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The relationship between attention and avoidance coping in anorexia nervosa: functional magnetic resonance imaging study

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Background

Numerous studies have demonstrated attentional control difficulties and high avoidance coping in patients with anorexia nervosa. Attention is a critical coping resource because it enables individuals to demonstrate self-control and complete goal-directed behaviours.

Aims

We aimed to examine whether attentional control difficulty is related to high avoidance coping, and investigate the neural underpinnings of attentional control difficulties in individuals with anorexia nervosa.

Method

Twenty-three patients with anorexia nervosa and 17 healthy controls completed questionnaires that assessed attention and coping, and underwent functional magnetic resonance imaging while performing a go/no-go task.

Results

Patients with anorexia nervosa showed weaker attentional control, higher omission error rates and higher avoidance coping compared with healthy controls. Attentional control difficulty was associated with higher avoidance coping in both groups. Functional magnetic resonance imaging analysis showed less deactivation in regions representing internal mental processing, such as the praecuneus, cuneus and left lingual gyrus, during the no-go condition. Moreover, weakened deactivation of the left lingual gyrus was associated with higher commission error rate in the anorexia nervosa group.

Conclusions

Our results suggest that patients with anorexia nervosa may have difficulty in maintaining attention to external ongoing events because of disturbance from internal self-related thought, and support the notion that attentional control difficulties underlie the frequent use of avoidance coping in anorexia nervosa.

Keywords

Anorexia nervosa; attention; coping; functional magnetic resonance imaging; self-referential processing.

Coping and its classification

Coping style is important for reducing the injurious effects of strong stressors and plays a significant role in the pathogenesis of anorexia nervosa.[1] Coping refers to the cognitive and behavioural effort required to manage psychological distress, and coping failure leads to physio-psychological stress responses.[2] Coping style has frequently been classified into approach and avoidance styles.[3] Under this classification, efforts to diminish or eliminate stressors proactively (e.g. help-seeking, planning and problem-solving) are classified as approach coping, whereas efforts to avoid a stressor (e.g. abandonment, denial and cognitive avoidance) are classified as avoidance coping.

Coping in anorexia nervosa

Previous studies have indicated that patients with anorexia nervosa tend to use more avoidance coping and less approach coping compared with healthy controls.[4,5] In addition, longitudinal studies have indicated that individuals who later develop eating disorders use avoidance coping more at baseline, and the frequency of avoidance coping increases as symptoms progress.[6] Moreover, with recovery, their tendency to use avoidance coping decreases, whereas their tendency to use approach coping increases.[7] This suggests that avoidance coping is a risk factor for anorexia nervosa as well as a predictor of recovery.

Coping and attention

In the field of coping studies, various psychological factors, such as optimism, self-efficacy and self-esteem, were originally suggested to be coping resources.[8] However, cognitive functions, such as executive functions[9] and attention,[10] have also recently been examined. Executive function is theorised as a group of higher-order cognitive abilities, such as cognitive flexibility, planning, decision-making, working memory and attention, which enable individuals to demonstrate self-control and successfully complete goal-directed behaviour.[11] Among these higher-order cognitive abilities, attention is considered a critical factor for coping; as noted by Hocking et al,[10] attention is required to shift attention away from a stressor toward a coping attempt, and may influence the choice or effectiveness of the coping strategy. Hocking et al[10] examined the relationships between attention, coping and psychological outcomes, and discovered that selective attention and attentional control both had significant indirect effects on anxiety through secondary control coping, which describes the effort required to become accustomed to the stressor by modifying cognition or regulating attention.

Attention in anorexia nervosa

Numerous studies have shown abnormal attentional processes in patients with anorexia nervosa. For example, patients with anorexia nervosa show higher attentional bias not only toward body shape,[12] but also social stimuli.[13] Several studies have also indicated that patients with anorexia nervosa have difficulties with attentional orientation control, which is a top-down aspect of attention.[14]

Aims

Given the evidence, it can be hypothesised that attentional control difficulties underlie avoidance coping in patients with anorexia nervosa. However, the relationship between attention and coping in this population remains unclear. To address this issue, we examined whether attentional control is related to avoidance coping in patients with anorexia nervosa. Additionally, we used functional magnetic resonance imaging (fMRI) to investigate the neural underpinnings of attentional control difficulty in patients with anorexia nervosa.

