

## Altered attentional control linked to catastrophizing in patients with Irritable Bowel Syndrome (IBS)

### Abstract

#### Objectives

Our study aimed to investigate differences in attentional control between patients with Irritable Bowel Syndrome (IBS) and healthy participants and to examine the link between attentional control and IBS catastrophizing. Previous research has shown that patients with chronic functional illnesses have lower levels of attentional control. However, no previous study has found altered attentional control in patients with IBS or directly investigated the link between attentional control and catastrophizing.. We also aimed to establish whether anxiety is associated with attentional functions in patients with IBS.

#### Design and Methods

In this cross-sectional study, we compared 41 IBS patients with 39 healthy matched control participants on attentional functions using an Attention Network Task (ANT). IBS catastrophizing (Gastrointestinal-Cognitions), IBS symptom severity (GSRS-IBS), Depression, Anxiety and Stress (DASS-21), and Visceral Anxiety Sensitivity (VSI) were assessed using self-report measures.

#### Results

IBS patients had lower attentional control compared to healthy participants ( $t(78) = -2.75, p = .007, d = 0.62$ ). Groups did not differ in alerting or orienting attention. IBS patients with lower attentional control scored higher on IBS catastrophizing than those with higher attention control,  $t(38.59) = 2.186, p = .032, d = 0.66$ . Anxiety was related to orienting attention in the IBS group ( $\rho = .38, p = .015$ ).

#### Conclusions

IBS patients displayed reduced attentional control. Crucially, those patients with lower attentional control also had more catastrophizing thoughts than patients with better attentional control. These findings suggest that improving attentional control could be a valid target for psychological interventions for IBS.

### Introduction

Irritable Bowel Syndrome (IBS) is a chronic illness with symptoms of abdominal pain and altered bowel function (diarrhoea and constipation). IBS is a functional illness with a complex aetiology, a wide range of maintaining factors and inconsistent biomarkers (Enck et al., 2016). It has been proposed that psychological processes may play an important role in the maintenance of this condition (Elsenbruch, 2011; Halpert & Drossman, 2005). Specifically catastrophizing which is a tendency to think about and believe in the likely occurrence of the worst possible outcomes of a situation has been linked with the affective dimension of pain (pain suffering) in IBS patients (Lackner & Quigley, 2005). Importantly, reductions in general catastrophic thinking and pain-specific catastrophizing have been shown to mediate symptom improvement and quality of life in IBS patients (Garland et al., 2012; Hunt, Moshier, & Milonova, 2009). Although, in a study by Labus and colleagues (2013) the mediation effect of catastrophizing on symptom severity was only trending towards significance. They also found the mediating effect of catastrophizing is dependent on baseline levels of quality of life, with stronger effects when quality of life is low before treatment begins (Labus et al., 2013).

In addition, subconscious cognitive processes could play a role in symptom maintenance in IBS. For example, cognitive biases that serve the automatic detection of symptom cues (e.g. hypervigilance) have been found in IBS patients (Afzal, Potokar, Probert, & Munafò, 2006; Chapman & Martin, 2011; Phillips, Wright, & Kent, 2014; Tkalcic, Domijan, Pletikosic, Setic, & Hauser, 2014). However,

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fewer studies have examined alterations in more general cognitive processes such as executive functioning or memory in IBS patients. Given evidence of altered general cognitive functioning in other chronic functional illnesses such as Chronic Fatigue Syndrome/ME (Hou et al., 2014; Hughes, Chalder, Hirsch, & Moss-Morris, 2017; Martin & Alexeeva, 2018; Togo, Lange, Natelson, & Quigley, 2015) and Fibromyalgia (Miró et al., 2011), it is surprising that research on altered executive functions in IBS patients is far less prevalent. One study found a subtle deficit in episodic visuospatial memory in IBS patients (Kennedy et al., 2013). The authors also report that visuospatial memory was correlated with altered morning cortisol levels which could be evidence for the negative impact of HPA-axis dysregulation on hippocampal-mediated cognitive performance (Kennedy et al., 2013).

Keeping in mind that executive functions are highly relevant for mental health, emotional regulation and goal attainment (Diamond, 2013; O'Bryan, Kraemer, Johnson, McLeish, & McLaughlin, 2017; Posner & Rothbart, 1998; Richey, Keough, & Schmidt, 2012), executive functions may be a vital component for emotional, social and occupational wellbeing in patients with a chronic illness. They may be particularly relevant for patients who have to cope with an illness such as IBS that involves frequent episodes of pain and disturbed bodily functions (e.g. diarrhoea).

One fundamental executive function is attentional control (Diamond, 2013). Attentional control is characterized by intentional, effortful control over attention that serves to inhibit task irrelevant distraction. Importantly, low attentional control has been associated with

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maladaptive cognitive thinking styles such as worrying and catastrophizing (Fox, Dutton, Yates, Georgiou, & Mouchlianitis, 2015; Heathcote et al., 2015). For example, Fox and colleagues (2015) showed that deficits in attentional control were associated with greater difficulty in controlling negative thought intrusions and that “improvements in attentional control were associated with improvements in the ability to suppress worry related thought intrusions” in people with pathological worries (Fox et al., 2015, p. 593). To examine the relationship between attentional control and maladaptive illness specific catastrophizing in IBS patients, IBS catastrophizing was operationalized as symptom specific catastrophic thoughts as described in the Gastrointestinal Cognitions Questionnaire (Hunt, Ertel, Coello, & Rodriguez, 2014). Similarly, in IBS patients, the degree of IBS catastrophizing could be partly dependent on their levels of attentional control. IBS patients with the greatest deficits in attentional control may be those who suffer most from illness-specific catastrophizing. Understanding attentional control in IBS patients and how it relates to IBS catastrophizing may be helpful in developing treatments for IBS.

