International Journal of Arts & Education Research

THE EFFECTS OF MEALTIME ON ACTIVITIES AND INTELLECTUAL PERFORMANCE IN OFFSPRING AND YOUNGSTERS

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ABSTRACT

Ordinary mealtime use is associated with higher intake of key vitamins and natural resources. This may boost the probability of meeting nutritional requirements. Conversely, mealtime skippers may not make up for missed nutrients at other. Indeed, a review of mealtime and the diet of adults confirm that mealtime eaters consume better quality diets that include more fiber and nutrients and fewer calories than mealtime skippers. Popular mealtime foods help people meet recommendations for these food groups. Mealtime also contributes to whole grain intake (over 30% of the intake) which is known to reduce the risk of diabetes and coronary heart disease. A number of studies have shown that use of mealtime is associated with a more positive temper including greater alertness, hedonic tone and a reduction in anxiety in the period shortly after use. With so much information still unknown regarding the specific links between breakfast foods and school performance, policy makers, educators, and parents must not only support regular breakfast consumption, but also seek to modify students' nutritional intake based on the most current research available in the field. Breakfast consumption is a global and costly issue, requiring the attention of policy makers to determine the best use of funds and program implementations. Educators daily compete with a myriad of learning impediments in their classrooms, not the least of which is improperly nourished students who struggle with focus and knowledge retention.

Keywords: Children, breakfast, diet, nutrition, cognition, academic achievement, achievement gap, socioeconomic factors.

1. INTRODUCTION

The slogan mealtime is used in a number of traditions. Studies offer reliable definitions of mealtime including: intake after all night fasting; the first feast of the day; intake before the start of daily activities; intake within two hours of waking; any food or beverage frenzied among 05.00 and 09.00; intake before 10.00; and intake a feast in the morning that provides among 20-35 percent of daily energy needs [3]. Given this variation in definition one might expect significant variation in the observed effects. However, there is generally a fine consensus about both health and behavioral effects of consuming mealtime and these are summarized here. There have been recent concerns that fewer people are now intake mealtime and this has been definite in nationwide representative surveys (Haines et al., 1996; Kant and Graubard, 2006). For example, in the USA mealtime use among adults aged 20 to 74 years decreased from 86 percent in 1965 to 75 percent in 1991. It has also been found that mealtime cons umption has declined in offspring, with the steepest drop being observed amongst adolescents aged 11 to 18 years (Siega-Riz, Popkin and Carson, 1998) [22]. This

effect has been confirmed in data from the National Health and Nutrition Examination Surveys (NHANES) and results from the 2001-02 survey showed that offspring are less likely to consume mealtime as they get older. For example, among offspring aged two to five years about 95 per cent eat mealtime.

1.1 Mealtime and dietary suggestion

Ordinary mealtime use is associated with higher intake of key vitamins and natural resources (Rampersaud et al., 2005; Ruxton and Kirk, 1997) [2]. This may boost the probability of meeting nutritional requirements. Conversely, mealtime skippers may not make up for missed nutrients at other feasts (Morgan, Zabik and Stampley, 1986). Indeed, a review of mealtime and the diet of adults confirms that mealtime eaters consume better quality diets that include more fibre and nutrients and fewer calories than mealtime skippers (Timlin and Pereira, 2007) [8]. Popular mealtime foods help people meet recommendations for these food groups. Mealtime also contributes to whole grain intake (over 30% of the intake) which is known to reduce the risk of diabetes and coronary heart disease.

Milk is the most commonly frenzied mealtime food (frenzied by over 50% of people who eat mealtime at home) and this, again, helps to meet dietary recommendations for this type of food. Similar results have been reported for fruit intake, with fruit or fruit juice use at mealtime being linked with greater total fruit intake over the day (Quan et al., 2000 [1]). Other research shows that mealtime use is associated with lower BMIs (Cho et al., 2003) and a reduced risk of weight gain (van der Heijden et al., 2007). These results have been confirmed in studies of offspring and adolescents (e.g. Utter et al., 2007). Other research has examined which components of mealtime are related to better weight management and the findings support beneficial effects of cereal (e.g. Bazzano et al., 2005) and milk products (Zemel et al., 2004).

