Effects of cereal bars for breakfast and mid-morning snacks on mood and memory

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Abstract
The aim of the present study was to examine the effects of consuming cereal bars, given either for breakfast or a mid-morning snack, on mood and memory. Thirty-two volunteers (16 males, 16 females; mean age, 20 years 9 months) were randomly assigned to one of four groups formed by combining breakfast (cereal bar versus no breakfast) and snack (cereal bar versus no snack) conditions. A baseline session was completed at 08:30 h followed by breakfast at 9:00 h, another test at 10:00 h, followed by a mid-morning snack and then a final test at 12:00 h. In each session, volunteers rated their mood and carried out four memory tasks: free recall; recognition memory; a verbal reasoning task; and a semantic processing task. The results showed that volunteers who consumed a cereal bar for breakfast felt more alert, happy and sociable and less anxious. In addition, they also recalled more words in a free recall task. When the cereal bar was consumed as a mid-morning snack, alertness and hedonic tone increased, especially in the group who received no breakfast. The group who had no breakfast reported reduced anxiety after consumption of the snack. Recall was also improved after the snack. These findings show that consuming cereal bars for breakfast felt more alert, happy and sociable and less anxious. In addition, they also recalled more words in a free recall task. When the cereal bar was consumed as a mid-morning snack, alertness and hedonic tone increased, especially in the group who received no breakfast. The group who had no breakfast reported reduced anxiety after consumption of the snack. Recall was also improved after the snack. These findings show that consuming cereal bars in the early and mid-morning leads to beneficial behavioural effects. The results confirm earlier research on effects of breakfast and extend our knowledge of effects of snacks. Consumption of cereal bars may have important practical applications especially in situations where preparation of breakfast is difficult.

Keywords: Cereal bars, breakfast, snacks, memory, mood

Introduction
A number of studies have shown that consumption of breakfast is associated with improved memory and a more positive mood. These effects have been demonstrated with a variety of different types of breakfast—for example, a cooked breakfast (Smith et al. 1994), breakfast cereal (Smith et al. 1999), a high-protein drink (Benton and Sargent 1992), and glucose drinks (Benton and Parker 1998). Commercially available cereal bars have now been developed, and as these often have the same nutrient composition as traditional breakfast cereals it is reasonable to assume that similar behavioural effects will be obtained following consumption of a cereal bar for breakfast. This hypothesis was tested in the present study.

A variety of different aspects of memory have been shown to improve following the consumption of breakfast. The clearest benefits are often seen with episodic memory.
tasks such as free recall of a list of words. In contrast, other aspects of memory such as retrieval from semantic memory or use of working memory (as in verbal reasoning tasks) show less reliable effects. This issue was also examined in the present study.

Results from a number of studies suggest that consumption of breakfast is associated with a more positive mood (Smith et al. 1994, 1999; Lloyd et al. 1996; Pollitt and Mathews 1998; Holt et al. 1999; Benton et al. 2001). Some studies suggest that the mood changes reflect the nutrient composition of the breakfast (for example, Holt et al. 1999), whereas others have demonstrated that most types of breakfast lead to a more positive mood (for example, Benton et al. 2001). Some studies suggest that the effect of breakfast on mood may be short-lived (for example, Smith et al. 1999), whereas others have demonstrated that, for at least some types of breakfast (e.g. high-fibre meals), the effects may persist throughout the morning.

One of the problems with many studies of meals is that they consider the meal in isolation. Many people will follow breakfast by mid-morning drinks and/or a snack. Smith et al. (1994) reported that ingestion of caffeine did not modify the effects of breakfast. Little is known about the effects of snacking on behaviour, and even less about the combined effects of breakfast and a later snack. Benton et al. (2001) found that a mid-morning snack improved recall and was associated with the more positive mood. However, no effect of breakfast on memory was demonstrated in this last study and the effect of the snack on mood interacted with consumption of breakfast, with the snack removing the negative mood associated with breakfast. Given the failure of the study to replicate the established effect of breakfast, it was felt important to examine breakfast and snacking again using cereal bars rather than cornflakes.

Methods

Participants

Thirty-two students participated in the study (16 males, 16 females; mean age, 20 years 9 months; age range, 18–26 years).

Design

Volunteers were randomly assigned to one of the four groups: no breakfast, no mid-morning snack; breakfast (a cereal bar), no mid-morning snack; no breakfast, a mid-morning snack (cereal bar); and breakfast (a cereal bar), mid-morning snack (a cereal bar).