Why might IBS patients have altered attentional control? Eysenck’s Attentional Control Theory (Eysenck & Derakshan, 2011; Eysenck, Derakshan, Santos, & Calvo, 2007) proposes that anxiety impairs the smooth functioning of the executive functions related to intentional, goal related attention and favours stimulus driven processing. It specifies that executive inhibitory processes such as attentional control are responsible for limiting the interference of irrelevant stimuli (Eysenck & Derakshan, 2011; Eysenck et al., 2007). The

theory also proposes that attentional control could be negatively affected by anxiety and crucially that these executive inhibitory processes would be impaired, even in the absence of threat (Eysenck & Derakshan, 2011; Eysenck et al., 2007). This is because the most effective strategy to detect the onset of an unpredictable threat is to allocate attention widely, rather than keep it focused on a particular task (Eysenck et al., 2007). Hypervigilance is a process that facilitates stimulus driven processing and the above mentioned findings on hypervigilance in IBS patients support this theoretical approach. In addition, to detect threat quickly, it would also be adaptive to orient towards threat (shift attention towards threat) at a faster rate in order to prioritize processing sensory input from that location. This and shifting attention towards locations that hold valuable information for goal attainment are the focus of orienting attention (Fan, McCandliss, Sommer, Raz, & Posner, 2002; Petersen & Posner, 2012). More specifically, orienting attention involves “disengaging attention from its current focus, moving attention to the new target... and engaging attention at the new target” (Fan et al., 2009, p. 210). Anxiety may enhance the efficiency of the orienting network by heightening the relevance of threat related and goal related cues. Many IBS patients have a co-morbid anxiety disorder (Enck et al., 2016; Janssens, Zijlema, Joustra, & Rosmalen, 2015) and feel anxious about sensations in the abdominal region as well as the context in which they may occur (visceral anxiety sensitivity) (Labus, Mayer, Chang, Bolus, & Naliboff, 2007; Porcelli, De Carne, & Leandro, 2014). It is therefore important to investigate if IBS patients have lower levels of attentional control and higher orienting

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attention, and if so, if attentional functioning is related to their levels of anxiety and visceral anxiety sensitivity.

Furthermore, attentional control and orienting attention can be objectively measured with the reaction time based Attention Network Task (ANT) (Fan et al., 2002). This task also measures phasic alertness or alerting attention, which is defined as “the ability to increase in response readiness to a target subsequent to an external warning stimulus” (Fan et al., 2009, p. 209). Although considered largely independent functional and structural networks, attentional control, orienting and alerting attention have been shown to interact with each other (Fan et al., 2009). For example activated alerting attention seems to inhibit attentional control (in the form of conflict resolution), whereas cues that orient attention towards a target appear to enhance conflict resolution (Fan et al., 2009). The focus of the current investigation is on differences in attentional control and orienting attention between IBS patients and healthy participants. The findings on alerting attention measure will also be reported.

A recent study including the attention network task reported no differences in attentional control between IBS patients and a healthy control group; however, they did find faster reaction times for alerting and orienting attention in IBS patients (Hubbard et al., 2015). This study had a small sample size (15 IBS patients and 14 control participants) and was carried out under different conditions (notably in an fMRI scanner).

### **Summary and Research Questions**

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To summarize, attentional control, catastrophizing thoughts, anxiety and visceral anxiety sensitivity appear to be clinically important factors for IBS symptom maintenance. Therefore investigating these factors and their relationship to each other is clinically relevant and important from a perspective of treatment development. To the best of our knowledge no previous study has investigated the relationship between attentional control and maladaptive illness cognitions in IBS patients. In the hypotheses below, attentional control and orienting attention refer to the attentional control and the orienting attention indices of the ANT.

Primary hypothesis:

- 1.1 Patients with IBS have lower attentional control compared to healthy participants.

Secondary hypotheses:

- 2.1 In patients with IBS, lower attentional control is related to higher anxiety and higher visceral anxiety sensitivity.
- 2.2 Patients with IBS with lower attentional control have higher scores on IBS catastrophizing compared to patients with IBS with higher attentional control.
- 2.3 Patients with IBS have better orienting attention compared to healthy participants.
- 2.4 In patients with IBS, the level of orienting attention correlates with levels of anxiety and visceral anxiety sensitivity, where higher scores on the orienting index relate to higher anxiety and visceral anxiety sensitivity.

## Methods

### Participants

This study has a cross-sectional design. Participants were matched in age and gender. Participants (healthy and IBS) were recruited from the University of Oxford and the general public. IBS patients were also recruited via a doctor's referral from local Gastroenterology clinics. Students from the University's Experimental Psychology department were able to receive study credits for participating. All other participants received monetary compensation. To match each of the participating IBS patients with a healthy participant of the same gender and similar age ( $\pm 5$  years), healthy participants were selected based on gender and age from a larger participant pool of the study.