1.2 Mealtime and healthiness

Mealtime use is associated with lower levels of cholesterol (Stanton and Keast, 1989; Resnicow, 1991). Similarly, diets rich in fibre and whole grains are associated with a reduced risk of coronary heart disease (Djousse and Gaziano, 2007) [28]. Metabolic syndrome is a cluster of risk factors that are linked with being obese, having an increased risk of diabetes and coronary artery disease. Research shows that diets rich in whole grains and dairy products (key components of many mealtimes) are associated with a reduced risk of metabolic syndrome (Baxter, Coyne and McClintock, 2006) [24]. Dietary fibre from mealtime cereals may also improve digestion (Smith, 2010,

b). There is also evidence that whole grain wheat may have a pre-biotic effect (Costabile et al., 2008) and that use of wheat bran can reduce levels of harmful bacteria such as *Clostridia* (Deaville, Gibson and Smith, in preparation). Intake mealtime also contributes nutrients that are important to bone health, with the main source being milk.

Other research (Smith and Rees, 2000; Smith, 2002a) has shown that mealtime use is associated with reduced susceptibility to the common cold. Smith (2002a) found that mealtime use was associated with lower cortical levels. Cortical often induces immunosuppressant and this provides a plausible mechanism for some of the health benefits

associated with mealtime. Indeed, Li et al. (2007) found that mealtime use was associated with significantly higher numbers of NK cells and a significantly lower number of T cells than volunteers who did not ordinary consume mealtime.

The main emphasis of the present chapter is on the behavioural effects of intake mealtime and these will be reviewed in the following sections.

2. MEALTIME AND COGNITIVE TASK

2.1. Studies of adults

There has been considerable interest in the acute effects of feasts on human performance and temper (see Smith & Kendrick 1992; and Mahoney, Taylor and Kanarek, 2005, for reviews). The overall aim of the present section is to review this evidence to determine whether mealtime influences temper and performance, and to examine whether selective effects are observed depending on the type of feast eaten, task performed, characteristics of the person intake the feast and whether caffeinated beverages are frenzied as part of mealtime [18].

Results showed that in the no-mealtime condition, there was a tendency towards slower reaction times. However, this was the only condition in which caffeinated coffee was not given and the results may reflect this [27]. This was replicated when the same subjects were re-tested. Five out of six of the females showed a significant increase in simple reaction time in the no mealtime condition, while three out of six showed a significant increase in choice reaction time in the same condition [16]. Clearly results from studies with such a small number of subjects must be treated with caution. Tuttle et al. (1950) carried out a similar experiment comparing mealtime and no-mealtime conditions, with testing taking place 3 hours after mealtime. Six of the ten subjects showed no change in reaction time in the no-mealtime condition (as compared to mealtime), three showed a significant increase in reaction times, while one subject's effect time better radically during the no-mealtime situation. Again, it is hard to sketch positive conclusions from such a study. Another study (Tuttle et al. 1952) found no effect of mealtime on reaction times. One study (King et al. 1945) assessed visual and motor functioning 2 h and 3 h after the use or omission of mealtime [13]. The outcome showed that these functions were impaired when mealtime was not eaten compared to when it was. Richards (1972) compared a standard mealtime with a no-mealtime condition. The volunteers were chosen so that half habitually ate mealtime and half no mealtime [11]. A range of performance measures were employed: a visual search task, a short term memory task, vigilance task and a coding task.

1. Testing was carried out in the late morning. Participants were tested on five occasions: once following their normal mealtime, twice following the standard mealtime and twice following no mealtime. A modified Latin-square design was used to balance order of conditions [21]. The use or omission of mealtime did not alte and when volunteers were free r performance. Rather, performance was most impaired when subjects changed from their normal feast. This led to the view that 'the occasional omission of mealtime is more deleterious than the constant omission'. Benton and Sargent (1992) compared the effects of no mealtime and use of a high protein drink on spatial memory and immediate recall of a word list. Half the subjects were habitual mealtime eaters and half did not usually eat

mealtime. Use of the high protein drink increased the speed with which both memory tasks were completed. Benton and Parker (1998) confirmed that mealtime improves aspects of memory and suggested that this may reflect several different mechanisms.

