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Mood, eating behaviour and attention

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ABSTRACT

Background. Obesity is a growing health problem, but most people find dieting unsuccessful. Three studies examine possible reasons for the difficulty and the extent to which dieting-related reductions in cognitive function are associated with mood and well-being.

Method. In Study One, 49 female dieters were compared with a control group of 31 matched non-dieters on measures of well-being, mood, eating behaviour (Dutch Eating Behaviour Questionnaire), and attention. Study Two examined two measures of restraint to examine why previous studies find high restrainers are prone to react to emotion. Study Three experimentally manipulated mood using music and the standard Velten Induction Procedure to examine attention in restrainers and emotional eaters.

Results. Dieting was found to be associated with deficits in sustained attention. This finding was further supported by the demonstration of a significant impairment in performance following a negative mood induction in high emotional eaters whereas high restrainers were relatively unaffected by the mood challenge.

Conclusions. We suggest that different aspects of eating behaviour have dissociable effects on cognitive-affective function. Trait tendencies to restrained eating are associated with attentional deficits, but are not further affected by mood disruption. It is the long-term tendency to eat when emotional that combines with current emotional state to trigger cognitive deficits.

INTRODUCTION

We are interested in examining the ways in which long-term styles of eating behaviour interact with short-term fluctuations in mood to determine cognitive deficits, and thereby contribute to the success or failure of attempts to diet. Obesity is a common and growing health care problem. While dieting programmes are the most widely used treatments of obesity, attempts to control body weight by dieting are generally unsuccessful.

Why is dieting so difficult to maintain? Recent research suggests that dieting is associated with impairments in cognitive function (Green & Rogers, 1995, 1998; Wing *et al*. 1995). For example dieters have deficits in sustained attention (Rogers & Green, 1993), slower reaction times and poorer immediate memory recall (Green *et al*. 1994). Explanations of dieting-induced cognitive deficits tend to focus on diet related preoccupation. However, such an account does not address the role of mood or well-being and how each of these may relate to eating behaviour. We consider each of these variables in turn.

Green and colleagues (1993, 1998) have focused on preoccupation. Their results suggest that preoccupations with food or body shape deplete processing resources both by their potential to distract and by the effort expended during attempts to manage these thought intrusions. Individuals who are currently dieting have a smaller working memory span compared to non-dieters and this reduction is working

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memory capacity has been linked to an increased preoccupation with thoughts concerning food and eating (Green *et al*. 1997).

The role of affect remains equivocal with most studies suggesting that dieters and non-dieters do not differ in mood levels (e.g. Green & Rogers 1995; Green *et al*. 1997). However, these studies have used undergraduate participants where variance in mood may be relatively small. We need to check, first, whether mood may nevertheless play a role in community samples of dieters to ensure that results are generalizable to a population with a wide range of mood disturbance. Secondly, mood in these studies has typically been measured using only anxiety and depression scales. We need to examine the role of other moods such as anger/hostility, confusion/bewilderment and fatigue as well as anxiety and depression. Thirdly, although negative mood has been most often assessed, there is evidence that positive mood can have independent effects from negative mood, and needs to be assessed separately (Watson *et al*. 1988). Consistent with this increased interest in positive aspects of psychological functioning, scales that assess well-being are now available (Ryff, 1989), which have not been used before in dieters. We wished to check the extent to which dieting behaviour reduces well-being, and whether all aspects of dieting affect well-being in the same way.

Eating behaviour is generally characterized in terms of emotional eating, dietary restraint and susceptibility to external food related cues. Green *et al*. (Green *et al*. 1997; Green & Rogers, 1998) propose that the effort of maintaining self-control through dietary restraint, combined with the presence of intrusive preoccupation about food is largely responsible for such impairments in attention. It is important to understand restraint because the long-term maintenance of dietary control appears to be associated with the tendency to suddenly lose such control, over-eating rather than limiting food intake. While a considerable body of research has been conducted exploring restraint as the primary variable in the regulation of eating behaviour (Federoff *et al*. 1977; Schotte *et al*. 1990; Green & Rogers, 1993; Green *et al*. 1994) there has been a paucity of studies exploring the contribution of emotional eating. In addition it is not clear which of these aspects of eating behaviour (restraint or emotional eating) may contribute more to cognitive-affective deficits associated with dieting.

We describe three studies. Study One replicates, in a community sample of dieters, findings of a cognitive deficit previously been found in student populations, but also suggests that different aspects of eating behaviour affect mood and cognition differently. In particular, high levels of restrained eating are associated with deficits in sustained attention, but they do not appear to be associated with disturbed mood. Study Two examines whether the lack of association between restraint and mood was due to the measure we had used. Study Three manipulates mood experimentally. It confirms that cognitive deficits associated with high restraint are not mood mediated, and that mood enters the picture only for those who are prone to eat when emotional.

STUDY ONE

Method

Participants

Dieting participants (who had been dieting for a minimum of 5 weeks) were recruited from local Weight Watcher classes and from adverts placed in the local paper. A total of 49 female community (non-student) dieters (mean age = 45·62 (14·15) years) were recruited. A comparison group consisting of 31 female non-dieters (mean age = 40·84 (13·33 years)) was recruited from Bangor School of Psychology's Departmental Participant Panel. There were no significant age differences between the groups ($P < 0{\cdot}05$). All participants had normal (or corrected to normal) vision and reported general good health. Dieters were asked how long they had maintained their current diet but no past history of previous diets was taken. All participants were paid for participation. The mean BMI of the dieting group was 28·92 (5·90). This BMI was significantly higher than that of the non-dieting group (BMI 23·55 (3·44); $F(1, 73) = 17{\cdot}62$; $P = 0{\cdot}0001$) and was co-varied for in all relevant analyses.

Design and procedure

Each participant was tested individually in a session lasting approximately 45 min. After providing informed consent participants com-

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pleted a measure of current hunger. Participants then completed the following measures.

Bakan vigilance task

This task consisted of a visual analogue of the Bakan task (Bakan, 1959) using MEL V2 software. Participants were presented with a rapid sequence of digits appearing on the VDU. During this display, participants press the space bar if they detect a sequence of three-odd or three-even numbers. The stimulus presentation rate was 100 stimuli per min, with an exposure duration of 600 ms per stimulus and no inter-stimulus interval. There were eight potential correct hits per minute per block. A total of 3 blocks were used in this study.