A-priori sample size calculations using G\*Power (Faul, 2014; Faul, Erdfelder, Lang, & Buchner, 2007) with a power of .80 and alpha of .05 revealed that a sample size of 45 participants per group would be needed to detect between group differences with a medium effect size of  $d = 0.6$  or higher.

### Eligibility Criteria

#### *Inclusion*

To be included, all participants had to (a) be willing and able to give informed consent (b) be at least 18 years and less than 70 years of age, (c) speak English fluently and (d) have normal or corrected to normal vision. Participants with IBS had to meet the Rome III criteria for IBS and were required to have a diagnosis of IBS from their GP or Gastroenterologist.



### *Exclusion*

Participants were excluded if they met any of the following exclusion criteria: (a) insufficient manual dexterity to complete the tasks (b) diagnosis of dementia, amnesia or delirium; a dissociative disorder; an eating disorder; a personality disorder; schizophrenia or any other psychotic disorder; a substance related or induced disorder (c) a diagnosis of a gastrointestinal disorder other than IBS (e.g., Crohn's disease, ulcerative colitis, coeliac disease) or (d) a chronic physical condition involving pain other than IBS. Healthy participants were excluded if they met the Rome III criteria for IBS.

Participants were excluded if they had any of the listed psychiatric diagnoses because some of these patients may not have been able to give informed consent for the study (e.g. patients with dementia). In addition it was not known how a co-morbid psychiatric illness would interact with the main outcome (attentional control).

### **Questionnaires**

#### **IBS Symptom Severity**

The Gastrointestinal Symptom Rating Scale for IBS (GSRS-IBS) (Wiklund et al., 2003) is a 13-item self-report rating scale that assesses the severity of IBS specific symptoms over the past week. Symptom severity is measured on a 1-7 point scale that ranges from 'no discomfort at all' to 'very severe discomfort'. The total score ranges between 13 and 91. In the current study, Cronbach's alpha for the total scale in the IBS groups was .76.

### **Gastrointestinal Cognitions Questionnaire**

The Gastrointestinal Cognitions Questionnaire (GI-Cognitions) is a 16-item questionnaire that measures the extent to which participants believe in catastrophic cognitions about their IBS symptoms on a 0-4 scale (0= not at all, 4 = very much) (Hunt et al., 2014). Specifically, it measures the degree of symptom interference in social and occupational situations, the belief that people will react negatively to symptoms, and the belief that symptoms are disgusting. This questionnaire has been shown to discriminate between patients with IBS, patients with Crohn's disease and healthy controls and it explains unique variance in symptom severity (Hunt et al., 2014). In the current study, Cronbach's alpha was .89 in the IBS group.

### **Depression Anxiety Stress Scale**

The short version of the Depression-Anxiety-Stress Scale (DASS-21) measures symptoms of depression, anxiety and stress (Henry & Crawford, 2005). The scale has 21 items and three subscales: depression (DASS-D), anxiety (DASS-A) and stress (DASS-S). Each item is measured on a 4 point Likert scale from 0 - 3 (0 = not at all, 3 = almost always). Scores for each subscale were multiplied by two to allow for comparison with the original 42 item scale and its classifications for symptom severity (Henry & Crawford, 2005). In the present study, Cronbach's alphas for depression, anxiety and stress were .92, .83 and .85 in the IBS group and .85, .63 and .89 in the healthy group.

### **Visceral Sensitivity Index (VSI)**

Gastrointestinal specific anxiety was assessed with a 15-item Visceral Sensitivity Index (VSI) (Labus et al., 2004). Participants

indicated their level of agreement with items on a 1 (strongly agree) - 6 (strongly disagree) scale. Items relate to anticipatory anxiety about sensations in the abdominal region (e.g., I often feel discomfort in my belly could be a sign of a serious illness). Items were reverse-scored so that higher scores reflect higher gastrointestinal anxiety. Previously the scale showed excellent internal consistency (Cronbach's  $\alpha = .93$ ) and good convergent, concurrent and divergent validity was demonstrated (Labus et al., 2004, 2007). Cronbach's  $\alpha$  in the current sample was .90 in the IBS groups and .95 in the healthy group.

### Cognitive Computer Task

#### Attention Network Task

The attention network task (ANT) measures attention control, orienting and alerting attention (Fan et al., 2002). In this study a short version (Hou et al., 2014) of the original task was used. In the task, a string of five white arrows on a black background was presented above or below a central fixation cross on a computer's monitor. The central arrow either pointed in the same ( $\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow$ , congruent) or opposite ( $\rightarrow\rightarrow\leftarrow\rightarrow\rightarrow$ , incongruent) direction to the other four peripheral arrows (Figure 1). Participants were instructed to indicate the direction of the central arrow using the computer's keyboard. The difference in reaction time (RT) between the incongruent and congruent condition is referred to as a conflict score and it reflects executive attentional control. Higher conflict scores reflect lower executive attentional control. To assess alerting and orienting attention, the display of the arrows is preceded by three cue conditions (Figure 1): 1) no cue, 2) central warning cue and 3) a