Other studies have suggested that the size and composition of mealtime influence the post-feast response. Lloyd et al. (1996) compared low fat/high carbohydrate, medium fat/medium carbohydrate, high fat/low carbohydrate and no-mealtime conditions [32]. No clear differences in performance were observed as a function of type of mealtime but subjects given the low fat/high carbohydrate mealtime (which was most similar to their normal feast) reported improved temper compared to the other conditions. Nabb and Benton (2006) compared mealtimes that contained either high or low levels of carbohydrate, fat or protein. Better memory was associated with use of feasts that more slowly released glucose into the blood. This benefit of a low glycaemic index mealtime has been confirmed in animal studies (Benton et al., 2003) and in offspring (Wesnes et al., 2003; Ingwersen et al., 2007). The next section reports two studies (Smith, Kendrick and Maben, 1992; Smith et al., 1994) which examined the effects of mealtime on irritation and a range of different aspects of performance. The type of mealtime was manipulated and the influence of caffeinated drinks examined. The experiments also investigated whether personality, intake habits, gender and previous night's sleep modified any effect of mealtime on behavior [3]. The first experiment examined the effects of two types of mealtime on sustained attention tasks (i.e. tasks which show an effect of lunch), temper and cardiovascular functioning. Volunteers were given either caffeinated coffee or decaffeinated coffee after the feast (or no feast). This was done to investigate whether caffeine modified any effects of mealtime, and secondly, as a positive control to show that the tests used here were sensitive to changes in state produced by caffeine (Lieberman 1992).

In the first study a among subject design was used and volunteers were assigned to one of the six conditions formed by combining the three mealtime and two caffeine conditions. Volunteers were either assigned to a nomealtime condition, a cooked mealtime condition or cereal/toast mealtime. Details of these are shown below:

(1) Cereal/toast mealtime: 1 oz. cornflakes; 150ml skim milk 2tsp sugar; 1 slice wholefeast toast; 10g polyunsaturated margarine/butter; 25g marmalade.

(2) Cooked mealtime: 2 eggs, scrambled skim milk; 2 thin slices back bacon; 1 slice wholefeast bread/toast; 10g polyunsaturated margarine/butter.

After mealtime participants were either given de-caffeinated coffee or decaffeinated coffee with 4 mg/kg of caffeine tablets added. Mealtime had no effects on performance of sustained attention tasks. In contrast, caffeine improved performance of these tasks [33]. No interactions among mealtime conditions and personality were found in any of the analyses. Similar results were found when gender was included as a factor. Smith et al. (1994) examined effects of mealtime on performance of memory tasks [36]. Use of mealtime improved recall and recognition of a list of words but had no beneficial effects on working memory or semantic memory tasks. Again, effects of mealtime were not modified by caffeine or by personality and gender. Mealtime had no effect on free recall in the late morning or

after lunch, which suggests that the effects of mealtime on episodic memory are restricted to a few hours after the feast.

Smith, Clark and Gallagher (1998) extended the above results by showing that use of mealtime may also improve spatial memory [26]. However, the most robust effects of mealtime on memory are found in free recall tasks and these effects have been observed after use of high carbohydrate cereals (Smith, in preparation, a) and cereal bars (Smith and Wilds, 2009; Smith and Stamatakis, 2010). Similarly, a mid-morning cereal bar may also have beneficial effects when frenzied after a small mealtime (Smith and Wilds, 2009). There have been a few studies that have examined effects of mealtime in elderly adults. Early studies by Tuttle and colleagues (Tuttle et al., 1952, 1953) found little evidence for an effect of mealtime on the cognitive function of elderly people [23]. Recent studies have demonstrated both acute effects of mealtime and effects of the mealtime habit. Kaplan et al. (2001) found that carbohydrate intake was associated with improved performance of a short term memory task, whereas a protein mealtime was associated with reduced forgetting in a paragraph recall task. Smith (1998) found that elderly adults, aged among 60 and 79 years, who ate mealtime cereal every day performed better on a test measuring intellectual functioning than those who frenzied mealtime less frequently [20]. It should be noted that this last result could reflect an effect of intelligence on mealtime use rather than a causal effect of mealtime use on intelligence. Further intervention studies are needed to assess the effects of mealtime on cognitive function in the elderly.

