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Research report

Perception of emotion and bilateral advantage in women with eating disorders, their healthy sisters, and nonrelated healthy controls

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ABSTRACT

Background: Eating disorders (EDs) are characterized not only by disordered eating, but also by other psychopathology. In this exploratory study, we examined the ability of women with different diagnoses of EDs, their unaffected sisters, and healthy unrelated controls to recognize their own and other's emotions. We also looked at interhemispheric integration of emotion recognition and its relationship with depression.
Method: Five groups of women participated: 1. anorexia nervosa restricting (AN-R) and 2. (AN-B/B) binge/purge, 3. bulimia nervosa binge/purge, (BN-B/P), 4. healthy sisters of women with ED, and 5. unrelated healthy controls. We used two questionnaires measuring alexithymia and depression, and two lateralized experimental tasks requiring recognition of facial emotion. Unilateral versus bilateral presentation allow the indexing of interhemispheric integration.
Results: Alexithymia: All the ED groups were found to be more alexithymic and depressed on the self report scales compared to the two healthy groups. Depression completely mediated alexithymia in the AN-R group but not in the AN-B/P and BN-B/P patients. Sisters of ED women were more alexithymic than unrelated controls. *Lateralized facial emotion recognition:* ED women showed no deficits in recognizing basic emotions. However, the clinical groups did not show a bilateral advantage whereas the two healthy groups did so.
Conclusions: We present three conclusions: we show, for the first time, evidence for a deficit in hemispheric integration in EDs. This implies that EDs may be a disconnection syndrome; alexithymia characterizes women with EDs and members of their family; depression is manifested differently in AN-R, than in women who binge/purge.

Eating disorders (EDs) are characterized by attempts to control body behaviors such as restricting food intake, likely associated with a significant reduction in weight (anorexia nervosa restricting type—ANR), binging a significant amount of food and purging it thereafter (bulimia nervosa-binging/purging type—BN-B/P), and a combination of the two disturbances (anorexia nervosa-binging/purging type—AN-B/P). Nevertheless, eating behavior abnormality is not the only abnormality presented in EDs. These disorders may be associated also with a high comorbidity of depression, anxiety, obsessionality, and impulsivity (Anestis et al., 2009; Fernandez-Aranda et al., 2008; Peterson et al., 2010). In addition, alexithymia (Cserjesi, 2009; Fassino et al., 2007; Kessler et al., 2006) and impairment in social cognition may also occur to a greater extent in AN and BN patients in comparison to non-ED controls (Harrison et al., 2009; Legenbauer et al., 2008).

Alexithymia is defined in terms of a difficulty in identifying, understanding, and describing one's own emotions (Bagby et al., 2006). This deficit may contribute, in turn, also to the misperception of other people's emotions. Adolphs et al. (2000) presented a model of emotion recognition deriving from facial

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expressions. According to this model, we may recognize other peoples' emotions by identifying with them. We interpret their facial expression by mentally visualizing ourselves with that facial expression and recognizing what we feel when we make that expression. Adolphs et al. (2000) found that watching other peoples' facial expressions activates cerebral somatosensory areas of motor facial muscles of the viewer, which are connected to emotional facial expressions. Thus, in order to correctly understand other peoples' emotions, we have to be able to correctly interpret our own. Wrong interpretation of our internal emotional cues may lead to wrong interpretation of other peoples' emotions and, in turn, to difficulties in social cognition, such as those presented in ED patients (e.g., (Rothschild et al., 2011; Zucker et al., 2007). In addition, Ridout et al. (2010) reported an association between greater eating and body image-related disturbances and a deficit in emotion recognition in a non-clinical population.

Recent studies of emotion recognition and alexithymia in EDs have shown an overall impairment in these attributes in women with AN (see Oldershaw et al. (2011) for an excellent review) and BN (de Groot et al., 1995). Furthermore, alexithymic disturbances have been found to persist in ED patients even after the amelioration of ED-related symptoms. Nevertheless, whereas some studies show that elevated alexithymia scores in AN women may disappear when controlling for depression (Parling et al., 2010), others report that both in AN-R (Sexton et al., 1998) and BN, (de Groot et al., 1995) alexithymia scores remain significantly higher than those of healthy controls, even when depression is controlled for. This latter finding converges with a recent study from our group (Rothschild et al., 2011) showing that women with B/P spectrum EDs (AN-B/P and BN) present with a lower ability to infer causality in the context of interpersonal relationships than healthy controls. Importantly, this deficit in social cognition is predicted by the severity of ED symptomatology, and not by comorbid depressive symptoms.

Emotion recognition is closely linked to theory of mind (ToM) capabilities. In their review of social–emotional processes in eating disorders, Oldershaw et al. (2011) report that the ability of women with AN to infer the mental states of others is impaired in the acute stage of the illness. Harrison et al. (2009) and Russell et al. (2009) posit the likelihood of pervasive difficulties in both emotion recognition and ToM capabilities in AN. Recently, Harrison et al. (2010a,b) assessed the stability of deficits in emotion recognition and regulation in AN over time. These authors found that whereas on measures of emotion recognition, both acutely ill and recovered AN women are significantly different from healthy controls, on measures of emotion regulation, women who have recovered from AN are not different from healthy controls. Accordingly, deficits in emotion recognition might represent a premorbid trait of women vulnerable to AN, whereas deficits in emotion regulation may be state-dependent, indicative of the acute stage of the illness, that may normalize with recovery.