Self-report measures

Upon completion of the Bakan task, participants completed a number of self-report measures about their eating behaviour and appetite, mood, well-being and an eight-item visual analogue eating/mood scale (VAS). This latter scale assessed current eating concerns (e.g. pre-occupations with food; control over eating; and urges to eat) in addition to current emotional state. Measures of eating behaviour and appetite consisted of a four-item Hunger Scale (Grand, 1968); and the Dutch Eating Behaviour Questionnaire (DEBQ) (Van Strien *et al.* 1986). All factors on the DEBQ have high internal consistency and factorial validity with Cronbach's alpha coefficient of 0·90. Examples of items from the three subscales are 'How often do you refuse food or drink because you are concerned about your weight?' (restraint); 'Do you have a desire to eat when you are depressed or discouraged?' (emotional eating); and, 'If you see or smell something delicious do you desire to eat it?' (external cues).

Mood

Mood measures consisted of the short-form of the Profile of Mood States (POMS-SF) (Nulty *et al.* 1987) and the Positive and Negative Affect Schedule (PANAS) (Watson *et al.* 1988). Two versions of this latter scale were used, one reflecting current mood ('right now') and one referring to mood experienced over the prior month to testing ('over the last month'). This scale has been reported to have good internal consistency, with positive and negative affect being uncorrelated and good test–retest stability over a 2 month period (Watson *et al.* 1988).

Well-being

Well-being assessed using Ryff's (1989) 84-item scale of Psychological Well-being (PWB). It measures six dimensions of positive psychological functioning: autonomy; environmental mastery; personal growth; positive relations with others; purpose in life; and self-acceptance. Each scale has high internal consistency with an average Cronbach's coefficient alpha on each scale $> 0{\cdot}85$.

Results

Data were analysed using the Statistical Package for the Social Sciences (SPSS, 1995) with univariate analysis of variance (ANOVA) or multivariate analysis of variance (MANOVA) used where appropriate. Relevant data were logarithmically transformed where necessary to stabilize variance and reduce skew in the distribution. Pearson's product moment correlation coefficients were employed in all correlational analyses (all two-tailed). Data from 8/53 (15%) dieting participants were lost from Bakan task performance due to technical reasons.

Characteristics of dieting and non-dieter groups

Table 1 provides a summary of differences in eating behaviour as measured by the Hunger Scale, VAS, DEBQ and BMI. Differences between dieters and non-dieters on the Hunger Scale were assessed by one-way ANOVA. Results revealed no differences between dieters and non-dieters in terms of the number of hours since last ate; number of hours until next meal; and, amount of favourite food that could be eaten 'right now' (all $P > 0{\cdot}05$). Dieters did however report significantly lower levels of hunger compared to non-dieters ($F(1,76) = 4{\cdot}87$; $P = 0{\cdot}03$). Differences between dieters and non-dieters on the VAS were assessed by MANOVA. Results revealed an overall significant effect ($F(8,64) = 4{\cdot}13$; $P = 0{\cdot}001$). Subsequent univariate analyses showed dieters to report significantly more preoccupation with thoughts of food ($F(1, 71) = 13{\cdot}67$; $P = 0{\cdot}0001$), and to perceive themselves as having less energy compared to non-dieters ($F(1, 71) = 4{\cdot}10$; $P = 0{\cdot}04$).

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Table 1. *BMI, hunger and eating behaviour in dieters and non-dieters*

	Dieters Mean (S.D.)	Non-dieters Mean (S.D.)
BMI	28·92 (5·90)	23·55 (3·44)**
Hunger rating	1·51 (0·84)	2·00 (1·10)**
VAS		
Food preoccupations	5·63 (2·80)	3·14 (2·83)**
Energy levels	5·03 (2·59)	6·31 (2·71)*
DEBQ		
Emotional eating	3·39 (0·94)	2·59 (0·97)**
Dietary restraint	3·69 (0·64)	2·20 (0·77)**
External eating	3·33 (0·60)	3·07 (0·56)

* $P < 0{\cdot}05$; ** $P < 0{\cdot}01$.

Analysis of the DEBQ data (MANOVA) revealed an overall significant effect ($F(3, 73) = 32{\cdot}01$; $P = 0{\cdot}0001$); dieters were shown to be significantly more prone to eat when emotional, and to have significantly higher levels of dietary restraint, compared to non-dieters ($F(1, 75) = 13{\cdot}16; 84{\cdot}56$; $P = 0{\cdot}001, 0{\cdot}0001$, respectively). As found in our pilot work, the susceptibility to external cues was the variable that least differentiated dieters from non-dieters ($F(1, 75) = 3{\cdot}75$; $P = 0{\cdot}06$) and thus will not be considered further. Note that for the other two scales, restraint and emotional eating, although both were elevated in the dieters, they did not correlate with each other, for dieting group ($r(46) = -0{\cdot}11$; $P > 0{\cdot}05$).

Mood and well-being: dieters and non-dieters

Results of a MANOVA conducted on the well-being scale (consisting of six subscales) revealed an overall significant effect ($F(6, 67) = 2{\cdot}90$; $P = 0{\cdot}01$). Subsequent univariate analysis revealed between group differences on measures of personal growth and self-acceptance ($F(1, 72) = 13{\cdot}95$; $4{\cdot}40$; $P = 0{\cdot}001$ and $0{\cdot}03$, respectively), with dieters reporting lower scores (see Table 2). A MANOVA conducted on the POMS and PANAS mood data revealed an overall significant between-group difference ($F(10, 51) = 2{\cdot}52$; $P = 0{\cdot}01$). Subsequent univariate analysis showed that dieters were more fatigued than non-dieters and had significantly less vigour ($F(1, 60) = 5{\cdot}26$ and $3{\cdot}81$; $P = 0{\cdot}02, 0{\cdot}05$, respectively) (Table 2). There were no significant between group differences in terms of positive or negative affect on the PANAS ($P > 0{\cdot}05$) although a trend was shown whereby dieters reporting lower items on positive items on the PANAS over the last month (mean (M) = 31·87) compared to non-dieters (M = 35·17).