2.2 Studies of offspring

There have been a number of reviews of the effect of mealtime on the cognitive performance of adolescents and offspring (Rampersaud et al., 2005; Mahoney, Taylor and Kanarek, 2005; Hoyland, Dye and Lawton, 2009) and the main findings can be summarised as follows. There have been over forty studies published on this topic (see Appendix 1) in the last 60 years (see Hoyland, Dye and Lawton for details of the literature) [10]. The results confirm the adult literature showing that mealtime has a beneficial effect on cognition, with the strongest support for improvements in memory. This effect is most readily apparent when nutritional status is compromised. Less is known about the effects of different types and sizes of mealtime so the role of mealtime size and composition requires further consideration. Wyon et al. (1997) reported that offspring did better on tests of creativity, physical endurance and mathematical ability when they frenzied a high energy mealtime compared to use of a low energy mealtime. Michaud et al. (1991) confirmed these results using a short-term memory task. Other studies (Mahoney et al., 2005) report an oatfeast mealtime leads to better performance compared to a ready-to-eat cereal (especially in girls). Most studies ha ve investigated offspring rather than adolescents [30]. A recent study of high school students (Widenhorn-Muller et al., 2008) showed that mealtime had no effect on sustained attention but improved visuo-spatial memory in males. Studies of school mealtime programmes suggest that such interventions can have positive effects which may reflect an effect of these programmes on school attendance. In addition, mealtime use in offspring and adolescents is associated with a superior nutritional profile and better weight management.

3. EFFECTS OF MEALTIME ON TEMPER

A number of studies have shown that use of mealtime is associated with a more positive temper including greater alertness, hedonic tone and a reduction in anxiety in the period shortly after use. Maridakis, Herring and Connor (2009) demonstrated that these effects could be demonstrated using a range of differing measuring instruments. Similarly, they have been found with different types of mealtime (e.g. Smith, Kendrick and Maben, 1992**)** and as volunteers were free to select from a range of mealtime cereals (Smith, Clark and Gallagher, 1999) or cereal bars (Smith and Wilds, 2008). These results have been confirmed in studies of adolescents (Widenhorn-Muller et al., 2008) and offspring (Smith, in press) [9]. Other research has suggested that different macronutrients have selective effects on temper (e.g. simple versus complex carbohydrates, Pasman et al., 2003) though it is often uncertain whether such things return factors such as satisfactoriness. Similarly, some research suggests that temper is more negative after a short power rather than high energy mealtime (Lluch et al., 2000). Effects of habitual use may also modify the acute effects of mealtime, with deviation from habitual mealtime being associated with a more negative temper (Lloyd et al., 1996). The effects of habitual mealtime use patterns on longer term happiness will now be considered.

4. MEALTIME AND HAPPINESS

Smith (2003) has discussed the relevance on the concept of happiness in nutrition research. The concept of happiness has become increasingly important since the acknowledgement that there is more to health than the absence of disease. In some areas of research happiness has been replaced by “quality of life” or some other term that relates to the ability to function well (both physically and mentally) and to have a positive temper state. In the area of nutrition the term “functional food” is widely used and this refers not only to the beneficial effects related to chronic disease but to potential improved happiness. Use of mealtime has been shown to be associated with various aspects of the multi -dimensional concept of happiness and some examples are given in the following section. Wetzler and Ursano (1988) showed that mealtime use was associated with better psychological happiness in a cross-sectional analysis of over 6,000 individuals. In the largest study, Huang et al. (2010) examined associations among mealtime skipping and health-related quality of life in a national representative sample (N=15,340) from the 2005 Taiwan National Health Interview Survey. The results showed that mealtime skippers had significantly lower scores (poorer happiness) on 5 out of the 8 domain scores on a quality-of-life questionnaire, the SF-36 (lower general health; reduced vitality; poorer social functioning; poorer emotional roles; and reduced mental health). Smith (1998) examined the relationship among mealtime use and subjective reports of health and health related behaviours in a general population sample (126 subjects aged among 20 and 79 years). Individuals who frenzied a cereal mealtime each day were less depressed, less emotionally distressed and had lower levels of perceived stress than those who did not eat mealtime each day. Those who frenzied mealtime had a healthier life style than the others as they were less likely to be smokers, drank less alcohol and had a healthier diet. However, the relationship among cereal mealtime use and health was present regardless of differences in the other health-related behaviours. A subsequent study (Smith,

1999) attempted to replicate and extend the above result. The general population sample in this study (262 volunteers aged among 21 and 85 years, mean age: 60.9 years) was older than the sample in the previous study. Individuals who frenzied mealtime cereal everyday reported better mental and physical health than those who frenzied it less frequently [7]. This association was still present when demographic factors, indicators of lifestyle such as smoking, or other aspects of diet were covaried.

