



## Research report

## Mood and the macro-nutrient composition of breakfast and the mid-day meal

David Benton<sup>\*</sup>, Helen Brock*Department of Psychology, University of Swansea, Swansea, Wales SA2 8PP, United Kingdom*

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## ABSTRACT

Six hundred and eighty-six individuals were approached at mid-day after they had chosen a meal in a cafeteria. They were asked to rate their mood during the morning and list what they had eaten that morning. Both males and females who had eaten breakfast rather than fasting reported that they had been happier and more relaxed during the morning. The macro-nutrient compositions of breakfast and lunch were calculated and related to mood during the morning. In males, but not females, the consumption of more carbohydrate in the morning was associated with feeling happy rather than sad and relaxed rather than stressed. Further examination demonstrated that in males the amount of fat, protein and total energy consumed was not associated with mood; that is there was a selective relationship between carbohydrate intake and mood. It was not possible to establish whether the nature of breakfast influenced mood or the pre-existing mood influenced the choice of breakfast although both explanations are plausible. In females, however, there was no relationship between carbohydrate intake and mood, possibly a reflection of the smaller amounts consumed. The suggestion that mood during the morning might influence food choice at mid-day was considered but no association was found.

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## Introduction

To date the majority of studies of the effect of diet on subsequent mood have considered individuals under laboratory conditions, often involving eating meals unusual either in size or in macro-nutrient composition. The present study therefore related the macro-nutrient composition of freely chosen meals to the mood of nearly seven hundred individuals going about their everyday lives.

Mood can influence food choice, in particular a negative mood is known to stimulate the consumption of palatable foods. Chocolate is a good example, as its consumption is often a response to negative mood (Benton, 1999). In fact strong food cravings have been associated with being bored, anxious and having a dysphoric mood (Hill, Weaver, & Blundell, 1991) as well as depression (Lester & Bernard, 1991). Thus it was predicted that mood experienced during the morning would influence the choice of the lunch-time meal.

There have also been various reports that either the nature of the food eaten for breakfast (Pasman, Blokdijk, Bertina, Hopman, & Hendriks, 2003; Smith, Kendrick, Maben, & Salmon, 1994) or alternatively the macro-nutrient content of breakfasts (Holt, Delargy, Lawton, & Blundell, 1999; Lloyd, Rogers, Hedderley, & Walker, 1996; Nabb & Benton, 2006; Spring et al., 1989) influences mood during the morning. In particular the carbohydrate content

or the ratio between carbohydrate and protein has attracted attention. Specifically it has been suggested that a diet high in carbohydrate and low in protein will result in an increased availability of tryptophan, leading to enhanced levels of brain serotonin with an associated improvement in mood (Wurtman & Wurtman, 1989).

However, where the influence of the macro-nutrient composition of the meal has been examined, typically the intake of one macro-nutrient has been manipulated so that with isocaloric meals there are consequences for the intake of other nutrients. For example a high carbohydrate/low fat breakfast has been related to a positive mood (Lloyd et al., 1996; Wells & Read, 1996; Wells, Read, Uvnas-Moberg, & Alster, 1997). However, as isocaloric meals were examined, it was unclear whether it was critical for the meal to be low in fat or alternatively high in carbohydrate. In contrast, Lluch, Hubert, King, and Blundell (2000) compared two meals that offered either 500 kcal including 93 g of carbohydrate or 64 kcal including 15 g of carbohydrate. Clearly the finding that the larger breakfast was associated with feeling more content and less lethargic was consistent with the response being both to more carbohydrate and/or greater total energy intake. In addition the larger meal offered more energy than is usually consumed for breakfast.

Thus laboratory findings obtained to date are difficult to interpret and do not necessarily consider meals typically consumed. However, as there are repeated suggestions from laboratory studies that the nature of meals influence mood, the present study related freely chosen meals to mood experienced under everyday conditions. Various questions were addressed:

<sup>\*</sup> Corresponding author.

E-mail address: [d.benton@swansea.ac.uk](mailto:d.benton@swansea.ac.uk) (D. Benton).

whether the decision to eat breakfast as opposed to fasting was associated with mood; whether mood during the morning was associated with the macro-nutrient content of breakfast; whether mood during the morning was associated with the macro-nutrient content of the meal chosen at mid-day.