Method

Participants and procedure

Participants were individuals with anorexia nervosa who were outpatients of Kyoto University Hospital and age-matched healthy controls. The exclusion criteria for healthy controls were meeting the criteria of Axis I in the DSM-IV-TR,[15] neurological disorders or diseases affecting the metabolism of the central nervous system, insufficient ability to consent owing to a medical condition and a body mass index of ≤12 kg/m^2. Diagnosis and subclassification of anorexia nervosa was confirmed by a psychiatrist, who conducted structured interviews using the Japanese version of the DSM-IV-TR. Data from two of the participants were excluded from the analysis because of artifacts in the magnetic resonance imaging (MRI) data. The analysed participants consisted of 23 patients with anorexia nervosa (10 with restricting type and 13 with binge-purging type; mean age 37.04 years, s.d. 9.88; age range 21–49 years, average duration of illness 16.96 years) and 17 healthy controls (mean age 36.24 years, s.d. 10.59; age range 21–54 years).

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. All procedures involving human patients were approved by the ethics committee of Kyoto University Graduate School and Faculty of Medicine (approval number R0992), and written informed consent was obtained from all participants.

Self-report questionnaire

Approach coping and avoidance coping were assessed using the Japanese version[16] of the Brief Coping Orientation to Problems Experienced (COPE) Inventory.[17] Based on a previous study,[18] the approach coping score was assessed according to the total score of active coping, planning and acceptance, whereas the avoidance coping score was assessed according to the total score of denial, behavioural resignation and self-blame. Attentional control was assessed using the Japanese version of the Effortful Control Scale (J-ECS).[19] The J-ECS was developed by extracting the Effortful Control Scale from the Adult Temperament Questionnaire,[20] to focus on executive attention in adults. The J-ECS contains three subscales: inhibitory control, which refers to the capacity to suppress inappropriate approach behaviour; activation control, which refers to the ability to perform an action when a person is unwilling to perform the action; and attentional control, which refers to the capacity to focus and to shift attention.[21] Effortful control is defined as 'the efficiency of executive attention, including the ability to inhibit a dominant response and/or to activate a subdominant response, to plan, and to detect errors';[22] it involves the voluntary control of behaviours and attentional processes.[23]

fMRI task

A letter-based go/no-go task was used for the fMRI. The go/no-go task requires response inhibition as well as attentional control.[24] This task was used because the focus of the present study was to examine general attentional control rather than specific attention. All letters except X were used as 'go' stimuli, whereas X was used as the 'no-go' stimulus. For go stimuli, participants were instructed to press a button as fast as possible with the thumb of the dominant hand, and for no-go stimuli, they were instructed not to press the button. The frequency of go stimuli was adjusted to 67% (135 times), and the frequency of no-go stimuli to 33% (45 times). The presentation time of each stimulus was 600 ms and the interstimulus interval was randomly jittered from 1200 to 3600 ms. The presentation order of all stimuli was pseudo-randomised. The task consisted of three runs, with each run containing 60 trials. The duration of each run was 3 min, with a 1-min intermission between each run. Participants practiced seven trials before entering the MRI scanner, and started the actual experiment after confirming that they fully understood the procedure of the task. We used E-PRIME 2.0 Professional (https://psychology-software-tools.mybigcommerce.com/e-prime-2-0/; Psychology Software Tools, Sharpsburg, PA, USA) running on a Windows 7 PC to present the task and collect behavioural data.

