there remains the possibility that anxiety caused participants simply to engage more in the task or to push the joystick more than they would otherwise have done. To address this

Table 1. *Effects of 7.5% CO_2 inhalation on physiological measures and mood ratings*

	Experiment 1		*Experiment 2*	
	Air M (SD)	*7.5% CO_2 M (SD)*	*Air M (SD)*	*7.5% CO_2 M (SD)*
Heart rate	64.7 (10.6)	69.2 (12.3)	67.0 (13.4)	71.2 (13.2)
Systolic BP	102.7 (7.9)	106.2 (10.6)	105.6 (13.0)	109.5 (17.3)
Diastolic BP	71.6 (6.2)	73.5 (8.3)	70.5 (8.6)	70.5 (9.3)
STAI-S	31.2 (7.0)	41.4 (13.0)	35.8 (6.8)	44.1 (10.6)
PANAS-P	25.6 (6.8)	23.0 (6.8)	21.8 (6.1)	20.6 (6.2)
PANAS-N	11.4 (3.0)	15.6 (8.3)	11.2 (1.6)	14.6 (5.0)

Notes: BP = Blood Pressure; STAI-S = Spielberger State-Trait Anxiety Inventory (state subscale); PANAS-P = Positive and Negative Affect Schedule (positive affect subscale); PANAS-N = Positive and Negative Affect Schedule (negative affect subscale).

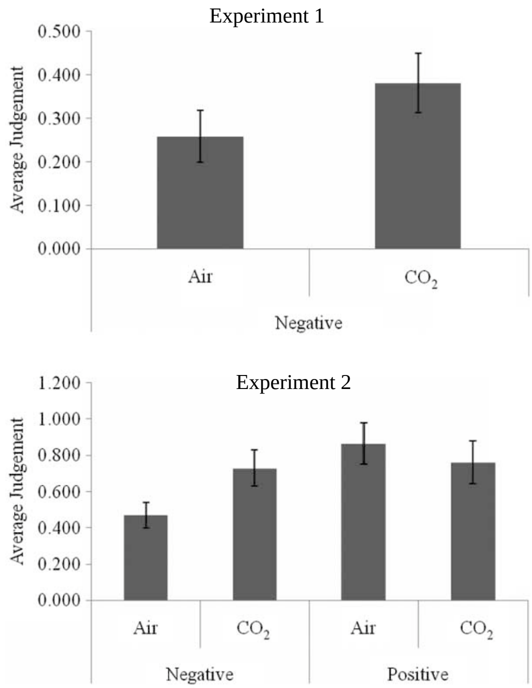

Figure 1. *Effects of 7.5% CO_2 inhalation on judgement of negative and positive behaviour on a CCTV monitoring task. Error bars represent SEM.*

possibility in Experiment 2, we included both a positive and a negative judgement for the task. We also recruited a larger sample size to achieve sufficient statistical power to detect an effect of similar magnitude to that observed in Experiment 1.

EXPERIMENT 2

Methods and materials

Experiment 2 was identical to Experiment 1 apart from the following differences. Participants each watched a total of 24 one-minute clips taken from the same database of videos as used in Experiment 1. We used the same clips from the same six camera locations from around the city, using additional clips from the same six camera locations. Presentation of these clips was split into five blocks: block 1 (baseline), block 2 (first inhalation), block 3 (first inhalation), block 4 (second inhalation) and block 5 (second inhalation). Within each inhalation two blocks were therefore presented, one of which required a positive judgement, and one a negative judgement, and this order was quasi-randomised in a 2 (Gas) $\times$ 2 (Judgement) design. Participants did not complete any other behavioural tasks.

The negative judgement was similar to the suspiciousness judgement used in Experiment 1 but participants were asked to rate the amount of negative behaviour shown in the videos. For the positive judgement they were asked to rate the amount of positive behaviour shown in the videos. Pushing the joystick forwards in the negative condition indicated perceiving negative behaviour, and pushing the joystick forwards in the positive condition indicated perceiving positive behaviour. Again, participants were told to make a continuous judgement, moving the joystick to the appropriate level at all times, and using any intermediate levels of the joystick positions.

We again excluded the first one second of ratings for every video. Statistical analyses were comparable with Experiment 1, but Judgement (negative, positive) was included as an additional within-subjects factor in the analyses of CCTV data.