## Methods

### Subjects

Six hundred and eighty-six individuals, mean age 22.5 years, were recruited after being approached between 1100 and 1400 in a university cafeteria: 358 were male and 328 female. With only a very few exceptions all those who were approached took part in the study.

### Procedure

The procedure was approved by the local ethics committee. Before they became aware of the study subjects freely chose food from a range of hot and cold meals and snacks. After written informed consent was obtained the experimenter recorded the meal that was purchased and later using standard portion sizes (Davies & Dickerson, 1991), food tables (Food Standards Agency, 2002) and manufacturers information, estimated the energy and macro-nutrient content. The decision to obtain only brief information was made to allow rapid data collection when meals were becoming cold. In this way participation was encouraged.

### Questionnaire

Using visual analogue scales of 100 mm, four indications of mood and motivation during the morning were assessed using the adjectives happy/sad, relaxed/stressed, active/inactive, interested/bored. All foods eaten that morning were recorded and the macro-nutrient content calculated. In particular whether breakfast had been consumed was recorded, defined as the consumption of food in the hour following getting up in the morning.

### Statistical analysis

Those who had and had not eaten breakfast were compared using Students 't' test and the association between mood and the macro-nutrient content and meals was considered by calculating Pearson-moment correlations. The influence of consuming a particular level of a macro-nutrient was further considered by dividing the sample into thirds depending on the amount consumed. Any interaction between nutrients was considered using a two way between subjects analysis of variance. As males and females on average consumed very different size meals, and in particular the amount of carbohydrate differed markedly, they were considered separately.

**Table 1**

The association between eating breakfast and mood during the morning.

	Males		Females	
	N = 123	N = 235	N = 91	N = 237
	Fasted	Breakfast	Fasted	Breakfast
Inactive/active	38.2 (3.0)	41.1 (2.9)	46.8 (3.1)	45.4 (3.1)
Sad/happy	57.0 (3.2)	62.6 (2.7)*	57.2 (2.9)	62.6 (2.5)*
Boring/interesting	39.7 (2.9)	43.1 (2.6)	45.9 (2.7)	47.5 (2.9)
Stressed/relaxed	49.7 (3.3)	57.8 (3.0)**	49.5 (3.2)	56.6 (2.9)*

Those who ate breakfast were significantly different from those who fasted.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

## Results

### Breakfasts

Table 1 reports the mood of those who either did or did not eat breakfast. In both males and females, those who ate breakfast reported that they had been happier and more relaxed during the morning.

### Macro-nutrient content of breakfast

The macro-nutrient content of the food consumed during the morning is reported in Table 2: as expected females consumed fewer kcal. When the means and percentiles for particular nutrients were examined it was apparent that the greatest difference was found in the amount of carbohydrate consumed. The 50th percentile for females was 37 g of carbohydrate and the 75th percentile was 51 g: these figures contrasted with males where the comparable figures were 68 and 87 g.

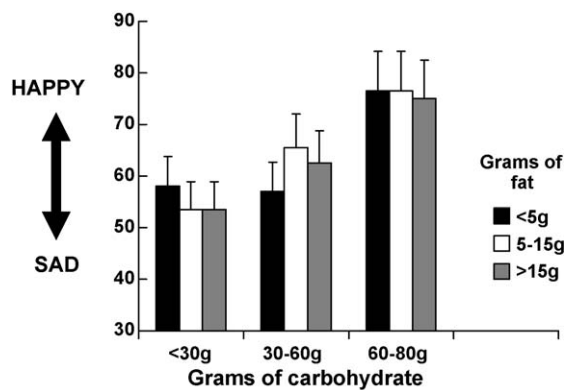
The consumption of macro-nutrient during the morning was correlated with mood during the morning. In males there was no significant association between the consumption of protein, fat or total energy and any of the four ratings of mood. However, there was a significant positive correlation between the amount of carbohydrate eaten and feeling happy rather than sad (0.16,  $p < 0.002$ ) and feeling relaxed rather than stressed (0.14,  $p < 0.01$ ). In females there was no relationship between carbohydrate intake and mood. In fact there was only one significant association between a macro-nutrient and a rating of mood. Those who ate more protein reported the morning as having been more interesting (0.15,  $p < 0.003$ ).