fMRI data acquisition

All data were acquired with a 3-Tesla MRI scanner (Siemens Trio, Erlangen, Germany) at the Human Brain Research Center, Graduate School of Medicine, Kyoto University. First, a T1-weighted sagittal image was acquired for positioning (repetition time 20 ms, time to echo 5 ms, flip angle 40°, field of view 281 × 281 mm, slice thickness/gap 10 mm/2 mm). Then, functional images were obtained with an echo-planar imaging sequence (repetition time 2400 ms, time to echo 30 ms, flip angle 90°, field of view 192 × 192 mm, matrix size 64 × 64, slice thickness/gap 3 mm/0 mm, 38 interleaved axial slices). The full fMRI acquisition consisted of 297 volumes, but the first six volumes were excluded to ensure signal stability. Finally, high-resolution T1-weighted structural images were acquired (magnetisation-prepared rapid gradient-echo sequence, repetition time 2000 ms, time to echo 3.4 ms, flip angle 8°, field of view 225 × 240 mm, slice thickness 1 mm, 208 axial slices). Participants wore earplugs to reduce noise and laid on their back on the scanner bed. They performed the task by pressing the button with the device held in their dominant hand. Visual stimuli were presented on an MRI-compatible liquid crystal display, and participants viewed the stimuli through a mirror attached to the head coil.

Statistical analyses

Psychological and behavioural data

The total scores for approach coping, avoidance coping and the subscales of J-ECS were calculated. For behavioural data, omission error rate (proportion of not pressing the button during the go condition), commission error rate (proportion of pressing button during the no-go condition) and reaction time were calculated. For each group, these parameters were subjected to *t*-tests and correlation analyses.

fMRI data

Pre-processing

FSL5 (FMRIB Software Library, Department of Clinical Neurology, University of Oxford, UK; www.fmrib.ox.ac.uk/fsl/, Mac)[25] and SPM12 (Wellcome Department of Imaging Neuroscience, University of London, UK; https://www.fil.ion.ucl.ac.uk/spm/software/spm12/, Mac) were used for the fMRI analyses.

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Table 1 Participant demographics and behavioural data

	Anorexia nervosa ($n = 23$)		Healthy controls ($n = 17$)		*t*-test	
	Mean	s.d.	Mean	s.d.	*t*	*P*-value
Demographic data						
Age, years	37.04	9.88	36.24	10.59	0.25	0.81
Years of education	14.30	1.96	15.19	1.76	−1.44	0.16
BMI	14.40	2.94	21.15	2.83	−7.29	0.00
Duration of illness	16.96	8.69	–	–	–	–
Psychological data						
Effortful Control Scale						
Activation control	36.00	4.93	35.35	4.47	0.43	0.67
Inhibitory control	32.78	5.01	33.47	4.99	0.43	0.67
Attentional control	28.83	5.91	32.76	4.51	−2.30	0.03
Brief-COPE						
Approach coping	16.35	2.85	17.76	2.59	−1.61	0.12
Avoidance coping	13.70	2.58	10.82	2.74	3.39	0.00
Behavioural data						
Omission error rate	0.6	0.06	0.02	0.02	3.49	0.00
Commission error rate	0.11	0.08	0.10	0.06	0.70	0.49
Reaction time, ms	456.19	27.98	426.38	29.51	3.25	0.02

BMI, body mass index; Brief-COPE, Brief Coping Orientation to Problems Experienced Inventory.

After inter-scan slice timing correction, head motion was compensated for by using three-dimensional motion correction and data repair.[26] This repairing procedure aims to remove motion-related signal drop-out and involves searching for time points presenting (a) abrupt global signal change exceeding 1% and (b) frame-wise displacement exceeding a Euclidian distance of ±1 mm or ±1° rotation per repetition time. In addition, 24 parameters related to head motion were used to regress out motion effects. These functional images were co-registered to the T1 anatomical image. Then, the structural images were matched to a template via a tissue probability map. Functional images were also spatially normalised with the warping parameters from the structural image normalisation, and were resliced to 4-mm isotropic voxels.

Finally, a recently proposed denoising method[27,28] was used to cope with contamination from non-neural signal components. This procedure involves tracking regional variations of low-frequency oscillations of systemic origin, using the bandpass-filtered (0.008–0.07 Hz) global signal as an initial seed. The phase shift in each voxel was tracked up to 7 s up- and downstream to create a phase lag map, and the corresponding time-series were set for each region. This spatiotemporal lag structure was then regressed out from the original data. This process can be considered as a global signal regression tailored for each voxel that affects only the slow signal components. These functional images were spatially smoothed with a Gaussian filter with a full width at half maximum of 4 mm.