Table 2. *Mood, well-being and attention in dieters and non-dieters*

	Dieters Mean (S.D.)	Non-dieters Mean (S.D.)
Mood		
Fatigue	5·79 (4·12)	3·54 (3·77)*
Vigour	6·08 (3·84)	8·00 (4·03)*
Personal well-being		
Personal growth	4·75 (0·61)	5·24 (0·42)***
Self-acceptance	4·28 (0·98)	4·70 (0·76)*
Bakan Attentional Task	9·61 (4·72)	12·22 (4·25)*

* $P < 0{\cdot}05$; *** $P < 0{\cdot}001$.

Table 3. *Correlational differences between eating behaviour and well-being, mood, preoccupation with food, and BMI in dieters*

Measure	Emotional eating	Restraint	Differences in correlation (Z)
Personal well-being			
Autonomy	0·07	0·03	0·18
Environmental mastery	−0·49***	0·21	3·48*
Personal growth	−0·07	0·25	1·31
Purpose in life	−0·37*	0·18	2·67*
Positive relations	−0·34*	0·22	2·68*
Self-acceptance	−0·35*	0·21	2·68*
Composite PWB	−0·348	0·21	2·69*
PANAS ('last month')			
Positive	−0·28	0·16	2·08*
Negative	0·19	−0·28	2·23*
Food Preocc.	0·29*	0·07	1·06
Weight (BMI)	0·33*	−0·20	2·53*

* $P < 0{\cdot}05$; *** $P < 0{\cdot}001$.

Attention: dieters and non-dieters

The mean values for the Bakan attentional task by condition are also reported in Table 2. Analysis of Bakan data (number of correct hits) using ANOVA showed dieters to be significantly impaired in their performance compared to non-dieters ($F(1, 70) = 5{\cdot}71$; $P = 0{\cdot}01$). In order to check whether the differences between dieters and non dieters on measures of mood, well-being and Bakan task performance could be accounted for in terms of BMI status, all analyses were repeated with BMI entered as a covariate. Results remained significant, suggesting that between group differences were not attributable to differences in BMI status.

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Because dieters differed in their levels of restraint and emotional eating, these variables were partialled out in turn in an analysis of covariance (ANCOVA). When dietary restraint was removed, results showed no significant between group differences on the Bakan task ($F(1, 65) = 0{\cdot}72$; $P = 0{\cdot}40$). By contrast, covarying for emotional eating, differences between dieters and non-dieters on the Bakan task remained significant ($F(1, 65) = 3{\cdot}89$; $P = 0{\cdot}05$). This pattern of data suggests that the difference in Bakan task performance between dieters and non-dieters is largely attributable to the higher restraint scores in those who were also dieting. This raises the issue of how restraint and mood (both high in dieters) might inter-relate in the way they affect attention.

Correlates of eating behaviour and dieting

First, we looked at the correlations between restraint and emotional eating on the one hand, and mood and well-being on the other (see Pearson product correlation coefficients, Table 3). These showed that those reporting high emotional eating and those reporting high levels of dietary restraint showed significant differences in their associations with mood and well-being. Dieters who reported a greater tendency to eat in response to emotional cues generally reported poorer well-being: lower environmental mastery ($r(45) = -0{\cdot}49$; $P = 0{\cdot}001$); less purpose in life ($r(45) = -0{\cdot}37$; $P = 0{\cdot}01$); less positive relations with other ($r(45) = -0{\cdot}34$; $P = 0{\cdot}02$) and reduced self-acceptance ($r(45) = -0{\cdot}35$; $P = 0{\cdot}02$). By contrast, dieters who reported highly restrained eating showed no such correlations. Most were in the opposite direction, and significantly different from those for emotional eating. Emotional eating was also significantly correlated with food preoccupations, unlike restrained eating. Finally, high emotional eaters also had higher BMIs ($r(45) = 0{\cdot}33$; $P = 0{\cdot}02$) whereas the correlation between dietary restraint and BMI was significantly different and in the opposite direction ($r(45) = -0{\cdot}20$; $Z = 2{\cdot}53$; $P < 0{\cdot}05$).

Given this apparent dissociation in the effects of restraint versus emotional eating on mood and well-being variables, the question arose whether the Bakan attention measure, which was found to be associated with restraint, would correlate with mood. The correlations show that the Bakan task was not associated with either mood or well being (correlations ranged from $0{\cdot}01$ to $-0{\cdot}13$; $P > 0{\cdot}05$) or with BMI ($r = -0{\cdot}02$; *NS*).

Discussion

The aim of this study was to investigate the relationship between dieting, subjective well-being and cognitive function in a community (non-student) sample of dieters using a wider range of mood measures. As predicted, dieters reported themselves to be significantly more preoccupied with thoughts of food and eating. They were significantly more prone to eat when emotional, and reported higher levels of dietary restraint. While previous studies had not shown differences in mood, our results showed that although the affective consequences of dieting were relatively weak, they showed a consistent pattern, suggesting reliable differences in mood and well-being. They showed evidence of reduced overall well being and significantly increased levels of fatigue and reduced energy levels.

However, although dieters were impaired on a measure of sustained attention, (consistent with previous work, Rogers & Green 1993; Green *et al*. 1994) there was some evidence of a different pattern of associations between mood, eating behaviour and cognition. Those who had a greater tendency to eat when emotional showed significantly lower well-being and more disturbed mood. They also had higher BMIs. However, there was no evidence that these emotional differences affected attentional performance. In contrast, while high restrainers demonstrated no such relationship with well being and mood indices, high restraint was significantly associated with attentional performance. The data suggest that cognitive disruption associated with dietary restraint may not be mood sensitive. Disruption in mood seems to be more characteristic of emotional eaters. This pattern of data is consistent with a possible dual route to cognitive disruption, one involving restraint the other involving emotion.