In males the association between carbohydrate intake and feeling happy rather than sad was further examined. The carbohydrate intake was divided into those who consumed less than 30, 30 to 60 and between 60 and 80 g. Within each of these three groups those consuming less than 5, between 5 and 15 and over 15 g of fat were distinguished, producing nine groups in total. When the happy/sad dimension was considered the grams of

**Table 2**

The macro-nutrient content of breakfast.

	Mean (S.D.)	25th percentile	50th percentile	75th percentile
<b>Males</b>				
Carbohydrate	45.2 g (23.2)	13 g	68 g	87 g
Protein	10.2 g (8.3)	5.6 g	7.2 g	12.6 g
Fat	14.5 g (15.6)	2.6 g	14 g	16.4 g
Kilocalories	340 (229)	187	292	442
<b>Females</b>				
Carbohydrate	41.8 g (21.1)	15 g	37 g	51 g
Protein	8.3 g (4.6)	5.8 g	6.7 g	10 g
Fat	11.6 g (9.7)	2.6 g	13.8 g	15.3 g
Kilocalories	298 (176)	184	277	362



**Fig. 1.** The association between carbohydrate and fat intake and the mood of males. The data are means  $\pm$  standard deviations.

carbohydrate  $\times$  grams of fat interaction ( $F(4,199) = 0.49$ , n.s.) and the Fat main effect were non-significant ( $F(2,199)$ , 0.03, n.s.), although the carbohydrate main effect reached significance ( $F(2,199)$ , 4.55,  $p < 0.01$ ). Fig. 1 illustrates these data: those consuming more carbohydrate reported feeling happier, although fat intake did not influence this association. The most positive mood was found in males who consumed the highest levels of carbohydrate. The difference between those eating the middle and highest levels of carbohydrate was about 15 points on the happiness scale, whereas the difference in mood between those who consumed the lowest and the middle amounts of carbohydrate was only about 5 points. Thus it was the highest levels of carbohydrate that were most strongly related to a positive mood. These higher amounts of carbohydrate were consumed infrequently by females (Table 2). This observation suggests the hypothesis that the failure to find an influence of carbohydrate in women reflected the relatively low level of consumption although only intervention studies will establish whether this is the case.

Fig. 1 also illustrates that the total energy intake was not important: inevitably when more fat is added to a given level of carbohydrate the total caloric intake will increase. The energy consumed by those in the nine groups in Fig. 1 was calculated. In those eating less than 30 g of carbohydrate the consumption of the three increasing amounts of fat resulted in meals of on average 126, 174 and 237 kcal. The comparable figures with the consumption of 30–60 g of carbohydrate were 218, 296 and 359 kcal. Finally those eating between 60 and 80 g of carbohydrate consumed 294, 376 and 447 kcal depending on the fat intake. These calculations demonstrate that the total energy consumed did not influence the extent to which subjects were happy or sad.

A similar analysis was carried out by creating groups of those who consumed less than 6, between 6 and 12 and over 12 g of protein. When the possible role of protein consumption was considered in an analogous way to the previous consideration of the fat content, both the protein main effect ( $F(2,221) = 1.74$ , n.s.) and the carbohydrate  $\times$  protein interaction were non-significant ( $F(4,221) = 0.91$ , n.s.). There was an association between carbohydrate intake and the mood of males, irrespective of the intake of fat, protein or total energy. Thus the ratio between carbohydrate and protein intake was not associated with mood. For brevity the details are not presented but there was a similar association when being relaxed/stressed was considered. There was an association with the carbohydrate intake but not the other macro-nutrients.

#### Mid-day meal

To consider the association between mood during the morning on the choice of the mid-day meal only subjects who

stated that they did not eat identical meals each day were examined (about 85% of those approached). With both males and females on no occasion was there a significant correlation between mood during the morning and the macro-nutrient profile of the chosen meal.

