DOCTOR OF PHILOSOPHY

Changing children's eating behaviour

Using digital photography to measure the effects of two school-based interventions on children’s intake of macro- and micro-nutrients at lunchtime

Marcano-Olivier, Mariel

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Mariel Marcano-Olivier

Supervisor: Dr. Mihela Erjavec.

Second Supervisor: Professor Pauline Horne.

Chair: Dr. Simon Viktor.

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Summary

Poor childhood nutrition is a global phenomenon, contributing to obesity and the development of non-communicable diseases. The present thesis explores methods of improving child nutritional intake in a school setting. Here, we present four papers:

- A methodological paper, describing the validation of a newly designed method of collecting nutritional data in a canteen setting. We find that it is possible to accurately estimate nutritional intake in a fast-paced free-living environment using digital photography;
- An evaluation paper, exploring the impact of a school-based multicomponent intervention, the Food Dudes programme, on lunchtime nutritional composition. Results indicate that participation in the Food Dudes programme is associated with an increase in the consumption of fruit and vegetables, and a decrease in consumption of unhealthy food items;
- A systematic review, describing those studies in the literature focussed on improving children's eating behaviour through behavioural nudging. We report that, though many studies are successful, few studies use validated and reliable data collection methodologies, rendering results inconclusive;
- An experimental pilot study, exploring the influence of behavioural nudges on the fruit and vegetable consumption of primary school children. Significant improvements in fruit, vitamin C, and fibre consumption were observed following a simple behavioural nudge intervention.

The results presented in this thesis contribute to the literature investigating methods to measure, and promote childhood nutrition, and have implications for promoting research best-practice, and policy targeting poor childhood nutrition.

Contents

Chapter 1
The Importance of Good Nutrition in Childhood

The shift from palaeolithic patterns of eating (growing/gathering) has been attributed to a global increase in mass food production, distribution, and marketing (Brownell & Horgan, 2004). Popkin (2006) describes a global 'nutrition transition' away from fresh food consumption and towards a less nutritionally varied diet, associated with energy dense, nutrient sparse foods; humans are eating fewer fruit and vegetables, substituting these for less healthy, more convenient, and cheaper alternatives. The effects of this can be observed in the typically low levels of fruit and vegetable consumption, and high levels of mass produced convenience food consumption, across cultures (Gilbert & Khokhar, 2008; Jackson, Romo, Castillo, & Castillo-Duran, 2004), and in both adults (Kant, 2000; Kant & Graubard, 2005) and children (De Bourdeaudhuij et al., 2008; Jackson, Romo, Castillo, & Castillo-Duran, 2004; Ransley et al., 2007; Yngve et al., 2005). With the World Health Organisation (WHO, 2005) attributing a global increase in mortality from non-communicable diseases directly to insufficient fruit and vegetable consumption, it is important to develop strategies to address this phenomenon. Evidence suggests that childhood behaviours can predict adult lifestyle (Kelder, Perry, Klepp, & Lytle, 1994), and that childhood behaviours are more easily influenced than adult behaviour (Singer, Moore, Garrahie, & Ellison, 1995). Considering this, it may be that a focus on childhood eating behaviour will have the greatest impact on public health.

Poor Nutrition and Childhood Obesity

Childhood obesity is a worldwide phenomenon. Developing countries have reported increases in childhood obesity and related illness (De Onis, Blössner, & Borghi, 2010; Gupta, Goel, Shah, & Misra, 2012) whilst developed countries have reported a plateau of consistent high levels of obesity (Ogden, Carroll, Kit, & Flegal, 2014). With the observation of a trend for fat to be stored around the mid-region posing a significant risk for cardio-vascular disease (Griffiths, Gately, Marchant, & Cooke, 2013), in addition to evidence for the negative psychosocial impact of childhood obesity (Bell & Morgan, 2000; Irving, 2000; Thompson, Corwin, & Sargent, 1997), it has become a key priority of health providers and governments to address this multi-faceted issue (WHO, 2012). The WHO (2003) identified high energy dense diets to be an important factor contributing to obesity risk, whilst fruit and vegetable

intake has also been associated with weight status. Fruit and vegetables are often low in energy density, promoting satiety and, potentially, protecting against overeating and weight management issues (Epstein et al., 2001). When very low levels of these foods are eaten, they are often substituted with energy-dense, nutrition sparse foods (Miura, Giskes, & Turrell, 2009). Indeed, these consumption patterns are manifest in children's diets, and have been associated with childhood obesity.

Emmett and Jones (2015) conducted a systematic review and meta-analysis of research papers that have reported data from the Avon Longitudinal Study of Parents and Children (ALSPAC). The ALSPAC recruited pregnant women from three districts around Bristol (n = 14,062), and collected information pertaining to child food intake (utilising self-report measures) and child weight (utilising direct anthropomorphic measures) over a 13-year period. Strong associations were identified between dietary energy density in mid-childhood and the development of obesity by age 11. Researchers associated this body fatness increase directly with energy dense, nutrient poor foods, and diets lacking in fruit and vegetables, and suggested that interventions to protect against childhood obesity should aim to decrease energy dense food items, whilst increasing fruit and vegetable intake.

However, the association between diet and childhood obesity may not be so simple; with researchers often failing to find a significant relationship between energy density and child weight status (Guillaume, Lapidus, & Lambert, 1998; Rolland-Cachera, Deheeger, Akrout, & Bellisle, 1995), it may be that other factors are mediating this relationship. Carbohydrates are a significant source of energy, and research has identified a complex relationship between carbohydrate intake and weight status; not all carbohydrates equally contribute to weight management (Geiselman & Novin, 1982). A recent investigation identified that a diet rich in whole-grain carbohydrate may have a protective influence over the development of obesity, whilst a diet characterised by a high consumption of white bread was associated with an increased risk for excess weight gain, specifically increasing the risk for greater levels of abdominal fat (Serra-Majem & Bautista-Castano, 2015). Refined carbohydrates such as white bread are associated with higher levels of sugar, a sub-category of carbohydrate consistently associated with excess weight gain (Bray & Popkin, 2014; Keller & Bucher Della Torre, 2015; Ha et al., 2016). This relationship is supported by the success of reducing sugar-sweetened beverages on improving child weight status (Dooley, Moultrie, Sites, & Crawford, 2017).

A second significant contributor to dietary energy density is fat, with research consistently identifying that children prefer high fat food items (Birch, 1992; Johnson, Mcphee, & Birch, 1991). Some researchers have argued that a diet rich in fat and characterised by a positive energy balance is associated with an increased risk of obesity, as dietary fat is more readily stored as fat than other micronutrients (such as carbohydrates or proteins) when consumed in excess (Bray & Popkin, 1998). Indeed, dietary fat may be more greatly associated with excess weight than carbohydrate intake (Hall et al., 2015). This effect is observed in research finding a positive relationship between percentage fat intake and percentage body fat in children, but without identifying a relationship between energy density and fatness (Guillaume, Lapidus, & Lambert, 1998; Rolland-Cachera et al., 1995). These results indicate that a focus on increasing nutrient-dense food items in order to attenuate the impact of dietary fat may promote a healthy weight status (Epstein, Paluch, Beecher, & Roemmich, 2008).

Further support for the association between poor diet and childhood obesity can be observed in the influence of increasing fruit and vegetable consumption on Body Mass Index (BMI). Qian, Nayga Jr, Thomsen, and Rouse (2015) conducted a naturalistic study on the effect of free fruit and vegetable provision (FFVP) programme in schools in Arkansas, United States (US), a location associated with one of the highest rates of childhood obesity in the US. The FFVP programme gives children in elementary schools access to free fruit and vegetables to consume any time in the school day, not restricted to lunchtime or breaks, to promote a healthy diet. Data pertaining to BMI status were gathered from participating schools (in Arkansas, it is mandatory for the BMI of all public school children to be measures and recorded), and results indicated that participation in the FFVP programme was associated with a BMI percentile reduction of 4.2%. This study contributed to the literature linking increased fruit and vegetable consumption with a reduced risk of developing obesity (Tohill, Seymour, Serdula, Kettel-Khan, & Rolls, 2004).

Health Benefits of Fruit and Vegetables

However, the benefits of a diet rich in fruit and vegetables surpass weight management. Fruit and vegetables are rich in vitamins, which are associated with biochemical reactions; for example, vitamins A, E and C have antioxidant properties, exerting a protective influence over the detrimental effects of oxygen free radicals (OFRs, Shenkin, 2006). These OFRs are linked to the development of malignant properties in

tumors, amongst other stages of carcinogenesis (Dreher & Junod, 1996). It has been suggested that lifelong consumption of a diet rich in fruit and vegetables is most likely to promote these protective effects, with suggestions that these benefits are cumulative over time, and that this accumulation of health benefits is associated with a decreased risk of adult cancers (Maynard, Gunnell, Emmett, Frankel, & Smith, 2003). Supportive evidence for this association was reported by Pearson, Biddle, and Gorely (2009), who found that childhood fruit intake was inversely associated with the development of adult cancers. Indeed, fruit and vegetable intake has been associated with exerting a protective influence over the development of adult cancer in a variety of anatomical sites (Steinmetz & Potter, 1996). In addition to benefits associated from their micronutrient components, the macronutrient structure of fruit and vegetables may also protect against the development of cancer. Fruit and vegetables are generally high in fibre, a carbohydrate that is not broken down by digestive enzymes, that easily passes into the large intestine. Here, fibre is either fermented into gasses (hydrogen and carbon dioxide), or it can pass through the digestive system and bind to water, subsequently increasing stool weight. This activity promotes healthy bowel movement, and has been associated with a decreased risk of bowel cancer (Jacobs, 1988).

Research has identified that individuals with a diet high in fruit and vegetables (particularly green, leafy vegetables) may have a reduced likelihood of experiencing an ischemic stroke (Joshipura et al., 1999; Johnsen, Overvad, Stripp, Tjønneland, Husted, & Sørensen, 2003) with this relationship supported by a meta-analysis of cohort studies (He, Nowson, & MacGregor, 2006). Indeed, fruit and vegetable consumption has been associated with a lowered risk of the development of cardiovascular disease (Griep, Geleijnse, Kromhout, Ocké, & Verschuren, 2010; Hung et al., 2004), with this link supported by evidence that dietary antioxidant vitamin intake exerts a protective effect over coronary mortality (Knekt, Jarvinen, Reunanen, & Maatela, 1996; Knekt, Reunanen, Jävinen, Seppänen, Heliövaara, & Aromaa, 1994). Though this relationship has not always been supported with research evidence, possibly due to the influence of many other lifestyle factors that may predict cardiovascular disease risk (Dauchet, Amouyel, & Dallongeville, 2009), recent meta-analyses have concluded that increasing fruit and vegetable consumption exerts a protective effect against all causes of cardiovascular disease mortality (Oyebode, Gordon-Dseagu, Walker, & Mindell, 2014; Wang, Ouyang, Liu, Zhu, Zhao, Bao, & Hu, 2014). Whilst a causal influence for this effect has not been identified (Dauchet, Amouyel, Hercberg, & Dallongeville, 2006), the evidence suggests that a diet rich in fruit and

vegetables is recommended to reap these benefits, with those in the 90th centile of fruit and vegetable consumption reported to have a 15% reduced chance of developing heart disease than those in the 10th centile (Law & Morris, 1998).

Barriers to Investigating Behaviour Change

Though we have identified an area requiring intervention, there remain barriers to successfully addressing this issue; how to appropriately investigate changes in consumption behaviour. First, we consider issues of accessibility, and secondly issues with the methodological quality of research conducted.

Intervention Setting. Considering the existing literature describing the interventions that have used psychological principles to promote healthy eating in children, intervention settings fall into three main categories: home; community; or school based.

Home Based Interventions. Several interventions to promote healthy eating behaviour in children have been designed to be delivered in the home setting, often involving parents to deliver and monitor some intervention components. Whilst these interventions have reported success, there are limitations to implementing dietary interventions in a homebased setting. Knowlden and Sharma (2012) conducted a systematic review of home based interventions designed to target childhood overweight and obesity, and identified that such interventions typically do not include home visits to support the intervention, though all reviewed interventions included some element of at-home activity. Though home visits would increase the cost of the intervention and would thus be difficult to implement, it may be the case that a home observation would increase intervention fidelity and influence outcome. This results in the necessity to on compromise intervention quality to promote intervention accessibility – an intervention that is too expensive is unlikely to be commissioned to be in every home. Considering this, we must explore alternative avenues, whereby interventions are designed for mass implementation, whilst reducing cost.