spatial cue, which indicates the upcoming location of the string of arrows. Higher alerting scores reflect faster responses to trials in which a central warning cue had been displayed compared to trials without a cue. Higher orienting scores reflect faster responses to trials in which the location of the arrow-set was cued compared to trials with a central cue. The task consisted of 16 practice and 96 experimental trials. Each trial started with a central fixation cross (displayed for 400ms, 800ms, 1200ms or 1600ms), then a cue was displayed (100ms), followed by another central fixation cross (400ms) and finally the arrows were displayed until a response was made or for a maximum of 2000ms. The experimental trials were counterbalanced for cue condition, target location (above or below fixation), target direction (left or right), and congruency (congruent or non-congruent), giving 24 trials, each repeated 4 times and presented in a random order (4 repetitions x 24 trials = 96 block trials).

[insert Figure 1 here]

### *ANT Data Preparation, Error rates and outliers*

Practice trials were not included in the analysis. In line with Hou et al. (2014), RT trials with errors and outliers ( $<200\text{ms}$  and  $>2\text{SD}$  above each participant's mean) were excluded from the statistical analyses. Participants with error rates greater than 10% were not included and therefore one participant in the healthy group and one participant in the IBS group were excluded from further analysis.

Conflict (attentional control), alerting and orienting indices were computed using the following formulae: conflict score = mean RT

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incongruent trials – mean RT congruent trials; alerting score = mean RT trials preceded by no cue - mean RT trials preceded by a central cue; orienting score = mean RT trials preceded by a central cue - mean RT trials preceded by a spatial cue.

After the calculation of the indices, one participant in the healthy group was considered an outlier as they scored more than three standard deviations above the mean of the conflict scores and was subsequently excluded from the analysis.

### Procedure

The study ‘Cognitive and Emotional Factors in Illness and Health’ (CEFIH) was first approved by Oxford University’s Medical Sciences Inter-Divisional Research Ethics Committee (Reference Number MSD-IDREC-C1-2014-092 ) and was subsequently approved by the NHS Health Research Authority (National Research Ethics Service) (Reference Number 14/NW/1341). All participants completed several computerized tasks and a range of questionnaires as part of the Study (CEFIH). The ANT was one of these computer based tasks. The experimental session was carried out at the Department of Experimental Psychology and questionnaire data and demographic information was obtained via the online platform LimeSurvey (LimeSurvey Project Team & Schmitz, 2015) at least a day before completing the cognitive computer based tasks. Stimulus presentation and data collection was via E-Prime 2.0 (Psychology Software Tools, 2012). It takes approximately 5 minutes to complete the ANT.

### Statistical Plan

To analyse differences in attentional control and orienting attention between groups (IBS and Healthy), separate independent samples t-tests with conflict and orienting scores as dependent variables and group as between subjects variable were computed. To determine if these levels of attentional control and orienting attention were related to levels of anxiety and visceral anxiety sensitivity, bivariate correlations were employed. Differences in mean alerting attention between groups was analysed with an independent samples t-test. To investigate if IBS patients with lower attentional control have higher GI-cognition scores (IBS-catastrophizing) than IBS patients with higher attentional control, a one-way ANOVA with GI-Cognition scores as a dependent variable and Group (IBS with low attentional control, IBS with high attentional control, Healthy controls) was employed. Bivariate correlation analyses were run to investigate relations between IBS-catastrophizing and symptom severity.

Data were analysed using SPSS version 22 (IBM Corp., 2013). Effect sizes were reported using Cohen's *d*. Following Cohen (Cohen, 1988) and Olejnik and Algina (2000) for Cohen's *d* a small effect size = 0.2; medium effect size = 0.5; large effect size = 0.8.

### Results

#### Participants and Clinical Characteristics

One-hundred-and-four people with IBS and 145 healthy people were screened for eligibility using a self-report questionnaire. In the IBS group, 21 people were not eligible to take part (Reasons: outside of

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age range, no formal diagnosis of IBS, other GI disorder, other chronic physical condition, psychiatric diagnosis, not meeting Rome III criteria for IBS) and 83 were invited to participate. Forty-four participants with IBS completed the study assessments (39 declined to participate) and two of those participants were subsequently found ineligible. In the healthy group 16 people did not meet the eligibility criteria (Reasons: Other GI disorder, other chronic physical condition, psychiatric diagnosis, meeting Rome III criteria for IBS) and 129 were invited to participate. Seventy healthy participants completed the study assessments (59 declined to participate) and 29 of those were matched to other groups of the study. The final sample consisted of 42 participants with IBS and 41 healthy participants. Forty-one participants in the IBS group and 39 participants in the healthy group were eligible and included in the analyses (please see section ANT Data Preparation, Error rates and outliers for reasons for exclusion of participants from the analysis). Participant characteristics can be seen in Table 1.

In the ANT, on average 2.01 trials (2.1% of trials) were excluded due to erroneous responses and on average 3.56 (3.7%) outliers were excluded. On average 94.2 % of trials were included in the analysis. The groups did not differ significantly in trial-outliers, errors and trials included for analysis (between groups t-test, all  $p$ 's  $>.05$ ). The groups also did not differ in overall reaction time ( $t(79) = -.571$ ,  $p >.05$ ).

