Local and global visual processing and eating disorder traits: An event-related potential study

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Abstract

Recent studies have suggested that individuals with eating disorders show a stronger local processing bias and/or a weaker global bias in visual processing than typical individuals. In this study, healthy participants with varying scores on the Eating Disorder Examination Questionnaire (EDE-Q) performed the Navon task, a standard task of local and global visual processing, whilst electrophysiological measures were recorded. Global stimuli were presented that were made up of many local parts, and the information between levels was either compatible or incompatible. Participants were instructed to report the identity of either a global or a local target shape, while ignoring the other level. Higher EDE-Q scores were associated with enhanced amplitude of the P3 component during local visual processing, as well as greater P1 amplitude during local incompatible trials. These findings support the claim that eating disorders are associated with differences in local and global visual processing.

Highlights

* We investigated local and global visual processing in groups with low and high eating disorder (ED) traits.
* Behavioural performance on the Navon task of local and global visual processing was the same in the low and high ED groups.
* Electrophysiological results in the high ED group showed an enhanced P3 amplitude during local processing, and an enhanced P1 amplitude during local incompatible processing.
* The electrophysiological findings suggest that eating disorders may be associated with increased local visual processing.

Keywords: Eating disorders; global processing; local processing; central coherence; electroencephalography.

Introduction

There is consistent evidence to suggest that individuals with eating disorders may have deficits in visuospatial processing (Lena, Fiocco & Leyenaar, 2004; Zakzanis, Campbell & Polsinelli, 2010). Eating disorders have been associated with poor performance on the Rey-Osterrieth Complex Figure (ROCF; Osterrieth, 1994), a test that involves copying a complex visual image and is assumed to rely on the ability to focus on global level information in the image. Compared with control participants, those with eating disorders tend to focus more on the local components of the figure than its global shape (Harrison, Tchanturia & Treasure, 2011; Lopez et al., 2008a; Lopez et al., 2008b; Lopez et al., 2009; Tenconi et al., 2010). Conversely, individuals with eating disorders have demonstrated superior performance on visual tasks requiring processing of local detail, such as the embedded figures test (Southgate, Tchanturia & Treasure, 2008). Together, these findings suggest that individuals with eating disorders have a tendency to prioritise the processing of visual detail over global aspects of the visual input (Lask & Frampton, 2011; Lopez et al., 2008b). Indeed, a key aspect of eating disorders may be weak central coherence (Lopez, Tchanturia, Stahl & Treasure, 2008), which refers to a relative inability to successfully balance the processing of detail and context (Happé & Frith, 2006).

Until recently, research investigating local and global processing differences between individuals with and without eating disorders exclusively involved behavioural measures. A very recent study investigated the neural correlates associated with face identification in participants with Anorexia Nervosa (AN; Li et al., 2015). Using Event-Related Potentials (ERPs) they found smaller amplitudes in the P100 component in participants with AN compared to participants with Body Dysmorphic Disorder (BDD) and healthy controls, and smaller amplitudes in the face-related N170 component for both AN and BDD participants compared to healthy controls. As face identification depends on global level processing (Maurer, Le Grand & Mondloch, 2002), these findings indirectly support the notion that eating disorders are associated with a bias towards processing local level information in vision.

Neuropsychological methods used to date have involved complex tasks such as the ROCF and the embedded figures test which take relatively long to complete, making them less suitable for use in neuroimaging. The main aim of the current study was to examine the neural correlates associated with the local processing bias in individuals with high and low eating disorder traits, by measuring ERPs associated with local and global visual processing in the Navon task. In the Navon task, participants are presented with hierarchical stimuli, consisting of many local elements that make up a larger global shape (Navon, 1977; see Figure 1). The task is to identify a target stimulus at either the local or the global level, while ignoring the other level. There are two indices of local and global processing in the Navon task, namely the absolute speed of responding to local and global level targets, and the difference in latency between trials on which the information in the ignored level is compatible, versus incompatible with the current response. Typical participants tend to show a global processing bias by responding faster to global (versus local) targets, and having a smaller compatibility effect when responding to global (versus local) targets (Navon, 1977; Koivisto & Revonsuo, 2004; Pomerantz, 1983; see Kimchi, 1992, for a review).