However, this explanation is weak on two counts. First, it is *post hoc*, and requires experimental evidence that predicts the pattern at the outset. Secondly, this account is based on a correlational analysis; we need to examine the

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differential effect of restraint and of affective disturbance by manipulating mood experimentally. We return to both issues in Study Three. Before doing so, there is another aspect of the data that requires further examination: the suggestion that participants reporting high levels of dietary restraint were relatively immune to the effects of disturbed mood. This is not consistent with a great deal of previous research suggesting that restraint is highly mood-sensitive. This will be the focus of Study Two, where we attempt to show that the particular measure of restraint used in studies may be critical.

STUDY TWO

It has long been assumed that the long-term maintenance of dietary control is associated with the tendency to suddenly lose control, overeating rather than limiting food intake. The idea that restraint increases the chances of such disinhibition seems plausible. It agrees with many people's beliefs about the reasons why they sometimes lose control of a behaviour: that it was the result of 'holding themselves back' for too long. Bingeing is thus seen as the almost inevitable result of restraint. There is, however, increasing reason to believe that such a 'restraint-disinhibition' hypothesis may be due to a confound in the questionnaire measure of restraint that has typically been used.

Much of the early research on dietary restraint used the Revised Restraint Scale (RRS) (Polivy *et al*. 1978). This 10-item scale consists of two subscales: Weight Fluctuation (WF, four items) and Concern with Dieting (CD, six items). A number of studies found that individuals scoring high on the RRS scale ('high restrainers') show a disinhibition effect relating to food intake. For example, Blanchard & Frost (1983) found that Weight Fluctuation predicted body weight and mood related disinhibition of food intake. Ruderman (1985) found that the Concern with Dieting subscale predicted food intake disinhibition during negative mood induction. Schotte *et al*. (1990) found that film-induced negative affect triggered overeating in restrained eaters compared to non-restrained eaters. Despite these and similar results, the specificity of what the Revised Restraint Scale measures remains unclear.

The problem is that both subscales of the scale contain at least one item that asks about loss of control of eating. The Weight Fluctuation subscale contains an item asking about the maximum weight gained in a single week, while the Concern with Dieting subscale contains an item that explicitly asks about 'splurging'. It is therefore unsurprising to find that one or other of the subscales of the Revised Restraint Scale has been found to predict loss of control.

Although Polivy's RRS does correlate with restraint measured by other 'purer' measures of the concept (Wardle, 1986), this does not address the issue of whether the tendency to overeat may be a separable aspect of eating behaviour. Many authors (e.g. Van Strien, 1999) suggest that such separation is important: restraint may or may not be associated with the tendency to overeat on some occasions in some people. In Study One, we had used the Dutch Eating Behaviour Questionnaire (Van Strien *et al*. 1986), which overcomes the problem by separating 'restraint' from the 'tendency to eat when emotional'. Our results appeared to agree with Van Strien and colleagues: our group of dieters contained people who were highly restrained and people who tended to eat when emotional, but these aspects of eating behaviour emerged as distinct variables.

If we are to argue that: (*a*) dietary restraint can be relatively immune to affective disturbance: and that (*b*), any cognitive disruption due to affect will arise from the tendency to eat when emotional, then we need to check whether those who report losing control over their eating, and gaining weight rapidly score high on emotional eating but not on restraint.

Method

Participants

One hundred and three participants randomly selected from the Department of Psychology participant panel were contacted by telephone and invited to participate in a postal survey relating to eating behaviour, mood and personality. Ninety-three respondents agreed to participate in the study, of which 87 presented

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Table 4. *Means of Revised Restraint Scale and partial correlations with Dutch Behaviour Questionnaire*

Measure	Mean (S.D.)	Emotional eating (minus restraint)	Dietary restraint (minus emotional)
RRS (total)	22·67 (5·85)	0·61***	0·66***
CD (subscale)	13·38 (3·68)	0·60***	0·62***
WF (subscale)	9·29 (3·13)	0·36***	0·45***
How often diet (CD)	2·29 (1·15)	0·29**	0·69***
Max. weight loss 1 month (WF)	1·78 (0·83)	0·19	0·20
Max. weight gain 1 week (WF)	2·24 (1·03)	0·43***	0·38***
Weekly weight fluctuation (WF)	1·91 (0·79)	0·30**	0·26*
Weight fluctuation affect life (CD)	2·15 (1·00)	0·17	0·10
Splurging (CD)	1·60 (0·71)	0·61***	0·05
Preoccupation with food (CD)	2·06 (0·87)	0·42***	0·45***
Guilt at overeating (CD)	2·14 (0·97)	0·53***	0·57***
Conscious of eating (CD)	3·14 (0·77)	0·21	0·20
Pounds over desired weight at max. (WF)	3·35 (1·31)	0·18	0·45***

* $P < 0{\cdot}05$; ** $P < 0{\cdot}01$; *** $P < 0{\cdot}001$.

with complete data sets. The mean age of the 87 participants was 45·50 (19·50) with an average body mass index of 24·43 kg/m² (4·70). Twenty-two of the 87 respondents (25%) claimed to be dieting at the time they completed the questionnaires.

Materials

Participants completed the following self-report measure.

Revised Restraint Scale (*RRS*) (Polivy *et al.* 1978)

This a 10-item scale consisting of two subscales: Weight Fluctuation (WF); and Concern with Dieting (CD). The WF subscale consists of four questions directly relating to how often and how much an individual's weight fluctuates over time for example, 'What is your maximum weight gain within a week?' and 'What is the maximum amount of weight that you have ever lost within one month?'. The Dietary Concern subscale of the RRS consists of six questions relating to current concerns regarding dieting such as 'Do you give too much time and thought to food?' and 'How conscious are you of what you are eating?'. The reliability coefficient for internal consistency (Cronbach's alpha) is 0·78 for the RRS (Laessle *et al.* 1989).

Dutch Eating Behaviour Questionnaire (*DEBQ*) (Van Strien *et al.* 1986)

This was used as described in Study One.

Positive and Negative Affect Schedule (*PANAS*) (Watson *et al.* 1988)

This was used as described in Study One.

