Breakfast and performance in schoolchildren

BY N. H. DICKIE AND A. E. BENDER

Department of Nutrition and Food Science, Queen Elizabeth College, Campden Hill, Kensington, London W8 7AH

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1. The results from two studies are reported of the effects on mental performance of omitting breakfast. The objective of the first study was to compare the performances of schoolchildren who habitually ate or did not eat breakfast. In the second study the effects of omitting breakfast by those accustomed to eating the morning meal were investigated.

2. Mental performance was assessed by two short-term memory tests (a simple cancellation test in which paired letters were marked on a page of random letters) and a memory-search test in which lines containing a group of specified letters were marked, a series of numerical additions, and an attention-demanding test (in which specified statements had to be verified).

3. Neither study revealed differences attributable to the omission or consumption of breakfast.

Reports that a considerable number of children arrive at school without breakfast have given cause for concern (Lynch, 1969; Bender *et al.* 1972; Bermingham, 1977). This concern is based on the wide-spread belief that mental and physical performance are below optimal by mid-morning if no breakfast has been taken (Robinson, 1968; Burton, 1976; Wells, 1981) and this belief, in turn, is based mainly on a series of measurements of performance termed the Iowa Breakfast Studies (see Dickie & Bender, 1982). However, a detailed examination of these reports and of other literature on the subject revealed that the evidence that 'breakfast is the most important meal of the day' is far from certain (Dickie & Bender, 1982).

In this paper the results from two studies which re-examine the effects on mental performance of omitting breakfast are reported. The objective of the first study was to compare the performances of schoolchildren who habitually omit breakfast with those who habitually eat breakfast. The objective of the second study was to investigate the effects of omitting breakfast on the mental performance of subjects who regularly eat breakfast.

The design of many of the earlier studies is open to the criticism that performance was often measured subjectively and in the present investigations a series of objective mental performance tests, suggested to us by the Medical Research Council Applied Psychology Units at Cambridge and Sussex, were applied, the results of which could be quantified.

METHODS

Study 1

Assessment of mental performance. The cancellation test (Simpson *et al.* 1976) is an intellectually simple task intended to measure visual acuity, attentiveness and vigilance. The test (Fig. 1) consisted of four pages of random letters and the subjects were instructed to cross off two or more identical letters where they occurred adjacent to each other horizontally. The test was performed for a timed period of 3 min. Scoring was based on both speed and accuracy. The number of letter pairs in the printed lines scanned expressed as a percentage of the total number of letter pairs present on the sheet served as a measure of speed. Accuracy was measured by the number of letter pairs found as a percentage of those contained in those printed lines scanned during the time period.

Cancellation test: paired letters to be detected.

QLRFDXKDWLQNUTQCWTQVJBWYSNZZHD
WQVZULEFDRWDUJPXEWAOEANFDIJSNL
HLJQAATETQCYCTEALBIYNADYZMDTTD
HZYPESHLSPIANFJVYGNXFTPWYFWLNN
FRLVAZZLSWRROAAITMYOCOJRRLUMLK
VCLKSAZEASQJSOXUQIUCWYHLJQELKJ
OKRTNCWKMHTFPXMHVJADDWFYOKZBKM

Memory and search task MAST 6: six-letter version. Lines containing letters ACZKLT to be marked.

PRHXQADQDXJFBJDHJQTQ ×
ZJAZUEFCZMGKWMRLINCT ✓
NRGMMHWGDFNKYQZAUEET ×
JBARJZWJFBJQYYUCSNYH ×
WZPUGWQECTLNMRUQEWRY ×
JZFUTILFSGGACUGTPEPW ×

Simple addition test.

22	57	45	86	67
31	54	14	13	17
28	54	16	43	36
63	29	62	66	54
45	64	58	26	51
189	258	195	234	225

Sentence verification task: statements to be marked 'True' or 'False'.

(1) Star isn't above plus ✶ T F
(2) Plus below star ✶ T F
(3) Plus above star ✶ T F
(4) Star isn't below plus ✶ T F
(5) Plus isn't above star ✶ T F

Fig. 1. Four tests of intellectual function.

Subjects and procedure. From a series of three London comprehensive schools, 227 first-year pupils (average age 12·5 years) performed the cancellation test. Of these 118 were re-tested on the same day of the following week. On each day the pupils were tested before and after lunch at 12.00 and 14.00 hours; if lack of breakfast reduced performance the difference would be expected to disappear after the mid-day meal. By comparing the percentage change in speed and accuracy scores after lunch each child served as his own control. The ability to perform the test as such is not important.

A further 260 fourth-year pupils (average age 15·3 years) were tested before and after lunch and of these eighty-nine repeated the cancellation test on another day.