Electrophysiological studies using the Navon task have identified certain ERP components associated with global and local processing in this task. Compared to global level processing, local level processing has generally been associated with greater amplitudes of the posterior P1 component and the N2 component (Han, Liu, Yund & Woods, 2000; Han, Fan, Chen & Zhuo, 1999; Han, He, Yund & Woods, 2001) as well as longer N2 latencies and smaller amplitudes of the P3 component (Han, Fan, Chen & Zhuo, 1997). However, Heinze, Hinrichs, Scholz, Burchert and Mangun (1998) report that the P1 component is not always greater during local processing. The enhanced ERP amplitudes during local processing have been interpreted to reflect the greater demand on cognitive resources posed by the requirement to ignore the typically biased global level. Additionally, when the local and global level information was incompatible, the effect on the N2 and P3 amplitudes was greater during local processing than global processing (Han, Fan, Chen & Zhuo, 1997), suggesting that the global level interfered with local visual processing more than vice versa. Finally, there is some evidence that global information is processed more strongly in the right hemisphere and local information more strongly in the left hemisphere (Evans, Shedden, Hevenor & Hahn 2000), although such lateralisation of activity is not always found (Jiang & Han, 2005).

In the current study, we compared the ERPs recorded during performance of the Navon task in healthy participants with either high or low scores on the Eating Disorder Examination Questionnaire (EDE-Q; Fairburn & Beglin, 1994; Fairburn, 2008). In terms of behaviour, we predicted that if eating disorder traits were associated with a reduced global processing bias, then the typical indices of a global bias (faster responses and reduced distractibility during global, compared to local processing) should be attenuated in the high (versus low) EDE-Q group. In terms of electrophysiology, we predicted that the ERP effects associated with local processing in typical participants (larger P1 and N2 amplitude, longer N2 latency, smaller P3 amplitude, left lateralisation of activity) will be modulated in participants who report high levels of eating disorder symptoms. As the available evidence of differences in global and local processing between people with and without eating disorders is largely limited to behavioural measures, this study aims to provide a greater understanding of neural correlates underlying such differences.

Method

Participants

Thirty-four healthy female participants aged between 18 and 57 (*M* = 28.10, *SD* = 10.24) participated in the experiment. Data from four participants with a high number of artefacts in the ERPs were excluded from further analysis. All participants had normal or corrected-to-normal vision. An advertisement was created for the study that detailed the study procedure (including the EEG procedure and questionnaires), the aim of the study was not mentioned. This advertisement was shared via social media. The majority of participants were postgraduate students recruited from the Psychology Department at Goldsmiths, University of London. The remaining participants were known to the experimenters and approached in person or via email. None of the participants received compensation for participating in the study. Participants with a diagnosed eating disorder were excluded from the study. All gave informed consent and the study was approved by the Ethics Committee at the Department of Psychology, Goldsmiths, University of London.

Measures

Eating Disorder Examination Questionnaires (EDE-Q)

The Eating Disorder Examination Questionnaire (EDE-Q) (Fairburn & Beglin, 1994; Fairburn, 2008) was used to assess the level of eating disorder symptomatology over the past 28 days. It consists of 28 items that are rated by the participant on a 7-point scale (from 0-6), where a higher score indicates greater pathology. Five further items assess the current weight and height of the participant, and whether they have missed any menstrual periods. The EDE-Q has been found to be both reliable and valid (Luce & Crowther, 1999; Peterson et al., 2007) as well as valid for screening for eating disorders in a community sample (Mond, Hay, Rodgers, Owen & Beumont, 2004). Mond et al. (2004) found that the mean global score for eating disorder cases was 3.09 (*SD* = 0.83) compared to a mean global score for non-cases of 1.30 (*SD* = 0.96). For the purpose of this study a median split was used to separate the participants into two groups. Those that fell into the lower 50% were included in the low EDE-Q group and those that fell into the higher 50% were included in the high EDE-Q group. This method has been used on both clinical samples (Striegel et al., 2010; Rawal, Williams & Park, 2011) and non-clinical samples (Duckham et al., 2012; Martijn, Vanderlinden, Roefs, Huijding, & Jansen, 2010). Martijn et al. (2010) used a median split on EDE-Q subscales to create ‘high’ and ‘low’ body concern groups on the EDE-Q and found a median of 1.70. This is similar to the median found in this study of 1.78.