Results and Discussion

Table 4 shows the means and standard deviations of items in the RRS. Pearson correlation coefficients were used first to examine whether there was any correlation between the restraint and emotional eating subscales of the DEBQ. They were found to correlate significantly ($r(87) = 0{\cdot}27$; $P = 0{\cdot}01$). Secondly, we examined the correlation between the RRS (total score) and DEBQ subscales. As predicted, the RRS correlated with both the Restraint ($r(85) = 0{\cdot}68$; $P < 0{\cdot}001$), and Emotional Eating ($r(85) = 0{\cdot}61$; $P < 0{\cdot}001$) subscales of the DEBQ. Of even greater interest was the pattern of correlation between the restraint and emotional eating subscales of the DEBQ with the 10 individual items of the RRS. Partial correlation coefficients (controlling for either DEBQ restraint or emotional eating as appropriate) are shown in Table 4.

These correlations show that the subscales of the DEBQ (restraint and emotional eating) share common variance with the subscales of the RRS (concern with dieting and weight fluctuation). Of particular interest for our present purposes, two of the items ('maximum weight gain in 1 week' and 'splurging') load more highly on the emotional eating subscale of the DEBQ than on

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the restraint subscale. The most explicit RRS item referring to loss of control of eating ('splurging') correlates with DEBQ emotional eating ($r(85) = 0{\cdot}60$), but not DEBQ restraint at all ($r(85) = 0{\cdot}09$), and these correlations are significantly different from each other ($Z = 3{\cdot}8$; $P < 0{\cdot}001$).

These data confirm that the RRS does indeed confound restraint and emotional eating. This may have arisen because the scale was derived from models based on the eating behaviours of unsuccessful dieters (Van Strien, 1999). Although such dieters may be in the majority, confounding two variables that contribute to such lack of success limits our ability to examine why such failure occurs. In any event, it has resulted in a number of experiments using the RRS that have attributed effects to restraint, when they may have inadvertently been observing the effect of another variable, emotional eating. In particular, many of the studies investigating stress-induced overeating have categorized participants using only the RRS scale. In such studies high restrainers are those most likely to show disinhibited eating following an affect challenge. Models generated to account for these findings explain disinhibited eating as the direct result of restraint itself. The idea is that the introduction of a stressor disrupts the control these individuals normally try to exert over their eating: it distracts attention (Greeno & Wing, 1994). Restraint is conceived as a sort of 'coiled spring', with the ever present tendency for the spring to unwind given a moment's relaxation of vigilance.

An alternative 'affect hypothesis' sees the problem of disinhibition as located in a person's sensitivity to affect, not in restraint *per se*. Restraining food intake involves setting up a goal. Overeating involves violating this goal, exactly the circumstances in which one would predict some increase in affective disturbance (Oatley & Johnson-Laird, 1987). Response to such affective changes will depend on trait factors such as Neuroticism and the tendency to eat when emotional. The latter trait may cause a highly unstable positive feedback loop in which such eating continues to violate the original goal even more, creating further emotional disturbance and further eating. This would predict that the effect of mood on cognitive performance will occur through its interaction with emotional eating as much or more than in its interaction with restraint. This is the focus of Study Three.

STUDY THREE

Study One raised the importance of distinguishing between restraint and emotional eating in understanding the mediators of dieting related cognitive impairment. It showed that dietary restraint appeared to reduce performance on an attentional task irrespective of level of affect. There appeared to be a dissociation between restraint (affecting attention but unrelated to mood) and emotional eating (unrelated to attention but related to mood). Common to both findings is the lack of correlation between mood and attention. However, because the data was correlational, it says little about the direction of cause. In addition, because we had not examined the effect of a mood challenge on performance, the failure to find any involvement of mood in the association between level of restraint and attentional deficit may have been due to the fact that mood was not actually disturbed at the time the participants were performing the tasks.

Recent developments in cognition and emotion research (see Williams *et al*. 1997, for a review) show that the effect of long-term traits on current behaviour depends on whether they are 'activated' by current mood. (For example, accurate prediction of relapse and recurrence in major depression depends on the measurement of dysfunctional attitudes when mood is disturbed; Segal *et al*. 1999.) Only by manipulating mood can we see whether the effect of restraint or emotional eating on cognitive performance is moderated by current mood levels. In this experiment, therefore, we introduced an experimental manipulation of negative mood, randomly allocating participants to receive either a negative or a neutral mood induction procedure and examining their attentional performance. We predicted that high emotional eaters, because of their vulnerability to negative affect, would be more susceptible to show cognitive deficits following a negative mood induction procedure compared to low emotional eaters. By contrast, high restraint would be associated with trait-like cognitive deficits that would not be affected by mood disruption.

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Method

Participants

Thirty-nine participants with a mean age of 48·86 (16·02) from Study Two were selected to participate in Study Three. The mean BMI of this group was 24·99 kg/m² (5·45). They were selected on the basis of their scores on the DEBQ, in order to produce a group of high *versus* low scorers on the restraint subscale and high and low scorers on the emotional eating subscale. Selecting participants on the basis of their previously known eating behaviour enabled us to investigate emotional eating and restraint on an *a priori* basis, rather than relying on *post hoc* division of the groups. Twenty-six per cent of this sample group were currently dieting at the time of testing.

Participants were randomly allocated to receive either a negative or neutral mood induction procedure. Prior to allocation all participants completed the Beck Depression Inventory (Beck, *et al*. 1961) to ensure suitability for the mood induction. (It was planned that participants scoring $\geqslant 15$ should be excluded from the negative condition, but in the event no-one had to be excluded, so this scale will not be referred to further.) There were no significant between group differences in terms of age or BMI.

Measures

In addition to the eating behaviour and mood questionnaires used in Study One, we used a Visual Analogue Mood Scale containing four mood descriptors (happy, sad, refreshed, alert) which participants rated on a 10 cm scale before and after mood induction. The Bakan vigilance cognitive function task was used, as in Study One.

Mood induction procedure

A combination of the standard Velten Mood Induction procedure and music was employed. Participants were randomly allocated to receive either 30 negative (self-referent) or 30 neutral (factual) statements typed on individual white cards to be read out aloud while listening to the music (10 min). For the negative condition participants listened to Prokofiev's 'Russia under the Mongolian Yoke', recorded at half speed; and in the neutral condition Brahm's 2nd and 3rd movements from the 3rd symphony. Both pieces have previously been employed in mood induction studies (e.g. Clark & Teasdale, 1985). A portable compact disc player with headphones was used.