Community based interventions. Other research has focussed on the development of healthy eating interventions that target communities. These interventions are typically linked to the existing community projects and children's clubs, such as boy scout groups (Thompson et al. 2009) or community support groups for disadvantaged children (Somerville, Kessler, Wallace, & Burns-Whitmore, 2012). Bleich, Segal, Wu, Wilson, and Wang (2013) conducted a systematic review of community based interventions designed to prevent childhood obesity,

and concluded that though results published in the literature are promising, there is not enough evidence to confidently assert the effectiveness of community based programmes. Further, research among specific communities presents issues regarding accessibility and subsequent generalisability. Thompson et al. (2009) utilised a sample of boy scouts, a predominantly white, middle class, and exclusively male sample. Should interventions be designed to promote healthy eating behaviour in the interests of public health, limiting the intervention to a specific (and relatively privileged) sample, such as those attending extracurricular activities, will not benefit those who are more disadvantaged, and, indeed, are reported to consume greater quantities of energy dense-nutrient poor food items (Singh, Siahpush, & Kogan, 2010). Some programmes designed to promote healthy eating behaviour in relatively disadvantaged populations have also reported success (Somerville et al., 2012). Although research suggests that poor eating habits and childhood obesity are prevalent in both economically advantaged and disadvantaged children (Singh et al., 2010), the most recent data from developed countries like the US or the UK show that the prevalence is higher in lower socioeconomic strata of society (Bann, Johnson, Li, Kuh, & Hardy, 2018). Considering this, it may be the case that interventions designed to be delivered in an environment accessible to all children will have the greatest benefits for public health.

School based interventions. One setting accessible to all children in the developed world is the school environment. The potential for school-based intervention is supported by a recent systematic review conducted by Racey et al. (2016), who assessed the effectiveness of school based interventions designed to improve dietary intake. They found that such interventions demonstrated success in decreasing childhood obesity risk, echoing the conclusions of previous systematic reviews (Katz, 2012; Knai, Pomerleau, Lock, & McKee, 2006; Van Cauwenberghe et al., 2010), with greatest success being associated with those interventions with a longer duration and increased visits from intervention specialists. It was also found that interventions incorporating home based activities were associated with poorer outcomes, assumed to be the result of poor intervention execution, such as parental passivity. These findings suggest that the school setting is optimal for intervention implementation, but that intervention design would benefit from a specific focus on school activities, and consistent, regular intervention monitoring.

Methodological Quality of Existing Research. Regardless of their setting, in order to conclude the effectiveness of interventions we must first be confident that our measures of

consumption are reliable and valid. Measures of consumption that have been used in the existing literature fall into two broad categories; direct measures and indirect measures. Much research into consumption has utilised self-report (indirect) methods of data collection (Contento, Randell, & Basch, 2002; Wind et al., 2008; Schagen et al., 2005), with food diaries, food frequency questionnaires (FFQs), and 24-hour recall questionnaires being amongst the most frequently employed tools to gain insight into an individual's eating patterns, whilst direct methods (employed by Contendo, Randell, and Basch [2002], and McKenzie [1991], for example) include direct observation of eating behaviour and simultaneous recording of data. Pears et al. (2012) compared direct and indirect measurement of fruit and vegetable consumption in primary-age school children. For the direct measure, each portion of fruit and vegetable was weighed before and after consumption, and the amount of the food item consumed was calculated in grams. A 24-hour dietary recall interview was employed as the indirect measure, and was completed by teachers at the school in the dining hall before being sent home with the child after school to be completed by parents. Upon analysis, it was discovered that the measures had yielded contrasting results in evaluating the effects of a school-based intervention, the Food Dudes, on children's eating: the dietary interview failed to detect any difference in fruit and vegetable consumption, whilst direct observation recorded a significant 15.6 gram mean increase in fruit consumption in the intervention school, and a 12.9 gram mean decrease in vegetable consumption in the matched control participants. These findings indicate that indirect observation methods may be lacking the sensitivity required to identify modest, but significant, changes in dietary behaviour. Pears et al. (2012) concluded that such dietary measures are unlikely to be sufficiently accurate to determine whether or not an intervention has been successful in encouraging behaviour change. Considering this, it is likely that direct observation of consumption behaviour is superior to indirect methods, which lack the sensitivity required to investigate intervention effects.

Key Theoretical Approaches in Psychology That Have Been Applied to Understanding and Changing Eating Behaviour

In order to investigate and improve dietary behaviour, we must first understand the mechanisms guiding that behaviour, and those which promote behaviour change. Main models that have been applied to changing dietary behaviours include the Transtheoretical Model of Behaviour Change (TMBC; Prochaska & Velicer, 1997); the Theory of Reasoned

Action (TRA; Ajzen & Fishbein, 1980) and Theory of Planned Behaviour (TPB; Ajzen, 1985); and Social Learning Theory (SLT; Bandura, 1971).

Transtheoretical model of behaviour change. The TMBC was developed by Prochaska and Valicer (1997), and has been described as the 'dominant' behaviour change model (Armitage, 2009). This model integrates theory with components of multiple psychotherapies to promote positive behaviour change by providing strategies to guide an individual towards a target behaviour. Several constructs are present in the TMBC, including the stages, processes and levels of behaviour change, self-efficacy, and decisional balance.

The *stages* of behaviour change include (i) *precontemplation*, where individuals do not intend to change their behaviour in the near future; (ii) *contemplation*, when individuals decide that they want to change their behaviour; (iii) *preparation*, when individuals are ready to change; (iv) *action*, where the behaviour has now been changed but requires will power to maintain; (v) *maintenance*, after the behaviour has been changed, and this change has been maintained for more than six months; and (vi) *relapse*, which may occur at any time. The processes of change are those activities that individuals engage in to progress through the stages of change. Ten *processes* of change are described, including *dramatic relief*, where individuals are said to feel anxiety over the perceived inability to change a behaviour, or relief at information regarding other people successfully changing that behaviour, and *self liberation*, where individuals are said to be achieving a belief in their ability to change. The five *levels* of change consider the complexity of change, and different therapeutic intervention foci are recommended for each increasingly complex level of change. These levels and their corresponding recommended therapies include: symptom/situational problems (behaviour and exposure therapy); current maladaptive cognitions (cognitive therapy and rational emotive behaviour therapy); current interpersonal conflicts (interpersonal therapy); family/systems conflicts (structural family therapy); and long-term intrapersonal conflicts (psychoanalytic therapies).

At the core of the TMBC is the notion of *self-efficacy*. According to self-efficacy theory (Bandura, 1977), an individual is more likely to succeed in a task if they have a greater belief in their ability, thus, the TMBC focuses on promoting this belief and regularly assesses this by calculating an individual's overall confidence score, based on assessments of situational temptations. Interventions and goals are then planned accordingly by the practitioner. In addition, the practitioner will gage decisional balance, how an individual

cognitively weighs the gains and losses associated with changing the target behaviour. These are recorded on a decisional balance sheet, and are expected to change in cognitive weight as the individual progresses through the stages. Indeed, research studying the change of 48 target behaviours in 100 samples has identified that the losses are heavily weighted in the precontemplation stage, begin to lessen their influence in the middle stages, and at the action level, the perceived gains of behaviour change are the most influential (Hall & Rossi, 2008).

The success of the TMBC based interventions is manifest in research observing a positive influence on smoking cessation (Prochaska, DiClemente, Velicer, & Rossi, 1993; Prochaska et al., 2001; Prochaska, Velicer, Fava, Rossi, & Tsoh, 2001), stress management (Evers, Prochaska, Johnson, Mauriello, Padula, & Prochaska, 2006), and weight management (Johnson, 2008), and has also been specifically applied to consumption behaviours. Research indicates that the TMBC framework and constructs can predict fruit and vegetable consumption behaviour in adults (Horwath, Schembre, Motl, Dishman, & Nigg, 2013) and adolescents (Di Noia, Schinke, Prochaska, & Contento, 2006), with subsequent computer-based interventions found to be associated with an increase in fruit and vegetable consumption (Di Noia, Contento, & Prochaska, 2008). The TMBC framework has also been found to have a positive influence on childhood eating behaviours, with Frenn, Malin, and Bansal (2003) reporting TMBC intervention to be negatively associated with fat consumption in a large sample of culturally diverse middle school children; however, fruit and vegetable consumption was not targeted in this study.

Overall, whilst the existing evidence indicates the potential for the TMBC based interventions to elicit a positive change in (older) children's diet, no studies have been published specifically investigating this effect. Indeed, it seems likely that the personalised nature of TMBC interventions, which take into account each individual's level of change and attenuate behaviour change strategies to these, is not conducive to mass implementation in a cohort of children with varying levels of motivation and high variability in the processes guiding their behaviour. It also seems unlikely that very young children's behaviour is governed by the same principles as adolescents' or adults' actions.

Theory of reasoned action and theory of planned behaviour. The TRA was developed by Ajzen and Fishbein (1980) to describe how individuals formulate their intentions, which subsequently predict behaviour, though behaviour is ultimately moderated by actual control.

The TRA considers a number of concepts, including (i) *behaviour*, an observable event; (ii) *intentions*, here considered as the perceived probability of engaging in a behaviour; (iii) *attitude*, the individual's personal disposition towards the favourableness of the behaviour, influenced by instrumental aspects (i.e., anticipated consequences) and experiential aspects (i.e., perceived experiences); and (iv) *perceived norms*, the perceived social pressures to engage in the behaviour, influenced by injunctive norms (i.e., perceptions of how one should behave) and descriptive norms (i.e., perceptions of how others behave).

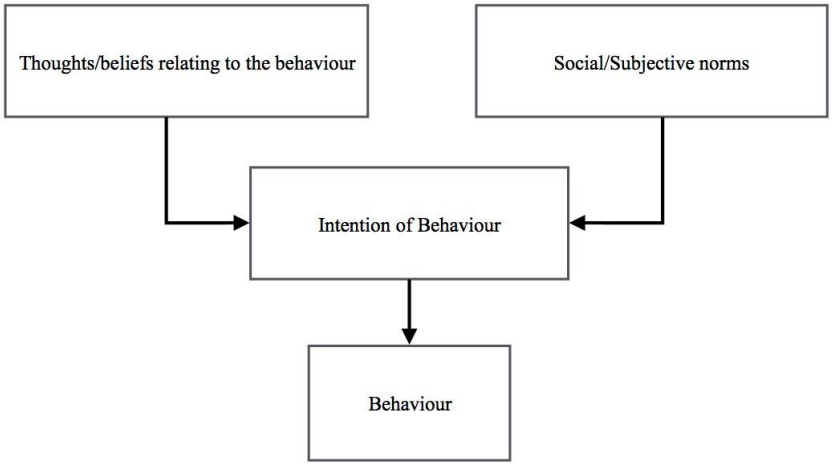

Figure 1.1. The Theory of Reasoned Action adapted from Ajzen and Fishbein, 1980

The authors of the TRA postulate that attitudes towards the behaviour and perceived norms associated with the behaviour influence intention (see Figure 1.1). The TRA has been applied to a variety of behaviours, with research indicating that it can predict 'whistle blowing' (Richardson, Wang, & Hall, 2012), infant-feeding choices (Manstead, Proffitt, & Smart, 1983), and intention to vaccinate (Roberto, Krieger, Katz, Goei, & Jain, 2011). However, these behaviours may all be considered rational. The TRA has received criticism for being insufficient to explain volitional behaviour, such as those behaviours influenced by affect (Hale, Householder, & Greene, 2002), and so the TPB was developed by Ajzen (1985) in order to improve upon the predictive power of the TRA.

The TPB builds upon the TRA by including a further predictive factor; *perceived behavioural control*, which is defined as an individual's belief in their ability to engage in a behaviour, influenced by capacity (thematically similar to self efficacy [Bandura, 1977]), and actual control. Attitudes, perceived norms, and perceived behavioural control influence

intention, which subsequently influences behaviour; however, perceived behavioural control may bypass intention and directly influence behaviour (see Figure 1.2).

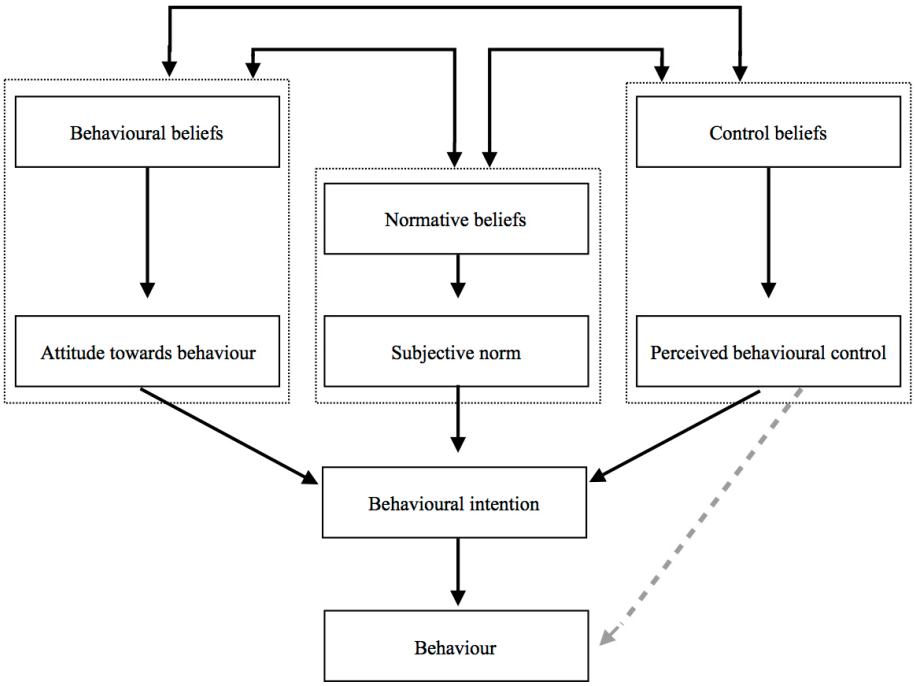

Figure 1.2. The Theory of Planned Behaviour adapted from Ajzen (1985).