Breakfast classification. By means of a short questionnaire completed before each test period the children were placed into one of four groups: (1) Breakfast and mid-morning snack, (2) breakfast, no mid-morning snack, (3) no breakfast but a mid-morning snack, (4) no breakfast and no mid-morning snack. The term breakfast was regarded as any solid food taken on the morning of the test before arriving at school, while the term mid-morning snack included food or drink taken at break time. All subjects ate a school lunch or sandwiches.

Statistical analysis. The Kruskal–Wallis one-way analysis of variance (Siegel, 1956) was used to determine whether there were any significant differences between the groups on the basis of each pupil's percentage change in score at the pre- and post-lunch tests.

Study 2

Assessment of mental performance. Two short-term memory tasks, a simple addition test and a sentence verification test were used in this study. The memory and search test (MAST),

originally adapted from one used by Folkard *et al.* (1976), was essentially a paper and pencil visual search test in which the memory load can be varied. The subject's task was to search through a series of lines of twenty random letters and indicate with a tick or a cross whether or not each line contained all the members of a subset of four or six letters printed at the top of the sheet (Fig. 1). For convenience the tests using subset sizes four and six will be referred to as MAST 4 and MAST 6 respectively.

The simple addition test (Baddeley & Flemming, 1967; Simpson *et al.* 1976) consisted of a series of five two-digit numbers (Fig. 1). The subject's task was to add up the numbers and each sheet contained seventy addition sums.

The sentence verification task devised by Clark & Chase (1972) is an example of an attention-demanding test. Considerable individual differences in performance have been obtained, yet these differences have not been attributed to knowledge possession. Performance on the task has been shown to be related to reading rate (Mathews *et al.* 1978). In the sentence verification test the subject was presented with a list of sentences each purporting to describe the arrangement of the signs + and * (Fig. 1). The subject's task was to indicate whether the sentence was a true or false description of the signs. The test comprised five sections each with a different random order of sixty-four items.

The subjects were instructed to work as quickly and accurately as possible and were given 2 min on each MAST, 5 min on the addition test and 2 min on each section of the sentence verification task. The tests were scored on speed (the number of questions attempted), achievement (the number of questions correctly answered) and accuracy (the number of questions correctly answered, as a percentage of the speed score). The results were also assessed on the basis of the changes in scores between successive test sessions.

Subjects and procedure. The study was conducted in a series of four boarding schools. The breakfast customarily eaten by the pupils was typically a substantial one, often providing more than 2·1 MJ. In the first investigation fifty-five pupils (average age 17 years) were tested using MAST 4, MAST 6 and simple addition tests consecutively. In the second investigation fifty-three pupils (average age 16·2 years) were tested using the sentence verification task. In each investigation the subjects were randomly assigned into two groups and were tested on three consecutive days of 1 week following their normal breakfast routine (breakfast was served at approximately 07.45 hours, evening meal at 19.30 hours). In this way it was hoped to stabilize performance and mitigate the effects of practice. The following week the subjects were again tested on three consecutive mornings but the experimental group omitted breakfast, while the control group ate their breakfast as usual. Subjects in the experimental group were instructed not to eat or drink anything (except water) from the time they awoke until after testing was completed, between 11.00 and 11.30 hours. In the first investigation twenty pupils formed the control group while thirty-five pupils formed the experimental group. In the second investigation twenty pupils acted as controls while thirty-three omitted breakfast on test days 4, 5 and 6. It was originally intended that the number of subjects in the experimental and control groups would be the same. The discrepancies in the numbers in each group arise through disqualification due to guessing, misreading of instructions, forgetfulness over breakfast arrangements or absenteeism.

Statistical analysis. The differences in MAST 4, MAST 6 and simple addition scores between the control and experimental groups were evaluated using Student's *t* tests (Snedecor & Cochran, 1967). The Mann–Whitney U test (Siegel, 1956) was used for the sentence verification test data.

Table 1. *Results of cancellation tests carried out before and after lunch on first-year pupils in four food pattern groups*
(No. of subjects given in parentheses)

	Day 1								Day 2							
	Speed				Accuracy				Speed				Accuracy			
Group	a.m.	p.m.	% change	SEM	a.m.	p.m.	% change	SEM	a.m.	p.m.	% change	SEM	a.m.	p.m.	% change	SEM
1 Breakfast and mid-morning snack	56·1 (94)	68·4	134·7	6·0	81·1	81·3	102·2	1·8	73·0 (46)	83·5	121·0	5·4	84·2	82·9	99·2	1·9
2 Breakfast, no mid-morning snack	52·7 (96)	67·9	136·6	4·3	86·3	83·6	97·9	1·6	65·9 (34)	75·8	124·0	6·9	87·2	84·2	97·3	1·8
3 No breakfast, mid-morning snack	58·1 (23)	73·5	132·2	8·0	80·3	81·1	102·2	3·2	79·8 (18)	90·5	117·5	5·9	85·3	81·5	96·0	2·4
4 No breakfast, no mid-morning snack	62·6 (14)	71·4	114·8	9·5	80·8	79·7	99·6	4·8	76·5 (20)	84·1	117·9	8·4	82·1	79·7	97·4	2·7

Differences not statistically significant, $P > 0{\cdot}05$.