Design

This study employed a mixed design with Mood Condition (negative/neutral) as a between subjects factor and Time (pre-mood induction/post-mood induction) as a within subjects factor. A second set of analyses focused on the roles of emotional eating and restraint and the differential response of these factors to the mood manipulation. Groups representing high/low emotional eaters and high/low restrainers had been identified *a priori* in the selection of participants for this study (see participants description). Analyses were performed with a $2 \times 2 \times 2$ (Mood Condition $\times$ Eating Behaviour $\times$ Time) repeated measures ANOVA on all measures.

Procedure

Participants were seen individually in an experimental room. At the start of each session all participants were given an information sheet describing the nature of the experiment and their informed consent was obtained. This was followed by completion of the BDI, PANAS and visual analogue scales for which they were instructed to answer according to how they were feeling 'at this moment in time'. Participants completed the baseline cognitive function task. Mood induction procedures followed: participants listened to either the neutral or negative music and simultaneously read the appropriate statements for 10 min. For the negative condition we followed the procedure used in previous mood induction research, informing participants that the procedure would not necessarily produce a negative mood state automatically, therefore they were to try to allow the feelings to occur. Following mood induction, participants completed the mood scales and performed the cognitive task again still listening to the music to maintain the mood. At the end of the experiment all participants were fully debriefed and encouraged to ask questions. Care was taken to ensure that participants in the negative condition were not suffering any lingering effect of the induction.

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Results and discussion

We first describe a series of analyses investigating the effects of the mood manipulation on mood and cognitive function. We then examine the role of emotional eating and dietary restraint.

Mood manipulation check

Since all of the visual analogue mood measures (alert, refreshed, happy and sad) were significantly correlated with each other ($P = 0{\cdot}0001$) a single 'negative mood index' was calculated by summing the separate mood scales and taking the average. (Scores on the 'sad' variable were reverse scored.) A resulting 2×2 (Mood Condition $\times$ Time) ANOVA with this mood index as the dependent variable revealed a main effect of Time ($F(1, 37) = 10{\cdot}33$; $P = 0{\cdot}003$) (due to an overall decrease in mood over time). However, this effect was modified by the predicted interaction between Mood Condition $\times$ Time ($F(1, 37) = 4{\cdot}92$; $P = 0{\cdot}03$). *Post hoc* analyses showed that within group differences on the negative mood index at Time 1 and Time 2 were non-significant within the neutral condition ($t(20) = 0{\cdot}71$; $P > 0{\cdot}05$), but significant within the negative mood condition ($t(17) = 3{\cdot}87$; $P = 0{\cdot}001$). Participants were significantly less happy following the negative mood induction compared to the neutral one.

Mood and cognition

A main effect of Time which bordered on significance was reported ($F(1, 37) = 3{\cdot}63$; $P = 0{\cdot}06$) for the Bakan task (M, Time 1 = 11·53 and Time 2 = 12·79). Paired *t* tests revealed that this improvement over time was wholly accounted for by change within the neutral condition only ($t(20) = -2{\cdot}37$; $P = 0{\cdot}03$). Participants in the negative mood condition failed to demonstrate similar improvement over time ($t(17) = -0{\cdot}57$; NS). The explanation for this pattern of results becomes clearer when the differences between emotional eaters and restrainers are examined.

Emotional eating, mood and cognition

Our sample had been selected to yield a group of high emotional eaters ($N = 19$; M = 3·17; S.D. = 0·10) and a group of low emotional eaters ($N = 20$; M = 1·65; S.D. = 0·46). A series of $2 \times 2 \times 2$ (Emotional eating $\times$ Mood Condition $\times$ Time) ANOVAs were performed with Emotional eating and Mood Condition as between subjects factors and Time as a within subject factor. There were no significant main effects or interactions with emotional eating across all the self-report measures of mood ($F < 1$ in all cases). For the Bakan task, the results showed a marginal significant main effect of Time ($F(1, 35) = 4{\cdot}17$; $P < 0{\cdot}05$), due to the well-known practice effect on this task. However, this effect was modified by a significant Emotional eating $\times$ Mood Condition $\times$ Time interaction ($F(1, 35) = 5{\cdot}51$; $P = 0{\cdot}025$). This interaction was due to the pattern of Bakan performance under different mood conditions for high emotional eaters (see Table 5a). Planned comparisons revealed that Bakan task performance by the high emotional group in the negative condition at Time 2 (M = 10·88) was significantly poorer compared to that in the neutral condition (M = 15·10) Planned comparisons also revealed a significant improvement between performance at Time 1 (M = 11·90) and that at Time 2 (M = 15·10) ($t(9) = -2{\cdot}40$; $P = 0{\cdot}04$) in the neutral condition for high emotional eaters. In contrast, in the negative condition, there was no improvement in performance (in fact, just the opposite) between Time 1 and Time 2.

Table 5a. *Bakan Task Performance of high and low emotional eaters pre- and post-negative and neutral mood induction*

	Negative mood		Neutral mood	
Emotional	Pre-	Post-	Pre-	Post-
Low	11·00 (6·00)	13·33 (8·07)	11·27 (6·98)	12·00 (7·86)
High	12·00 (6·36)	10·88 (3·08)	11·90 (4·45)	15·10 (3·98)

Table 5b. *Bakan Task Performance of high and low restrained eaters pre- and post-negative and neutral mood induction*

	Negative mood		Neutral mood	
Restraint	Pre-	Post-	Pre-	Post-
Low	14·11 (5·46)	15·22 (6·13)	14·20 (4·23)	16·10 (4·35)
High	8·88 (5·64)	9·00 (4·60)	9·18 (6·12)	11·09 (7·13)

Dietary restraint, mood and cognition

Our sample had been selected to yield a group of high restrained eaters ($N = 20$; M = 3·09;

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S.D. = 0·58) and a group of low restrained eaters (N = 19; M = 1·96; S.D. = 0·64). A series of 2 × 2 × 2 (Restraint × Mood Condition × Time) ANOVAs were performed with Restraint and Mood Condition as between subjects factors and Time as a within subject factor. The means and standard deviations for the Bakan task for high and low restrainers are shown in Table 5b.