To the best of our knowledge, only two studies (Dahlman, 1996; Guttman and Laporte, 2002) have directly examined alexithymia in family members of women with EDs. Dahlman reports that mothers of daughters with EDs reveal higher scores on the Toronto Alexithymia Scale (TAS) than mothers of healthy controls. Guttman and Laporte (2002) report that daughters with EDs evince higher levels of alexithymia than both their parents, and that in their sample, there was a trend for higher levels of alexithymia in families of women with EDs compared with families of healthy controls. Interestingly, although no association was shown in this study between the scores on the alexithymia scale of fathers and daughters with EDs, a correlation was found between the mothers' scores on the TAS subscale that measures externally oriented thought, and the daughter's scores on the TAS subscale that measures difficulty in identifying feelings. Guttman and Laporte (2002) conclude that in general, most parents in families with daughters with EDs are not alexithymic, and that a crucial element in the appearance of alexithymia may be related to disturbances in family relationships. One of the goals of the present study is to test emotion recognition among women with EDs and their sisters, who are subject to a similar family environment.

Emotion recognition is closely linked to hemispheric and interhemispheric brain activity. Clinical studies of social behaviors in brain damaged patients (e.g., Fournier et al., 2008) and developmental studies (e.g., Workman et al., 2006) suggest that the right cerebral hemisphere is most implicated in deficits and in the development of complex social understanding. By contrast, imaging studies of social cognition (Lieberman, 2007), and models of emotional face processing, propose the involvement of a widespread network of brain regions, including both hemispheres, in these tasks. In addition, patients with unilateral damage to *both* hemispheres evince deficits in tasks requiring ToM capabilities. Accordingly, current data suggests that the integrity of both hemispheres, and probably also interhemispheric integration, are necessary for normal social cognition.

Hemispheric connectivity is dynamic, and is affected by the complexity of the task and of the stimuli. A large number of studies have shown that when tasks are complex, the ability to divide processing load between the hemispheres results in higher levels of performance (e.g. Belger and Banich, 1992, 1998; Weissman and Banich, 1999, 2000; Weissman et al., 2000). This phenomenon is known as the *bilateral advantage*.

A recent model proposed by Nunn et al. (2008) suggested that the varied symptoms of AN may result from dysfunction in the insula, arguing that such a dysfunction can explain much of the variation in both imaging and behavioral studies. These authors suggest that the inconsistent lateralization patterns that have been reported in AN, may be the result of bilateral insular dysfunction in *either* hemisphere. The main function of the insula is as an integrator of functioning of a large number of other brain regions, specifically balancing body homeostasis and adaptation to the environment. Dunsmoor and Schmajuk (2009) have proposed that the insula, together with the dorsolateral prefrontal cortex, subserve the representation of the conditioned stimulus in human fear conditioning. It has been implicated in a wide range of psychiatric disorders (Nagai et al., 2007) and proneness to anxiety (Paulus and Stein, 2006). Because its main function can be conceptualized in terms of a connection system, Nunn et al.'s hypothesis can be seen as a definition of AN as some kind of disconnection syndrome.

The goals of the present study are based on the complexity of the findings with respect to deficits in the recognition of emotions of others and alexithymia in EDs, on the putative role of maladaptive hemispheric connectivity and insular functioning in EDs, and the finding of some deficit in these traits also in first degree relatives of ED patients. We have previously shown that healthy sisters of women with EDs have a personality profile that is similar to healthy control participants, but a neuropsychological profile that is similar to their ED siblings (Hason-Rozenstein et al., in press). We interpreted these results as indicating that the neuropsychological deficits evinced in ED patients are not a secondary consequence of ED-related symptomatology, but rather, represent a general deficit in cognitive processes that may run in their families. In that study, we used neutral cognitive tasks (a spatial task using bar-graphs, and a verbal task using emotionally neutral words).

In the present study we aim to examine the performance of women with different types of EDs, their healthy sisters, and unrelated healthy controls on a questionnaire that taps their ability to identify their own emotions (the Toronto Alexithymia Scale), and on a facial emotion identification task.

In the experimental task, we present pairs of faces evincing basic emotions (happiness, anger) either directly to one of the hemispheres [in the left visual field (LVF) directly to the right hemisphere (RH) and in the right visual field (RVF) directly to the left hemisphere (LH)], or bilaterally, one to each hemisphere. In this last condition, interhemispheric communication is necessary for completion of the task. In order to ensure that performance differences arise from differences in the processing of emotions, and not differences in perceptual abilities, we use the same stimuli and design in two different tasks: in the Identity Matching task, participants are required to match the faces by the identity of the actor, ignoring the emotions displayed on the faces. In the Emotion Matching task, they are asked to match the faces by the emotion displayed on the faces ignoring the identity of the actors.

We tested the following hypotheses:

1. The ED groups will show significantly higher alexithymia scores than the unrelated healthy control group.
2. The ED group will show a specific deficit related to emotion recognition. Thus, the pattern of responses of women with EDs will differ from that shown by the healthy unrelated control participants only in the Emotion Matching task, but not in the Identity Matching task.
3. As EDs may involve lower levels of interhemispheric connectivity, we expect the patient groups to evince a smaller bilateral advantage than the healthy control group.
4. The findings with respect to the healthy sisters group are not clear. If the source of the differences in alexithymia, emotion recognition of others and/or hemispheric connectivity, is a familial trait, we expect the sisters of the women with EDs to be similar to the clinical groups. However, if these differences are related to ED symptoms, we expect the sisters to be similar to the healthy, unrelated control group.