Table 2. *Results of cancellation tests carried out before and after lunch on fourth-year pupils in four food pattern groups*
(No. of subjects given in parentheses)

	Day 1								Day 2							
	Speed				Accuracy				Speed				Accuracy			
Group	a.m.	p.m.	% change	SEM	a.m.	p.m.	% change	SEM	a.m.	p.m.	% change	SEM	a.m.	p.m.	% change	SEM
1 Breakfast and mid-morning snack	72·2 (71)	82·4	124·8	5·7	77·9	78·6	104·8	2·9	90·6 (37)	90·4	101·2	2·7	78·0	83·6	109·9	3·0
2 Breakfast, no mid-morning snack	70·9 (147)	82·2	121·7	2·7	83·7	83·0	100·7	1·4	90·3 (37)	94·7	106·6	2·8	85·2	86·0	101·5	1·8
3 No breakfast, mid-morning snack	70·8 (19)	83·9	122·2	6·1	79·5	81·5	104·6	5·5	87·3 (7)	89·8	104·5	5·0	75·5	78·0	106·3	6·3
4 No breakfast, no mid-morning snack	65·2 (23)	80·4	123·3	5·8	86·4	88·2	104·1	2·9	94·3 (8)	97·1	103·6	3·2	74·4	80·8	111·3	6·6

Differences not statistically significant, $P > 0{\cdot}05$.

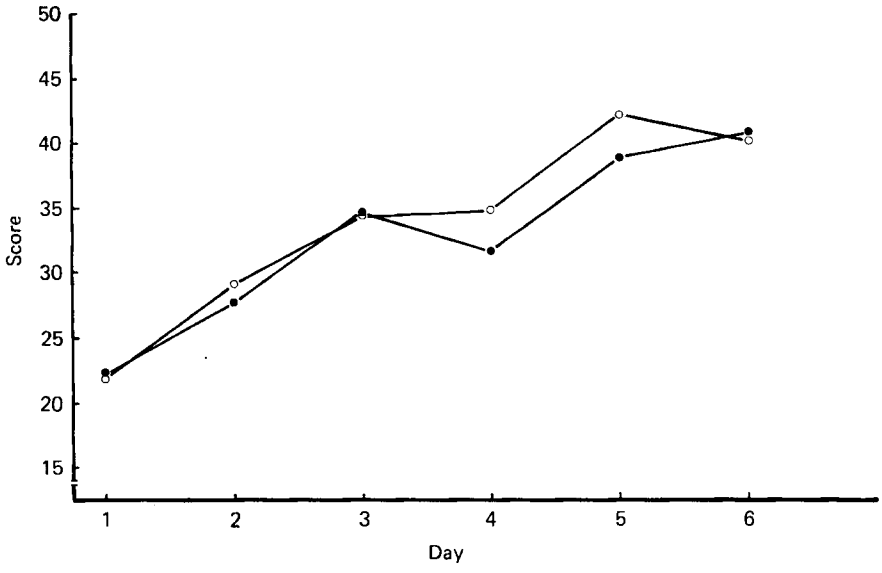

Fig. 2. Memory and search task (MAST 6) mean speed scores. Control group (●—●), twenty subjects ate breakfast throughout the study. Experimental group (○—○), thirty -five subjects ate breakfast on days 1, 2 and 3 and then omitted breakfast on days 4, 5 and 6.

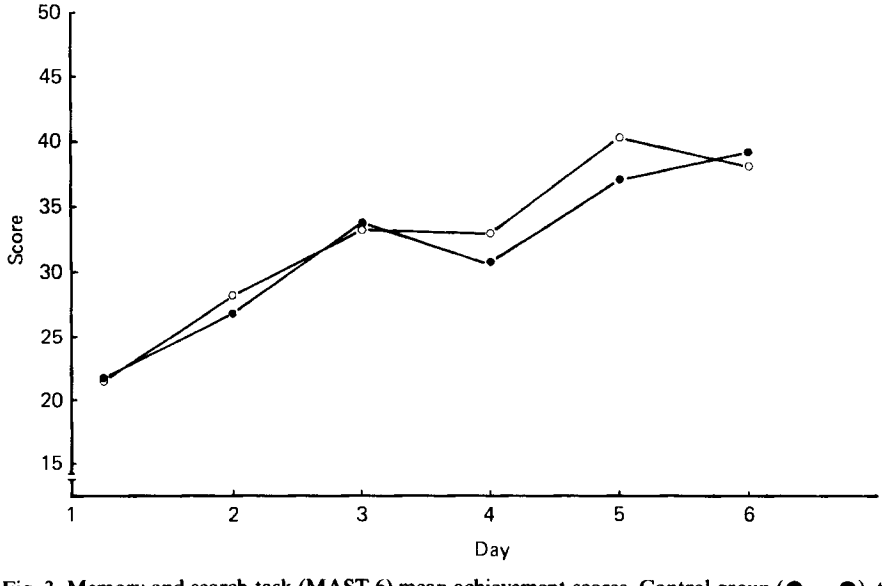

Fig. 3. Memory and search task (MAST 6) mean achievement scores. Control group (●—●), twenty subjects ate breakfast throughout the study. Experimental group (○—○), thirty-five subjects ate breakfast on days 1, 2 and 3 and then omitted breakfast on days 4, 5 and 6.