Smith (2003) continued to study this topic and in the next study considered young adults (189 volunteers, aged among 19-21 years, mean age 19.6 years) living at home. The results showed that skipping mealtime was associated with reports of poorer health and that ordinary mealtime cereal use is associated with better reported health. The effects of mealtime could not be explained by other health-related behaviours or other aspects of diet. In the latest study (Smith, 2010,a) the sample were two hundred and thirteen offspring, (108 female, 105 male; mean age: 8.11 years, s.d. 2.04 years), recruited from schools in Cardiff, Wales. Baseline measures of mealtime use and different aspects of reported happiness, such as mental health; cognitive functioning; alertness; physical health; and digestive problems, were recorded. Following this offspring were allowed to try three cereals and selected the one that they found most acceptable (63 choose *Cornflakes;* 63 *Rice Krispies***;** and 53 *Rice Krispies Multigrain*). The baseline results showed that those who frenzied mealtime cereal were perceived as having better happiness including fewer mental health problems, a more positive temper, higher alertness and fewer bowel problems than those who did not consume mealtime. This was confirmed in the intervention study with mealtime cereal use being associated with reports of lower depression, emotional distress and fatigue, greater alertness, fewer cognitive problems, and fewer minor symptoms and bowel problems.

These effects were apparent after both the first and second week. They were also observed for all cereals. Overall, the results of this study show that mealtime cereal use by offspring is associated with greater happiness. There is evidence that mealtime use per se improves happiness and effects appear to be most pronounced with mealtime cereal in combination with dairy products (O'Sullivan et al, 2009). One type of mealtime cereal that has a large effect is high fibre cereal. Research has also shown that increasing dietary fibre from wheat bran cereals decreases fatigue and increases energy (Smith *et al*., 2001). Smith (in press, b) conducted secondary analyses of data from this study. Initial analyses examined associations among high fibre intake and happiness (emotional distress, fatigue, cognitive difficulties and somatic symptoms). The results showed that high fibre intake was associated with increased happiness. Subsequent analyses examined whether the effects of total fibre intake could be accounted for by ingestion of specific sources of fibre, namely mealtime cereal and fruit/vegetables. The results showed that it was the mealtime cereal that was largely responsible for the increased happiness. Digestive problems are also associated with reduced happiness and a second set of analyses examined whether the benefits of fibre were due to a reduction in digestive problems. The results showed that digestive problems reduced happiness but these effects were independent of the effects of fibre. The next section considers mechanisms that might underlie behavioural

effects of mealtime.

5. UNDERLYING MECHANISMS

5.1 Mealtime is superior than nothing

Results clearly show that use of mealtime improves temper and cognition compared to intake no mealtime. It has been suggested that mealtime removes the negative effects of fasting and the mechanism has often been conceptualised in terms of providing a supply of energy to the brain (see next section). However, recent research suggests that the mechanisms are likely to be more complicated. In a series of studies Smith (in preparation, b) examined when use of mealtime cereal led to an improvement in temper and memory. The first study examined effects observed after a cereal lunch (following use of a normal mealtime). The cereal use was associated with a more positive temper but no benefits were seen for the free recall task. This suggests that it is not just the feast that is important. A next study examined things of intense cereal in the premature sunset after a day of fasting. Use of cereal improved temper but did not improve memory. These results suggest that use of mealtime cereal improves temper whenever it is eaten but the memory effects depend on it being frenzied early in the day. The effects of mealtime, or rather a high carbohydrate mealtime, have often been explained in te rms of changes in serotonin (Fernstrom and Wurtman, 1971). Such a mechanism could explain the association among ordinary use of mealtime and happiness, although it may also be the case that it is happiness that influences food choice (Christensen and Somers, 1996). It is likely to be the case that a number of peripheral and central mechanisms underlie the effects of mealtime on behavior and further research is required to elucidate these mechanisms.