The TPB has been applied to behaviour change, with research indicating that the TPB can predict donations to charity (Van der Linden, 2011), condom use (Albarracin, Johnson, Fishbein, & Muellerleile, 2001), and healthy eating behaviour (Conner, Norman, & Bell, 2002). Whilst some research suggests that the TPB may predict fruit and vegetable consumption in children (Gratton, Povey, & Clark-Carter, 2007), supporting evidence is sparse, with other investigations failing to identify an effect (Lien, Lytle, & Komro, 2002). Evidence suggests that the variables included in TPB may not be sufficient to predict or moderate health behaviour, as the TPB does not consider perceived need (McConnon et al., 2012), unconscious behavioural influences (Sheeran, Gollwitzer, & Bargh, 2013), or the influence of engaging in the behaviour on subsequent behavioural intention (McEachan, Conner, Taylor, & Lawton, 2011). Indeed, considering these criticisms, some theorists have called for the TPB to be retired (Sniehotta, Presseau, & Araújo-Soares, 2014), and alternative theories, such as SLT, to be utilised in order to promote positive behaviour change.

Social learning theory. Bandura (1971) developed SLT to explain behaviours learned in interpersonal contexts that were not sufficiently explained by other models of learning behaviour (Bandura & Walters, 1963). The key assumptions of the SLT are that (i) learning is a cognitive process; (ii) learning can occur vicariously through observation of others (models) and by observing those actions being rewarded or punished (vicarious reinforcement); (iii) learning may occur without an observed behavioural change; (iv) reinforcement is associated with, but is not essential to, learning; and that (v) the learner is an active recipient of information, with cognition, behaviour, and environment providing mutual influencers (reciprocal determinism). Bandura (1961) stated that modelling may be achieved by observing behaviour directly, sought through instruction, or symbolic (where media provides models, e.g. cartoon characters).

Bandura's SLT has been found to predict a number of behaviours, including adolescent smoking (Akers & Lee, 1996), ecstasy use (Norman & Ford, 2015), and intimate partner violence (Powers, Cochran, Maskaly, & Sellers, 2017). SLT has also been applied to healthy eating behaviour (Carmody, Istvan, Matarazzo, Connor, & Connor, 1986). Michie, Jochelson, Markham, and Bridle (2009) have identified, through meta-analysis, that the SLT may be successful in promoting behaviour change, but they suggest that the effectiveness of these strategies was lower than anticipated, possibly due to poor application of theory to practice. Considering this, it is important to identify those components of the SLT that can be effectively applied to positive behaviour change, and promote interventions that incorporate these components.

Maintaining Behaviour Change

The theories discussed, and their associated interventions, highlight the potential for positive behaviour change. However, behaviour change and behaviour maintenance are not synonymous, and indeed research has indicated that intervention effects may not be sustained over time (Avenell, 2004; Dombrowski, Avenell, & Sniehott, 2010). Kwasnicka, Dombroski, White, & Sniehotta (2016) concluded in their recent systematic review, that in order for behaviour change to be sustained, one consistent motivating factor must be present, to counteract motivation depletion to engage in the target behaviour, before this behaviour change becomes unconscious and habitual. These motivators may be actual enjoyment of the target behaviour, satisfaction with behavioural outcome, self-determination, or the behaviour being congruent with the individual's values, and individuals designing interventions to elicit

behaviour change may benefit from considering these factors during intervention development. A further suggestion to promote the longevity of behaviour change maintenance may be to focus on the manipulation of non-conscious processes, rather than deliberative processes (Marteau, Hollands, & Fletcher, 2012). Many processes that guide our behaviour are unconscious (Bargh, & Morsella, 2008), and Hollands, Marteau, and Fletcher (2016) suggest that interventions targeting these processes may be more likely to promote lasting behaviour change than those with a focus on instruction. Interventions incorporating these principles are further discussed in the Choice Architecture and Behavioural Nudges section later in this chapter.

Key Approaches that Work in Changing Eating Behaviour

Considering that the application of theory to intervention development has yielded inconsistent results (Michie et al., 2009), a focus on developing interventions based on the specific elements of behaviour change approaches that have been found to be successful in eliciting positive behaviour change may promote long-term intervention success.

Modelling. Modelling is a component of SLT, and describes how an observer can learn a behaviour without the necessity to directly experience the behaviour or outcome (outlined above, Bandura, 1961; Bandura, 1971). According to SLT, in order for an observed behaviour to influence future behaviour, the observer must experience several processes; attention, retention, reproduction, and motivation. In order for learning to occur, the observer must attend to the model enacting the behaviour. Attention is influenced by both observer characteristics (e.g. arousal) and the characteristics of the observed behaviour (e.g. relevance to the observer). Following this, the observer must be able to retain this information. Retention is influenced by the characteristics of the observer (e.g. cognitive capabilities) and the behaviour (e.g. complexity). Then the observer must reproduce the behaviour, though reproduction may be limited by sensorimotor ability, and finally, the observer must be motivated to maintain the learned behaviour. Factors associated with the model that may influence likelihood of imitation include the observation of the behaviour being reinforced (Flanders, 1968), model age, whereby models of a similar age or slightly older have the greatest influence over imitation (Brody & Stoneman, 1981), and the presence of multiple models (Fehrenbach, Miller, & Thelen, 1979).

Systematic review has identified a strong association between role modelling and food consumption (Cruwys, Bevelander, & Hermans, 2015), with parents (Brown & Ogden, 2004) and peers (Salvy, De La Haye, Bowker, & Hermans, 2012) being key influencers. Indeed, interventions utilising modelling to promote healthy childhood eating behaviour have yielded promising results. Natale et al. (2014) developed an intervention to combat obesity in a child day-care setting for pre-school children, utilising parents and teachers from 12 centers to promote a healthy eating and physical activity role modelling curriculum, where parents were taught how to effectively model healthy eating behaviours (16 centres were observed as no treatment controls). Results indicated that parents in the intervention condition were successful in significantly increasing the fruit and vegetable consumption of their children through the use of role modelling, whilst an increase in unhealthy food consumption was observed in the control condition. Teachers were found to have no significant influence over children's eating behaviour. Similar benefits were found by Stock et al. (2007), who paired younger children (fourth grade) with slightly older (seventh grade) 'healthy buddies' in a peer-modelling healthy lifestyle intervention. The healthy buddies (seventh grade children) were taught how to model healthy eating and physical activity for their younger counterparts, and also how to overcome the challenges associated with choosing healthy options. Results indicated that both healthy buddies and their younger counterparts showed an increase in healthy behaviour, and lesser increases in BMI and systolic blood pressure over time, compared to no-treatment control students. The results of these studies indicate the potential for a positive influence of parents and peers on childhood eating behaviour.

Reinforcement. Operant conditioning (Skinner, 1938) is a component of the behaviourist theory of learning, and describes how individuals learn through a process of reward and punishment. Five behavioural consequences are described, these include: *positive reinforcement*, where a behaviour is followed by a reward being added to the environment (e.g. eating a sweet results in a pleasant taste); *negative reinforcement*, where a behaviour results in the escape from something unpleasant in the environment (e.g. closing a window may remove a cold draught); *positive punishment*, where a behaviour is followed by something unpleasant being added to the environment (e.g. not tying shoelaces may result in falling and experiencing pain); *negative punishment*, (e.g. behaving in a rude manner may result in attention from others being withdrawn) ; and *extinction*, where the behaviour that was previously rewarded is no longer effective in eliciting the reward, and so the behaviour is

ceased (e.g. a child helping with household chores to earn pocket money may stop this behaviour if monetary rewards are no longer given). If reinforced, a behaviour is more likely to be continued. If punished, a behaviour is less likely to be repeated. However, the influence of reinforcers can be moderated in several ways (Miltenberger, 2011), including: satiation/deprivation (a reinforcer is more salient when the individual is deprived of it, e.g. food will be more reinforcing to a hungry individual); immediacy (a reinforcer is more salient if presented immediately after the associated behaviour); contingency (that reward can only be gained by engaging in a specific behaviour); and size (the reinforce must be 'worth' engaging in the behaviour).

The principles of reinforcement have been successfully applied to promoting childhood healthy eating behaviour. Cooke et al. (2011) compared the use of tangible reward, social reward, and no reward (mere exposure/control) to promote vegetable liking in a sample of 472 children aged 4 to 6 years old. Children were individually invited to taste a vegetable, and were then rewarded for tasting the vegetable with either a sticker (tangible reward), or praise ("Brilliant, you're such a good taster!"). Children in the no reward (mere exposure/control) condition were invited to taste the vegetable, but received minimal social interaction. Results showed vegetable liking to increase significantly in all conditions, with these results most prominent in the reward conditions, though no significant difference in vegetable liking was observed between the intervention conditions. These effects were maintained in the intervention condition at a three month follow-up, however, liking in the mere exposure condition had returned to baseline levels.

Alternative uses of reward-based interventions have been designed to utilise a token economy in an otherwise unchanged school dining environment. Loewenstein, Price, and Volpp (2016) trialled the effectiveness of a rewards-based intervention in 40 elementary schools and involving 8,000 children. Schools were assigned to either a three- or five-week intervention condition. During the intervention period, children received a token worth 25 cents that could be spent at the school carnival or book fayre each time they consumed at least one portion of vegetables. Results indicated that two months after the withdrawal of the intervention, the number of children consuming at least one portion of vegetables in the three week and five week interventions remained 21% and 44% (respectively) above baseline consumption scores. The results of these studies suggest that rewards can be effectively utilised to promote engagement in childhood healthy eating behaviour.

However, the use of rewards to promote positive behaviour has received criticism, with some academics claiming that the use of extrinsic motivation may extinguish intrinsic motivation, resulting in worse behavioural outcomes following the withdrawal of contingent rewards (Deci, Koestner, & Ryan, 1999). Indeed, rewarding a behaviour may indicate to children that the target behaviour is unpleasant, and decrease motivation to engage in the behaviour in the absence of a reward (Newman & Taylor, 1992). However, research has identified some variables that make rewards more likely promote target behaviour, these include ensuring that the rewards are highly desirable, whilst also indicating that the target behaviour is independently rewarding and enjoyable (Cameron, Banko, & Pierce, 2001). These variables must be considered when developing a rewards based intervention. Of course, in most interventions designed to promote healthy eating, children are not intrinsically motivated to eat target foods; this can be seen from very low baselines. Therefore, the issue of external reinforcement of eating diminishing children's intrinsic motivation to eat target foods does not arise.

Mere exposure effect. The mere exposure effect, or familiarity principle, is the phenomenon whereby individuals develop a preference for something simply as a result of increasing familiarity. This was first systematically investigated by Zajonc (1968), who identified that expressed liking of familiar words was significantly higher than liking of a novel word. He later expanded his research to include assessment of the liking of polygons, photographs of expressions, and nonsense words, demonstrating the generalisability of the mere exposure effect (Murphy & Zajonc, 1993).

Indeed, the influence of mere exposure has been observed on eating behaviour (Pliner, 1982), evidenced by investigations suggesting that children are more likely to accept a new food item if it is visually similar to a food item with which they are familiar (Tuorila, Meiselman, Bell, Cardello, & Johnson, 1994). This influence has been successfully applied to healthy eating intervention, with research indicating that picture-book exposure to food items increases the likelihood of children consuming that food item in the future (Houston-Price, Hill, Kennedy, & Owen, 2010). However, interventions seldom utilise mere exposure as the sole component of an intervention to promote lasting changes to eating behaviour, possibly due to research indicating that the impact of mere exposure may be insufficient to promote lasting behaviour change (Cooke et al., 2011).

Repeated tasting. Similar to the concept of the mere exposure effect is the influence of repeated tasting, with research suggesting that repeated tasting of a food item (up to 15 exposures) increases expressed liking for, and consumption of, that food item (Caton et al., 2013; Sullivan & Birch, 1998; Wardle, Herrera, Cooke, & Gibson, 2003). This is theorised to be due to a biological adaptation, whereby repeated exposure to the taste of a food increases its perceived pleasantness; you can 'train' your taste buds to like new foods (Lowe, 2014).