Previous research has found that mood and anxiety (as well as eating disorder symptoms) are associated with a local processing style (Derryberry & Reed, 1998; Fredrickson, 2004; Zadra & Clore, 2011). Therefore to fully understand the characteristics of the current sample additional psychometric measures were used in this study (see below). Additionally as a large proportion of the participants recruited for the study were postgraduate students, an assessment of intelligence was used to investigate if the two groups significantly differed on IQ. See below for full details.

State/Trait Anxiety Index (STAI)

The State/Trait Anxiety Index (STAI; Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983) was used to measure levels of anxiety. It consists of 40 items; 20 measuring state anxiety and 20 measuring trait anxiety. These items were rated by the participant on a 4-point Likert scale (from 1-4). The STAI generates two scores, each ranging 20-80, where a score greater than 70 indicates anxiety pathology. The STAI has been shown to be both reliable and valid (Spielberger et al., 1983; Spielberger, 1989).

Beck Depression Inventory-II (BDI-II)

The Beck Depression Inventory-II (BDI-II; Beck, Steer & Brown, 1996; Beck, Ward, Mendelson, Mock & Erbaugh, 1961) was used to measure the presence of depressive symptoms. It consists of 21 items each rated on a 4-point Likert scale ranging from 0-3. The BDI-II generates a raw score between 0 and 63. The following cut-offs are recommended by Beck et al., (1996): sub-clinical 0-13; mild 14-19; moderate 20-28; and severe 29-63. The BDI-II has been found to be both reliable and valid (Beck et al., 1996).

The Maudsley Obsessional-Compulsive Inventory (MOCI)

The Maudsley Obsessional-compulsive inventory (MOCI; Hodgson & Rachman, 1977) was used to measure the presence of obsessive-compulsive symptoms. It consists of 30 items using a true/false response format. The MOCI produces a total ‘obsessionality’ score and four subscales: Doubting, Checking, Cleaning and Slowness. Gibbs and Oltmanns (1995) recommend a cut-off score of 14 or more indicates OCD psychopathology. The MOCI has been found to be both reliable and valid (Hodgson & Rachman, 1977; Thomas, Turkheimer & Oltmanns, 2000).

Wechsler Abbreviated Scale of Intelligence (WASI)

The two-subset form of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) was used to estimate Full Scale IQ (FSIQ). The Matrix Reasoning and Vocabulary subsets are used in the two-subset form as non-verbal and verbal estimates of FSIQ.

Visual stimuli

Navon Task

Four compound stimuli (taken from Caparos, Linnell, Bremner, de Fockert & Davidoff, 2013) were used (see Figure 1). Each stimulus consisted of a global shape (square or cross, subtending a visual angle of 4.4°) consisting of smaller local shapes (squares or crosses, subtending 0.6°). In two stimuli the same shape was presented at the global and the local level (compatible condition). In the two remaining stimuli different shapes were presented at the global and the local level (incompatible condition). Stimuli were presented on a 22inch computer monitor, at a viewing distance of 60cm. The stimuli were presented either at the centre of the screen or at 1.5° above or below the centre of the screen. This was done to prevent participants from employing a strategy whereby they simply narrow their attention to a single small area of the visual field when identifying local shapes. Participants are asked to identify either the global or local element of the figure (square or cross). This task generates two results; reaction time (ms) and error rate.





Figure 1. The compatible (top) and incompatible (bottom) compound stimuli used in the study (Caparos, et al., 2013). Images not to scale.