First-level analysis

In the first-level analysis (intra-individual analysis with a fixed-effects model), the activations for each of the conditions no-go-correct, no-go-incorrect and go were modelled according to the haemodynamic response function. A temporal derivative option was applied to the starting point of each stimulus, to absorb individual differences in haemodynamic response. Our target contrasts were no-go-correct versus go, to capture those voxels representing no-go-specific activity.

Second-level analysis

In the second-level analysis (group analysis with a random-effects model), the contrast images from the no-go-correct versus go contrast were used for within- and between-group analyses. In these analyses, activated regions satisfying $P < 0.001$ (uncorrected) at the voxel level and a cluster size of $k > 5$ were considered as significant regions. Age was included as a covariate in these analyses. Finally, correlation analysis was conducted in patients with anorexia nervosa between commission error rate and mean β-values (extracted from each region obtained from the group comparison analysis).

Results

Independent samples *t*-tests of demographic, psychological and behavioural data

There were no significant differences in age or years of education between the anorexia nervosa and healthy control groups. The anorexia nervosa group showed significantly lower body mass index than the healthy control group ($t = -7.29$, $P < 0.01$). The anorexia nervosa group showed a significantly lower attentional control score than the healthy control group ($t = -2.30$, $P = 0.03$), whereas no significant difference was found in activation control or inhibitory control. Regarding the Brief-COPE score, avoidance coping score was significantly higher in the anorexia nervosa group than in the healthy control group ($t = 3.39$, $P < 0.01$), whereas no significant difference was found in the approach coping score. As for the behavioural data, the anorexia nervosa group showed significantly higher omission error rate ($t = 3.49$, $P < 0.01$) and longer reaction time ($t = 3.25$, $P = 0.02$) than the healthy control group in the go trials. However, there was no significant difference in commission error rate in the no-go trials (see Table 1).

The scores for approach/avoidance coping and attentional control were examined in relation to behavioural and fMRI data for subsequent analyses because there were no significant differences in activation control and inhibitory control between the anorexia nervosa and healthy control groups.

Correlation analyses between attention and coping

There was a significant negative correlation between attentional control scores and avoidance coping in both the anorexia nervosa ($r = -0.51$, $P < 0.01$) and healthy control groups ($r = -0.75$, $P < 0.01$; see Fig. 1). For the go/no-go task, a significant positive correlation ($r = 0.43$, $P = 0.02$) was found between commission error rate and avoidance coping score in the anorexia nervosa group, whereas a significant positive correlation ($r = 0.43$, $P = 0.04$) was

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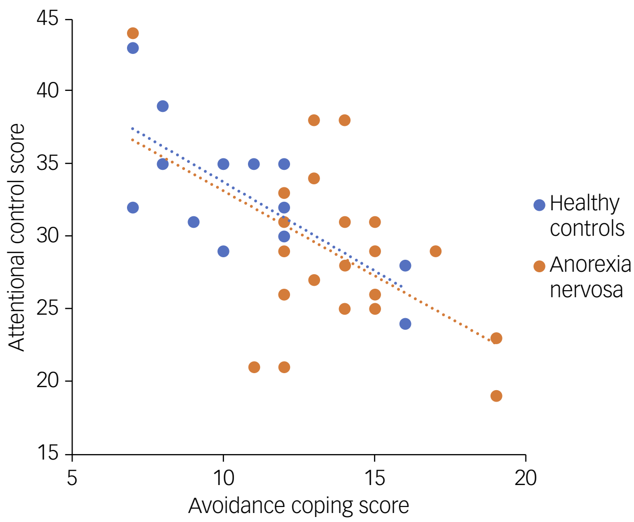

Fig. 1 Relationship between attentional control score and avoidance coping score in patients with anorexia nervosa ($r = -0.51$, $P < 0.01$) and healthy controls ($r = -0.75$, $P < 0.01$).

found between omission error rate and avoidance coping score in the healthy control group.

fMRI analyses

In the no-go-correct versus go contrast, the healthy control group showed significantly higher activation in the bilateral anterior insula (*Z*-value = left 4.26/right 4.11) and right supramarginal gyrus (*Z*-value = 3.55), whereas the anorexia nervosa group showed significantly higher activation in the same regions and the bilateral praecuneus (*Z*-value = left 3.53/right 4.83), bilateral middle frontal gyrus (*Z*-value = left 3.49/right 4.40) and occipital regions (see Table 2). The results for the go versus no-go-correct contrast are shown in Supplementary File 1 available at https://doi.org/10.1192/bjo.2021.963.