Assumptions of normality were assessed. In the IBS group, the conflict, depression and anxiety scores were not normally distributed.

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In the healthy group, the gastrointestinal cognitions, depression, anxiety, stress and VSI scores were not normally distributed.

[Enter Table 1 here]

### Attentional functions

Please see Table 2 for means and standard deviations of the conflict, orienting and alerting scores and the mean reaction time for each group (IBS, Healthy).

#### Attentional Control

An independent sample t-test with Group (IBS, Healthy) as between group variable and the conflict score as dependent variable was run.

The IBS group had significantly higher conflicts scores than the healthy group ( $t(78) = 2.75, p = .007$ ), with a *mean difference* of -17.07, BCa 95% CI [-27.97, -5.12]) and an effect size of  $d = 0.62$ .

#### Relationship between attentional control, anxiety and VSI

A bivariate correlation analysis was run with the conflict, anxiety and VSI scores in the IBS group. It was found that the conflict score was not significantly correlated with anxiety or VSI (all rhos  $< +/- .18$ , all  $ps > .05$ ).



### Orienting Attention

An independent sample t-test with Group (IBS, Healthy) as between group variable and the orienting score as dependent variable was run. The IBS group's orienting scores were not significantly different from those of the healthy group ( $t(78) = 1.03, p = .305$ ) with a *mean difference* of -6.07 BCa 95% CI [-17.35, 5.22]) and an effect size of  $d = 0.23$ .

### Relationship between orienting attention, anxiety and VSI

Bivariate correlation analyses were run with orienting attention, anxiety and VSI scores in the IBS group. It was found that anxiety significantly correlated with orienting attention ( $\rho(39) = .38, p = .015$ ). The correlation between VSI and orienting scores was not significant ( $\rho(39) = .14, p = .395$ ).

### Alerting Attention

An independent sample t-test comparing the IBS group and the healthy group on alerting attention revealed no significant difference between groups, ( $t(78) = 1.20, p = .232$ ). The *mean difference* was 6.28 with BCa 95% CI [-4.08, 17.66] and an effect size of  $d = 0.27$ .

[enter Table 2 here]

### Subgroup analysis

To analyse the data for hypothesis 2.2, comparing IBS patients with high and low attentional control, the IBS group was split into two groups with high and low conflict scores based on the median ANT conflict scores (72.45) of the IBS group. The IBS group with lower conflict scores ( $n=20$ ) had a mean conflict score of 55.88 ( $SD = 11.45$ ) and the IBS group with higher conflict scores ( $n=21$ ) had a mean conflict score of 104.32 ( $SD = 26.07$ ). This analysis was based

on a previously published analysis with CFS patients who were split into participants with high and low conflict scores based on the median conflict score in this group and then compared to each other and a healthy group on a third variable (Hou et al., 2014).

A one-way ANOVA with the GI-cognition scores as dependent variable and Group (IBS with high conflict scores, IBS with low conflict scores, Healthy controls) as between group variable showed a main effect of Group ( $F(2, 77) = 13.75, p < .001$ ). Planned contrasts between the IBS group with low conflict scores and the IBS group with high conflict scores showed that the participants with higher conflict scores had significantly higher GI-cognition scores ( $M = 29.14, SD = 12.89$ ) compared to the IBS group with low conflict scores ( $M = 21.15, SD = 11.05$ ),  $t(38.59) = -2.186, p = .032, d = .66$ , 95% CI [0.035, 1.294], see Figure 2.

[insert Figure 2 here]

The low and high conflict score subgroups did not differ significantly on IBS symptoms (GSRS-IBS), depressive symptoms, anxiety, stress (DASS), number of trials included in the analysis, or error rate (all  $t$ s (39)  $< 1.366$ ; all  $p$ s  $> .05$ ). The subgroups also did not differ significantly on gender ( $\chi^2(1) = .199$ , Fisher's exact test  $p = 1.0$ ), or education ( $\chi^2(1) = 3.228, p = .072$ ).

### **Relationship between symptom severity and IBS-catastrophizing**

A correlational analysis with symptom severity (GSRS-IBS) and GI-Cognitions was run in the IBS group. It was found that GSRS-IBS

scores positively correlated with GI-cognition scores ( $\rho$  (39) = .34,  $p = .029$ ).

### Discussion

The aims of this study were twofold: Firstly, to investigate if patients with IBS have lower attentional control and enhanced orienting attention compared to healthy participants and to examine if these levels of attentional control and orienting attention are related to levels of anxiety and visceral anxiety sensitivity. Secondly, the aim was to study the association between attentional control and catastrophizing. The results revealed significantly lower levels of attentional control in patients with IBS compared to healthy participants (Hypothesis 1.1 confirmed). In addition, IBS patients with lower levels of attentional control had more catastrophizing thoughts about IBS symptoms compared to IBS patients with higher attentional control (Hypothesis 2.2 confirmed). However, levels of attentional control were not related to levels of anxiety or visceral anxiety sensitivity in IBS patients (Hypothesis 2.1, not confirmed). In addition, there was no significant difference in orienting attention between groups (Hypothesis 2.3, not confirmed). However, levels of anxiety were positively related to enhanced orienting attention in IBS patients (Hypothesis 2.4, partially confirmed). This is the first study demonstrating altered attentional control in IBS patients and the relationship between attentional control and IBS specific maladaptive thoughts (catastrophizing).