In sum, we examine the ability of ED patients, their unaffected sisters and unrelated healthy control participants to identify their own emotions, as well as their ability to identify other people's emotions. We measured depression using the Beck Depression Inventory (Beck, 1996). Analyses of group differences, taking depression as a covariate may clarify the elusiveness of deficits in alexithymia in ED. Specifically, our design will allow us to clarify the interaction of depression (as measured by the BDI) with alexithymia scores and with performance on the facial emotion task, and to see whether this relationship differs among the diagnostic groups. This design also enables us to look at differential hemispheric interactions in the different groups.

1. Method

1.1. Participants

Ninety-six right handed women participated in the study. Handedness was assessed using a modified version of the Edinburgh Handedness Questionnaire (Oldfield, 1971). All women were native speakers of the Hebrew language with no diagnosis of learning disabilities or of attention deficit hyperactive disorder (ADHD). The participants were divided into five groups according to their main diagnosis: bulimia nervosa purging type (BN-B/P), anorexia nervosa purging type (AN-B/P), anorexia nervosa restricting type (AN-R), the ED patients' healthy sisters, and a control group of age matched non-ED healthy women. We did not include a group of BN non-purging type because during the year of the study we diagnosed only one woman with this disorder.

ED participants were recruited from the outpatient ED clinic at the Rambam Medical Center, Haifa, Israel and the adult and adolescent inpatient ED departments at the Sheba Medical Center, Tel Hashomer, Israel. No differences were found in any of the medical and psychological parameters assessed between inpatients and outpatients, or among patients from different treatment facilities. Accordingly, patients were grouped based on their specific ED subtype.

Non-related control participants included undergraduate psychology students from Haifa University, recruited by advertisements, and age matched friends of the participants. No differences were found in any of the dependent variables introduced between the two control populations. For their time and traveling expenses, the patients and their sisters received 75–150 NIS (matched to hospital policy). Non-related healthy control participants were rewarded with course credits or a present. Participants (and parents in the case of participants under the age of 18) signed a written informed consent after receiving a detailed explanation about the aims and methods of the study. The study was approved by the Helsinki Committees of both medical centers.

The healthy sisters group consisted of 9 sisters of patients with BN-B/P, 5 sisters of patients with AN-R, and 7 sisters of patients with AN-B/P. In the case of multiple siblings, the healthy sister included in the study was the one whose age was closest to the ill sister. The sisters group was not matched according to the diagnosis of the ill sibling, because of the well-known lack of stability of any specific ED diagnosis, and the potential to move to another diagnostic entity during the course of the illness (Fichter and Quadflieg, 2007). In addition, several of the healthy sisters had another ill sister with another ED diagnosis than that of the ill sister included in the study. Lastly, due to the relatively small number of the healthy sisters included in the study, any further subdivision would be impractical for statistical reasons.

Patients with EDs were assessed within 2–4 weeks of their admission to the respective treatment facility, when their medical and psychological condition was stabilized enough to be included in the study. Accordingly, although all AN patients were underweight on admission, the weight of several patients was already greater at the time of assessment than that required for the diagnosis of AN. Thus, when assessed, 11 patients with AN (6 with AN-B/P and 5 with AN-R) were still underweight [body mass index (BMI) < 17 kg/m^2], whereas the BMI of 21 patients (12 patients with AN-B/P and 11 with AN-R) was already equal or above17 kg/m^2. Nevertheless, the use of t-tests for unequal groups on all the dependent variables revealed no significant between-group differences in any of these variables. Therefore, patients with AN were pooled according to their ED subtype (AN-R vs. AB-B/P), irrespective of their present BMI.

Participants were either high school graduates or high school students. BMI data for the ED patients was collected from their medical files and for the sisters and the control group according to their own self-report.

Age, BMI scores, and Beck Depression Inventory (BDI) scores are presented in Table 1. It can be seen that no between group difference was shown for age ($p > 0.7$). A significant group effect was found for BMI [$F(4,89) = 14.78$, $p < 0.0001$]. As expected, the use of Duncan post hoc tests revealed that the AN-B/P and AN-R groups had a significantly lower BMI than the three other groups, who did not differ from each other. There was also a significant group effect in the BDI scores, with the three ED groups scoring all in the clinical range (Rotheram-Borus and Trautman, 1988), and the healthy sisters and unrelated healthy controls scoring within normal BDI range and not differing from each other.

1.2. Diagnostic tools

The diagnosis of an ED in the participants [according to DSM-IV (American Psychiatric Association Committee on Nomenclature and Statistics, 1994) criteria], or the lack of an ED in the control and the sisters groups, was achieved with a structured interview based on the ED criteria of the Structured Clinical Interview for DSM-IV Axis I Disorders-Patient Edition (SCID-I/P Version 2.0) (First et al., 1995). One control participant was excluded from the study for fitting the criteria for BN. None of the sisters reached the diagnostic criteria for an ED. All of the participants were independently interviewed by psychiatrists, clinical psychologists, or clinical social workers, all highly experienced in the diagnosis and treatment of EDs.

1.2.1. Experiment 1: perception of emotion: self report

Toronto Alexithymia Scale (*TAS-20*) (Bagby et al., 2006): this self-administered scale is comprised of 20 statements to which participants respond on a scale of 1–5 (the higher the score, the greater is the respective impairment). There are three subscales: difficulty in identifying feelings (DIF, 7 items) difficulty in describing feelings (DDF, 5 items) and externally oriented thinking (EOT, 8 items). The TAS-20 validity and reliability were first tested in 1994. Cronbach's alpha = 0.76 (Bagby et al., 1994). The internal reliability of the TAS-20 in the present study is high (Cronbach's alpha = 0.89) (964 Bagby et al., 1994).