5.2 Glycaemic index/load

A large number of studies have examined the effects of glucose on behaviour. The evidence for positive effects is not consistent although a number of studies have demonstrated beneficial effects of glucose on verbal memory (Hoyland, Lawton and Dye, 2008). Other studies have investigated the effects of feasts differing in glycaemic index, glycaemic load, the ratio of slow/rapid availability of glucose, the proportion of simple to complex carbohydrate, or the amount of rapidly versus slowly digested carbohydrate. Glycaemic index (GI) and glycaemic load (GL) are the most widely used indices. GI provides a measure of carbohydrate quality not quantity, whereas GL is a product of the food's GI and the amount of carbohydrate per serving. Gilsenan, de Bruin and Dye (2009) have reviewed studies comparing the impact of different GLs. A low- GI/high GL mealtime was associated with faster information processing whereas a high GI mealtime was associated with better immediate word recall. Further research is now required to determine whether mealtimes with these macronutrient compositions will have beneficial effects on the academic performance of offspring. The research to date does not inform on the precise mechanisms through which glucose influences cognition. The possible mechanisms are many and varied. For example, glucose is taken up by astrocytes, converted into lactate which is then released into extra cellular space to be taken up as an energy substrate by neurons. Many of the brain's neurotransmitters are derived from glucose metabolism which suggests that glucose may influence cognitive function by enhancing neurotransmitter synthesis during periods of neuronal activity. Alternatively, there could be a peripheral effect of glucose on memory due

to a neural signal being triggered when glucose is transported into cells. GL may also influence gastro-intestinal hormonal response which in turn may have effects on cognition.

5.3 Other mechanism

There are clearly a number of other mechanisms through which use of mealtime may influence behavior. These may reflect the macronutrient composition (e.g. effects of high fibre cereals), the micronutrient composition (e.g. fortification of cereals) or a more general influence on dietary intake and healthn [15].

6. EFFECTS ON REAL-LIFE COGNITIVE UTILITY AND PROTECTION

The major practical implications of mealtime use are to be seen in the areas of nutritional intake, weight management and health. Studies of offspring suggest that mealtime use may improve cognition and school attendance which leads to better academic achievement. Reviews of mealtime use and offspring's academic achievement (e.g. Ells et al., 2008) have concluded that there are short-term benefits [29]. However, they also point out the methodological problems present in many of the studies: failure to consider the impact of habitual diet; little consistency in the methodology across studies; use of measures with no known validation; failure to distinguish nutritional effects from the social effects of mealtime clubs; and, given most interventions have been of short duration, the results fail to quantify sustainability and longer term benefits. Little is known about the real-life behavioral implications of consuming mealtime for adults. For example, a literature search revealed no information on mealtime and accidents and errors at work (or outside of work), road traffic accidents or driving performance, or on productivity at work [26]. Chaplin and Smith (submitted) examined effects of mealtime use on the health and protection of a sample of 870 nurses. The results showed that accidents, injuries and cognitive failures at work were greater in those who rarely ate mealtime. In addition, stress at work was greater in the mealtime skippers. Further research is now required to extend these findings to consider real-life activities outside of the workplace. In addition, it is essential to carry out interventions rather than just cross-sectional analyses.

7. DISCUSSION

The observable conclusion to be drawn from the literature reviewed here is that mealtime is good for you. This is true when one considers a number of different areas such as nutritional intake, weight management and health [18]. The same conclusion applies when one considers behavioural outcomes, with mealtime being associated with a more positive temper, improved cognition and, in the longer term, better happiness. These conclusions generally hold for well-nourished offspring, offspring with nutritional deficiencies and adults (young, middle-aged and the e lderly). Given the robust evidence for beneficial effects of mealtime it is rather surprising that we have made relatively little progress in understanding the underlying mechanisms (both psychological mechanisms and the CNS changes that underpin these) [14]. Furthermore, compared to other aspects of intake and drinking (e.g. consuming caffeine) we know relatively little about the practical benefits of mealtime at work, rest and play. Future research must extend our current knowledge by conducting translational research that will provide appropriate information for future policy and practice.

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