There was a main effect of restraint on positive items on the PANAS ($F(1, 35) = 4·67$; $P = 0·04$). High restrainers reported higher levels of positive affect overall across all mood conditions (M = 32·05) compared to low restrainers (M = 27·17). For the Bakan task, the predicted main effect of restraint was found ($F(1,35) = 10·43$; $P = 0·003$). High restrainers had significantly impaired performance on the Bakan task (M = 19·02) compared to low restrainers (M = 29·8). Given that high restrainers differed from low restrainers in terms of positive affect we repeated the analysis on the Bakan task covarying for mood. The main effect of restraint remained significant suggesting the effect of restraint on a vigilance task was independent of mood.

Note that whether participants were high or low restrainers made no difference to their performance in the Bakan task under the different mood conditions. Was this because the high restrainers were less affected by the mood induction in the first place? Recall that the high restraint group had higher positive PANAS scores, so they may have changed less in their mood in the negative condition. In order to examine this, we looked at the pre-post changes in mood (positive PANAS, 'right now') in high and low restrainers. In the low restraint group (the group that was generally less positive) this score fell by 4·0 points (from 29·44 to 25·44) following the negative mood induction. However, the high restraint group fell by exactly the same amount (from 33·78 to 29·78).

Dietary restraint and emotional eating

The above analyses examined the impact of emotional eating and restraint on cognitive function and mood separately, finding effects of mood in the high emotional eaters, but not in the high restrainers. We wished also to examine how these aspects of eating behaviour might interact to determine Bakan performance. A 2 × 2 (Emotional Eating × Restraint) factorial ANOVA was carried out on the Bakan task data. Results demonstrated a main effect of restraint for the Bakan task ($F(1, 35) = 11·43$; $P = 0·002$), but no interaction with level of emotional eating.

GENERAL DISCUSSION

The aim of the current series of studies was to investigate the factors mediating dietary related cognitive deficits, focusing specifically on the relationship between affect, eating behaviour and cognitive deficits. The results of Study One suggested that attentional deficits could be found in an older, community sample of dieters. Although dieters were significantly impaired in mood and well-being, these variables were associated with tendencies to eat when emotional, and not with restrained eating. Yet it was restrained eating that was most closely associated with the attentional deficits. These data are consistent with previous work (Rogers & Green, 1993; Green *et al*. 1994).

This potential dissociation in the effects of restraint and emotional eating was further investigated in Study Two. We confirmed Van Strien's (1999) suggestion that high levels of restraint were associated with hypersensitivity to affective disturbance in other studies because the scale used to assess restraint confounds 'restraint' and 'disinhibited eating' in the same scale. In Study Three, experimental control was exercised in a mood challenge paradigm. The results showed that while high restrainers were largely immune to the effects of a mood challenge, there was a significant impairment in performance following a negative mood induction in high emotional eaters.

Before discussing these results further, some methodological considerations must be noted. First, in Study One the dieting sample was recruited from Weight Watchers and from advertisement in a local newspaper. It is possible that these recruitment procedures biased the sample, producing a more highly motivated group than would be typical of the average dieter. In addition we did not specify a particular type of diet or a threshold of calorie intake above which participants would be excluded. The role of exercise was also not considered. This means that the results for the dieters in Study One are derived from a group of people,

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some of whom may not be successful in restricting their calorie intake. However, much previous research has been confined to student dieters who are typically normal weight (and therefore more likely to be attempting to diet for 'non-health' reasons). Thus, although there may be a need to be cautious in generalizing from our sample to the general population of dieters that are the focus of concern for health professionals, our findings are nevertheless more valid than previous student samples.

Secondly, there is the issue of our choice of task to measure attention. The particular task (Bakan Task) was chosen on the basis that previous studies had found this measure to be sensitive to dieting status and dietary restraint. Additional studies have shown that these effects are also found with measures of working memory capacity (Green & Rogers, 1998), but future studies are needed to investigate whether these results generalize to other forms of sustained attention. Nevertheless, the task used suggested an interesting dissociation that it is to this that we now turn.

Previous research has not distinguished different aspects of eating behaviour in the aetiology of cognitive and affective functioning. Our results from analysis of both correlational and experimental data suggest that emotional eating and dietary restraint may interact with mood in different ways to influence cognition. Emotional eating *per se* had no effect on sustained attention. However when high emotional eaters were primed by negative affect, significant decrements in performance resulted. In both Study One and Three, a main effect of restraint was demonstrated on performance on the attentional task. High restrainers were more impaired on this task compared to low restrainers. High restrainers also reported higher levels of positive affect in Study Three, but when this effect was covaried out, the impact of restraint on attentional performance remained. This implies that although mood can affect attentional performance in combination with the tendency to eat when emotional, the effect of restraint on attention is not mediated through mood. This is consistent with Green & Rogers (1998) and Green *et al*. (2000).

But if restraint does not explain the mood effects then what does? We propose instead an 'affect' model: that high restraint only renders a person vulnerable to over-eating if they react to violations of their restraint goals by experiencing some degree of emotional disturbance, *and* react to emotional disturbance by eating. In all the previous studies investigating individual differences in disinhibited eating behaviour under stress, high restrainers were identified using the Revised Restraint Scale (Polivy *et al*. 1978) and as Study Two indicated, this scale contains a number of items which actually reflect emotional eating rather than dietary restraint *per se*. Since previous studies of the effect of mood in high restraint groups, whether on disinhibited eating or on cognitive impairment, have ignored the emotional eating variable, they can address only part of the picture.

One of the potential values of the affect model is that it can be more precise about exactly when a person is likely to show disinhibited behaviour or cognitive deficits. Put more formally, loss of control or cognitive disruption occurs: (*a*) when a person believes they have violated a goal (in the case of dieters, the goal of eating less); (*b*) when that violation creates mood disturbance; and (*c*) when a person has a pre-existing tendency to eat when they are emotional.