One barrier to the utilisation of repeated tasting to promote fruit and vegetable liking is food rejection and neophobia, a specific distrust or fear of novel food items (Raudenbush & Frank, 1999). It has been hypothesised that children's rejection of vegetables (particularly, cruciferous vegetables) can be attributed to evolutionary advantage (Steiner, 1977); bitter tastes are often an indication of a poisonous substance. Children becoming more mobile between the ages of 2 and 6 years old would increase their exposure to new and potentially toxic foods, and behaviours such as food neophobia and the rejection of bitter tastes may have been an evolutionary adaptation (Cashdan, 1994). Indeed, the observation of food neophobic behaviours in capuchin monkeys (Visalberghi & Addessi, 2000), and rats (Rozin, 1976), further supports this evolutionary hypothesis. This evidence suggests that encouraging a child to taste a food item may prove difficult, and so further behaviour modification techniques must be employed to promote consumption behaviour change.

Behavioural nudges and choice architecture. One assumption of behavioural economics is that behaviour is guided by a continuous analysis of the costs and benefits associated with engaging in a behaviour. Thaler and Sunstein (2008) describe one component of this as *nudge theory* which refers to *choice architecture*, the way that an environment is presented to individuals and the influence that this presentation has on decision making, and *behavioural nudges*, aspects of choice architecture that increase the salience of a specific choice. The aim of altering the choice architecture to promote a particular choice is to 'nudge' an individual towards a specific decision, but without limiting other competing choices. It is postulated that much of daily decision making is not done consciously or rationally.

Behavioural nudge interventions designed to promote childhood healthy eating behaviour have yielded promising results. Anzman-Frasca et al. (2015) compared children's food orders at a US restaurant chain before and after menu modifications to promote healthier food choices. Menu modifications included adding more healthy meals to the children's

menu, increasing the variety of healthy side dishes, and removing French fries and soda as the default components of a children's meal (though these items were still available if requested). Results indicated a significant increase in selection of healthy meals and side dishes, and a significant decrease in total calories ordered. Choice architecture has also been amended in the school cafeteria to promote healthy food item selection. Ensaff et al. (2015) implemented several changes in a secondary school canteen, including offering sliced fruit in take-away containers, promoting healthy sandwiches with stickers identifying them to be a healthy choice, and displaying whole fruit on a decorative stand. Results indicated that participants were 2.5 times more likely to select a healthy food item during the intervention period compared to baseline. These results indicate that modifying the environment without limiting choice can have a positive influence on healthy eating behaviour.

Overall, the present list of behaviour change tools that have been successfully applied to change children's diets for the better is by no means exhaustive, but it lists the key variables that can be comparatively easily introduced or manipulated to influence children's food choices, and their consumption of previously ignored or disliked foods, including fruit and vegetables.

Aims and Objectives of the Present Thesis

To summarise, children are not consuming an adequate quantity of fruits and vegetables to promote optimum health (De Bourdeaudhuij et al., 2008; Jackson, Romo, Castillo, & Castillo-Duran, 2004; Ransley et al., 2007; Yngve et al., 2005), and the lack of quality data collection methodology limits our ability to apply and investigate intervention strategies which yield valid, conclusive results. The present thesis describes a newly developed and validated digital photography data collection method, applicable to many environments, and can be utilised by researchers investigating nutritional consumption to compare any aspect of nutrition, regardless of intervention type or variable under scrutiny (e.g. can be used to compare weight, any macro-/micronutrient) (see Chapter 2), and demonstrate it's applicability in two experimental chapters. First, we utilise the measure to evaluate a complex, multicomponent intervention, the Food Dudes (see Chapter 3). The

digital photography measure was successful in identifying substantial differences in consumption over time for several variables, but also sufficiently sensitive to detect modest but significant changes in vegetable consumption. Considering that multicomponent interventions are seldom implemented in schools due to their high cost, we identified through systematic review that simple, nudge-based interventions are currently being investigated as a method of changing children's eating behaviour in schools (see Chapter 4). However, much of this research had been conducted using unreliable self-report measures, or unvalidated direct visual estimation methods, presenting a gap in the literature for a well constructed, well powered study into the use of nudges to promote healthy eating behaviour in schools. Finally, we demonstrate the applicability of the digital photography measure in an investigation designed to fulfil this gap in the literature, and identified promising results for fruit consumption.

Chapter 2

Measuring Lunchtime Consumption in School Cafeterias: A Validation Study of the Use of Digital Photography

The following describes a study designed to validate the use of our digital photography protocol to measure children's consumption at lunchtime. We specifically designed this protocol for use in a fast-paced school cafeteria setting. This paper was written for researchers with an interest in measuring childhood nutrition and school lunchtime consumption since, at the time of writing, the few existing validation studies used contrived conditions and their methods remain to be shown to work in the hectic school settings, under time and space pressures common to real life data collection. The only 'applied' validation that we identified in the existing literature utilised rather imprecise coding and generous agreement criteria (Olafsdottir et al., 2016). The present study describes a method that was designed to be better, and presents a well-run and well-powered validation. A more in-depth description of the digital photography protocol was made freely available on the first author's Research Gate page, and can be found in Appendix 4.

Prior to submission to a journal, these findings have been presented at two international conferences:

Marcano-Olivier, M. I., Horne, P. J., Viktor, S., Pearson, R., and Erjavec, M. (2016, June) *Accurate Assessment of Nutritional Intake in School Cafeterias: A Validation of the Digital Photography Method*. Poster Presented at the 8th European Association for Behaviour Analysis, Enna, Sicily. (See Appendix 6)

Marcano-Olivier, M. I., Horne, P. J., Viktor, S., Pearson, R., and Erjavec, M. (2017, June) *Accurate Assessment of Nutritional Intake in School Cafeterias: A Validation of the Digital Photography Method*. Paper presented at the Annual Meeting for the International Society for Behavioural Nutrition and Physical Activity, Vancouver, Canada. (See Appendix 5)

At the time of thesis submission, this paper was under review in Public Health Nutrition, a peer-reviewed journal that publishes research for the interest of epidemiologists, health promotion specialists, academics and researchers, with an aim to promote the use of nutrition in disease prevention, and to identify solutions to public health issues. This is an indexed open access journal (IF=2.48) promoting a wider, international readership.

Authors' Contributions

MMO designed and coordinated the study, processed and analysed data, and drafted the manuscript. RP contributed with data collection, inputting, and second coding. PJH contributed with editing. SV advised on statistical analysis and results. ME obtained funding, supervised all aspects of the research, and co-wrote the final manuscript. All authors have read and approved the final manuscript.

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Abstract

This study validated a non-invasive digital photography measure of food consumption suitable for use in busy school cafeterias. A small research team recorded children's

lunchtime consumption in one primary and one secondary school over seven working days. Participants' (N = 258) lunchboxes or dinner trays were photographed pre- and post-consumption, and food items served were weighed pre- and post-consumption, for comparison. Using standardised digital images, consumption of each food item was estimated to the nearest 10% to calculate the approximate weight consumed in grams. Results indicated that, for each food category, (i) consumption estimates based on photography were accurate, yielding only small differences between the weight- and photograph-based judgments (M_{BIAS} = 0.15-1.64 grams, equating to 0.45-3.42% of consumed weight), and that (ii) good levels of inter-rater agreement were achieved, ranging from moderate to near perfect (Cohen's $\varkappa$ = .535-.819). This confirmed that consumption estimates derived from digital photography were accurate and could be used in lieu of objective weighed measures. Our protocol minimised disruption to daily lunchtime routine, kept the attrition low, and enabled better agreement between measures and raters than was the case in the existing literature. Accurate measurements are a necessary tool for all those engaged in nutrition research, intervention evaluation, prevention, and public health work. We conclude that our simple and practical method of assessment should be used with children across a range of settings, ages, and lunch types.

Key Words: Validation, Consumption, Digital Photography, Cafeteria, School, Visual Estimation, Children, Nutrition, Diet.

Introduction

In the past two decades, the onset of affordable, easy to use, good-resolution digital photography had provided the researchers with a convenient new tool for dietary assessment. The appeal of this method includes creation of permanent records which can be examined in several ways, by more than one independent coder, and to a greater level of detail, than is the case with visual estimation of consumption performed 'in situ' (Martin et al., 2014). Using digital photography, small teams of observers, causing minimal disruption in busy dining

environments, can capture the information on portions (servings) and plate waste from a large cohort of participants (McClung et al., 2017). In principle, this information can subsequently be stored, re-analysed, and shared. Therefore, digital image collection had replaced the more traditional methods for estimating consumption, both direct (e.g. weighing of foods and plate waste; visual estimation by a group of observers present at meals) and indirect (e.g. using dietary diaries or recall). Further, some recent reports are emerging that are investigating how images can complement other forms of dietary assessment as prompts and as complementary data sources (Lazarte, Encinas, Alegre, & Grandfeldt, 2012; Ptomey et al., 2015a; Ptomey et al., 2015b).

Many studies have used photography-aided visual estimation without reporting the validity or reliability of this method (Becker et al., 2013; England et al., 2016), but several validation reports have also appeared in the literature. Some of these publications considered only the reliability of the photography estimates without checking their accuracy against any other measure (Christoph, Loman, & Ellison, 2017; Swanson, 2008; Swanson, 2009). Others have compared estimates based on digital photographs to weighing of the foods under controlled lab conditions. For example, Williamson et al. (2004) have used a contrived scenario where plates of food were arranged by the researchers and plate waste mimicked by subtracting precisely weighed amounts of foods, and Sabinsky, Toft and Andersen (2013) assessed accuracy in consumption estimations from photographs of typical sandwiches that children may bring from home to school. These studies show that, in principle, raters' estimates based on digital photographs can be sound, but they cannot validate data collection protocols performed under free-living conditions.

Pouyet, Cuvelier, Benattar, and Giboreau (2015) addressed this issue by examining photography-based dietary assessment in a geriatric setting, and Nicklas et al. (2017) looked at utilising caregivers as data-collectors, using iPhones to remotely photograph total weekly food consumption of preschool children. However, these studies have administered their protocols in quieter environments where meals and plate waste can be photographed at leisure, out of the way of diners or canteen staff, or indeed in their complete absence. Hanks, Wansink, and Just (2014) attempted to validate digital photography in a real-life school canteen setting; however, data were only collected during one lunch period, and available foods were those that are typically distributed in pieces and do not mix, such as chicken nuggets, sandwiches, or cookies, which are very different from 'wet' foods like stews or

curries or baked beans that are sauce-based and spread on the plate, mixing with other ingredients, and which make the plate waste much more difficult to estimate.

In a systematic review of evidence for image-assisted dietary assessment, Gemming, Utter, and Mhurchu (2015) called for better validation studies using criterion measurement and protocols capable of capturing information in free-living research with children and adolescents. To our knowledge, only one recent investigation reported a successful validation of photographic estimates against weighed measures with school-provided meals' data collected in two primary school cafeterias (Olafsdottir et al., 2016) albeit using very generous agreement criteria.

Considering this gap in the literature, the present study had been designed to validate a simple but versatile protocol for collection of consumption data in free-living cafeteria environments, in primary and secondary school settings, and for meals provided both by caterers and by parents.

Method

Aim

This study was designed to validate the use of digital photography as a method of nutritional data collection in busy school cafeterias, by (i) comparing estimates of consumption from digital photographs to weighed measures, and (ii) establishing inter-rater reliability of photography-based estimates.

Participants

Following the distribution of opt-out parental consent forms (see Appendix 7 and 8), and study information sheets to head teachers (see Appendixes 9 and 10) and staff members (see Appendixes 11 and 12), 131 children from a primary school in North Wales and 127 children from a secondary school in the West Midlands took part. Both samples were well gender balanced (67 females in primary and 59 in secondary school) and represented a wide range of ages: 5-10 years old for primary (with 24 children in year 1; 25 in year 2; 23 in year 3; 20 in year 4; and 29 in year 5) and 11-18 years for secondary school (30 in year 7; 17 in year 8; 35 in year 9; 23 in year 10; and 19 in year 13). Participants were of a predominantly Caucasian origin, reflecting the demographics of their regions (rural Wales and urban England, respectively). Nineteen children (7%) were excluded because of incomplete data,

leaving a final sample of 239 participants. Each child contributed data for one lunchtime meal.

Materials

To conduct the photography measure, 4 digital cameras were used (Fujifilm Finepix, 16 mega pixels, Model no. AX650). To standardise photographs, cameras were positioned on tripod stands (Tiffen Davis, & Sanford, Vista EXPLORERV 60-Inch Tripod), with tape measures and protractors available to ensure correct set-up; the camera was approximately 45cm away from the plate, and at a 45 degree angle. This ensured that photographs contained consistent size and depth information necessary for coding.

Food items were either displayed on paper plates for lunchbox meals, or plastic school dinner trays. Plain white paper participant identification tags were attached to lunchboxes. White self-adhesive participant identification labels were attached to red metallic wrist bands given to each participant to wear during lunchtime, and to the plate/tray for later coding of the food and waste in each photograph. Non-latex gloves were worn at all times by researchers when handling food items.