Between-group analyses showed that the anorexia nervosa group had greater activity than the healthy control group in the midline region, extending from the cuneus to praecuneus (*Z*-value = 4.60), left lingual gyrus (*Z*-value = 3.68) and midline praecuneus (*Z*-value = 3.39) in the no-go-correct versus go contrast. Because of the characteristics of the fMRI group comparison analyses, it was difficult to determine whether the results represented greater or weakened deactivation in the anorexia nervosa group. To address this issue, we extracted mean β-values from each condition from each group and visualised these in Fig. 2, which indicated that the anorexia nervosa group had less deactivation than the healthy control group in the no-go condition (see Fig. 2). No significant regions were found for the healthy control group versus anorexia nervosa group contrast.

Finally, a correlation was performed between mean β-values of the no-go-correct versus go contrast in regions obtained from the analysis above (cuneus, left lingual and praecuneus) and commission error rate in the anorexia nervosa group. Results showed that the activity of the left lingual gyrus significantly correlated with commission error rate in the anorexia nervosa group ($r = -0.45$, $P < 0.02$; see Fig. 3).

Discussion

The purpose of the present study was to examine the relationship between attentional control and avoidance coping, and to investigate the neural substrates of such relationships in patients with anorexia nervosa. Our results indicated that attentional control difficulty is associated with high avoidance coping. Furthermore, the brain regions obtained from the group comparison were regions that represent internal mental processing, which suggested that sustained attention to ongoing events is easily disturbed by internal thought in those with anorexia nervosa.

Results of the *t*-tests showed that patients with anorexia nervosa had low attentional control and high avoidance coping compared with healthy controls. These results are consistent with previous studies of attention[14] and coping[6] in anorexia nervosa. Additionally, the anorexia nervosa group exhibited a higher omission error rate in the go trials compared with that of the healthy control group. Results of previous studies using the go/no-go have been inconsistent. One study found that the anorexia nervosa group showed high omission and commission error rates relative

Table 2 Brain regions showing higher activation in the within-group no-go-correct versus go contrast

		MNI coordinates				
Regions	Left/right	X	Y	Z	*Z*-value	Cluster size, mm^3
Healthy controls						
Anterior insula	Left	−30	24	−2	4.26	164
Anterior insula	Right	30	16	−10	4.12	156
Supramarginal gyrus	Right	62	−48	34	3.55	56
Anorexia nervosa						
Praecuneus	Right	10	−68	38	4.83	420
Middle frontal gyrus	Right	46	24	42	4.40	372
Anterior insula	Left	−30	20	−6	4.38	128
Supplementary motor cortex	Left/right	−2	20	62	4.33	112
Lingual gyrus	Left	−22	−96	−10	4.29	156
Occipital pole	Right	14	−96	−2	3.99	168
Lingual gyrus	Right	22	−40	−6	3.89	36
Middle frontal gyrus	Right	42	4	26	3.77	48
Supramarginal gyrus	Right	46	−52	30	3.72	72
Anterior insula	Right	34	12	−6	3.68	60
Praecuneus	Left	−10	−76	38	3.53	32
Thalamus proper	Left	−6	−8	2	3.51	36
Middle frontal gyrus	Left	−42	24	−42	3.49	56
Middle occipital gyrus	Right	30	−76	10	3.18	20

Regions satisfying $P < 0.001$ at the voxel level and a cluster size of $k > 5$ are shown.