Beck Depression Inventory (Beck, 1996): this self-administered 21-item scale measures different depressive symptoms. Participants rate items on a 4-point scale ranging from *rarely* (0) to *often* (3). Alpha Cronbach for the BDI in the present study is high, Cronbach's alpha = 0.94. Previous studies report Cronbach's alpha that is between 0.85 and 0.95 (e.g. (Pollice et al., 1997).

1.2.2. Experiment 2—recognition of emotion: experimental task

We used two tasks requiring the matching of pairs of faces. All stimuli were created from the Ekman faces series (Ekman and Friesen, 1976). Four types of face pairs were presented according to the identity of the persons and emotions: Same Face–Same Emotion (SFSE), comprised of identical pictures; Same Face–Different Emotion (SFDE), comprised of pictures of the same person conveying different emotions; Different Face–Same Emotion (DFSE), comprised of two different faces conveying the same emotion; and Different Face–Different Emotion (DFDE), comprised of different people conveying different emotions. Examples are shown in Fig. 1.

The pairs of faces were presented in three conditions: both faces in the LVF, both faces in the RVF, or one face in each visual field (bilateral visual fields—BVF). Each pair of faces was presented for 160 ms to ensure lateralization. The stimuli were presented 1.5° of visual angle from the center of the screen. The size of each photo was 2 × 3 cm. The BVF condition allows for the assessment of interhemispheric transfer, as a correct response can result only from comparison of information initially presented to different hemispheres. There were 24 pairs of each type, resulting in 96 experimental trials in each task. The order of the trials was randomized once, and all participants received the same order.

The participants were tested individually. All performed the Emotion Matching task before the Identity Matching task. In the Identity Matching task, the participants were asked to determine if the two pictures are of the same person (the SFSE and SFDE pairs require a 'same' response and the DFSE and DFDE require a 'different' response). In the Emotion Matching task the participants were presented with the same stimuli, but were asked to determine if the people in the pictures were showing the same emotion (the SFSE and DFSE require a 'same' response, and the SFDE and DFDE require a 'different' response).

Table 1
Mean age, body mass index (BMI), and Beck Depression Inventory (BDI) scores (standard deviations are in parentheses).

	AN-R (N = 16)	AN-B/P (N = 18)	BN-B/P (N = 19)	Sisters (N = 20)	Controls (N = 23)	F (4,89)	p
age	23.90 (9.9)	22.32 (5.4)	23.0 (7.6)	25.36 (9.4)	23.68 (5.9)	0.24	ns
BMI	17.86 (1.8)	17.78 (2)	21.93 (1.8)	21.78 (2.5)	21.64 (3.5)	14.78	0.0001
BDI	27.93 (16.3)	26.12 (13.6)	20.11 (13.6)	6.15 (5.2)	6.36 (5.7)	18.02	0.0001

Note: AN-R—anorexia nervosa, restricting type; AN-B/P—anorexia nervosa, binging/purging type; BN-B/P—bulimia nervosa, binging/purging type; and ns—not significant.

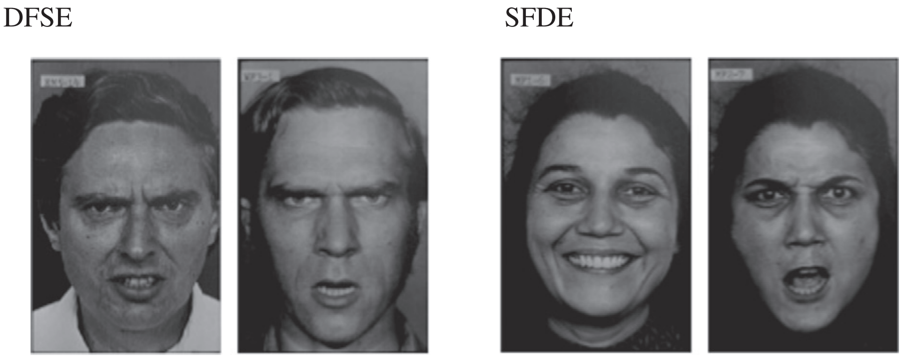

Fig. 1. Examples of the experimental stimuli. DFSE = different face, same emotion; SFDE = same face, different emotion. In the Identity Face Task the participants match the pairs by the identity of the individual; in the Emotions Face Task the participants match the pairs by emotion.

2. Results

2.1. Validity across measures

A correlation analysis of performance measures of 92 participants in the lateralized tasks and on the TAS revealed several relationships. The scores on the TAS were not related to the performance on the Face Identity Matching task. However, TAS scores were significantly correlated with the percent of error scores on the Emotion Matching task in all three visual field conditions. In the bilateral presentation condition (BVF), errors were positively correlated with the scores on the three subscales of the TAS (DIF: $r(90)=0.28$, $p<0.01$; DDF: $r(90)=0.22$, $p<0.05$; EOT: $r(90)=0.36$, $p<0.005$). Performance in each of the peripheral visual fields was correlated with one of the subtests: in the LVF with EOT ($r(90)=0.29$, $p<0.01$) and in the RVF with DDF ($r(90)=0.23$, $p<0.01$).

2.1.1. Experiment 1: perception of emotion: self report

We had complete data (TAS scores, BMI, and BDI scores) from 92 women: 14 women with AN-R, 17 women with AN-B/P, 18 women with BN-B/P, 21 sisters, and 22 unrelated healthy controls. Correlation analyses (across all participants, N = 92) revealed that BMI and BDI were significantly related to both total scores and to the subscale scores on the TAS. These are shown in Table 2.