Procedure

E-prime software version 1 (Schneider, Eschman, & Zuccolotto, 2002) was used to present the stimuli and collect behavioural responses. Participants viewed the visual stimuli in the following order: i) viewed instructions on identifying global shapes followed by a block of 24 global target practice trials; ii) viewed instructions on identifying local shapes followed by a block of 24 local target practice trials; iii) completed eight blocks of 72 trials each. The stimuli were presented in blocks to minimise the number of switches as previous research has suggested that individuals with eating disorders have weaknesses in set-shifting (Tchanturia et al., 2004). Prior to each block the participant was instructed to identify global or local shapes in the upcoming block (total four global blocks and four local blocks). Global and local blocks alternated, and the starting condition was counterbalanced across participants. Each trial began with a fixation cross (1000ms), followed by a blank screen (500ms). Next, a compound stimulus was presented and remained on the screen until the participant had made a response. Responses were collected via a computer keyboard, and participants were instructed to use their left index finger to press the ‘A’ key if the target shape was a square and to use their right index finger to press the ‘L’ key if the target shape was a cross. After the response a blank screen (500ms) was followed by the next trial. After completing the Navon task participants filled out the self-report measures (EDE-Q, BDI-II, STAI and MOCI; order counterbalanced across participants). Participants then completed the WASI. Finally, participants received a debrief form and the contact information for the local university counselling service, the mental health charities BEAT, Anorexia and Bulimia Care, Mind and Anxiety UK.

EEG recording and data analysis

The electroencephalogram (EEG) was Direct Current-recorded using a Bio-Semi ActiveTwo measurement system, a low-pass filter of 100 Hz and a high pass filter of 0.16 Hz and a sampling rate of 512 Hz. Sixty-four electrodes were fitted in a cap in accordance with the international 10-20 system. The horizontal electro-oculogram (EOG) was recorded from two electrodes places at the external canthi of the eyes. EEG data was analysed using Brainvision Analyzer (Brain Products), and re-referenced to the average of the right and left electrodes. A low-pass filter of 40 Hz and a high pass filter of 0.53 Hz were applied. The EEG was epoched from 100ms before stimulus onset until 600ms after stimulus onset. Epochs containing blinks (automatic detection, ± 80 µV at Fpz), horizontal eye movements (automatic detection, EOG ± 30 µV) or movement artefacts (automatic detection, ± 80 µV at all other electrodes) were removed from further analysis. ERPs were collapsed across trials for the four compound stimuli (disregarding stimulus position). Based on the distribution of the P1 and P3, a selection of posterior electrodes was selected for further analysis. Mean amplitude values were calculated for the P1 (95-115ms) at (O1/O2, P03/P04, and P07/P08), and P3 (250-400ms) at (P1/P2, P3/P4 and P03/P04).

Statistical Analysis

Histograms, the Kolmogorov-Smirnov and the Shapiro-Wilk tests were used to assess the data for normality. The following variables were found to be non-normally distributed: Age, EDE-Q Restraint, EDE-Q Eating Concern, EDE-Q Weight Concern, BDI-II and MOCI. For these group comparisons the Mann Whitney-U test was used. All other variables were found to be normally distributed. T-tests were used to assess the difference between the High EDE-Q and Low EDE-Q groups for the following variables: EDE-Q Global, STAI trait and STAI state.

For the behavioural data three-way mixed ANOVAs were used, and post-hoc analysis was conducted using two-way repeated measures ANOVAs separately for High EDE-Q and Low EDE-Q groups.

For the ERP data four-way mixed ANOVAs were used, and post-hoc analysis was conducted using two-way repeated measures ANOVAs separately for High EDE-Q and Low EDE-Q groups. Further post-hoc analysis on the P3 data were conducted using Bonferroni corrected t-tests.

For the mixed ANOVAs the homogeneity of inter-correlations assumption was tested using Box’s M statistic. Wilks’ Lambda value was used if this assumption was met. If this assumption was violated then Pillai’s Trace statistic was used as it is robust to this violation (Field, 2013). Partial Eta Squared (ηp2) effect sizes were calculated for all mixed ANOVAs (Cohen, 1998; 0.01=small; 0.06=moderate; 0.14= large). The data were analysed using the statistical software package IBM SPSS version 22.

Results

Sample Characteristics

For the 30 participants included in the analysis, EDE-Q global scores ranged from 0 to 4.47. A median split was used to create groups with either high or low eating disorder symptomatology (see Table 1).