#### Discussion

The percentages of subjects who did not eat breakfast (34.4% of males and 27.7% of females) is broadly similar to previous studies of young adults, although the percentage varies with sociocultural factors such as parental eating patterns and socio-economic status (Pearson, Biddle, & Gorely, 2009). In the United States, a cross-sectional examination of eating breakfast found that the instance declined throughout childhood and adolescence, so that at 18 years of age 25.1% of males and 35.3% of females did not eat breakfast (Siega-Riz, Popkin, & Carson, 1998).

The finding that those who had eaten breakfast were happier and less stressed (Table 1) is consistent with previous observations that those who fast rather than eat breakfast report a poorer mood (Benton & Parker, 1998; Benton, Slater, & Donohoe, 2001; Holt et al., 1999; Lloyd et al., 1996; Smith, Clark, & Gallagher, 1999; Smith et al., 1994; Widenhorn-Müller, Hille, Klenk, & Weiland, 2008). It is possible in the present study that those with a poorer mood might be more likely to miss breakfast or alternatively that not eating breakfast leads to a poorer mood. However, because in studies in which people were randomly assigned to eat breakfast or fast, breakfast consumption resulted in a more positive mood (Benton et al., 2001; Holt et al., 1999; Lloyd et al., 1996; Smith et al., 1994, 1999; Widenhorn-Müller et al., 2008), it is likely in the present study that food consumption resulted in an improved mood. However, the correlational nature of the present data makes it difficult to distinguish between the possibility that those who ate breakfast had a better mood prior to eating breakfast and the possibility that eating breakfast (and specifically carbohydrates at breakfast) influenced mood.

A major finding was that males eating more carbohydrate for breakfast reported a positive mood (Fig. 1). In fact several intervention studies have found that high carbohydrate/low fat breakfasts were associated with positive mood (Lloyd et al., 1996; Wells & Read, 1996; Wells et al., 1997). These intervention studies are consistent with the suggestion that the present results reflected the influence of the carbohydrate content of the meal. However, because in these studies a high carbohydrate intake was associated with a low fat intake, and the interaction between these two macro-nutrients was not examined, it was unclear which macro-nutrient was influential. A novel aspect of the present results is that in males it was possible to specifically associate an improvement in mood with carbohydrate (Fig. 1) rather than the intake of fat, protein or total energy, although we cannot exclude the possibility that pre-existing mood influenced the choice of food.

That the level of carbohydrate intake influenced males, but not females, was unexpected as both have been found to respond to the content of meals (Holt et al., 1999; Lloyd et al., 1996). However, the lower total energy consumed by females to a large extent reflected a lower intake of carbohydrate, rather than of protein or fat (Table 1). The truncated range of carbohydrate intake may have reduced its influence on the mood of women. In fact when a response to an experimentally provided meal has been previously reported, the amount of carbohydrate experimentally offered to female subjects has tended to be more than would be freely chosen when eating normally. Women in the present sample consumed 15 g at the 25th percentile, 37 g at the 50th percentile and 51 g at the 75th percentile, whereas Lloyd et al. (1996) compared 56.2, 74.8 and 98.7 g of carbohydrate and Holt et al. (1999) 36.4, 55.1, 66.3, 77.5 and 90.2 g of carbohydrate.

Although many previous studies have compared isocaloric meals, the present results suggest that, at least within the parameters considered, the amount of energy provided by the meal did not influence mood (Fig. 1). Michaud, Musse, Nicolas, and Mejean (1991) found no difference in the reaction to a breakfast of 389 rather than 634 kcal. Similarly Macht (1996) found no difference in mood after consuming breakfasts of 432 rather than 127 kcal. An exception was the report that a difference in mood resulted from eating 500 rather than 64 kcal (Lluch et al., 2000), although this involved comparing a meal much larger than normally consumed with one much smaller than typically eaten. These findings should be placed in the context of the size of freely chosen meals that were in females about 300 and in males 340 kcal (Table 2). A message for future studies is that the study of meals of a size typically chosen may not need to create an isocaloric intake. This is an important observation as it allows the role of particular nutrients to be considered while considering meals that are representative of typical eating patterns.