Results

Characteristics of participants. Participants ($n = 37$; 57% female) were aged 24.87 years on average ($SD = 7.29$), had an EPQ-R Neuroticism score of 9.32 ($SD = 5.26$), a STAI-T score of 34.77 ($SD = 6.32$), and an ASI score of 14.59 ($SD = 6.40$). At baseline, participants had, on average, an STAI-S score of 32.43 ($SD = 6.30$), a PANAS-P score of 28.57 ($SD = 5.90$) and a PANAS-N score of 11.65 ($SD = 2.18$). No participants had taken part in Experiment 1.

Cardiovascular and subjective data. A series of paired-samples t-tests of cardiovascular data did not indicate any effects of CO_2 inhalation, compared with air, on diastolic blood pressure, $t(36) = -0.69$, $p = .95$, $\eta^2 = .00$, but higher systolic blood pressure, $t(36) = -2.56$, $p = .015$, $\eta^2 = .15$, and heart rate, $t(36) = -2.40$, $p = .022$, $\eta^2 = .14$, in the CO_2 condition compared with the air condition. For questionnaire data, STAI-S, $t(36) = -4.30$, $p < .001$, $\eta^2 = .33$, and PANAS-N, $t(36) = -4.19$, $p < .001$, $\eta^2 = .33$, scores were higher in the CO_2 condition compared with the air condition, while there was no effect for PANAS-P scores, $t(36) = 1.63$, $p = .11$, $\eta^2 = .07$. These data are presented in Table 1. Similar effects were observed for VAS fearful, relaxed, anxious, happy, feel like leaving, tense, nervous, worried and stress, ps $< .004$, η^2s $> .22$, but not VAS alert or sedated, ps $> .75$, η^2s $< .01$.

CCTV rating data. Repeated-measures ANOVA of CCTV data, with Gas (air, CO_2) and Judgement (negative, positive) as within-subjects factors indicated an effect of Judgement, $F(1, 36) = 8.40$, $p = .006$, $\eta^2 = .19$, reflecting higher mean ratings for positive behaviour than negative behaviour. This was qualified by a Gas × Judgement interaction, $F(1, 36) = 6.32$, $p = .017$, $\eta^2 = .15$. Post hoc tests indicated no difference in ratings of positive behaviour, $p = .43$, $\eta^2 = .02$, but greater mean ratings of negative behaviour, $p = .007$, $\eta^2 = .19$, during the CO_2 inhalation compared with the air inhalation. The order term was non-significant and was removed from the model. These results are presented in Figure 1.

Discussion

In Experiment 2, we found evidence that participants rated the scenes as more negative under inhalation of CO_2 than inhalation of air, but did not show a similar pattern for ratings of positive behaviour. This suggests that the effects of CO_2 inhalation are specific to judgements of negative behaviour, and not simply due to participants engaging more in the task or pushing the joystick more than they would otherwise have done. As in Experiment 1, these effects did not appear to be due to changes in subjective non-specific arousal, given the lack of effect of CO_2 inhalation on ratings of alert and sedated. We again observed effects on heart rate consistent with the autonomic arousal known to be associated with elevated anxiety, and also observed an effect on systolic blood pressure (which was not observed in Experiment 1, suggesting that this effect of CO_2 inhalation is less stable than the effect on heart rate).

GENERAL DISCUSSION

In two experiments we have found evidence that an experimental manipulation of state anxiety changes participants' interpretation of natural behaviour in a CCTV monitoring task. More specifically, our hypothesis that participants would be more likely to report the presence of suspicious/negative behaviour during 7.5% CO_2 inhalation compared with air inhalation was supported. While we cannot exclude the possibility that these effects were due to non-specific effects experienced by participants during the 7.5% CO_2 inhalation, the strong and consistent effects of our procedure on subjective ratings of anxiety and its physiological correlates (i.e., heart rate), and the fact that our finding is consistent with the literature on interpretative bias in anxiety (Blanchette & Richards, 2010), support the likelihood that the effects we observed are due to elevated anxiety. Our results are novel in terms of how the anxiety was elicited, the nature of the interpretative bias, and the ecological validity of the task (modelling, as it does, behaviour that may be observed among control room and CCTV operators). The videos we used depicted everyday scenes of people shopping, commuting, and interacting in a variety of urban environments. For this reason, the task models, to a great extent, the everyday interpretation of typical real-world events.