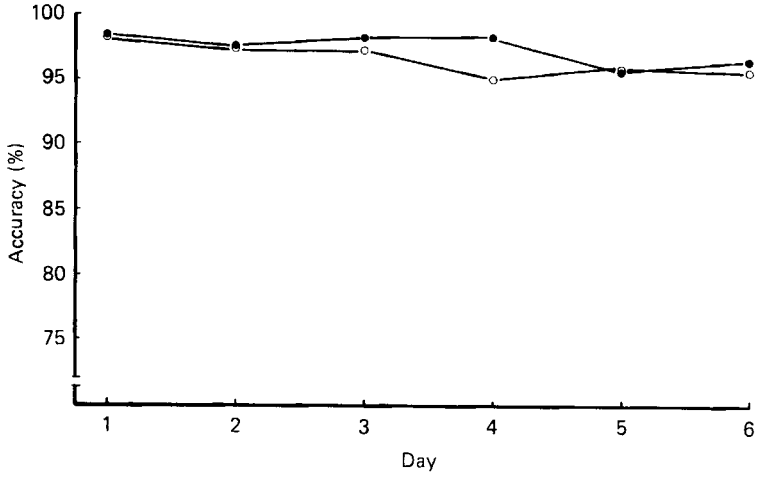

Fig. 4. Memory and search task (MAST 6) mean accuracy scores. Control group (●—●), twenty subjects ate breakfast throughout the study. Experimental group (○—○), thirty-five subjects ate breakfast on days 1, 2 and 3 and then omitted breakfast on days 4, 5 and 6. Standard errors of the means did not exceed ±0·9.

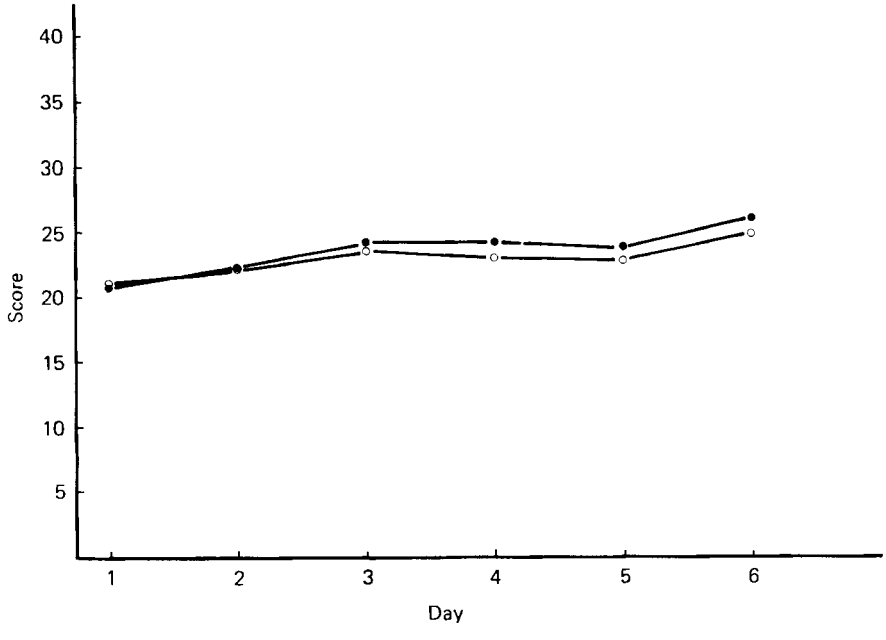

Fig. 5. Simple addition mean speed scores. Control group (●—●), twenty subjects ate breakfast throughout the study. Experimental group (○—○), thirty-five subjects ate breakfast on days 1, 2 and 3 and then omitted breakfast on days 4, 5 and 6.