Procedure

On recruitment the volunteers were informed about the nature of the study and signed an informed consent form. Prior to the test day, they were familiarized with the testing procedure. On the evening prior to the study the participants limited their alcohol consumption to a maximum of 4 units and refrained from consuming food after 22:00 h. On the actual test day, volunteers consumed no food prior to the study and only drank water.

Baseline mood and memory data were collected at 08:30. Further test sessions were carried out at 10:00 and 12:00 h. Breakfast (a cereal bar) was consumed at 9:00 h and the mid-morning snack (a cereal bar) at 10:30 h.
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Mood and memory tests

All mood and memory tasks were presented on personal computers. A response box was attached so that responses could be made without using the keyboard.

Mood

This was measured using 18 bi-polar visual analogue scales (e.g. drowsy–alert, tense–calm; after Herbert et al. 1976) presented on the screen of the computer. Three factor scores were derived: alertness, hedonic tone and anxiety.

Memory tasks

Free Recall Task. A list of 20 words was presented on the screen at a rate of one every 2 sec. At the end of the list, the volunteer had 2 min to write down (in any order) as many of the words as possible.

Delayed Recognition Memory Task. At the end of the test session, volunteers were shown a list of 40 words, which consisted of the 20 words shown at the start of the session plus 20 distracters. They had to decide as quickly as possible whether each word had been shown in the original list or not.

Logical Reasoning Task (Baddeley 1968). In this task the participants were shown statements about the order of the letters A and B followed by the letters AB or BA (e.g. A follows B: BA). They had to read the statement and decide whether the sentence was a true description of the order of the letters. If it was, the participants pressed the T key on the keyboard; if it was not, they pressed the F key. The sentences ranged in syntactic complexity from simple active to passive negative (e.g. A is not followed by B). Participants carried out the task for 3 min.

Semantic Processing Task (Baddeley 1971). This test measures speed of retrieval of information from general knowledge. Volunteers were shown a sentence and had to decide whether it was true (e.g. canaries have wings) or false (e.g. dogs have wings). The number completed in 3 min was recorded.

Cereal bars

Cereal bars were given for both breakfast and the mid-morning snack. Participants were allowed to select one of five types of bar (Kellogg’s Nutrigrain bars: Apple, Blueberry, Fruit/yoghurt or Strawberry; or Kellogg’s Elevenses) and each bar provided 555/133 KJ/kcal, 25.5 g carbohydrate, 1.5 g protein, 2.96 g fat and between 0.75 and 1.11 g fibre.

Results

Analyses of covariance with the baseline measures as covariates were carried out separately on the post-breakfast and post-snack scores.
Effects of the breakfast cereal bar

Table I presents the mood ratings for the four groups. Those who consumed breakfast (a cereal bar) were significantly more alert ($F_{1,27} = 46.92, P < 0.0001$), had a higher hedonic tone ($F_{1,27} = 17.28, P < 0.0005$) and were less anxious ($F_{1,27} = 3.55, P < 0.05$, one-tail). There were no significant differences at this stage between groups who subsequently either received nothing or a cereal bar in the middle of the morning.

Analyses of the memory data showed that the only task influenced by consumption of a cereal bar for breakfast was the free recall task (see Table II). Consumption of breakfast (a cereal bar) was associated with significantly better recall ($F_{1,27} = 19.76, P < 0.0005$).

Effects of the mid-morning cereal bar

Two sets of analyses were carried out. The first used the baseline score as the covariate, and the second used both baseline and post-breakfast scores. These analyses address whether breakfast effects persist and whether consumption of a mid-morning cereal bar snack modifies these or has independent effects. In addition, one can consider effects of a mid-morning cereal bar while covarying any effects of the breakfast cereal bar present prior to the consumption of the snack.