In contrast to our findings, Hubbard and colleagues (2015) found that compared to a healthy control group, IBS patients have heightened

alerting and orienting attention, but they found no difference in attentional control. Due to their small sample size (15 IBS, 14 controls), the authors reported effect sizes rather than p-values to avoid making Type 1 or Type 2 errors. Hubbard and colleagues found a large effect for orienting attention (Hedge's  $g = -.91$ ) whereas we found a small effect (Cohen's  $d = 0.18$ ), our respective effect sizes for alerting attention were similarly small ( $g = -.34$ ,  $d = -.27$ ) and Hubbard and colleagues found a small effect for attentional control ( $g = -.20$ ), where we found a medium effect ( $d = .62$ ). However, regardless of the statistical method of reporting, their findings are largely inconsistent with the present study. Perhaps the inconsistencies are moderated by a third variable. One possibility is that the participants completed the task under different conditions in the two studies. In Hubbard (2015) the participants completed the computer task in a functional magnetic resonance imaging (fMRI) scanner whereas participants in the current study completed the task in a non-medical setting. Although fMRI scans are generally known to be safe, lying in a giant, noisy magnetic tube in a hospital setting could induce a temporary heightened level of stress which might have altered task performance differentially for the IBS and the control group. In the scanner setting, the IBS patients had lower scores on orienting attention and similar scores on attentional control, compared to their matched healthy control subjects under the same conditions. In the current study (without the scanner), the IBS patients had lower attentional control and similar levels of orienting attention compared to their matched healthy control subjects. This would indicate a differential response between groups (Healthy and IBS) on orienting attention and attentional control under potentially

stressful situations. Hence, IBS patient's performance on orienting attention is perhaps different in situations with acute elevated stress levels (as in the Hubbard study) and more similar to the performance of healthy participants under conditions of lower stress (in the current study). Similarly IBS patients' performance on attentional control may be different in situations with low stress levels (as in the current study) and more similar to the performance of healthy participants under conditions of elevated stress (in the Hubbard study). Thus examining the orienting attention and attentional control response under varied levels of stress in IBS patients may be a fruitful area for future study. Alternatively, the lack of a statistical difference in attentional control in the Hubbard study (2015) could be explained by their small sample size (15 IBS patients, 14 healthy controls) and thus lower power to detect differences between groups.

In the IBS group, a large positive correlation between anxiety and orienting attention was found. This could be an indicator that anxiety interacts with the orienting functions of the attentional network. However, no directional or causal inferences can be made.

Counter to our hypothesis, which was based on Attentional Control Theory, we found no evidence for impaired attentional control as a function of anxiety. This leads to the conclusion that differences in attentional control between IBS patients and healthy control subjects could be due to one or more other factors. Firstly, it is possible that patients with IBS had lower attentional control before the onset of the illness which may have made them more susceptible to developing IBS.. For example, Posner and Rothbart (2007) have suggested that functioning of the attentional network may be a trait characteristic.

However, it should be noted that the reliability of the indices of attentional functions measured by the ANT are moderate for the index of attentional control and low for the indices of orienting and alerting attention (Macleod et al., 2010). In addition, it has not been established whether this is due to task characteristics or variability among individuals (Macleod et al., 2010). Secondly, we cannot exclude the possibility that lower attentional control is one of the symptoms IBS. Previous studies exploring attentional differences between patients with a long-term health condition and healthy control participants found deficits in attentional control, for example, in patients with Chronic Fatigue Syndrome (CFS) (Hou et al., 2014; Togo et al., 2015) and Fibromyalgia (Miró et al., 2011). This suggests that there could be a bio-psychological interaction that plays a role in the aetiology, disease progression and maintenance of the illness.

We also found evidence that IBS patients with lower attentional control had more catastrophizing thoughts related to IBS compared to IBS patients with relatively higher attentional control. Our findings align with those of Fox and colleagues (2015) who found that the level of worrying (assessed by the level of difficulty in suppressing negative thought intrusions), was related to lower levels of attentional control. Although worrying and catastrophizing are considered to be related but distinct concepts (Lackner & Quigley, 2005), they are both self-relevant, negative and intrusive. . They are both self-relevant, negative and intrusive. Importantly, both have the potential to exacerbate IBS symptoms, physical pain and the affective dimension of pain (pain suffering) (Lackner & Quigley, 2005).

In summary, the findings of this study show that IBS patients have lower attentional control and that this lower attentional control may be associated with maladaptive cognitive thinking styles such as catastrophizing. In the broader context, empirical evidence seems to point towards the relevance of attentional control in restraining the distracting effect of intrusive thoughts.

### Implications for treatment

Computerized attentional control training and mindfulness training are two promising approaches to increase attentional control. Recent studies have aimed to improve attentional control both directly through attentional control training (Fox et al., 2015) and indirectly via working memory training (Sari, Koster, Pourtois, & Derakshan, 2015). Both studies show that attentional control can be trained using different computerized methods (a flanker task and a progressively more difficult n-back task). Importantly, gains in attentional control were related to relevant clinical targets such as a reduction in thought intrusions. Training on these tasks can easily be implemented using online computerized training modules.