Based on clinical cases Wurtman and Wurtman (1989) developed the hypothesis that carbohydrates can relieve depression. A meal almost exclusively carbohydrate was suggested to increase levels of tryptophan in the blood, leading to enhanced serotonin synthesis in the brain and improved mood. It was proposed that the choice of high carbohydrate foods can be a form of self-medication. The present finding that a higher intake of carbohydrate was associated with being happier (Fig. 1) could be seen superficially as supporting the Wurtman hypothesis. However, Benton and Donohoe (1999) summarized 30 human studies that had looked at meals that differed in the percentage of calories that came from protein rather than carbohydrates. The ratio of carbohydrate to protein in a meal influenced the resulting ratio between tryptophan and long chain neutral amino acids (LNAA) in the blood. However, you needed less than 2% of the calories in the form of protein to ensure that the level of tryptophan increased. With larger amounts of protein the increase does not occur, in fact the proportion of the LNAAs that is tryptophan declines (Benton & Donohoe, 1999). In the present study less than 2% of the present population had eaten food items during the morning that offered less than 2% of the calories as protein, the level associated with an increased level of blood tryptophan. Thus it is improbable that the positive mood (Fig. 1) associated with greater carbohydrate intake reflected serotonin synthesis induced by low protein/high carbohydrate meals. Simply too much protein had been eaten.

Although much of the research in this area has been driven by the hypothesis that the macro-nutrient content of breakfast will have consequences for both mood and cognition, it should not be forgotten that the pre-existing mood could potentially explain the present findings. There is considerable evidence that a negative mood stimulates the consumption of palatable foods (Benton, 2002), although in the present study the mood experienced over the morning did not influence the macro-nutrient composition of the mid-day meal. In addition as palatable foods also tend to be high in fat, a specific choice of carbohydrate (Fig. 1) would not be expected to be generated by a pre-existing negative mood.

The alternative explanation, that eating high amounts of carbohydrate had a positive influence, is not without its problems. An association between carbohydrate intake and mood was found for males but not for females. It was suggested above that it was possible that females didn't eat enough carbohydrate to affect their mood, but why then did eating breakfast as opposed to fasting improve mood in both males and females? There may be more than one mechanism. Eating breakfast, any breakfast, is better than fasting. Yet some breakfasts appear to be better than others. It should be recalled that the study of the macro-nutrient content of the meals only considered those who had eaten within an hour of rising and did not include those who had chosen not to eat.

Although not considered in the present study, it would be interesting to examine the nature of the carbohydrate consumed, in particular whether glucose is slowly or rapidly released into the blood stream. Benton, Kumari, and Brain (1998) found in young adult males, those whose blood glucose levels fell more rapidly in a Glucose Tolerance Test were more likely to be irritable. The possibility that there might be an interaction between individual differences in the ability to control blood glucose and the carbohydrate content of breakfast was suggested by Nabb and Benton (2006). They compared the response to breakfasts that contained 15, 30 or 50 g of carbohydrate. In fact those with pre-existing better glucose tolerance reported a generally more positive mood. However, eating breakfasts containing greater amounts of carbohydrate resulted in reports of being tired rather than energetic in the late morning. Superficially these findings from an intervention study contradict any suggestion that the present data reflect a short-term positive response to carbohydrate consumption.

A possible explanation is offered by the observation of de Castro (1987) who examined dietary diaries maintained for nine days. He found that mood prior to eating a particular meal did not influence the nature of the food consumed. However, overall nutritional intake over an extended period was related to mood. A higher proportion of energy as protein was associated with depression, whereas when a higher proportion of energy came from carbohydrate this was positively associated with reported energy and negatively with depression. Although only correlational data, de Castro (1987) failed to find an association between mood prior to a meal and the nutritional composition of the meal chosen. Yet an association between mood and carbohydrate intake over a period of time was observed. A possibility to be considered is that the presently reported level of carbohydrate intake should be viewed as a marker of general dietary style. That is those who consumed high levels of carbohydrate in the present study did so habitually. If so then any positive mood would reflect not what was eaten on the specific day of the study but rather what had been eaten over a period of days and weeks.

Ultimately in the present study it is not possible to distinguish the influence of pre-existing mood from the impact of macro-nutrients on mood. It is similarly not possible to distinguish a short-term reaction to a meal from a longer-term reaction to dietary style. However, the present findings will, hopefully, direct future research to studies of more ecological valid meals and raise a question as to the importance of carbohydrate intake.

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