This hypothesis predicts that individuals high in emotional eating may over-eat when any goal is violated so long as such violation creates affective disturbance. Thus, it is not the restraint of eating that is critical, except that it sets up a large number of potential situations where the goal may be violated. Any such restraint, such as attempts to restrain smoking or drinking or shopping, will have a similar effect. The affect hypothesis is additionally useful in that it predicts the times when such overeating will occur and who is most vulnerable. It will occur at times when a person is upset, and it will occur for those who tend to eat when emotional. That is, not all restraint produces disinhibition. The restraint/control hypothesis assumes that any attempt to control produces a tendency to rebound when control is disrupted, but does not say why this should occur at the time it does. The affect hypothesis asserts that if a distraction or goal violation does not cause mood disturbance, it will not trigger an episode of loss of control or cognitive disruption.

In summary our studies provide additional information on the relationships between eating behaviour, mood and cognition, The tendency

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to eat when emotional is a vulnerability factor representing as it does the sensitivity to changes in levels of affect. High restrainers on the other hand are insulated from such mood fluctuations unless they are also people who eat when emotional. The data suggest that the key to successful dieting without cognitive disruption is to learn how to deal with times when there is increased risk of affective disturbance (however caused). In the past this has focused on teaching individuals to deal with negative mood. This study suggests that increasing positive mood and well-being is as important, perhaps by making a person less sensitive to the small negative events and hassles that would normally conspire to violate a person's goals.

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REFERENCES

Bakan, P. (1959). Extroversion-introversion and improvement in an auditory vigilance task. *British Journal of Psychology* **50**, 323–332.

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J. & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry* **4**, 561–571.

Blanchard, F. & Frost, R. O. (1983). Two factors of restraint: concern for dieting and weight fluctuations. *Behaviour Research and Therapy* **21**, 259–267.

Clark, D. M. & Teasdale, J. D. (1985). Constraints on the effects of mood on memory. *Journal of Personality and Social Psychology* **48**, 1595–1608.

Fedoroff, I. C., Polivy, J. & Herman, C. P. (1997). The effect of pre-exposure to food cues on the eating behaviour of restrained and unrestrained eaters. *Appetite* **28**, 33–47.

Grand, S. (1968). Color word interference: an investigation of the role of vocal conflict and hunger in associative priming. *Journal of Experimental Psychology* **77**, 31–40.

Green, M. W. & Rogers, P. J. (1993). Selective attention to food and body shape words in dieters and restrained non-dieters. *International Journal of Eating Disorders* **14**, 515–517.

Green, M. W. & Rogers, P. J. (1995). Impaired cognitive functioning during spontaneous dieting. *Psychological Medicine* **25**, 1003–1010.

Green, M. W. & Rogers, P. J. (1998). Impairments in working memory associated with spontaneous dieting behaviour. *Psychological Medicine* **28**, 1063–1070.

Green, M. W., Rogers, P. J., Elliman, N. A. & Gatenby, S. J. (1994). Impairment of cognitive performance associated with dieting and high levels of dietary restraint. *Physiology & Behaviour* **55**, 447–452.

Green, M. W., Elliman, N. A. & Rogers, P. J. (1997). Impaired cognitive processing in dieters: failure of attention focus or resource capacity limitation? *British Journal of Health Psychology* **2**, 259–267.

Green, M. W., Rogers, P. J. & Elliman, N. A. (2000). Dietary restraint and addictive behaviours: the generalisability of Tiffany's (1990) cue reactivity model. *International Journal of Eating Disorders* **27**, 419–427.

Greeno, C. G. & Wing, R. R. (1994). Stress-induced eating. *Psychological Bulletin* **115**, 444–464.

Laessle, R. G., Tuschl, R. J., Kothaus, B. C. & Pirke, K. M. (1989). A comparison of the validity of the three scales for the assessment of dietary restraint. *Journal of Abnormal Psychology* **98**, 504–507.

Nulty, D. D., Wilkins, A. J. & Williams, J. M. G. (1987). Mood, pattern sensitivity and headache: a longitudinal study. *Psychological Medicine* **17**, 705–713.

Oatley, K. & Johnson-Laird, P. N. (1987). Towards a cognitive theory of emotions. *Cognition & Emotion* **1**, 29–50.

Polivy, J., Herman, C. P. & Warsh, S. (1978). Internal and external components of emotionality in restrained and unrestrained eaters. *Journal of Abnormal Psychology* **87**, 497–504.

Rogers, P. J. & Green, M. W. (1993). Dieting, dietary restraint and cognitive performance. *British Journal of Clinical Psychology* **32**, 113–116.

Ruderman, A. (1985). Dysphoric mood and overeating. *Journal of Abnormal Psychology* **103**, 505–510.

Ryff, C. D. (1989). Happiness is everything or is it? Explorations on the meaning of psychological well-being. *Journal of Personality and Social Psychology* **57**, 1069–1081.

Schotte, D. E., Cools, J. & McNally, R. J. (1990). Film-induced negative affect triggers overeating in restrained eaters. *Journal of Abnormal Psychology* **99**, 317–320.

Segal, Z. V., Lau, M. A. & Rokke, P. D. (1999). Cognition and emotion research and the practice of cognitive-behavioural therapy. In *Handbook of Cognition and Emotion* (ed. T. Dalgleish and M. Power), pp. 705–726. Wiley: Chichester.

SPSS (1995). *Statistical Program for Social Sciences*. SPSS Inc.: Chicago.

Van-Strien, T., Frijters, J. E., Bergers, G. P. & Defares, P. B. (1986). The Dutch Behaviour Eating Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behaviour. *International Journal of Eating Disorders* **5**, 295–315.

Van Strein, T. (1999). Success and failure in the measurement of restraint: notes and data. *International Journal of Eating Disorders* **25**, 441–449.

Wardle, J. (1986). The assessment of restrained eating. *Behaviour Research Therapy* **24**, 213–215.

Watson, D., Clark, L. A. & Tellegan, A. (1988). The development and validation of brief measures of positive and negative affect. The PANAS Scale. *Journal of Personality and Social Psychology* **54**, 1063–1070.

Williams, J. M. G., Watts, F. N., MacLeod, C. & Mathews, A. (1997). *Cognitive Psychology and Emotional Disorders*, 2nd edn. John Wiley & Sons: Chichester.

Wing, R. R., Vazquez, J. A. & Ryan, C. M. (1995). Cognitive effects of ketogenic weight-reducing diets. *International Journal of Obesity* **19**, 811–816.

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