Procedure

Data were recorded over four consecutive days (Monday – Thursday) in the primary school, and three consecutive days (Monday – Wednesday) in the secondary school. On these days, researchers arrived at the school early and set up a data collection area in the school gym. One researcher was present during each participating class registration period to distribute identification stickers and wristbands, and to explain the research to the children. Pre-consumption photographs and weights were then taken for each food item provided to the children. The protocol differed depending on whether the participant had a lunchbox or was given a school dinner.

Lunchboxes. Participants' lunchboxes were collected during registration and taken to the study area to be photographed. The contents of each box were spread on a paper plate. They were clearly visible and any items that could be unwrapped (e.g. sandwiches in tin foil or cling film) were exposed for the purpose of the photograph. Those items that could not be unwrapped (e.g. yogurts) were photographed and weighed in their wrapping, and the weight of each wrapping type (e.g. small yogurt pot) was deducted from the pre-weight record. Items

were then individually weighed and these weights were recorded on data collection sheets (see Appendix 13). Those items that were comprised of more than a single component (e.g. a 'ham sandwich') were weighed as a single item, and weights of fillings were approximated based on separate measurements (see below). Lunchboxes were restored and returned to participants after morning break time.

School dinners. Estimate food measurements were calculated by asking caterers to serve researchers five portions of every food item available to children. Each portion was weighed on a plastic dinner tray and from this a mean was calculated for each food item. All food items weight were recorded. The portion that was closest to the mean for that food item was photographed (to be used as a reference for a typical portion). At lunchtime, participants were instructed to come to researchers after they had been served their lunch, but before they sat down to eat, so that a pre-consumption photograph could be recorded for each child.

At lunchtime, all children sat down to eat as usual. Once the participants had finished eating, they handed their lunchbox or dinner tray to the researchers positioned at the back of the hall by the waste bins, to protect against attrition from children disposing of waste food before it had been photographed. Researchers photographed the dinner trays or contents of each lunchbox, and weighed each remaining food item individually (in the same manner as the pre-consumption data collection) before returning lunchboxes to participants or disposing of plate waste and returning dinner trays to the cafeteria staff.

Data Processing and Coding

Weighed consumption measures. For each child, consumption was calculated by subtracting post-consumption weight from estimated pre-consumption weight, (or known pre-consumption weight stated on branded snack packaging), for each recorded food item.

Consumption estimates from digital photographs. Following our unpublished pilot work, consumption analysis training protocol was developed for the present study. A representative sample of photographs from the data set, showing a variety of home- and school-provided lunches and the associated plate waste, were coded jointly and then independently by a pair of raters. The percentage consumed for each food item was estimated to the closest 10% (on an 11-point scale, from 0-100% consumed) using the pre- and post-

consumption photographs. Successful completion of the training, manifest in the raters fully agreeing on over 90% of items, was achieved in approximately two working days. Figure 2.1 illustrates pre- and post-consumption plate photographs from the present data set. Following training, the lead researcher coded all data; to calculate inter-rater agreement, a second rater independently coded 40% of the total food items.

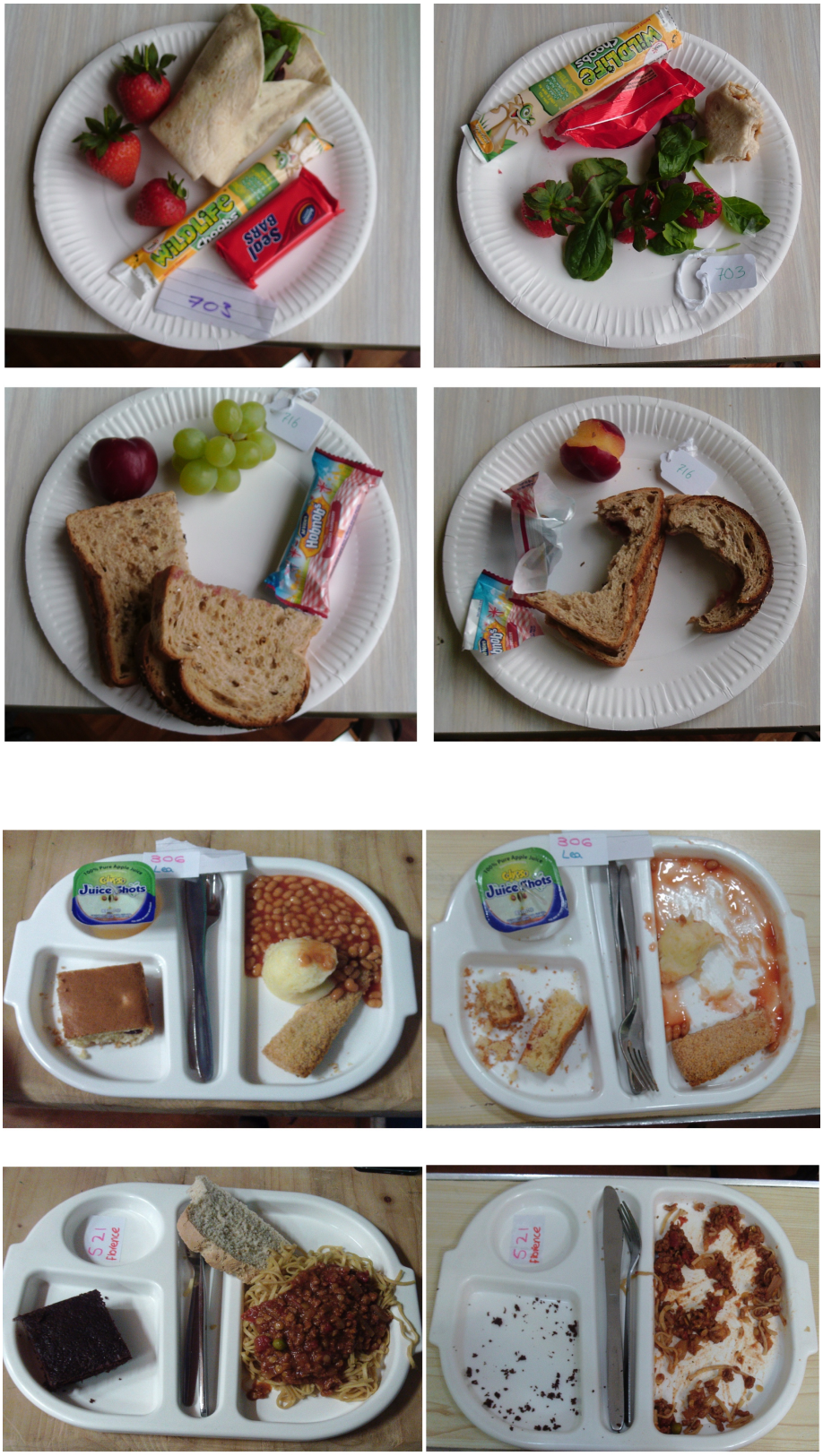

Figure 2.1. An example of pre- and post-consumption photographs of school-provided lunches served on trays and parent-provided lunches photographed on paper plates.

Next, these percentage consumption estimates were converted to weights. The weight in grams for each food item in lunchboxes was judged by referring to product information published by the manufacturer (e.g. a Nutri-grain ® soft baked fruit cereal bar weighs 37g according to published product information, and so this was the weight recorded for Nutri-grain ® bars and supermarket own-brand varieties). Where this information was unavailable (e.g. for sandwiches), an average sandwich weight was calculated from published product information (e.g. the average "medium" slice of bread weighs 40g, the average "small" bread roll weighs 60g), and weighing samples (e.g. making 5 cheese sandwiches and weighing the components independently to estimate an average sandwich filling weight for commonly presented food items). For example, the average cheese sandwich on sliced bread was estimated to weigh 100g in total, with additional fillings (e.g. cheese and ham) increasing the estimated weight by 20g per filling, or 5g per salad filling (e.g. cheese and lettuce). Participants were also often presented with pieces of fruit, and so estimates were calculated from an average sized piece of fruit (e.g. an average apple weighs 70g, with 60g edible flesh, minus 10g for core; an average 'snack size/kids size' apple weighs around 50g with 40g edible flesh).

Following this protocol, it was possible to estimate the weight of each food item that children consumed in grams. For example, if a participant was judged to have consumed 70% of a Nutri-grain ® bar then 26g was consumed, or if a participant consumed 80% of a mean 64g portion of carrots then 51g was consumed.

Preliminary data analyses. All data were inputted into the IBM Statistical Package for the Social Sciences (SPSS) version 22, including participant number, food item, pre- and post-weight records, weight consumed, first rater percentage estimations, second rater estimations, and agreed estimated weight consumed. Where the first and second coder disagreed on how much of a food item was consumed by 10%, the estimation from the first coder was taken, and where they disagreed by more than 10%, the middle value was used to calculate the estimated weight consumed.

Global weights of food consumed by each participant were calculated by adding the weights from each recorded item. Next, to provide more detailed validation measures, all food items were allocated to one of four broad categories: (i) Main Starch item; (ii) Fruit and Vegetable; (iii) Meat, Dairy, and Wet foods; and (iv) Snack foods. These categories were based on similarity in the way the food items appear on a plate (e.g. compact [a potato] or spread [baked beans]); the approximate weight of servings (e.g. a Snack [crisps] weigh less

than a Main Starch item [jacket potato]); and the approximate volume of the food items. All categories were broad so that they may contain enough data items to sufficiently power the subsequent analyses.

For lunchboxes, the Main Starch was typically a sandwich, whilst for school dinners it was more varied, with potatoes, pasta, rice, and pizza regularly presenting. In the Fruit and Vegetable category, a typical lunchbox portion included bananas, apples, and cucumber, whilst participants that ate school dinners were more likely to be served peas, sweetcorn, or carrots. Meat, Dairy, and Wet food items in lunchboxes were typically yogurts or cocktail sausages, whilst commonly presenting items in school dinners included sausages, custard, and baked beans. Finally, in lunchboxes, regularly presented Snack items included packets of crisps, cake bars, and cookies, whilst for school dinners they included shortbread and brownies, often provided as the 'sweet'.

Statistics and Sample Size Calculations

Comparing weight- and photography-based data. Bland-Altman plots and analyses were used to compare the accuracy of consumption estimations made from digital photographs with objective weighed measures. Previous published research utilising this analysis does not typically publish sample size calculations, though Bland and Altman (1986) suggest that, while the appropriate sample size is subjective, a sample of N=100 would promote a sensitive analyses, whilst a sample of N=200 would be ample. Therefore, we ensured that all samples on which a Bland-Altman analysis was conducted exceeded N=100. Percent relative error (PRE) is a measure of precision, and is a ratio of the absolute error (the difference between two measurements) to the size of the actual measure, expressed as a percentage. This was used to consider the acceptability of the magnitude of the bias.

Determining inter-rater agreement. Cohen's $\varkappa$ was used to identify the level of agreement on consumption estimates from digital photographs between raters, and we ensured it was sufficiently powered. The sample for each food item category exceeded N=87, the minimum sample necessary to power Cohen's $\varkappa$ at 90%, where the null value was set at .40 and the proportion of positive ratings was anticipated to be high (Sim & Wright, 2005). Agreement could be classed as either slight (0-.20) or fair (.21-.40), though these results would not be considered significant; moderate (.41-.60); substantial (.61-.80); or near perfect (.81-1) (Landis & Koch, 1977).

Results

Overall Consumption

Global weights per plate (total estimated weight of food consumed by each participant) were calculated for each measurement method. Table 2.1 shows these weights in grams, together with provided serving sizes (provision), in primary and secondary schools, for lunchboxes and school dinners. It can be seen that, in all categories, children consumed over 80% of the provided food.

Table 2.1.

Provided and consumed food in grams for the lunches in each school and meal type.

	Primary school				Secondary school			
	Lunch Box		School Dinner		Lunch Box		School Dinner	
	M	SD	M	SD	M	SD	M	SD
Provided	283.29	106.85	253.47	60.24	246.51	117.62	239.86	105.61
Consumed	229.21	109.84	204.43	64.73	199.22	92.62	223.41	86.62

Three factors were analysed for differences in food provision and food consumption: school, lunch type, and gender. As all data were positively skewed, Mann-Whitney U tests were used. There were no differences, except that children in the primary school were provided with larger lunchbox meals than their secondary school counterparts ($U = 1686$, $p = .008$, $r = -.23$).

Bland-Altman analyses, presented in Figure 2.2 and Table 2.2, show that the bias resulting from the photographic method was small considering total consumption for each of the schools and for each type of lunch; standard error (SE) varied from 0.53% to 2.44% of the mean.