Additionally, cognitive models of mindfulness predict that mindfulness-based interventions are well suited to train attention regulation and attentional control (Hölzel et al., 2011; Teasdale, Segal, Mark, & Williams, 1995). This is because most mindfulness programmes teach participants the skilful and intentional use of their attention (Baer, 2003; Kabat-Zinn, Lipworth, & Burney, 1985).

Indeed, previous studies have shown that various types of mindfulness programmes can affect attentional control (Becerra, Dandrade, & Harms, 2017; Jha, Krompinger, & Baime, 2007; Tang

et al., 2007) in healthy participants. However, no study has tested specifically if mindfulness induced changes in attentional control are predictive of reduced catastrophizing and worrying in patients with IBS. This could be a worthwhile direction for future studies.

### **Limitations**

Due to the cross sectional nature of this study, other explanations for our findings need to be considered. As discussed above, we cannot exclude the possibility that patients with IBS had lower attentional control before their symptoms of IBS commenced. Perhaps lower attentional control prior to the onset of symptoms predisposes individuals to develop more severe worries if symptoms do occur. In addition, the participants in our study generally had a high level of education which might limit the generalizability of our findings. Moreover, participants were included only if they reported a medical diagnosis of IBS. This diagnosis was not re-confirmed by a third party as part of this study, thus some diagnoses may be outdated. However, participants did have to meet the Rome III criteria for IBS which is an additional indicator that IBS is present. Finally, the questionnaire measures were obtained before the attentional task was completed. As such a prospective study would be necessary to confirm our hypothesis that attentional control is predictive of IBS catastrophizing.

### **Conclusion**

Using a validated, computerized, reaction time based method to test attentional networks, this study found that patients with Irritable Bowel Syndrome have lower attentional control compared to healthy participants. Attentional control is relevant for emotional regulation



and goal attainment. Thus attentional control training, of which there are several simple methods, could be beneficial to IBS patients.

Those patients with the lowest level of attentional control were also those who had more catastrophizing thoughts about their condition.

Therefore attentional control training may be particularly beneficial to such patients.

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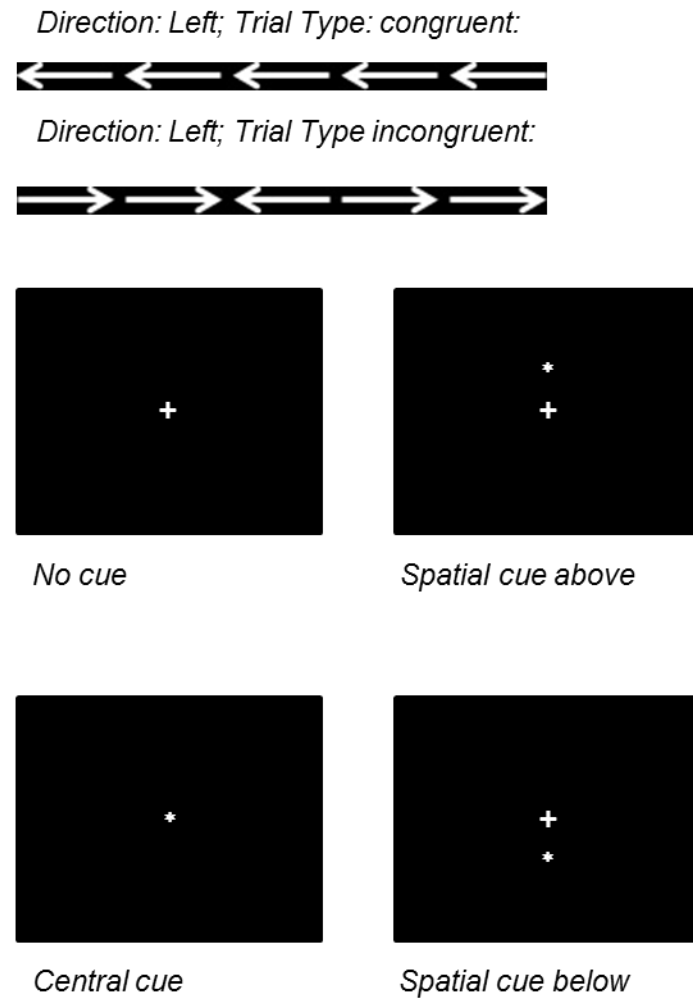
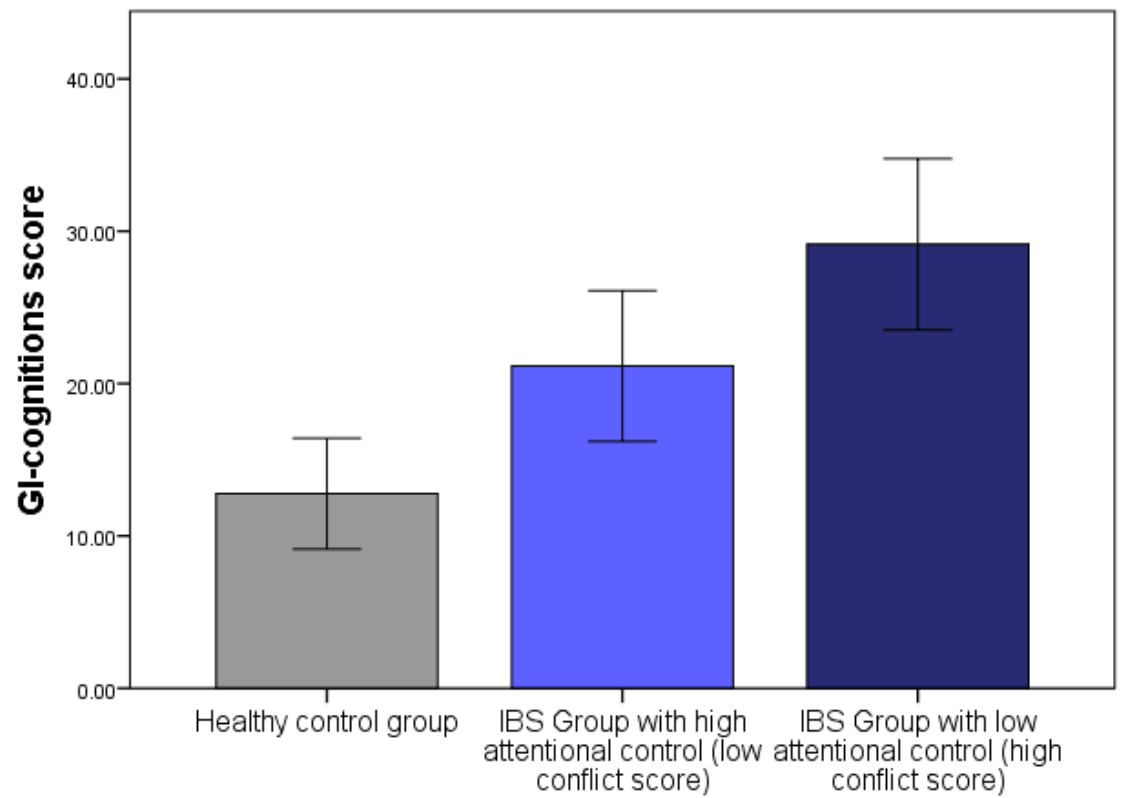