The interpretative bias was shown following 7.5% CO_2 inhalation but not following air inhalation, serving to further validate the 7.5% CO_2 model in humans. We have previously presented evidence providing a pharmacological validation of the model (Bailey et al., 2003, 2005, 2007, 2008) but in the current study we have shown that inhalation of 7.5% CO_2 is also associated with predictable cognitive effects, supporting our earlier findings in this area (Garner et al., 2011). Furthermore, this is the first time that an anxiety-related interpretative bias has been demonstrated using this task. We argue that the ability to record participants' interpretation of natural behaviour in real time represents a substantial improvement in terms of ecological validity. Reassuringly, the nature of the interpretative bias observed in the current study is entirely consistent with more traditional experiments (Blanchette & Richards, 2010), further supporting the reliable impact of anxiety on interpretation of ambiguity.

We observed consistent effects of 7.5% CO_2 inhalation on subjective anxiety and physiological measures of arousal associated with elevated anxiety, namely heart rate, although effects on blood pressure were not consistent across both experiments. This is in line with previous studies, where clear and robust effects are typically observed on ratings of anxiety and measures of heart rate (Cooper et al., 2011; Garner et al., 2011). Physiological arousal is an integral feature of anxiety (Ulrich-Lai & Herman, 2009), and future studies should attempt to determine whether subjective or physiological aspects of anxiety most strongly influence the cognitive effects we observed.

One limitation of the current study is that we are not able to say precisely how the interpretative bias arises. As would be expected of CCTV footage from a busy city centre the videos contain large amounts of dynamic information, often with many people entering and exiting the recorded area. Thus, there are many possible "events" that a given participant could choose to look at and interpret. When inhaling 7.5% CO_2 participants indicated that the videos contained more suspicious/negative information than when they were inhaling air. Our assumption is that this is due to a reduction in the threshold of what counts as being suspicious, consistent with theoretical models of anxiety (Mathews & Mackintosh, 1998); an event seen as benign in the air condition is perceived as being more negative in the 7.5% CO_2 condition. However, it could be that in the 7.5% CO_2 condition participants make a decision as to whether an event is suspicious/negative more quickly, and are thus able to process a greater number of events. Therefore, the apparent increase in perceived negative information could be due either to a reduction in the threshold for identifying something as suspicious/negative or an increase in the efficiency with which such events are processed. However, we do not think this is likely—data from other tasks indicates that inhalation of 7.5% CO_2 slows reaction times (Cooper et al., 2011), and if the process of resolving ambiguity is correspondingly slowed the number of processed events would in fact be lower. Unfortunately we are not able to definitively resolve these two possibilities with our current data.

Future studies should therefore examine whether the effects we observed are due to reduced threshold for identification or increased efficiency of processing, for example by requiring participants to report the number of "events" they detect. Additionally, it would be interesting to record participants' eye movements during the task. Research suggests that anxiety is associated with hypervigilance to threat-related stimuli (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007), and measuring eye movements during the interpretation task can assay the allocation of visual attention in dynamic naturalistic scenes (Howard et al., 2009; Howard, Troscianko, & Gilchrist, 2010), under different states of anxiety, and with different goals guiding search (i.e., detection of positive or negative behaviour; M. W. Eysenck, Derakshan, Santos, & Calvo, 2007; Mogg & Bradley, 1998). Other methodologies, such as the use of ambiguous homographs or scenarios will also allow the mechanisms by which the inhalation of 7.5% CO_2 influences interpretative biases to be better understood.

Another limitation is that instructions differed slightly between experiments—in the first participants were instructed to evaluate "suspicious behaviour", whereas in the second they were instructed to evaluate "negative behaviour" or "positive behaviour". This change in instructions was necessitated by the desire to explore the effects of judgement valence on interpretative bias. Nevertheless, these different instructions may have generated somewhat different demand characteristics, and may explain the somewhat higher ratings made in the second experiment. However, given the similarity in the pattern of results observed for judgement of "suspicious behaviour" in the first experiment, and "negative behaviour" in the second experiment, we are confident that any demand characteristics did not systematically distort our results.

Finally, we were unable to explore whether the effects of experimentally induced state anxiety on interpretative bias differed as a function of trait anxiety. Our experiments were neither designed nor powered to explore this possibility. However, theoretical models make clear predictions regarding the interplay of state and trait anxiety on cognition and the processing of threat information (Mogg & Bradley, 1998). Therefore, the 7.5% CO_2 inhalation technique provides an important opportunity to explicitly test these predictions in participants pre-selected for high and low levels of trait anxiety.

In conclusion, the current study develops previous work showing a cognitive bias for the negative interpretation of ambiguity in anxiety. The findings are novel in terms of how the anxiety was elicited, the nature of the interpretative bias, and the ecological validity of the task. This gives a greater understanding of 7.5% CO_2 inhalation as a model of anxiety and how anxiety influences the subjective interpretation of complex information in a naturalistic task.

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