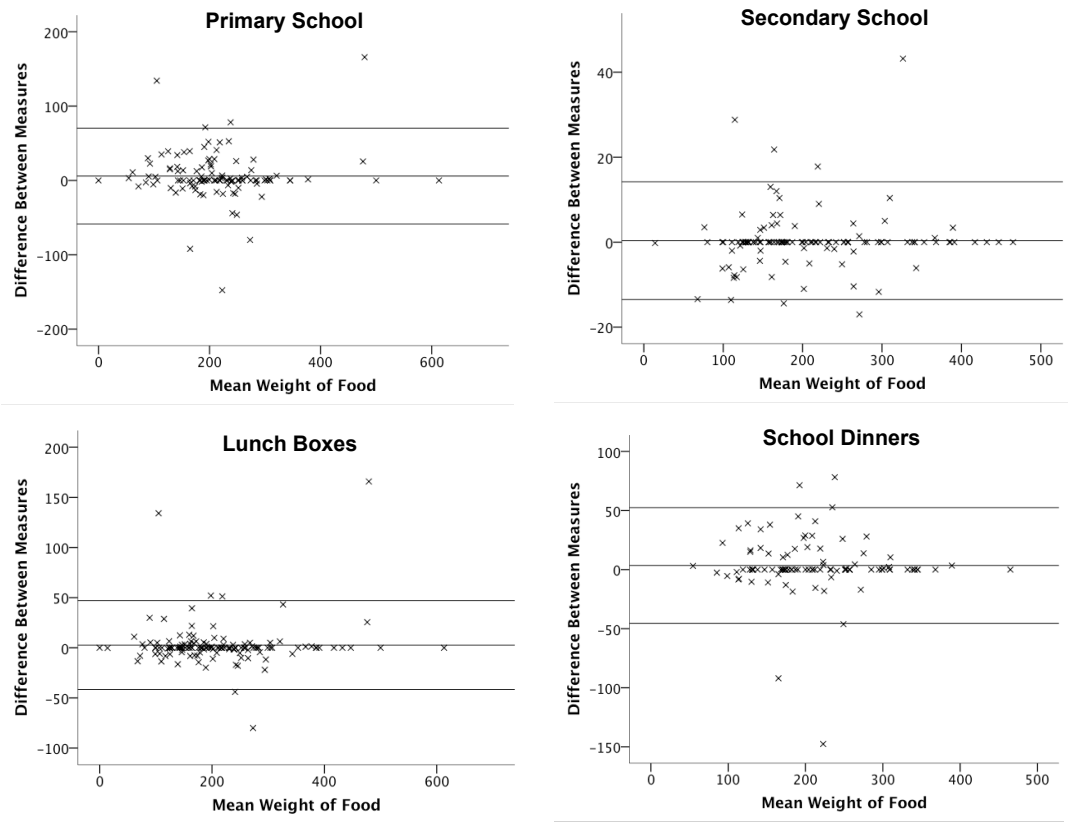

Figure 2.2. Bland-Altman plots comparing consumption estimates (in grams) made from digital photographs and weighed measures by each school and meal type.

Table 2.2.

Bland-Altman analysis results for all meals (in grams) classified by school and lunch type.

		N	Bias	SD of Bias	Limits of Agreement		SE of 95% CI	PRE
School	Primary	116	5.86	32.92	-58.66	70.38	5.29	2.25
	Secondary	123	.36	7.07	-13.5	14.22	1.10	-.09
Lunch	Lunchbox	137	2.67	22.60	-41.63	46.97	3.34	.96
	School Dinner	102	3.52	24.98	-45.44	52.48	4.28	1.14

Consumption of Foods in Each Category

Descriptive statistics for foods consumed in each category, based on weight measurements, are shown in Table 2.3.

The results of the Bland-Altman analysis, shown in Figure 2.3 and Table 2.4, indicate that the estimated consumption of food items derived from digital photographs presented an acceptably small bias for all categories, with SE ranging from 1.05% to 2.05% of the mean.

However, PRE statistic value for the Fruit and Vegetable subcategory was 10.55%, showing lower reliability than the others. Similarly, a one sample t-test identified a significant difference between the two measures for the category of Fruit and Vegetables ($t_{(323)} = 2.893$, $p = .004$), but no significant difference between the measures for all other categories. This result reflects a comparably higher variation in Fruit and Vegetable serving sizes. Although cafeteria staff were requested to serve standardised portions this did not always happen, leading to some disparities between the pre-consumption estimated weights and the actual weights of the portions served and, consequently, to less accurate consumption estimates, similar to those reported in other research (Buzby & Guthrie, 2016). While our (well powered) analyses registered this effect as significant, the actual differences were very small: The average consumed portion weighed 47.91 grams and this was overestimated via photography by 1.64 grams (3.42%) on average.

Table 2.3.

Provision and consumption in grams for four food categories.

	Number of Portions				Provided (Grams)		Consumed (Grams)	
	Primary		Secondary					
	Lunch Box	School Dinner	Lunch Box	School Dinner	M	SD	M	SD
Main Starch	54	84	65	43	101.54	47.84	84.96	51.10
Fruit and Vegetables	62	68	98	5	66.39	45.26	47.91	41.51
Meat, Dairy and Wet	4	63	27	22	65.39	51.5	57.51	45.37
Snacks	100	42	64	27	37.44	25.92	33.42	26.82

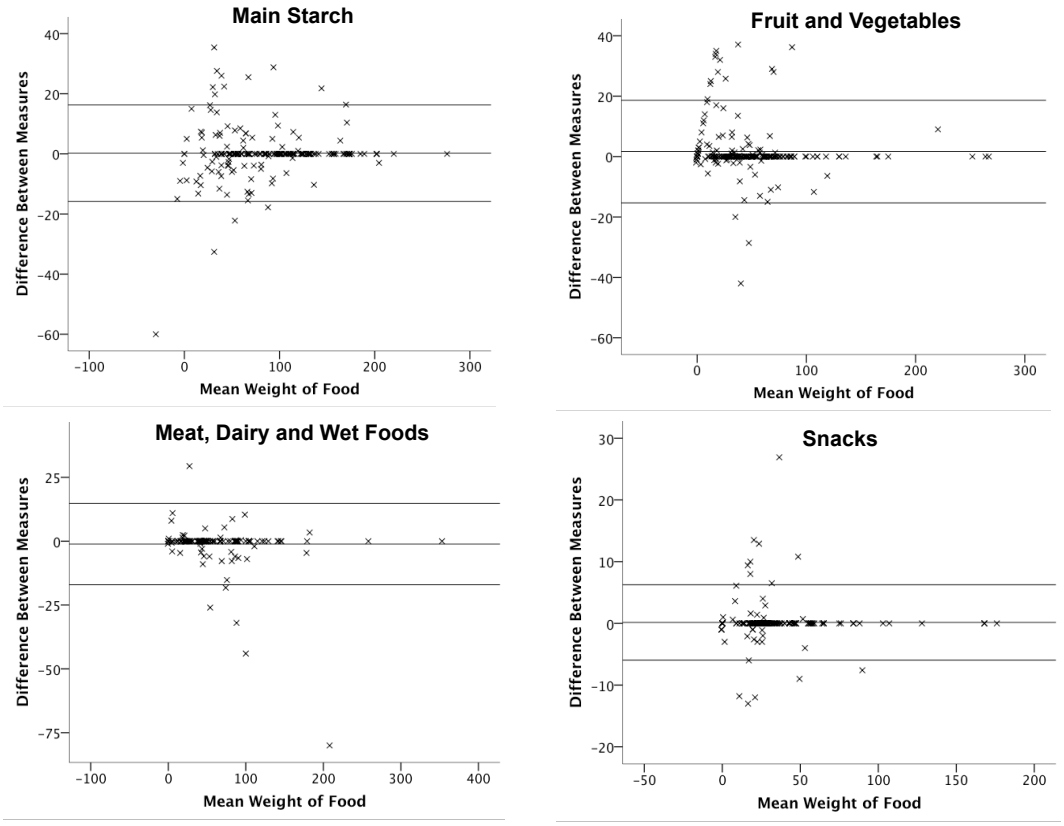

Figure 2.3. Bland-Altman plots comparing consumption estimates (in grams) made from digital photographs and objective weighed measures by category.

Table 2.4.

Bland-Altman analysis results for the four food categories.

Category	N	Bias	SD of Bias	Limits of Agreement		SE of 95% CI	PRE
Main Starch	246	0.22	8.19	-16.03	16.27	0.90	3.04
Fruit and Vegetables	233	1.64	8.67	-15.35	18.63	0.98	10.55
Meat, Dairy and Wet	186	-1.14	8.12	-17.06	14.78	1.03	0.16
Snacks	233	0.15	3.12	-5.97	6.27	0.35	1.12

Inter-Rater Agreement

For the full sample, a substantial level of agreement was achieved (Cohen's $\varkappa$ = .679, *CI* = .64 -.72). Categories of Main Starch ($\varkappa$ = .581, *CI* = .50 - .66) and Fruit and Vegetables ($\varkappa$ = .535, *CI* = .46 - .62) achieved moderate agreement; substantial agreement was achieved for Meat, Dairy, and Wet Foods ($\varkappa$ = .781, *CI* = .71 - .85); and near perfect agreement was

achieved for Snack items ($\varkappa$ = .819, *CI* = .76 - .88). The percentage agreement achieved for each category is typical of that previously accepted in key studies utilising digital photography (Olafsdottir et al., 2016; Williamson et al., 2014). The breakdown shown in Table 2.5 confirms that coding disparities, where recorded, were seldom large for any of the categories.

Table 2.5.

Percentages of inter-rater agreement and disparities for the four categories.

Category	Full Agreement	10% Disparity	20% Disparity	> 20% Disparity
Main Starch	81.00	7.60	2.50	8.90
Fruit and Vegetables	83.60	11.00	2.70	2.7
Meat, Dairy and Wet	95.20	4.80	-	-
Snacks	94.10	2.90	1.50	1.50

Discussion

This investigation supports the use of digital photography as a valid and reliable method of data collection for free-living research in busy school dining environments. We have found that photographic estimates can be equivalent to weighed measures for most food types, and that a high level of inter-rater agreement can be achieved using the present protocol. This has significant implications for the collection of nutritional data in children.

The current study extends the findings of previous investigations in several important ways. Whilst a digital photography method has been validated for use with sandwiches brought from home in a contrived study (Sabinsky, Toft, & Andersen, 2013), the use of digital photography has never before been shown to be accurate for lunchboxes in a real-life setting. By developing a protocol that has been validated against weighed measures for items brought from home and consumed in a school cafeteria, this investigation has satisfied a gap in the existing literature. This finding should be of interest to researchers measuring children's consumption in the countries where parental lunch provision is the norm (e.g. Canada; Norway; Ireland), and those where a mixed supply is used (e.g. UK; Australia). Further, previous investigations conducted in a real-life setting have focused on younger,

primary age children (Olafsdottir et al., 2016), whilst the current study supports the use of our digital photography method in both primary and secondary school settings.

The present paper also presents a more accurate measure of consumption than the previously published research. By utilising an 11-point scale (0-100% consumed in 10% increments), rather than continuous unbounded estimation in grams, the digital photography measure of the present study yielded greater alignment with the weighed measure than has previously been achieved in research with children (Olafsdottir et al., 2016). We consider that continuous weight estimation from photographs may have led the researchers to adopt comparably lenient criteria. For example, +/-25% weight discrepancies between the two measures were considered as 'acceptable agreement' in one recent validation study (Olafsdottir et al., 2016), where the authors reported pre-consumption measures and plate waste measures separately, further inflating the number of agreements. By contrast, we used a measure of consumption for each meal, which is the variable of most interest to researchers.

The present method combined accuracy comparable to the weighed measures with the convenience of unobtrusive group data collection, avoiding some of the problems of other commonly used methods (National Cancer Institute, 2016). We acknowledge that accurate visual estimation of consumption is clearly a more complex skill to master than direct recording of food weights. Nevertheless, we have found that a modest amount of training sufficed to produce reliable coding of a large number of food types. The trained coders conserved their accuracy over a period of several months without refresher training and continued to obtain good inter-rater agreement on completed datasets.

Based on pilot work, our protocol addressed procedural challenges common to free-living investigations. For example, we carefully positioned the researchers and recording equipment to minimise disruption but maximise visibility and children's compliance with measurements, reducing attrition to one or two participants per day and thereby ensuring that any data loss would have a negligible impact on overall results. We adjusted our data collection methods to suit two very different cafeteria settings – a small school (200 students) in a rural area with a strictly regimented lunchtime routine and a large school (2000 students) in an urban area with a more relaxed approach to the lunch period. We examined different lunch types, including lunchboxes brought from home and school dinner meals in the analysis, and recorded consumption from children with ages spanning 5 to 18 years old. The unequivocal success in a variety of settings, lunch types, and ages supports the

generalisability and ecological validity of the digital photography method described in the present paper.