We analyzed the data using a GLM procedure for unequal groups, with BMI and BDI as covariates. We used Total Score and the score on each of the subscales as dependent variables. These analyses revealed a significant main effect of group for the Total Score of the TAS-20 [$F(4,85)=2.76$, $p<0.05$], and for the EOT subscale [$F(4,85)=3.79$, $p<0.01$]. The main effect of group was marginal for the DIF [$F(4,85)=2.23$, $p=0.07$] and DDF subscales [$F(4,85)=2.13$, $p=0.08$]. The means of the total score and of the three subscales are shown in Fig. 2.

Table 2
Correlation coefficients of the relationships between BMI, BDI, and scores on the TAS-20, over the entire sample (N = 92). All of the correlation coefficients are significant with $p<0.05$.

	Total score	DIF	DDF	EOT
BMI	−0.35	−0.32	−0.31	−0.20 (p = 0.05)
BDI	0.70	0.68	0.64	0.31

Note: DIF—TAS-20 subscale of difficulty in identifying feelings; DDF—TAS-20 subscale of difficulty in describing feelings; and EOT—TAS-20 subscale of externally oriented thinking.

Pairwise planned comparisons were computed for the total TAS-20 score and the 3 TAS-20 subscales among the different groups, with both BMI and BDI as covariates. These comparisons reveal the patterns shown in Table 3. Accordingly, the two B/P spectrum groups, but not the AN-R group, differ from the controls on either total TAS-20, or the TAS-20 DIF and/or DDF subscales. No differences were found between the three patient groups in total TAS-20 or any of its subscales. Non-significant results from the comparison of very different means (as in the comparison of the total TAS-20 scores of the AN-R group and the controls, see Fig. 2) imply that the difference in TAS scores are mediated by depression. Most interestingly, the sisters group, while not being different from the unrelated healthy controls on the BDI, are significantly different from them on the TAS-20.

2.1.2. Experiment 2—recognition of emotion: experimental task

We analyzed the data of 90 participants for which we had BDI and BMI measures. The mean RT of correct responses and mean% of errors were analyzed, using group [AN-R (N = 14), AN-B/P (N = 17), BN-B/P (N = 17), controls (N = 22), and sisters(N = 20)] as a between groups factor, and task (Emotion Matching vs. Face Identity Matching) and visual field (LVF, RVF, BVF) as within subject factors. BMI and BDI were used as covariates in a GLM analysis for unequal groups.

The analyses revealed a 3-way interaction for the RT measure [$F(8,170)=2.32$, $p<0.05$], but not the error data. These patterns can be seen in Fig. 3. In addition, the task by visual field interaction was significant for the error data [$F(8,170)=22.28$, $p<0.0001$], as was the task by group interaction [$F(4, 85)=3.84$, $p<0.01$]. The main effect of task was significant for both measures, [RT: $F(1,85)=117.62$, $p<0.0001$;% of errors: $F(1,85)=133.74$, $p<0.001$], indexing the greater difficulty of the Emotion Matching task than the Face Identity Matching task (see Fig. 3), as was the main effect of visual field [RT: $F(2,170)=7.82$, $p<0.01$;% of errors: $F(2,170)=55.61$, $p<0.001$], reflecting the fact that both RT and% errors improved in the BVF condition in comparison to performance in the peripheral visual fields. The main effect of group was not significant in either measure.

Planned comparisons including the covariates of BMI and BDI reveal that the group by visual field interaction is significant

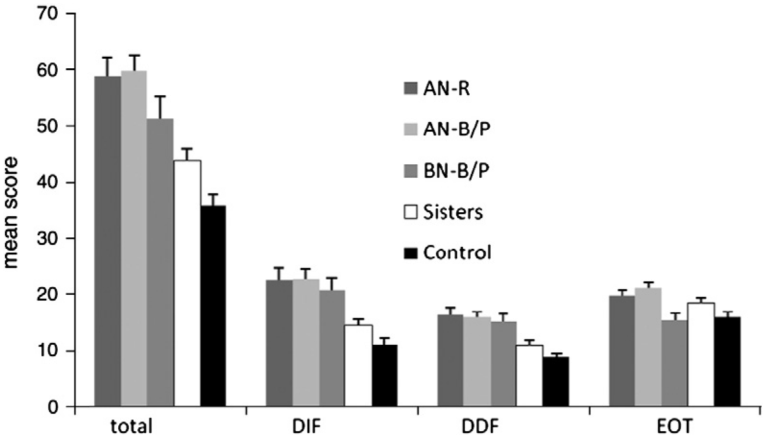

Fig. 2. TAS-20 scores for each of the groups (error bars are standard errors). Note: AN-R—anorexia nervosa, restricting type; AN-B/P—anorexia nervosa, binging/purging type; BN-B/P—bulimia nervosa, binging/purging type; TAS-20—Toronto Alexithymia scale-20; Total—TAS-20-Total score; DIF—TAS-20 subscale of difficulty in identifying feelings; DDF—TAS-20 subscale of difficulty in describing feelings; EOT—TAS-2-subscale of externally oriented thinking.

or marginally so in the Emotion Matching task [RT: $F(8,170)=1.99$, $p=0.05$;% of errors: $F(8,170)=1.78$, $p=0.08$], but not in the Identity Matching task ($p>0.4$). For both tasks, the main effect of group in the error data is marginal [Emotion task: $F(4,83)=2.04$, $p=0.09$; Identity task: $F(4,83)=2.11$, $p=0.08$].