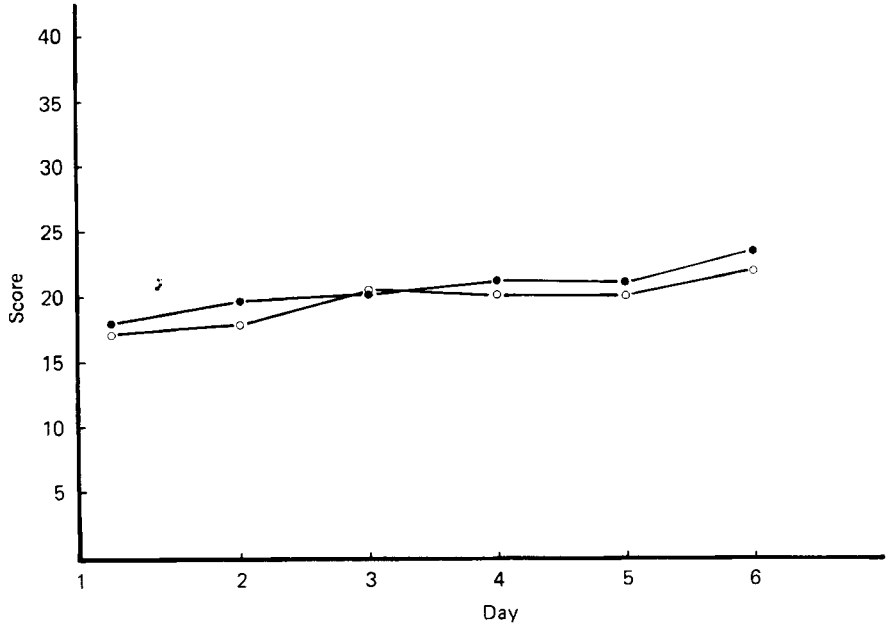

Fig. 6. Simple addition mean achievement scores. Control group (●—●), twenty subjects ate breakfast throughout the study. Experimental group (○—○), thirty-five subjects ate breakfast on days 1, 2 and 3 and then omitted breakfast on days 4, 5 and 6.

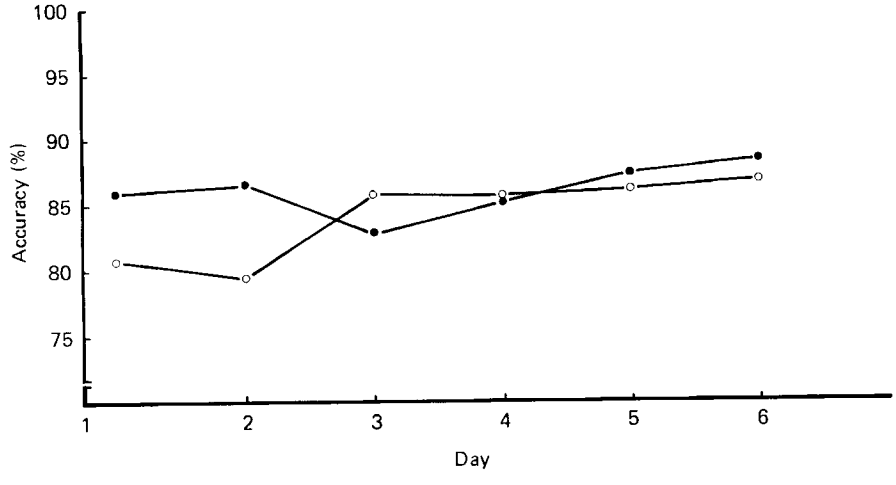

Fig. 7. Simple addition mean accuracy scores. Control group (●—●), twenty subjects ate breakfast throughout the study. Experimental group (○—○), thirty-five subjects ate breakfast on days 1, 2 and 3 and then omitted breakfast on days 4, 5 and 6. Standard errors of the means did not exceed ±2·6.

Table 3. *Mean percentage change in scores of 'memory and search test' for six letters (MAST 6) between successive days*

(Mean values with their standard errors; no. of subjects in parentheses)

Test days...		1–2		2–3		3–4		4–5		5–6	
Score	Group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Speed	Control (20)	133·8	6·3	128·0	6·1	93·8	4·1	124·9	6·6	104·4	5·0
	Experimental (35)	135·8	8·6	122·8	4·5	101·2	2·8	122·4	5·0	99·5	3·8
Achievement	Control	132·2	5·9	128·6	5·9	93·6	4·0	122·0	6·7	105·2	5·2
	Experimental	135·3	9·4	122·6	4·8	98·5	2·3	123·4	4·9	99·3	4·0
Accuracy	Control	99·1	0·7	100·7	1·1	100·1	1·0	97·6*	1·0	100·6	1·1
	Experimental	99·1	0·9	99·8	1·0	97·8	0·9	100·9*	0·7	99·8	0·8

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

Table 4. *Simple addition test expressed as mean percentage change in scores between successive sessions*

(Mean values with their standard errors; no. of subjects in parentheses)