Some compromises had to be made. Considering the school lunches, estimate weights for each food item available in the cafeteria were based on the average of five 'typical' servings. These estimates were used in lieu of weighing each portion before the participants ate their lunch. This commonly used method (Hanks, Wansink, & Just, 2014) was efficient and unobtrusive; it preserved the ‘real-life' nature of the investigation and prevented the food from cooling down before the children ate it, which would have made it less appetising. Nevertheless, it had its drawbacks. Although cafeteria staff were requested to provide all participants with equally sized servings, this did not always happen. Unlike foods like fish or bread that were well standardised (e.g. one fillet or one slice), spoonfuls of vegetables sometimes varied in size, leading to a disparity between the estimated and actual servings and introducing a source of noise into the dataset. This barrier to reliability has been previously identified in associated research (Thompson, Head, & Rodman, 1987). Even though we recorded a significant difference between data collection methods, a comparably high bias, and greater PRE for Fruit and Vegetable food category, the actual overestimation was less than a couple of grams on average. This is much less than discrepancies reported in other studies (Olafsdottir et al., 2016), and unlikely to adversely impact measurement. Our ongoing research in schools confirms that this method is sensitive enough to detect small changes in children’s fruit and vegetable consumption over time.

Due to the fast-paced nature of the school lunchtime environment, it was not possible to weigh each food item twice and so visual estimations of consumption were only validated against a single measure, without provision of inter-rater reliability. However, it is unlikely that measurement was inaccurate. The digital scales used were correctly set up and tested every morning prior to data collection.

Overall, we found the lunchtime provision and consumption to be matched across study settings, ages, lunch types, and genders. Somewhat counter-intuitively, children in primary schools brought more food in their lunchboxes than did their older counterparts. We considered by whom the food was being provided and concluded that the child’s lunchbox was more likely to be prepared by the parents at primary and by the children at secondary school age. Adolescents may have been less motivated to pack a substantial lunch and forego quantity and quality for ease, resulting in fewer food items. The finding that serving sizes

were not related to children's nutritional needs indicated that more attention should be given to providing appropriate portions as children grow and develop (Fisher & Kral, 2008).

Conclusion

This study presented a simple and versatile digital photography method for estimating lunchtime consumption of children in schools. We obtained a high agreement with the weighed measures and good inter-rater reliability using global consumption and food category scores, derived from the weight estimates of individual food items. These data can be used to calculate the energy content of children's meals and their micro- and macro-nutrient composition, using published nutrition tables and school meal recipes, to provide more detailed measures of consumption and its changes over time, for example in studies that seek to evaluate the effects of various school-based interventions (Marcano-Olivier, Horne, Viktor, & Erjavec, in submission).

Chapter 3
The Food Dudes Programme

Van Cauwenberghe et al. (2010) suggest in their systematic review that modifying childhood eating behaviour, and maintaining these changes, would be best accomplished with an intensive, multicomponent intervention. One multicomponent intervention that had been designed to encourage children to eat a wider variety of fruit and vegetables, and to develop a lasting liking for these foods, is the Food Dudes programme, a multicomponent school-based intervention theoretically rooted in Behaviour Analysis and Social Learning Theory (SLT). The Food Dudes incorporates a variety of psychological principles that can affect children's dietary choices; with the three most important being *role modelling*, *repeated tasting*, and *rewards* (or 3 Rs; see 'Key Approaches That Work' section in Chapter 1 for a discussion of the evidence supporting the effectiveness of these components).

The Foundation of the Food Dudes Programme

The Food Dudes programme was initially investigated using a single-participant (within-subjects) research design, commonly employed by behaviour analysts (Kazdin, 2012), with four participants aged 5 to 7 years old who regularly rejected particular fruits, vegetables and pulses ('fussy eaters'; see Horne, Lowe, Fleming, & Dowey, 1995). During phase one of the intervention, children were presented with a role modelling video directly before their evening meal. These characters were designed to encourage children to eat their target foods so that they can be full of 'special energy'. Following this, children were immediately presented with a pairing of target food items. If the child consumed 75% or more of their target foods, they were presented with a special reward the following day (small branded items such as pencil cases and rubbers), directly before the next modelling video presentation. During phase two presentation of target foods was reduced to once per week and, although tangible rewards were withdrawn, children were informed that if they ate their target food, they would be treated to a day out. Their progress was self-monitored with special stickers on a chart.

Measures of target food consumption were taken at baseline, phase one, phase two, and at two-month and six-month follow-ups, with results indicating that the intervention significantly increased the consumption of target foods. Target fruit were consistently consumed at 100% levels and consumption of vegetables and pulses was also observed to

significantly increase, although consumption was found to decline at follow-up, indicating a need for further intervention development.

The Development of the Food Dudes Programme

The success of the home pilot inspired the development of a school-based intervention, significantly increasing the number of children exposed to the Food Dudes. Horne et al. (2004) implemented a version of the Food Dudes intervention in an inner-city London school. During phase one of the intervention, children were read a letter addressed from the Food Dudes and/or presented with an episode from the Food Dudes video series in class. At lunchtime, children were then able to choose both a cooked vegetable (approximately 60g) and a whole fruit (approximately 80g), and were given a hand stamp for tasting (described as at least one bite, chew and swallow; days 1 to 4) or consuming (days 5 to 16) the fruit and/or vegetable. When this hand stamp was shown to their class teacher, they were given a Food Dudes reward. Children were also provided with home packs, materials to encourage them to record fruit and vegetable consumption at home, and prizes were awarded to those children who had reported a sufficient and/or a varied sample of fruit and vegetables on their chart.

Following the 16-day intensive phase one, consistent tangible rewards were withdrawn and replaced with intermittent tangible rewards, wall charts, and a second home pack for phase two. The wall charts were to be initialled by the class teacher when children had consumed sufficient fruit and vegetables at lunchtime and, when they were filled, every child in the class received a Food Dudes prize. By this point in the intervention, it was theorised that children would find the target foods intrinsically rewarding (Wardle et al., 2003), and so immediate tangible rewards were not necessary.

The results from this study indicate that the intervention was successful. Fruit and vegetable consumption significantly increased from baseline during the intervention and at a four-month follow-up, with the most substantial increases in consumption being recorded for those individuals who ate the least fruit and vegetables at baseline. Changes in target food consumption in the control school were minimal, and assumed to be associated with novelty effects of being presented with new food items (Hendy & Raudenbush, 2000).

These results are typical of those recorded when assessing the Food Dudes programme and have been replicated cross-culturally in the UK, Ireland, Sicily, Utah and California (US), and Milan (Italy) (Erjavec, Viktor, Horne, & Lowe, 2012). Indeed, the Food

Dudes intervention was found to have the greatest influence on children who ate the least fruit or vegetables in a sample of children in London, with a 17-fold increase observed in fruit consumption, and a four-fold increase observed for vegetable consumption (Lowe, Horne, Tapper, Bowdery, & Egerton, 2004). Additionally, when considering the influence of the Food Dudes programme on parental provision of fruit and vegetables, a long-term follow-up investigation in Ireland identified that fruit and vegetable provision had doubled at a one year follow-up (Horne et al., 2009).

The Current Food Dudes Programme

Though very similar to the original programme, the Food Dudes programme implemented in the present study had undergone further changes and improvements.

Following a major investment from Bangor University, in 2012/2013, all media were updated by a professional animations company, in line with high standards of television programmes and games available to children at the present time. As before, five DVD episodes combined live action and animation. They were presented to the children during the intervention to introduce them to the 'Food Dudes', four role model characters slightly older than the primary-age children, who eat lots of fruit and vegetables and manifest the benefits of a nutrient-rich diet (high energy, healthy skin and teeth etc.). Each character has a favourite fruit or vegetable, and favourite sports activity, modelling healthy diets and active lifestyles. Tom is a gymnast with fondness for tomatoes; Raz a dancer who likes raspberries; Rocco a football enthusiasts who enjoys his broccoli; and Charlie a martial artist whose favourite food is carrots. In contrast, the 'Junk Punks' are a group of four antagonists who consume lots of junk foods and no fruits or vegetables, and manifest the detrimental implications of a nutrient-poor diet. They are led by General Junk and his sidekick Miss De Meena; with two youths called Gruesome Twosome following their orders. In every episode, the Food Dudes protect the world against the evil Junk Punks who attempt to reduce the life force of the people on Earth by stealing all of the fruit and vegetables but are ultimately unsuccessful as they are lethargic lack the 'special energy' of the Food Dudes. These DVDs also contain a special song that tells the children that, "Fruit are supercool, veg are supercool, eat them home and school, be like the Food Dudes," and invites them to sing along. At the end of the videos, additional role modelling is provided by media personalities who are familiar to children (including sportspeople and children television presenters).

Still images of these characters are shown in Figure 3.1.

Figure 3.1. The Food Dudes Characters: Charlie (top left), Razz (top right), Rocco (bottom left), and Tom (bottom right).

As before, phase one of the intervention is conducted over 16 school days; 4 days a week for 4 school weeks. During phase one, on each Intervention day, a letter from the Food Dudes is read to children, or an episode of the Food Dudes DVD is shown in class. Directly following this, children are presented with a pairing of one portion of fruit and one portion of raw vegetable to eat in the classroom. As before, children received a tangible, Food Dudes branded reward for tasting (days 1 – 4) or consuming (days 5 – 16) their target fruit and vegetable.

During phase two, lasting until the end of the school year, the Intervention moves from the classroom to the dining room. Wall charts used in previous programmes are replaced by Food Dudes 'Level cards', capitalising on children's gaming experience to motivate them to progress through levels. Food Dudes Hall Monitors (children in older year groups) are given the responsibility of monitoring fruit and vegetable consumption and ticking the associated boxes on the Level cards. Once a Level card has been completed, it can be handed in to the Hall Monitors in exchange for a tangible reward. As the children progress through the Levels, more portions of fruits and vegetables must be consumed in order to receive a reward. This phase is also complimented by a makeover of the dining room in line with behavioural nudges described in previous chapters, which include Food Dudes posters and prompt cards in the dining hall, reminding children to eat their fruit and vegetables in order to be full of 'special energy', and menu changes to include more vegetables and fruit based desserts on two days a week.

The final phase of the intervention is Food Dudes Forever. This phase is similar to phase two, but tangible rewards are withdrawn and completion of Level cards is rewarded with online tokens that can be 'spent' on the Food Dudes website. Special tasting days and activities designed to expand children's liking of fruit and vegetables to novel examples are introduced in schools several times a year. This phase can continue throughout the child's primary school experience, with new students entering the school in Nursery and Reception classes completing the Full Force (phases one and two) independently of the rest of the school, before entering the Food Dudes Forever programme.

Results of the evaluations of the last iteration of the Food Dudes have not yet been published, but several papers have been presented at international conferences, including a demonstration of its effectiveness in Special Schools in Wales, with children who had a variety of disabilities including autism spectrum disorder (Erjavec, Roberts-Mitchell, French, Dolan, Horne, & Lowe, 2015), and in primary schools in England where a collaboration with caterers had been established to trial the changes in dining rooms and menus / provision (Erjavec, Horne, & Lowe, 2015). A nursery version of the programme, featuring younger Dudes and no Punks, with simplified contingencies and developmentally appropriate content, had also been shown to be effective (Sharp, Horne, Erjavec, & Lowe, 2015).

Introducing the First Paper in the Present Thesis

The following paper describes a study investigating the influence of the Food Dudes programme on the nutritional composition of children's lunchtime meals. This paper aims to inform the scientists who are studying child nutrition and evidence-based programmes that change children's food preferences and dietary habits, of the potential displacing effect that increasing fruit and vegetable consumption can have on the consumption of high fat, sugar, and salt food items when participating in the Food Dudes programme. This paper would also be of interest to health and educational professionals working to promote healthful eating behaviour in the school cafeteria, and more generally to Public Health Commissioners, School Governors, and Headteachers.

Prior to the journal submission, the present findings (while the analyses were in progress, and with final results completed) have been presented at international conferences:

Marcano-Olivier, M. I., Horne, P. J., Viktor, S., Pearson, R., Erjavec, M. (2015, September) *Displacing the Foods High in Fat, Sugar and Salt: Changes in Nutritional Composition of Children's Meals After the Food Dudes Healthy Eating Programme in UK Schools*. Poster presented at the 8th Association for Behaviour Analysis International Conference, Kyoto, Japan. (see Appendix 20)

Marcano-Olivier, M. I., Horne, P. J., Viktor, S., Pearson, R., Erjavec, M. (2016, September) *Displacing the Foods High in Fat, Sugar and Salt: Changes in Nutritional Composition of Children's Meals After the Food Dudes Healthy Eating Programme in UK Schools*. Paper presented at the 8th European Association for Behaviour Analysis, Enna, Sicily. (see Appendix 21)

Marcano-Olivier, M. I., Horne, P. J., Viktor, S., Pearson, R., Erjavec, M. (2017, June) *Displacing the Foods High in Fat, Sugar and Salt: Changes in Nutritional Composition of Children's Meals After the Food Dudes Healthy Eating Programme in UK Schools*. Paper presented at the Annual Meeting for the International Society for Behavioural Nutrition and Physical Activity, Vancouver, Canada. (see Appendix 22)

At the time of the Thesis submission, this paper was submitted to the International Journal of Behavioural Nutrition and Physical Activity (IJPNPA), same as the paper in the previous chapter, and targeting similar audiences.