Recall that bilateral presentation results in enhanced performance in healthy populations, reflecting the advantage conferred on processing difficult tasks when the load is distributed between the two cerebral hemispheres. In order to examine this effect more closely, we computed the difference between the BVF condition and the better of the two unilateral conditions. This bilateral advantage score in both RT and errors was then analyzed with a GLM model using group as a between subject factor and task as a within subject factor, with BMI and BDI as covariates. The analysis revealed a significant interaction between group and task in RT [$F(4,85)=3.03$, $p<0.05$], and a main effect of task for both measures [RT: $F(1,85)=10.11$, $p<0.005$; errors: $F(1,85)=20.98$, $p<0.001$]. The findings are illustrated in Fig. 4. It can be seen that for RT, the patient groups evinced a bilateral *disadvantage* in the Emotion Matching task, which was significant for the two AN groups. Both the control group and the sisters revealed an *advantage* in % of errors, which was not traded off for latency (as occurred in the AN-R group, who were more accurate in the BVF condition, but also much slower).

Table 3
The results of planned comparisons of scores on the Toronto Alexithymia Scale-20 (TAS-20).

	AN-B/P	BN B/P	Sisters	Controls
A. Total TAS-20 score				
AN-R	ns	ns	ns	ns
AN-B/P		ns	ns	$F(1,35)=4.6$, $p<0.05$
BN B/P			ns	ns
Sisters				$F(1,39)=10.12$ $p<0.005$
B. DIF				
AN-R	ns	ns	ns	ns
AN-B/P		ns	ns	$F(1,35)=3.10$ $p=0.08$
BN B/P			ns	$F(1,36)=6.08$ $p<0.05$
Sisters				$F(1,39)=6.08$ $p<0.05$
C. DDF				
AN-R	ns	ns	ns	ns
AN-B/P		ns	ns	$F(1,35)=3.20$ $p=0.08$
BN B/P			ns	$F(1,36)=5.8$, $p<0.05$
Sisters				$F(1,39)=4.74$ $p<0.05$
D. EOT				
AN-R	ns	$F(1,28)=3.49$ $p=0.07$	ns	ns
AP-B/P		$F(1,31)=4.11$ $p<0.05$	ns	ns
BN-B/P			$F(1,35)=8.55$, $p<0.01$	ns
Sisters				$F(1,39)=3.52$ $p=0.06$

Note: AN-R—anorexia nervosa, restricting type; AN-B/P—anorexia nervosa, binging/purging type; BN-B/P—bulimia nervosa, binging/purging type; DIF—TAS-20 subscale of difficulty in identifying feelings; DDF—TAS-20 subscale of difficulty in describing feelings; and EOT—TAS-20 subscale of externally oriented thinking. All comparisons are computed with body mass index (BMI) and Beck Depression Inventory (BDI) scores as covariates. Non-significant differences between very different means reflect the mediating effect of BDI on the responses to the TAS-20.