Test days...		1–2		2–3		3–4		4–5		5–6	
Score	Group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Speed	Control (20)	102·9	2·5	109·2	3·3	101·2	2·7	98·3	2·4	107·2	1·9
	Experimental (35)	102·6	2·6	109·4	2·3	100·9	2·0	97·1	2·1	111·2	3·3
Achievement	Control	103·8	4·0	105·5	5·1	105·3	4·1	101·4	4·4	107·8	2·6
	Experimental	104·6	4·3	119·8	5·1	101·6	3·5	99·0	3·6	114·5	5·1
Accuracy	Control	101·1	3·4	96·3*	2·9	103·8	2·6	103·2	3·6	100·7	2·0
	Experimental	102·0	3·4	108·9*	3·4	100·8	2·8	102·1	3·2	102·9	3·4

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

RESULTS

Study 1

The cancellation tests results are presented in Tables 1 and 2 as mean scores and as the mean percentage change for each pupil. There were no significant differences between the breakfast eaters and non-breakfast eaters in terms of their percentage change in speed or accuracy in the first- or fourth-year pupils.

Study 2

The results from the first investigation using the two short-term memory tasks and simple addition test show that there was no demonstrable effect due to the omission of breakfast. The results are presented for the MAST 6 and simple addition test in Figs. 2–7, while Tables 3 and 4 show the mean percentage change in scores between successive sessions. (Results for the MAST 4 are not included but showed no significant differences between the groups.)

Statistical analysis of the mean daily scores indicated that the experimental group showed a reduced performance ($P < 0{\cdot}05$) on two out of the six test days. This was apparently due to chance since one of these differences showed on day 2 when both groups continued to eat breakfast as usual during the establishment of the base line. At this stage the group

allocated to the experiment obtained a lower addition accuracy score than the group allocated as control.

Later, there were some differences between the experimental and control groups which were not consistent and cannot be regarded as being associated with lack of breakfast. Thus on day 4 the experimental group obtained a lower MAST 6 accuracy score ($P < 0{\cdot}01$) than the control group (95% *v.* 98·3%). Significant differences also occurred ($P < 0{\cdot}05$) in mean percentage change in accuracy on the simple addition test between sessions two and three (experimental group 108·9%, control group 96·3%). Further support for the suggestion that these changes could not be associated with lack of breakfast came from the observation that the omission of breakfast accompanied an improved performance between sessions four and five (MAST 6 accuracy score; experimental group 100·9%, control group 97·6%; $P < 0{\cdot}01$).

In the second investigation using the sentence verification task (Figs 8–10) there was only one significant difference between the groups during the experimental period. The control group obtained a significantly higher ($P < 0{\cdot}02$) accuracy score for section one on day 5. During the non-experimental period, however, several differences were found. On day 2 the control group obtained a significantly higher ($P < 0{\cdot}05$) accuracy score than the group allocated to the experiment. The control group also obtained significantly higher accuracy scores for sections one ($P < 0{\cdot}02$) and five ($P < 0{\cdot}05$) on day 3. The mean percentage change in speed, achievement and accuracy scores between successive sessions (Table 5) revealed no significant differences between the control and experimental groups. In particular, there were no changes between test sessions three and four when the experimental group omitted breakfast for the first time.

DISCUSSION

In the first study 487 children, seventy-nine having had no breakfast, were tested on one day and 207 children, fifty-three having had no breakfast, repeated the test on a second day, yet the investigation did not show any differences between the performance of the breakfast eaters and non-breakfast eaters.

The objective of the investigations in the second study was to examine the short-term effects on mental efficiency of omitting breakfast among regular breakfast eaters. It is possible that the effects on intellectual function might be demonstrated by depriving those accustomed to eating breakfast. Support for this possibility was given by a small-scale study by Richards (1971, 1972). This experiment involved a group of eighteen adult subjects, half of whom habitually omitted breakfast and the other half customarily ate a 'moderate meal' for breakfast. The subjects were tested first when they followed their usual breakfast routine and second when they had omitted or eaten a standardized breakfast providing approximately 1·9 MJ. Richards (1971, 1972) reported that there was no indication of any change in performance which could be attributed to the omission or consumption of breakfast. However, the results did show that for three of the four tests, the subjects tended to improve more in performance when they were tested after following their normal breakfast routine. Improvement in performance was consistently less when they departed from their normal meal routine. Richards concluded that the occasional omission of breakfast was more deleterious than the habitual omission.

The results from the present study did not show any performance change in subjects who omitted their accustomed breakfast on three consecutive days. The differences that were observed were of the order of 5% but they were not consistent and could not be ascribed to the omission of breakfast since differences also occurred during the non-experimental period.