Figure 1. The Attention Network Task showing two types of arrow displays, one congruent and one incongruent, and the four types of cue condition



**Figure 2. Gastrointestinal-Cognitions (IBS-catastrophizing) in the healthy control group, IBS patients with high attentional control (low conflict score) and IBS-patients with low attentional control (high conflict score). Error Bars represent two standard errors above and below the mean.**

**Table 1**  
***Participant Characteristics.***

	IBS <sup>a</sup> Group (n= 41) Mean (S.D.)	Healthy Control Group (n=39) Mean (S.D.)	t-value/ $\chi^2$ value
Age (years)	34.44 (15.70)	35.00 (15.63)	0.16
Gender	82.9% female; 17.1% male	84.6% female; 15.4% male	0.042
Educational Level	39% Up to and including A-levels <sup>b</sup> ; 61.0% Tertiary Education <sup>c</sup>	28% Up to and including A-levels <sup>b</sup> ; 71.8% Tertiary Education <sup>c</sup>	1.046
IBS Symptom (GSRS-IBS) <sup>d</sup>	46.37 (10.80)	18.82 (7.72)	13.18***
IBS Catastrophizing (GI-C) <sup>e</sup>	25.24 (12.55)	12.77 (11.36)	4.666***
Depression (DASS) <sup>f</sup>	12.24 (10.11)	5.49 (5.78)	3.691***
Stress (DASS) <sup>f</sup>	17.51 (8.87)	9.28 (7.98)	4.366***
Anxiety (DASS) <sup>f</sup>	10.78 (8.92)	3.33 (3.85)	4.889***
Visceral Anxiety Sensitivity (VSI) <sup>g</sup>	58.24 (14.83)	26.28 (15.06)	9.563***

<sup>a</sup>Irritable Bowel Syndrome; <sup>b</sup>no formal qualifications, GCSE, NVQ or vocational Qualification or at least 12 years of schooling; <sup>c</sup>University degree (Undergraduate, Masters, Post-Graduate); <sup>d</sup>Gastrointestinal Symptom Rating Scale for Irritable Bowel Syndrome; <sup>e</sup>Gastrointestinal Cognitions Questionnaire; <sup>f</sup>Depression, Anxiety, Stress Scale;

<sup>g</sup>Visceral Sensitivity Index

; \*\*\* p < .001

**Table 2**

*Attention Network Task (ANT) indices (msec) in the IBS and the healthy groups. Conflict, Alerting and Orienting Scores reflect differences among cue conditions of the ANT.*

	IBS (n=41)		Healthy (n=39)	
ANT Index	M (SD)		M (SD)	
Conflict Score <sup>1</sup>	80.69	(31.67)	63.62	(22.83)
Alerting Score	8.06	(18.14)	14.34	(27.69)
Orienting Score	38.19	(26.94)	32.11	(25.61)
	557.7			
Overall mean RT <sup>2</sup>	8	(101.58)	544.98	(100.06)

<sup>1</sup>Higher Conflict Scores reflect poorer attentional control; <sup>2</sup>Overall mean

RT is the mean Reaction Time across all cue conditions in the Attention Network Task.

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