Table 1. Means and standard deviations (SD) for age, and BDI-II, STAI, MOCI and estimated FSIQ scores for the High and Low EDE-Q groups.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Total Sample | Low EDE-Q | High EDE-Q |  |
|  | Mean | SD | Mean | SD | Mean | SD | Group difference |
| Age | 28.10 | 10.24 | 26.27 | 6.16 | 29.33 | 13.11 | *U* = 94.00, *p* = 0.437. |
| EDE-Q Global score  | 1.99 | 1.18 | 1.01 | 0.58 | 2.97 | 0.71  | *t*(28) = 8.30, *p* <0.001. |
| EDE-QRestraint score | 1.66 | 1.28 | 0.87 | 0.79 | 2.45 | 1.19 | *U* = 33.00, *p* = 0.001 |
| EDE-Q Shape concern score | 2.79 | 1.67 | 1.44 | 0.99 | 4.14 | 0.93 | *t*(28) = 7.70, *p* <0.001. |
| EDE-Q Eating concern score | 1.02 | 1.05 | 0.44 | 0.49 | 1.60 | 1.14 | *U* = 42.50, *p* = 0.003 |
| EDE-Q Weight concern score | 2.36 | 1.48 | 1.23 | 0.90 | 3.49 | 0.99 | *U* = 11.50, *p* < 0.001 |
| BDI-IIRaw score | 13.07 | 10.04 | 10.80 | 10.64 | 15.33 | 9.20 | *U* = 76.50, *p* =0.134 |
| STAI state T score  | 42.53 | 12.66 | 33.60 | 10.24 | 43.73 | 11.12 | *t*(28) = 2.60, *p* = 0.015 |
| STAI trait T score | 38.67 | 11.70 | 37.53 | 12.56 | 47.53 | 10.98 | *t*(28) = 2.32, *p* = 0.028 |
| MOCI Raw score | 8.37 | 7.51 | 9.01 | 9.90 | 7.67 | 4.24 | *U* = 102.00, *p* =0.662. |
| FSIQ | 110.1 | 8.67 | 110.5 | 8.28 | 109.73 | 9.32 | *t*(28) = .248, *p* = 0.806. |

Mean EDE-Q scores for the low and high groups were similar to the scores of 1.04 and 2.94 reported by Mond et al., (2004) as being on the 45th and 85th percentile respectively, for young adult women. T-tests showed significant difference between the Low EDE-Q group and the High EDE-Q group on EDE-Q global, EDE-Q shape concern, STAI state and STAI trait. Mann-Whitney U tests showed a significant difference between the Low EDE-Q group and the High EDE-Q group on EDE-Q restraint, EDE-Q eating concern and EDE-Q weight concern. The groups did not significantly differ on age, BDI-II, MOCI or FSIQ.

Behavioural Navon data

Trials in which response times exceeded 1500ms or were below 250ms were excluded. As shown in Table 2, reaction times for correct responses were entered into a 2 (Level: global, local) x 2 (Compatibility: compatible, incompatible) x 2 (Group: low EDE-Q, high EDE-Q) mixed Analysis of Variance (ANOVA). Box’s M value of 36.77 was associated with a *p* value of 0.001 suggesting that the covariance matrices were not equal thus Pillai’s Trace statistic was used.

Table 2. Mean reaction times (RT; milliseconds) and accuracy rates as a function of the experimental factors for Low and High EDE-Q groups (standard deviations (SD) in brackets).

|  |  |  |
| --- | --- | --- |
|   | Low EDE-Q | High EDE-Q |
| RT | Accuracy | RT | Accuracy |
| Global Compatible | 548 (127) | 0.969 (0.027) | 467 (71) | 0.957 (0.033) |
| Global Incompatible | 555 (116) | 0.946 (0.043) | 493 (74) | 0.939 (0.033) |
| Local Compatible | 535 (95) | 0.975 (0.029) | 467 (70) | 0.985 (0.013) |
| Local Incompatible | 548 (75) | 0.953 (0.040) | 532 (126) | 0.930 (0.103) |

The only significant effect was a main effect of compatibility, *F*(1, 28) = 6.95, *p* = 0.013, ηp2 = 0.199. Responses were faster for compatible stimuli (*M* = 504, *SD* = 99) than for incompatible stimuli (M = 532, *SD* = 101). Neither the two-way Level x Group interaction nor the three-way interaction were significant, suggesting that the two groups did not differ in terms of the two indices of the global processing bias.