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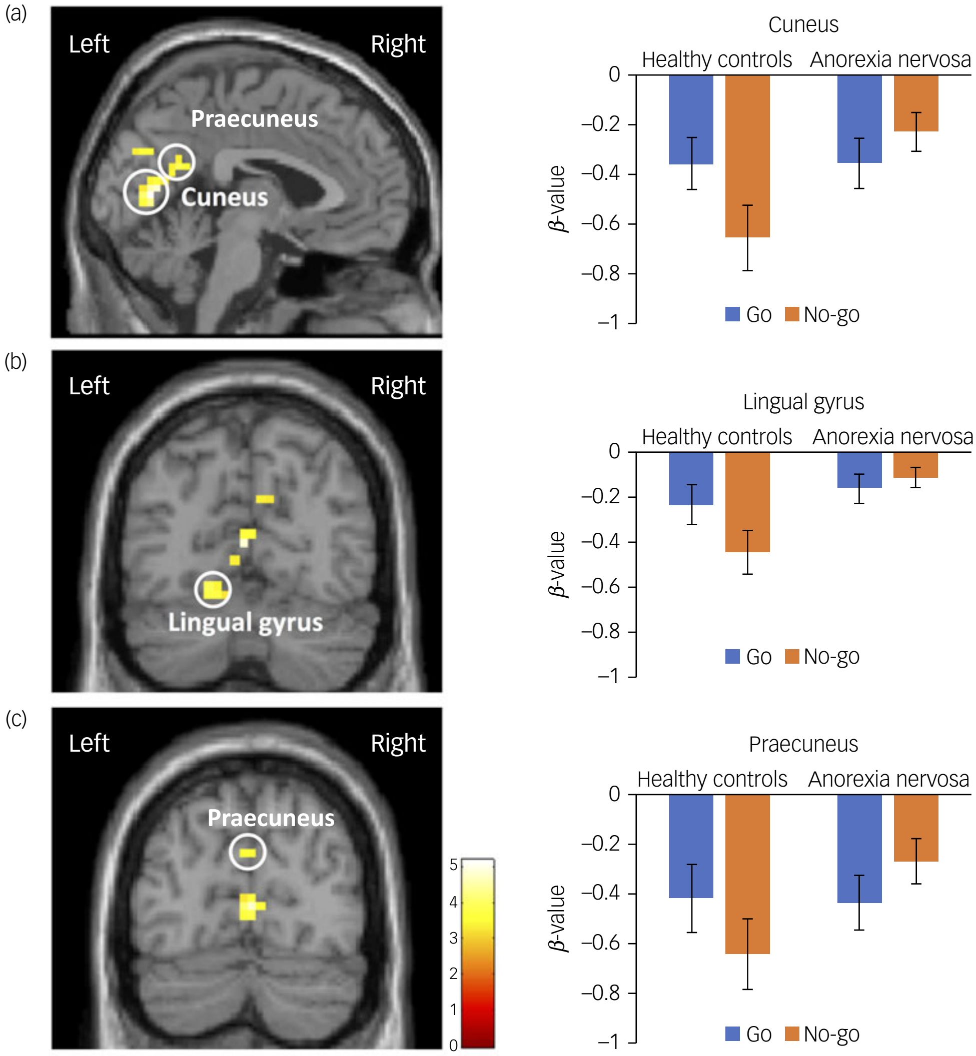

Fig. 2 Brain regions showing differences in the no-go-correct versus go contrast (anorexia nervosa > healthy control). Whole-brain group analyses showing less deactivation in patients with anorexia nervosa relative to healthy controls in the no-go-correct > go contrast in the (a) cuneus ($x = -2$, $y = -72$, $z = 6$, cluster extent 40, Z-value = 4.60) to praecuneus ($x = -2$, $y = -56$, $z = 22$), (b) left lingual gyrus ($x = -18$, $y = -68$, $z = -10$, cluster extent 11, Z-value = 3.68) and (c) praecuneus ($x = -2$, $y = -76$, $z = 30$, cluster extent 9, Z-value = 3.39). Regions satisfying $P < 0.001$ at the voxel level and a cluster size of $k > 5$ are shown.