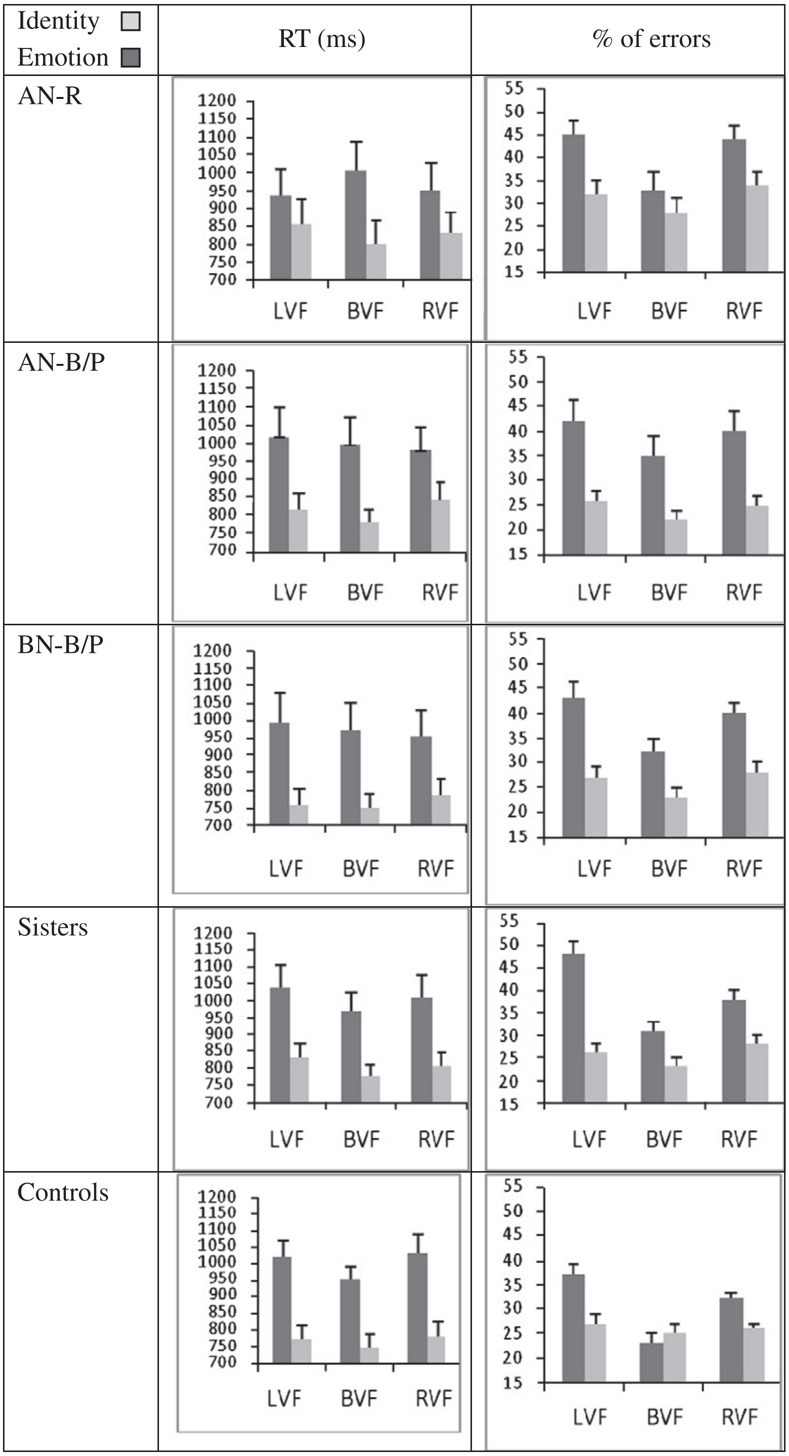

Fig. 3. RT and % of Error scores in the Emotional and Identity Matching Tasks. Error bars represent standard errors. Note: AN-R—anorexia nervosa, restricting type; AN-B/P—anorexia nervosa, binging/purging type; BN-B/P—bulimia nervosa, binging/purging type; RT—reaction time. LVF—left visual field; BVF—bilateral visual field; RVF—right visual field.

3. Discussion

The aim of this study was to explore four hypotheses. The first hypothesis examined alexithymia in EDs vs. healthy sisters and non-related controls, and was explored in Experiment 1. The results reveal two main findings. The first is that depression accounted for the differences between AN-R patients and healthy controls, but not for the differences

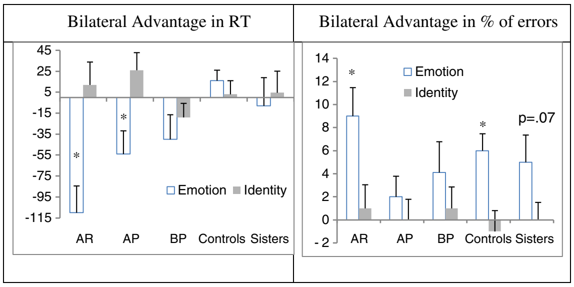

Fig. 4. Bilateral advantage (the difference between mean RT and mean % of errors in the better of the two peripheral visual fields vs. the bilateral presentation condition). Note: AN-R—anorexia nervosa, restricting type; AN-B/P—anorexia nervosa, binging/purging type; BN-B/P—bulimia nervosa, binging/purging type; RT—reaction time; a positive value indicates a better performance in the bilateral condition for the respective group.

between the two groups with B/P symptoms and healthy controls. Accordingly, women with both AN-B/P and BN-B/P are significantly more alexithymic than healthy controls, over and above the effects of depression (see Table 3). Previous studies have reported findings that are in keeping with our results. Thus, similar to our findings in AN-R patients, Parling et al. (2010), have also reported that difficulties in emotion recognition in AN are accounted for by depression. We have also replicated the results of de Groot et al. (1995), of elevated alexithymia in women with BN in comparison with healthy controls that is maintained even when depression is taken into account. Altogether these findings suggest that depression may have differential effects on emotion recognition in restricting versus binging–purging ED patients.

Several explanations can be forwarded for this phenomenon. In the case of AN-R, depression may adversely affect the individual's ability to identify and describe her feelings, by decreasing such cognitive capabilities as initiation, attention, concentration, and perception. This may be either a direct effect of depression (Parling et al., 2010), or be related to the effect of malnutrition on depression, cognitive dysfunctioning, and alexithymia (Pollice et al., 1997). Alternatively, the reduced ability of AN patients to tolerate intense negative affect, including depression (Fairburn et al., 2003), might increase their attempts to disregard, or adamantly deny (Bruch, 1973) any attempt toward identification and expression of their emotions. Similarly, if alexithymia is considered secondary to depression, as suggested by some (Parker et al., 1991) it can act as a defense against painful affect that the AN patient is unable to tolerate. Lastly, the constricted, rigid, perfectionistic and inhibited personality profile of many AN-R patients (Cassin and von Ranson, 2005) might be associated both with an overall increased sense of negative emotionality, including depression (Pollice et al., 1997), and with an inclination to avoid the expression and communication of their emotional life.

In contrast to AN-R women, B/P spectrum patients show traits indicative of elevated impulsivity and affective instability (Cassin and von Ranson, 2005; Vitousek and Manke, 1994). Hypothetically, the weaker association of alexithymia with depression in B/P patients might result from a greater influence of the patients' affective instability and impulsivity on their disturbed emotional expression and communication. Additionally, B/P symptoms have been suggested to reflect difficulties with affect regulation (de Groot et al., 1995), or alternatively, to represent attempts to regulate, or reduce, emotional pain (Tobin et al., 1991).

The second interesting finding from Experiment 1 is that the healthy sisters of women with EDs are significantly more alexithymic than unrelated healthy controls. This finding cannot be related to the mediating effects of depression, as the sisters were not different from the unrelated control group in the BDI, with both groups showing no evidence of depressive disturbance. In keeping with the results of Dahlman (1996) and Guttman and Laporte (2002), who reported some evidence of elevated alexithymia in family members of ED women vs. control families, our results also suggest a familial pattern for alexithymia. The cross-sectional design of our study does not allow us to speculate whether some threshold of alexithymia has to be crossed for the development of overt ED-related pathology, or alternatively, that the presence of ED symptoms may increase the level of alexithymia in already predisposed individuals.