Accuracy rates were entered into a 2 (Level: global, local) x 2 (Compatibility: compatible, incompatible) x 2 (Group: Low EDE-Q, High EDE-Q) mixed ANOVA (see Table 2). Box’s M value of 33.25 was associated with a *p* value of 0.002 suggesting that the covariance matrices were not equal thus Pillai’s Trace statistic was used. There was again only a main effect of compatibility, *F*(1, 28) = 20.75, *p* <0.001, ηp2 = 0.426. Accuracy was higher in compatible trials (*M* = 0.97, *SD* = 0.03) compared to incompatible trails (*M* = 0.94, *SD* = 0.058). Similar to the reaction time analysis, the two groups did not differ in terms of the two indices of the global processing bias in the accuracy rates.

ERP Data

Figure 2 shows the ERPs elicited at posterior electrodes in left and right hemispheres as a function of the experimental factors.

Right hemisphere

Left hemisphere

 High Compatible
 High Incompatible
 Low Compatible
 Low Incompatible

 High Global
 High Local
 Low Global
 Low Local

Figure 2. Grand-average ERPs elicited over posterior electrodes for low and high groups over the left and right hemisphere for global/local and compatible/incompatible stimuli.

*P1*

Mean amplitudes of the P1 component (95-115ms, pooled across O1, P03 and P07 for the left hemisphere and P04, O2 and P08 for the right hemisphere) were entered into a 2 (Level: global, local) x 2 (Compatibility: compatible, incompatible) x 2 (Group: low, high) x 2 (Hemisphere: left, right) mixed ANOVA. Box’s M value of 81.83 was associated with a *p* value of 0.018 suggesting that the covariance matrices were not equal thus Pillai’s Trace statistic was used.

The only significant effect in the P1 amplitude was an interaction between level, compatibility and group, *F*(1, 28) = 9.12, *p* = 0.005, ηp2 = 0.246 (see Figure 3). Follow-up two-way Level x Compatibility ANOVAs revealed no significant effects in the low group (all *p* values > 0.838), and a significant interaction between Level and Compatibility in the high group (*F*(1, 14) = 6.03, *p* = 0.028, ηp2 = 0.301 ). In the high group mean peak P1 amplitude was higher for local incompatible trials (*M* = 5.28, *SD* = 4.00) than local compatible trials (*M* = 4.51, *SD* = 3.65; *t*(14) = 2.93, *p* = 0.011). There were no other significant effects in the high group.

Figure 3. Mean peak P1 amplitudes in the low and high EDE-Q groups for global/local and compatible/incompatible trials.

*P3*

Mean peak amplitudes of the P3 component (250-400ms, pooled across P1, P3 and P03 for the left hemisphere and P2, P4 and P04 for the right hemisphere) were entered into a 2 (Level: global, local) x 2 (Compatibility: compatible, incompatible) x 2 (Group: low, high) x 2 (Hemisphere: left, right) mixed ANOVA. Box’s M value of 51.48 was associated with a *p* value of 0.500 suggesting that the covariance matrices were equal.

There was a main effect of level, *F*(1, 28) = 10.70, *p* = 0.003, ηp2 = 0.276. Mean peak P3 amplitudes were smaller for global trials (*M* = 5.61, *SD* = 3.68) compared to local trials (*M* = 6.36, *SD* = 4.0). There was also a main effect of compatibility, *F*(1, 28) = 14.68, *p* = 0.001, ηp2 = 0.344 . Mean peak P3 amplitudes were greater for compatible trials (*M* = 6.26, *SD* = 3.87) compared to incompatible trials (*M* = 5.71, *SD* = 3.89). Additionally, there was a significant interaction between level, compatibility and group *F*(1, 28) = 5.80, *p* = 0.023, ηp2 = 0.172 (see Figure 4).