to healthy controls,[29] whereas other studies found that neither omission nor commission error rates differed between anorexia nervosa and healthy control groups.[30,31] This inconsistency might result from different durations of illness in the samples. In contrast to the mean participant age of 27.3 years in the study by Seed et al,[29] participants in the studies that showed no difference in error rates were adolescents. The mean age of our participants was 37.0 years, and the mean duration of illness was 16.69 years. Therefore, it is probable that the mean duration of illness in the studies of adolescent anorexia nervosa was much shorter than that in our study. Omission error is considered a result of attentional lapses.[32] Thus, it is possible that impaired sustained attention underlies the high omission error rate in the anorexia nervosa group. Considering these facts together, sustained attention may be retained in adolescents with anorexia nervosa but impaired in patients with chronic anorexia nervosa, because of long-term undernutrition and low weight. However, studies on attention in chronic anorexia nervosa are limited, and further investigations are needed.

Correlation analyses showed that attentional control score was negatively correlated with avoidance coping score in both anorexia nervosa and healthy control groups, which suggests that attention is a critical cognitive coping resource in general.

The results of the within-group fMRI analyses revealed that both healthy control and anorexia nervosa groups showed significant activation in the bilateral anterior insula and right supramarginal gyrus, which represent the ventral attention network. The ventral attention network is involved in stimulus-driven attentional control and detection of salient stimuli,[33] and activation of the anterior insula during go/no-go tasks has frequently been reported in previous fMRI studies.[34] The anterior insula is considered to play a critical role in the switching between two major networks: the default mode network and central executive network, which are known to present competitive interactions during cognitive information processing.[35] The right supramarginal gyrus is involved in visuospatial and orienting attention.[36] Thus, it can be considered that recruitment of these regions reflects externally oriented attention during the no-go condition.

However, the between-group analysis revealed higher activation in the bilateral praecuneus, bilateral cuneus and left lingual gyrus in the no-go condition in the anorexia nervosa group. The β-value

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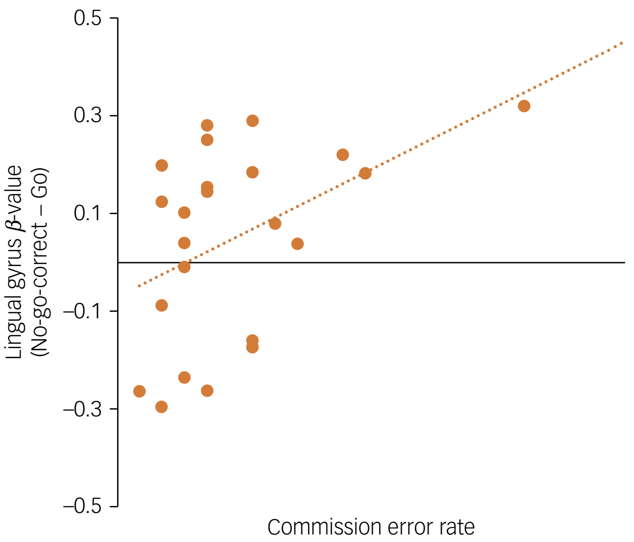

Fig. 3 Relationship between commission error rate and β-values extracted from the no-go-correct versus go contrast ($r = 0.451$, $P < 0.02$) in patients with anorexia nervosa.

extracted from each condition showed that these regions were deactivated during the go condition in both groups, and that the deactivation increased in the healthy control group but weakened in the anorexia nervosa group during the no-go condition. The praecuneus is considered a functional core of the default mode network[37] and is associated with self-referential processing,[38] which should be suppressed during the task. Considering the task design, the no-go stimuli can evoke the salient network of the participants. In this regard, we speculate that the healthy control group were better able to deal with salient target stimuli with efficient top-down attentional control, whereas the anorexia nervosa group failed to sustain attention because of disturbance from self-referential processing. Taken together, these results suggest that patients with anorexia nervosa may have difficulty in maintaining attention to external ongoing events, because of disturbance from internal self-related thought.