The second hypothesis of the present study, examined in Experiment 2, explored the likelihood of a deficit in the recognition of basic emotions of others in EDs in comparison to related and unrelated controls. Our results show that overall, women with EDs are as fast and as accurate in matching both facial identity and facial emotions as their unaffected sisters and unrelated healthy controls. Accordingly, our study has not shown a disturbance in basic emotion recognition in ED patients.

The third hypothesis tested in this study examines differences in bilateral advantage, a measure of interhemispheric communication, among the different groups. This hypothesis was tested by comparing the response times and accuracy of responses in the bilateral visual field condition with the better of the two unilateral conditions in Experiment 2. The results suggest that women with ED have less efficient interhemispheric communication than both their unaffected sisters and unrelated healthy controls (see Fig. 4). To our knowledge, this is the first report of such a phenomenon in EDs. The findings of the present study suggest that the disturbances in complex emotion recognition tasks found in ED patients (Harrison et al., 2010a,b) and their overall reduced social capacities in stressful conditions (Strober et al., 1997) might be related in part, to insufficient communication and integration between the two cerebral hemispheres.

Decreased integration among different brain regions has been previously reported in complex psychiatric phenomena such as schizophrenia, for both behavioral (Florio et al., 2008; Mohr et al., 2008) and electrophysiological measures assessed while performing a lexical decision task (Mohr et al., 2008). It has also been found in people with autistic spectrum disorders (e.g., Koshino et al., 2008; Nyden et al., 2004), specifically with regard to face processing. This finding has been interpreted as reflecting lower coherence in the brains of autistic individuals. Interestingly, symptoms of autistic spectrum disorders, in particular impaired social functioning, have been found to be overrepresented in AN patients. In some studies this impairment has been found only in the acute condition of the illness (Oldershaw et al., 2010) suggesting that it is the result of malnutrition, while others have found impaired social functioning particularly in AN patients who evidence a chronic course (Zucker et al., 2007), suggesting it to represent an important prognostic determinant. In our study we found evidence for lower levels of interhemispheric integration in all our ED groups, over and above the effects of BMI and depression.

The hypothesis that aspects of ED are related to impairments in interhemispheric integration, and that AN, at least, can be conceived as a disconnection syndrome, has recently received indirect support from a study showing that both men and women with strong handedness preferences – which reflect lower degrees or efficiency of hemispheric integration – reveal higher degrees of body-image distortion and elevated eating related pathology on the Eating Disorders Inventory-2 (Christman et al., 2007).

An additional unexpected interesting finding relates to the correlations found between the TAS-20 scores and performance on emotion recognition in our experimental task. Thus, all three TAS-20 subscales were found to correlate with the Emotion matching performance in the BVF condition, suggesting that interhemispheric integration is required both for the identification of one's own emotion and the recognition of the emotions of others. In addition, it is interesting to note that the TAS-20 subscale of DDF, which taps a difficulty in verbalizing feelings, was found to correlate with the percent of errors in emotion recognition in the RVF, where stimuli are initially processed by the LH which is specialized for language. By contrast, the TAS-20 subscale of EOT, which taps the degree of externally oriented thought, is correlated with percent of error scores in the LVF, where stimuli are initially processed by the RH, which has been implicated in subserving the ability to take different points of view (Guise et al., 2007). These patterns validate these lateralization patterns.

3.1. Limitations

Several limitations have to be mentioned with respect to our findings. The sample is relatively small, and we did not look at the effects of the valence of the emotion. Thus, we are unable at this stage to speculate whether the patterns found in our study are different for positive and negative emotions. We also did not examine more complex social emotions that might be differently processed from the simple facial tasks assessed in the present study.

In conclusion, the present study examined the recognition of basic emotions of oneself and others in ED patients, their healthy sisters and healthy non-related controls using a self report questionnaire and a lateralized performance design. The unique contribution of our study, in our opinion, although still preliminary at the present time, is the finding that healthy sisters of women with ED may also evince more difficulties and avoidance in the recognition of their own emotions as compared to non-related controls, although they are not as disturbed as their ill sisters. In addition, we report, for the first time, straightforward evidence that interhemispheric communication may be less efficient in women with different ED diagnoses in comparison to their unaffected sisters and to unrelated healthy controls. This finding suggests that such an interhemispheric deficit may represent either a marker or a result of the ED, rather than a trait that may run in families. It also adds EDs to a range of complex psychiatric illnesses characterized by deficits in social cognition that might result from lack of interhemispheric integration. We believe that closer and more direct measures of hemispheric integration in patients with ED may further clarify this hypothesis. We are currently examining interhemispheric transfer times for both disease-specific stimuli such as pictures of food or emotionally threatening situations, and disease-neutral stimuli, in ED samples. Given that interhemispheric communication is dynamic, it is important to see whether deficits in transfer are a general problem for all, or subgroups, of women with EDs, or whether they are specific to highly arousing stimuli. It would also be useful to test the effects of the valence of this arousal: is there a difference between positive and negative emotional arousal? In addition, future longitudinal research in larger samples of ED patients from the acute stage of their illness until achieving recovery, might shed more light on our preliminary results. In particular, it is important to delineate whether disturbances in emotion recognition represent a secondary derangement or an enduring trait, and its potential influence on the course and outcome of an ED.

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Conflict of interest

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