Follow-up two-way Level x Compatibility ANOVAs showed a main effect of compatibility in the low group, *F*(1, 14) = 5.13, *p* = 0.040, ηp2 = 0.268. Mean peak amplitudes were greater for compatible trials (*M* = 5.38, *SD* = 3.18) than incompatible trials (*M* = 4.91, *SD* = 3.47). In the high group there was a main effect of level *F*(1, 14) = 8.61, *p* = 0.011, ηp2 = 0.381. Mean peak amplitudes were smaller in the global trials (*M* = 6.41, *SD* = 4.14) than local trials (*M* = 7.23, *SD* = 4.47). In the high group there was also a main effect of compatibility *F*(1, 14) = 10.063, *p* = 0.007, ηp2 = 0.418. Mean peak amplitudes were greater in the compatible trials (*M* = 7.14, *SD* = 4.36) than the incompatible trials (*M* = 6.50, *SD* = 4.24). Finally, the interaction between level and compatibility was marginally significant in the high group, *F*(1, 14) = 4.57, *p* = 0.051, ηp2 = 0.246. Post-hoc analysis with Bonferroni correction indicated that during global level processing in the high EDE-Q group, P3 amplitudes were significantly greater in the compatible condition (*M*  = 7.02, *SD* = 4.53) than in the incompatible condition (*M* =5.80 , *SD* = 3.74; *t*(14) = 3.95, *p* = 0.001, *d* = 0.291). In other words, only in the high EDE-Q group was there evidence of a compatibility effect during global attention (and when the local level had to be ignored), but not during local attention (when the global level had to be ignored) (note 1).

Figure 4. Mean peak P3 amplitudes in the low and high EDE-Q groups for global/local and compatible/incompatible trials.

Discussion

The current study aimed to investigate the previous findings of a global weakness/local bias in visual processing, as found in those with eating disorders (e.g. Lopez et al., 2008ab), in healthy females with high and low eating disorder traits. We compared behavioural (reaction time and accuracy rate) and electrophysiological (mean amplitudes for the P1 and P3 components) measures of performance on a standard Navon task with hierarchical stimuli between two groups differing in terms of the level of self-reported eating disorder symptoms, and predicted that participants with high symptomatology would show a reduced global processing bias in both behaviour and electrophysiology. The results showed that although the two groups did not differ in the behavioural measures, in the ERPs there were significant differences in both the P1 and P3 components between the low and high eating disorder groups, indicative of an increased tendency to process local level information in the high EDE-Q group.

The P1 component showed a significant compatibility effect only on local processing trials in the high group. The P1 has been associated with spatial focusing (Hillyard & Anllo-Vento, 1998) and local stimuli tend to elicit greater P1 amplitudes than global stimuli (Han et al., 1997; Han et al., 1999; Han et al., 2000; Han, He & Woods, 2000; Han et al., 2001). During local processing the P1 was greater in the high EDE-Q group when global information was incompatible (versus compatible). This suggests that the high group may have exhibited increased spatial focus when the global information was incompatible with the current local target. This finding is consistent with previous research that found discrepancies in early visual components associated with global level processing between individuals with AN and healthy controls (Li et al., 2015).

In the P3 component, there were several differences between the low and high eating disorder trait groups. First, only in the high EDE-Q group was there a difference in P3 amplitude as a function of processing level, with greater amplitudes on local trials than global trials. The P3 amplitude is typically reduced in local trials compared to global trials (Han et al., 1997), and the increase in P3 amplitude on local (versus global) trials in the high group is in line with previous findings of a reduced tendency for global processing in individuals with eating disorders (Harrison, Tchanturia & Treasure, 2011; Lopez et al., 2008a; Lopez et al., 2009; Tenconi, et al., 2010). Second, there was some evidence that amplitudes in the high group were greater in the compatible (versus incompatible) condition during global level processing but not during local processing. P3 amplitude has been shown to decrease as the difficulty of a discrimination task increases (Polich, 1987), suggesting that the group with high levels of eating disorder symptoms had greater difficulty ignoring incompatible local level information.

The findings are also consistent with the clinical presentation of those with eating disorders. Many of those who display maladaptive eating behaviors appear to excessively focus on details, e.g., a preoccupation with rules regarding calorie content or nutritional composition of food, weight, shape and/or exercise routines (Lask & Frampton, 2011), at the cost of their overall health. Additionally personality characteristics such as perfectionism are commonly seen in those with eating disorders. It has been suggested that these characteristics may interact resulting in eating disorder symptoms (Lang, Lopez, Stahl, Tchanturia & Treasure, 2014), e.g., an excessively detailed focus on calories, and a drive to excel in calorie restriction.