The subjects in this study fasted for up to 16 h and were apparently able to perform as

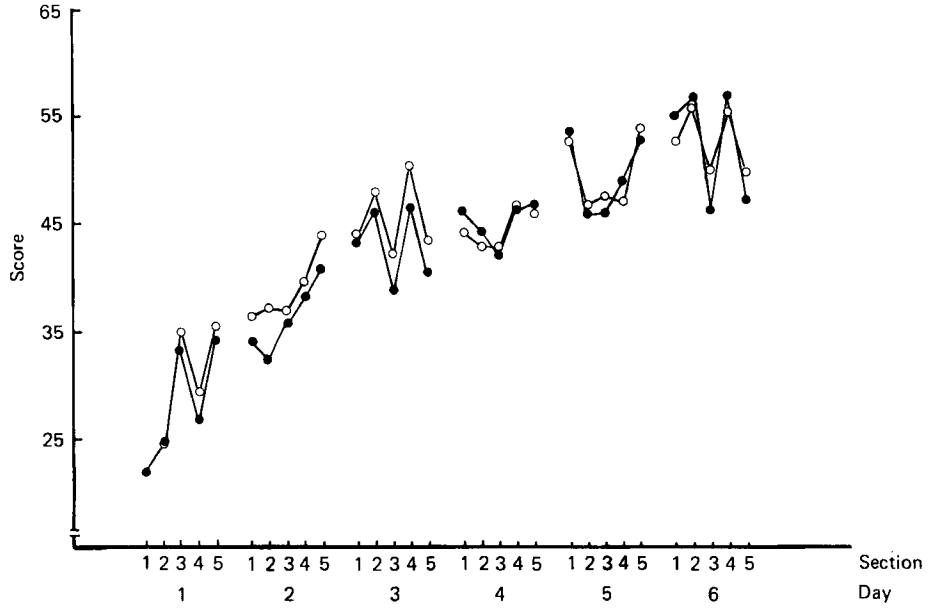

Fig. 8. Sentence verification task mean speed scores. Control group (●—●), twenty subjects ate breakfast throughout the study. Experimental group (○—○), thirty-five subjects ate breakfast on days 1, 2 and 3 and then omitted breakfast on days 4, 5 and 6.

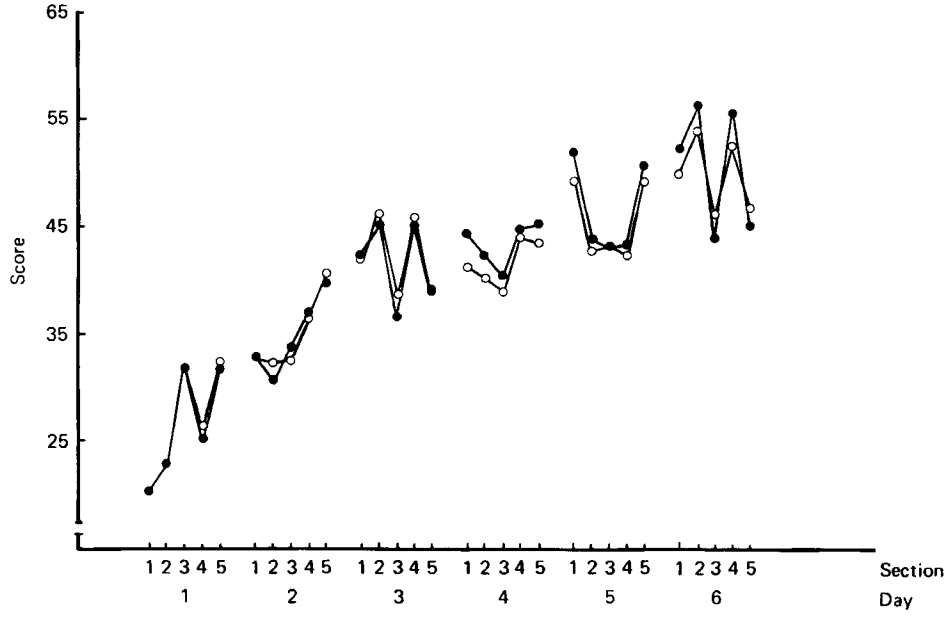

Fig. 9. Sentence verification task mean achievement scores. Control group (●—●), twenty subjects ate breakfast throughout the study. Experimental group (○—○), thirty-five subjects ate breakfast on days 1, 2 and 3 and then omitted breakfast on days 4, 5 and 6.