The cuneus and lingual gyrus are both involved in visual imagery processing.[36] For example, Benedek et al[36] examined brain mechanisms associated with externally and internally oriented attention by manipulating task stimulus accessibility: keeping the task stimuli on the screen for the external condition and masking the stimuli for the internal condition, so that participants had to perform the task ‘in their mind’s eye’. They found higher activation in the bilateral lingual gyrus and left cuneus in the internal condition, which suggests that activation of the lingual gyrus and cuneus represents internally oriented attention, specific to the processing of visual imagery. Thus, deactivation of these regions during the go condition and increased deactivation during the no-go condition in the healthy control group can be considered as reasonable results because attention is supposed to be oriented externally and more focused in the presence of no-go stimuli, to allow for effective detection and action. Weakened deactivation in these regions in patients with anorexia nervosa may reflect attentional vulnerability in the same manner as praecuneus activity. Alternatively, because the cuneus and lingual gyrus clusters obtained in this study were located adjacent to the praecuneus, it is possible that the signals in the cuneus and lingual gyrus represent the same neural activity as that in the praecuneus. These results suggest that internally oriented attention interferes with external goal-directed attention in patients with anorexia nervosa, and consequently, the anorexia nervosa group exhibited more errors during the task because internal and external attention were competing with each other. Consistent with these results, the correlation analysis within the anorexia nervosa group revealed the following: the weaker the deactivation in left lingual gyrus during the no-go condition, the higher the commission error rate in patients with anorexia nervosa. Thus, the association between weakened deactivation in the left lingual gyrus and commission error rate in patients with anorexia nervosa supports the notion that difficulty of attentional control in anorexia nervosa may be explained by altered brain activity in attention-related regions.

The present study has several limitations. First, we did not obtain activation in regions that have been consistently reported in previous fMRI studies using the go/no-go task, such as the dorsolateral prefrontal cortex or inferior parietal lobe in healthy controls.[34] One possible explanation for this is that regions recruited by the go/no-go task are highly dependent on task difficulty;[39] the task used in the study may have been too easy to detect significant activation in these regions in healthy controls. Second, we treated both restricting and binge-purging anorexia nervosa subtypes as a single group. Restricting and binge-purging types share the same psychopathology, such as an intense fear of gaining weight and body image disturbance, although the eating behaviour may seem rather opposing. However, a previous study found no significant difference in attentional control between restricting type and binge-purging type patients with anorexia nervosa.[40] Thus, the results of the present study can be considered to represent general anorexia nervosa features. A third limitation is that it was difficult to refer to causal relationships because of the cross-sectional nature of the study. We assumed a model in which attentional deficit led to frequent use of avoidance coping in anorexia nervosa. However, it is also possible that attention may have deteriorated because of the low mental health state resulting from an avoidance coping style. Furthermore, a spiral relationship, in which attentional difficulties further strengthen the tendency to use avoidance coping, can be assumed. Such causal relationships need to be elucidated by conducting longitudinal studies or intervention research. A final limitation is that the data sample was restricted to chronic anorexia nervosa, and it is therefore difficult to generalise the results obtained in this study to other age groups. However, the study revealed not only attentional control difficulties, but also an association between attentional control and maladaptive coping style in chronic anorexia nervosa. This association may be a core factor that prevents patients with chronic anorexia nervosa from recovering.

Despite these limitations, our results extend previous findings on attention difficulties and high avoidance coping in anorexia nervosa by demonstrating a neural basis. The findings demonstrate the presence of sustained attention difficulties and their neural underpinning in anorexia nervosa, and support the notion that attentional control difficulties underlie the frequent use of avoidance coping in anorexia nervosa. As for clinical significance, this study provides a novel insight into the fundamental cognitive training methods, such as attention training techniques or mindfulness meditation, that may be useful for treating anorexia nervosa.

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Supplementary material

Supplementary material is available online at https://doi.org/10.1192/bjo.2021.963

Data availability

The data that support the findings of this study are available from the corresponding author, T.N., upon reasonable request.

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Author contributions

T.N. formulated the research question, performed the research, analysed the data and wrote the article. M.I. formulated the research question, performed the research and wrote the article. K.U. formulated the research question, analysed the data and wrote the article. T.A. conducted fMRI data processing and analysed the data. E.M. and M.K. performed the research. S.N. designed the study. T.M. analysed the data and wrote the article.

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Declaration of interest

None.

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