In our results, there was no significant difference between the high and low EDE-Q groups in the behavioural measures of local and global processing. This suggests that the Navon task may be less sensitive than other neuropsychological tools in detecting individual differences in local and global processing. This notion is supported by a recent study showing that patients with body dysmorphic disorder performed worse on the embedded figures test of global visual processing, but did not show a greater local bias on the Navon task (Kerwin, Hovav, Hellemann & Feusner, 2014). However a one-trial task such as the embedded figures test was unsuitable in our study the main aim of which was to examine the neural correlates underlying known differences in local and global processing as a function of eating disorder traits. Moreover, unlike much previous work involving clinical samples which have suggested that eating disorders may be associated with reduced global processing, the current study used a non-clinical sample. Our result could therefore suggest that those in the high ED trait group had a more subtle local processing bias than the clinical samples investigated in previous research, and that the behavioural measures were insufficiently sensitive to show a difference as compared to ERP data in this sub-clinical sample. This interpretation would support a continuum model of eating disorders, in which the symptoms of eating disorders are seen to be on a spectrum as opposed to categorical diagnoses (Wildes & Marcus, 2013).

Although levels of depression, OCD and IQ were the same in the low and high EDE-Q groups in our study, the high EDE-Q group scored significantly higher on both state and trait anxiety (albeit anxiety scores were in the healthy normative range), compared with the low EDE-Q group. There is evidence to suggest that negative mood states, including anxiety, tend to be associated with a local processing style (Derryberry & Reed, 1998; Fredrickson, 2004; Zadra & Clore, 2011) and positive mood states with a global processing style (Gasper & Clore, 2002). It therefore remains possible that the differences in the ERP indices of local and global processing we observed between the low and high EDE-Q groups were in part driven by differences in anxiety levels between the groups. Further work is necessary to tease apart the relative contributions of eating disorders and anxiety to visual processing style.

The present findings show further evidence for an association between eating disorder traits and a local biased visual processing style. Some studies have found that a local bias in visual processing persists after recovery from an eating disorder and is present in healthy siblings (Lang et al., 2014). This provides some evidence to suggest that a local bias may be a predisposing vulnerability; it is possible that changes in visual processing style may somehow promote the development of eating disorders. If so, then the present findings have potential clinical implications, and provide support for therapies such as cognitive remediation therapy (CRT) for treating eating disorders. CRT targets cognitive strengths and weakness and through example tasks encourages individuals to employ new cognitive strategies (Tchanturia & Lock, 2011). For the treatment of eating disorders CRT is used to encourage individuals to employ different “thinking styles” such as a more global processing strategy or increased cognitive and behavioural flexibility, which in turn may help reduce their symptom severity. It has been suggested that it is particularly effective in individuals who have appeared ‘treatment resistant’ (Tchanturia & Lock, 2011). We note, however, that further work is needed to justify generalizing the findings from the current sub-clinical sample to the population with clinical eating disorders.

In summary, the current study investigated global weakness/local bias in visual processing in people with high and low eating disorder traits. Although there were no group differences in the behavioural measures of global/local processing, significant group effects in the P1 and P3 ERP components suggest that those with higher eating disorder traits as captured by a higher EDE-Q score have a more local processing style than those with low eating disorder traits.

Note 1.

Although we made no predictions regarding the N1, we also analysed this component for completeness. Mean amplitudes of the N1 component (144-184ms, pooled across P5, P07 and P7 for the left hemisphere and P6, P08 and P8 for right hemisphere) were entered into a 2 (Level: global, local) x 2 (Compatibility: compatible, incompatible) x 2 (Group: low, high) x 2 (Hemisphere: left, right) mixed ANOVA. There was a significant main effect of level, *F*(1, 28) = 10.15, *p* = .004, ηp2 = .266. Mean peak N1 amplitude was smaller in the global trials (*M* = -4.50, *SD* = 3.69), compared to the local trials (*M* = -5.01, *SD* = 3.99). The main effect of compatibility was also significant, *F*(1, 28) = 19.82, *p* <.001, ηp2 = .414. Mean peak N1 amplitude was smaller in compatible trials (*M* = -4.34, *SD =* 3.69) compared to incompatible trials (*M* = -5.17, *SD* = 3.98). Additionally, there was a significant main effect of hemisphere, *F*(1, 28) = 4.58, *p* = .041, ηp2 = .140. Mean peak amplitude was greater over the left hemisphere (*M* = -5.26, *SD* = 3.98) compared to the right hemisphere (*M* = -4.25, *SD* = 3.69). All other N1 effects, including all effects involving the group factor, were non-significant.

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