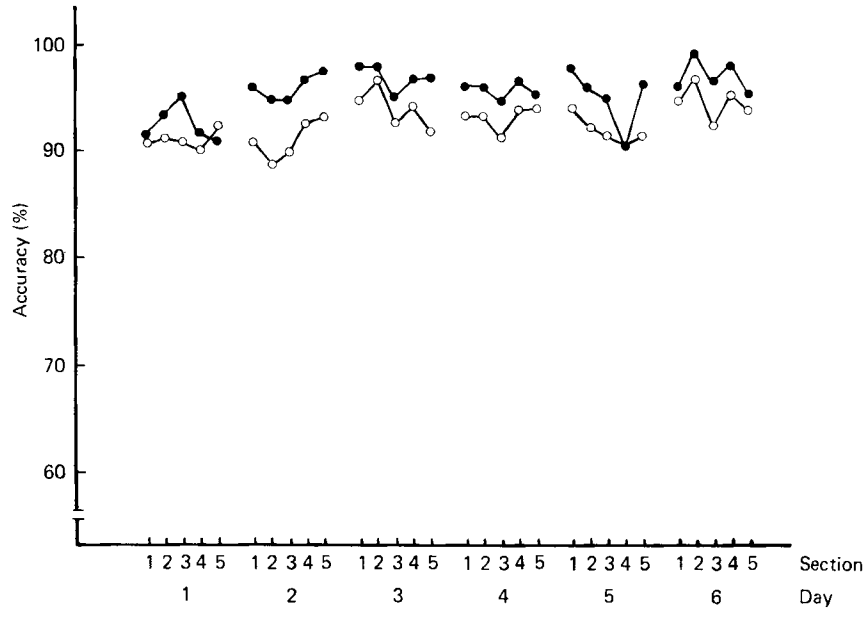

Fig. 10. Sentence verification task mean accuracy scores. Control group (●—●), twenty subjects ate breakfast throughout the study. Experimental group (○—○), thirty-five subjects ate breakfast on days 1, 2 and 3 and then omitted breakfast on days 4, 5 and 6. Standard errors of the means did not exceed ±3·9.

Table 5. *Sentence verification test expressed as mean percentage change in scores between successive sessions*

(Mean values with their standard errors; no. of subjects in parentheses)

Test days...		1–2		2–3		3–4		4–5		5–6	
Score	Group	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Speed	Control (20)	129·6	4·9	118·5	3·0	105·6	2·4	111·8	4·5	107·3	3·5
	Experimental (33)	133·7	3·8	115·9	2·0	100·7	3·1	108·1	3·3	104·4	1·8
Achievement	Control	135·6	6·9	119·7	3·1	104·4	2·3	110·3	3·4	108·8	3·4
	Experimental	133·2	3·9	119·5	1·9	100·1	2·9	105·9	3·1	109·0	2·6
Accuracy	Control	104·3	2·4	101·0	0·8	99·0	1·0	99·4	1·6	101·4	1·1
	Experimental	99·7	1·2	103·5	1·3	99·9	1·4	98·5	1·6	104·7	2·6

Differences not statistically significant, $P > 0{\cdot}05$.

well as control subjects who had eaten breakfast 3 h before the test. Further evidence comes from the observation that both groups of subjects demonstrated almost identical 'learning curves'. Initial performance of both the control and experimental subjects was similar and the improvement with practice was the same for both groups despite the 'dietary stress' of the experimental group.

The results from the two studies failed to demonstrate that the omission of breakfast is detrimental to late morning performance. This could either be because breakfast is unimportant or because the tests employed were not sufficiently discriminating to detect the effects of omitting breakfast. However, the tasks used have been shown to be sensitive

to a variety of stresses. For example, a cancellation task was included as a performance measure to detect an impaired alertness in subjects with 'high-normal' or 'above-normal' packed cell volume when compared with a control group (Willison *et al.* 1980). A 5 min addition test has been used to assess the mental efficiency of divers breathing oxy-helium or air (Baddeley & Flemming, 1967). This test has also been used to show differences in performance due to loss of sleep (Wilkinson *et al.* 1966).

Brooke (1973) suggests that two problems of methodology are presented by studies on extended fasting. First, due to the awareness of having been starved, subjects' own expectations of performance deteriorations may result in poorer performance; although there was no evidence of such an effect in the present studies. Secondly, with short-term assessment methods subjects may arouse themselves sufficiently to perform normally for the period required. This raises the problem of motivation which is well known to have a powerful influence on performance (Gagne & Fleishman, 1959).

There is much anecdotal evidence that children's attention, concentration and general behaviour at school are improved when they have been given food mid-morning, although few authors mention whether or not those children had breakfast (Keister, 1950; Laird *et al.* 1951; Tuttle *et al.* 1954). It is possible that this is true and that we have no means of quantifying or even measuring the effect. The application of a test may itself stimulate the child. The findings of Brooke *et al.* (1973) indicate this possibility. In their study on steel workers they observed a significant ($P < 0{\cdot}05$) reduction in accident rates when a high-energy drink was provided, but they were unable to show any measurable differences under supplemented or fasting conditions in the laboratory (Cooper & Brooke, 1974).

The earlier work described as the Iowa Breakfast Studies (Dickie & Bender, 1982) appeared to indicate that the omission of breakfast resulted in a deterioration in mental and physical performance later in the morning. Our results have failed to reveal any such detrimental effect. While our findings show that omission of breakfast is not detrimental, this does not rule out the possibility that there could be some deterioration of performance in normal daily activities because subjects usually tend to be more highly motivated during a test. One remaining possibility is that the types of test used do not reveal the change that occurs. If testing itself influences the results then stronger evidence of the omission of breakfast can be sought only by observation unknown to the subjects, but such observations are not sufficiently quantifiable to be useful.

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