Covarying baseline only. Table I presents the effects of having a snack on mood. Alertness ratings were higher at the final test session for those who had consumed a cereal bar for breakfast ($F_{1,27} = 16.83, P < 0.0005$) or a mid-morning cereal bar ($F_{1,27} = 9.98, P < 0.005$). The interaction between breakfast and snack conditions was nearly significant, which largely reflected the very low alertness in the no breakfast/no snack group. A similar pattern was seen for hedonic tone (breakfast, $F_{1,27} = 3.70, P = 0.06$; snack, $F_{1,27} = 9.21, P < 0.005$). The anxiety ratings showed a different pattern of effects with the only significant effect being the breakfast × snack interaction ($F_{1,27} = 7.78, P < 0.01$). Those who had no breakfast and then a snack were less

<table>
<thead>
<tr>
<th>Table I. Effects of breakfast (a cereal bar) and a mid-morning snack (a cereal bar) on mood.</th>
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<tbody>
<tr>
<td>No breakfast</td>
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<td>No snack</td>
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<tr>
<td>Alertness</td>
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<td>Calm (low anxiety)</td>
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Scores are the adjusted means and standard errors from analyses of covariance. High scores = more positive mood. Maximum scores: alertness, 400; hedonic tone, 300; calm, 150.
anxious than those who had neither breakfast nor a snack. However, those who had both breakfast and a snack reported a similar mood to those who just had breakfast.

Analyses of the memory data showed that only the free recall task revealed significant effects. Table II presents the effects of eating a mid-morning cereal bar on this task. In this analysis the only significant effect was the main effect of snack conditions \(F_{1,27} = 7.86, P < 0.01\), with those eating the cereal bar in mid-morning recalling more words at the final test session.

Covarying both baseline and post-breakfast effects. Analysis of the alertness ratings showed that there was a significant increase in alertness for those given the mid-morning cereal bar \(F_{1,26} = 14.47, P < 0.0001\) and a significant interaction between breakfast and snack conditions \(F_{1,26} = 6.90, P < 0.05\). This reflected the much greater difference between snack and no snack conditions in those who had consumed no breakfast. An identical pattern was found for hedonic tone (snack effect, \(F_{1,26} = 10.06, P < 0.005\); snack \(\times\) breakfast, \(F_{1,26} = 4.88, P < 0.05\)). The anxiety ratings showed that the snack was only beneficial in those who had eaten no breakfast. This resulted in a significant interaction between snack and breakfast conditions \(F_{1,26} = 8.69, P < 0.01\).

The only effect that was significant in the analysis of the recall data was the main effect of mid-morning snack conditions \(F_{1,26} = 9.39, P < 0.005\), reflecting the higher recall scores for those who consumed the cereal bar in the mid-morning. Again, there were no significant effects in the analyses of the other memory tasks.

The above analyses were repeated including gender as a factor, and none of the effects of breakfast or the mid-morning snack was modified by gender.

**Discussion**

The results obtained here show that consumption of a cereal bar for breakfast has beneficial effects on mood and memory. This confirms previous findings demonstrating beneficial effects of breakfast cereal. Indeed, this condition acts as a positive control, showing that the study had enough power and sensitivity to demonstrate these established effects. This means that one has more confidence in results obtained from the more novel mid-morning snack condition. Other studies that have examined snacking have failed to obtain effects of breakfast (for example, Benton et al. 2001). This probably reflects crucial procedural differences from the present study. For example, breakfast was given considerably later in the Benton et al. (2001) study and,
as mood and memory change rapidly over the early morning because of circadian variation, it is likely that different results will occur at different testing times. An obvious example of this is a study that looked at the effects of cereal given at lunchtime and in the evening on memory (Smith et al. in preparation). The results showed no effect of cereal on memory at these times, which confirms the general view that the effects of meals depend on when they are eaten (Smith and Kendrick 1992).

The present study is one of very few studies to have examined the effects of breakfast and a mid-morning snack on mood and memory in the late morning. Alertness and hedonic tone in the late morning were increased by both breakfast and a mid-morning snack. Memory for a list of words was better in the late morning for those who consumed a cereal bar snack. This confirms previous findings suggesting that the effects of eating cereal on memory are relatively short-lived.

The present study was not intended to address the issue of possible mechanisms underlying effects of breakfast and snacks on mood and memory. It is likely that multiple mechanisms are involved, but effects of glucose and insulin may be crucial (see Benton et al. 2001). Systematic manipulations now need to be carried out to address this issue (see Fischer et al. 2002; Benton et al. 2003). From an applied point of view, the present findings have important practical implications. Provision of carbohydrate has been shown to have beneficial effects in extreme real-life situations (e.g. sustained physical activity; Lieberman et al. 2002), and it is now important to extend this research to consider operational efficiency at work, in educational settings, and every day activities such as driving. It is also important to examine effects in subgroups who may obtain an even greater benefit from regular ingestion of carbohydrate (e.g. children and the elderly). Further studies should also manipulate the nature of the breakfast and snacks to determine whether other nutrients also lead to benefits at these times.

References


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