Authors' Contributions

MMO designed and coordinated the study, processed and analysed data, and drafted the manuscript. RP contributed with data collection, inputting, and second coding. PJH contributed with editing. SV advised on statistical analysis and results. ME obtained funding, supervised all aspects of the research, and co-wrote the final manuscript. All authors have read and approved the final manuscript.

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How Fruit and Vegetables Displaced the Foods High in Fat, Sugar and Salt: Changes in Nutritional Content of Children's Lunches After the Food Dudes Healthy Eating Programme

Abstract

Research into the effectiveness of the Food Dudes programme has shown increased fruit and vegetable consumption in primary schools, using direct observational measures. The present study was designed to extend this literature by using digital photography to estimate children's intake of macro- and micro-nutrients at lunchtime, before and after Food Dudes, allowing researchers to identify any other evidence-based health implications of programme participation.

Two primary schools were observed, one intervention school and one waiting-list control, and baseline data were collected over four days in each school at lunchtime. Following this, the Food Dudes programme was implemented in the intervention school. The intervention started with children's exposure to DVD episodes of Food Dudes characters who model the benefits of healthy food consumption, and repeated tasting of target fruit and vegetables rewarded by Food Dudes branded prizes, administered by teachers in classrooms for four consecutive weeks. This was followed by intermittently rewarded consumption of fruit and vegetables in the dining room, accompanied by positive changes to its menus and

choice architecture, over the rest of the school year. Follow-up data were collected over four days in each school two months after baseline. We employed a validated and sensitive photographic method to estimate individual children's (N = 112) consumption of fruit, vegetables, and their intake of calories, macro- and selected micro-nutrients.

Significant increases were observed in the intervention school, but not in the control school, for children's consumption of fruit, vegetables, and vitamin C intake, whilst decreases in total energy, carbohydrate, fat, saturated fat, and sodium were also recorded.

We have demonstrated that increases in children's consumption of fruit and vegetables led to decrease in calorie density of their lunches, as nutrient-dense plant-based foods replaced items high in fat, sugar, and salt. These results indicate that the Food Dudes programme produced a positive nutritional change with implications for its application as a healthy eating and weight management intervention.

Keywords. Food Dudes; digital photography; fruit and vegetables; plant-based foods; consumption; school lunch; cafeteria; healthy eating; children

Introduction

Children in most developed countries, including the UK, overconsume foods high in fats, sugar and salt, and do not eat enough fruit and vegetables, which increases their risk of ill health (British Medical Association [BMA], 2015). Data gathered by the National Child Measuring Programme (2015) suggest that approximately one third of children in England are either overweight or obese, with the prevalence of obesity more than doubling between reception year and year 6 pupils (9.1% and 19.1%, respectively). Research indicates that childhood weight status is a significant predictor of weight-related issues in later life (Daniels, 2009), though healthy eating interventions in childhood may serve as a protective factor against this outcome (Tran et al., 2014). The DOH (2011) pledged to support efforts to reduce childhood obesity, with the target of a sustained downward trend in the incidence of childhood obesity by 2020, and suggest that national level action is required to combat this phenomenon. The BMA (2015) agrees that promoting healthier diets in children is a public health priority. One setting accessible to all children, nationally, is primary school.

The school environment offers a convenient setting for implementing healthy eating interventions. Children spend most of their school day in classrooms where healthful

behaviour can be encouraged via curricular activities, and lunch is served and consumed in the school cafeteria, where key variables such as meal content and serving size can be controlled for those children who eat school-provided lunches (Gov, N.D). Several school-based multicomponent interventions have been developed to target poor childhood nutrition in the UK schools (Sahota et al., 2001; Warren, Henry, Lightowler, Bradshaw, & Perwaiz, 2003), reporting moderate effects on children's consumption. Many 'Healthy School' initiatives have been introduced regionally and nationally, although monitoring of their implementation and evaluation of their results on children's dietary habits and health outcomes remain patchy (Ogilvie, 2011).

The Food Dudes Healthy Eating Programme for primary schools (Horne et al., 2004; Horne et al. 2009; Lowe et al., 2004) is an evidence-based programme that has been adopted regionally in the Midlands of England and nationally in the Republic of Ireland. It promotes fruit and vegetable consumption utilising the principle of the three "Rs"; role modelling, repeated tasting, and rewards. Modelling has been acknowledged as a consistently effective tool for consumption behaviour modification (Bandura, 1971; Bandura, Ross, & Ross, 1961) and research has identified several factors that increase the likelihood of imitation, including observing a model's behaviour being rewarded (Flanders, 1968), the model being of a similar age or slightly older (Brody & Stoneman, 1981) and multiple models being present (Fehrenbach, Miller, & Thelen, 1979). Considering this, the Food Dude characters, presented in DVD episodes during the first stages of the intervention, were developed to be role models which incorporate these elements. In addition to this, children are given many opportunities to taste fruit and vegetables over the course of the programme. Repeated tasting of a food item has been associated with increased expressed liking for, and consumption of, that food item (Sullivan & Birch, 1998; Wardle et al., 2003). The final factor is contingent delivery of rewards for tasting, then eating all the target foods. It has been the view of some academics that the use of rewards when encouraging children to eat a food item that they view as undesirable can actually have detrimental effects on the child's liking of the target food (Newman & Taylor, 1992), potentially because the child may reason that if they are being rewarded for eating the food, then it must be an unpleasant food to eat. However, there are some variables that make rewards more likely to impact target behaviour, with the most effective rewards being found to be those that are highly desirable whilst indicating to the child that they are associated with a behaviour that is independently enjoyable and high-status (Cameron, Banko, & Pierce, 2001). As with the principle of role modelling, these factors

were considered when developing the tangible rewards and reward scheduling of the Food Dudes programme.

The Food Dudes programme has been shown to be successful in increasing fruit and vegetable consumption at snack time, lunchtime, and at home, particularly for those children who initially ate little-to-none of these food items at baseline (Horne et al., 2004; Horne et al. 2009; Lowe et al., 2004). The programme has also been found to be effective in a variety of primary school contexts, including in Ireland, where children take lunch with them into school requiring lunchbox food provision to be addressed (Horne et al., 2009), cross-culturally in Italy (Laureati, Bergamaschi & Pagliarini, 2014) and the United States (Wengreen, Madden, Aguilar, Smits, & Jones, 2013), with pre-school children (Horne et al., 2011; Sharp et al., 2015) and in special schools (Erjavec et al., 2015).

Whilst these previous evaluations have shown success, researchers have typically used direct observation to measure on consumption differences in fruit and vegetable consumption on a 5-point scale : 0; 25%; 50%; 75%; 100% (e.g., Horne et al., 2004). Though inter-rater agreement was high, and measures were more sensitive than standard dietary recall estimates in recording small but significant changes (Pears et al., 2012), these studies did not consider changes to children's consumption at a more detailed level of macro- and micro-nutrients. This has limited their ability to assess the nutritional impact of any displacing influence that participation in the Food Dudes programme may have on unhealthy food item consumption. Indeed, evidence suggests that increasing fruit and vegetable consumption through participation in the Food Dudes programme may result in a decrease in unhealthy snack consumption (Horne et al., 2009; Lowe & Horne, 2009), however, in the absence of finer-grained consumption estimates, the question remains as to what impact these changes have on actual nutrient intake.

The present study aims to answer these questions by evaluating the influence of the Food Dudes programme on total lunchtime consumption at both macro- and micro-nutrient levels.

Method

Aims

This investigation assessed the effectiveness of the Food Dudes Programme to a macro- and micro-nutrient level, identifying increases in children's lunchtime consumption of fruit and vegetables, and the potential displacement of less healthful foods.

Ethics

Approval to conduct this investigation was granted by the School of Psychology Ethics and Research Governance Committee at Bangor University (approval number: 2014000089). Opt-out consent forms were distributed to participants two weeks prior to study commencement.

Participants

One hundred and seventy-two children from two primary schools in Central Leeds, received information regarding their school's intention to take part in the present study, including an opt-out consent form (see Appendix 23). Eight parents chose to opt out of the Intervention school sample (9%), so 78 children from year 1 (n = 26), year 3 (n = 30), and year 5 (n = 22) took part. Twelve parents chose to opt out of the Control school sample (14%), leaving 75 children from year 1 (n = 25), year 3 (n = 29), and year 5 (n = 21). Both samples were gender balanced, and matched on size, deprivation status, Ofstead report, percentage ethnic minority and school dinner catering company (Leeds Catering).

Materials

To collect consumption data, we used four digital cameras (Fujifilm Finepix, 16 mega pixels, Model no. AX650), and standardised their placement using tripod stands, tape measures and protractors. Food items were displayed on white paper plates (lunchbox meals), plastic school dinner trays, or school dinner plates (school dependent). White self-adhesive participant identification labels were attached to each participant's school jumper, and then to their corresponding lunchbox or dinner tray/plate for later coding from photographs.

Procedure

Data collection. Data were recorded over four consecutive days (Monday – Thursday) at two time points (baseline and follow-up), spaced two months apart. The data collection protocol was identical at both time points.

A small team of researchers arrived at the schools prior to morning registration. One researcher was then entered each participating classroom to collect lunchboxes, distribute participant identification labels, and attach these to the corresponding lunchboxes where applicable. Those children who ate school dinners were told they would be given another sticker at lunchtime to put on their dinner tray. Researchers then briefly described to participants what they would be asked to do at lunchtime.

Lunchboxes were taken to the dinner hall, where their contents were removed and carefully displayed on a white paper plate before being photographed. Additional food information was recorded on data collection sheets (e.g. "Participant 108 – ham sandwich with lettuce," where the lettuce may not be visible on the photograph, or "Participant 304 – ham sandwich with cheese spread," where cheese spread may be mistaken for butter in a photograph; see Appendix 13). Lunchboxes were then returned to their corresponding classrooms before the school lunch hour began. For school dinner meals, estimate weights for each portion of each food item were required to assess nutritional intake. Estimate food weights were calculated by asking caterers to 'serve' researchers five portions of each food item available to select at lunchtime. These portions were weighed and a mean weight was calculated. Following this, the portion of food closest to the mean weight for each food item was photographed on a plastic dinner tray or plate, for reference.

Just prior to lunchtime, catering staff and lunchtime staff were requested to identify children wearing participation labels and ensure that these children brought their lunchbox and plate/tray waste to researchers when they had finished eating, and not to throw away any food items or wrappers, or swap food with their peers. This was immediately followed by lunchtime.

At lunchtime, children who brought lunch from home in lunchboxes sat to eat their meal as usual. Children who were consuming school dinners were given an additional participant identification label (corresponding with the number on the label placed on their school cardigan) to attach to their dinner tray/plate at the beginning of the dinner queue. At the end of the dinner queue, two researchers were situated to collect pre-consumption photographs of dinner trays/plates, before allowing children to sit and eat their dinner as usual. Once participants had finished eating, they handed their lunchbox or dinner tray/plate to researchers, who took post-consumption photos of each participant's lunch waste before returning lunchboxes to participant's classrooms and dinner trays/plates to catering and lunchtime staff.

Intervention procedure. Phase 1 of the intervention was conducted over 16 consecutive school days (Monday – Thursday for 4 weeks) in children's classrooms, and was teacher-led. Every day, children either watched an episode of the Food Dudes videos, which combined live action and animation to show the Dudes (see Appendix 24) battle the Junk Punks, villains with appalling dietary habits (see Appendix 25); or were read a letter from the Dudes. These cool characters modelled fruit and vegetable consumption, and urged the children through words and songs to be like them. At the same time, children were presented with one portion of fruit and one portion of vegetable each (see Appendix 26). During the first four days of Phase 1, they received a reward for simply tasting each of the presented food items; thereafter, they had to eat the full portions to receive a prize (small Food Dudes branded items of stationery and toys, see Appendix 27). Over the 16 days, four pairings of fruit and vegetables were presented at mid-morning snacktime four times each, on a rolling schedule. Children also recorded the fruit and vegetables that they ate at home, and received prizes for completing these home diaries, either on their own or with their carers' help.

During Phase 2, which lasted until the end of the school year, the intervention moved from the classroom to the dining room. Fruit and vegetables were no longer provided by the programme; instead, children were encouraged to bring more from home or to choose fruit and vegetables from the school menus. They were given Food Dudes 'Level cards' in lieu of immediate tangible rewards. To complete a Level card, children were required to eat a specified number of portions of fruit and vegetables and have this behaviour verified by a Food Dudes Hall Monitor (a child in an older year group given the responsibility of monitoring fruit and vegetable consumption) who ticked the associated box. Once a card has been completed, the child received a small tangible reward could take the card home. As the children progressed through the Levels, more portions of fruit and vegetables had to be consumed to gain a reward.

This phase also included changes to the choice architecture of dining to facilitate fruit and vegetable selection for children buying school dinners: displaying the available fruit and vegetables more prominently and increasing the variety provided by the school; substitution of foods high in fat, salt, and sugar (HFSS) with Food Dudes healthy meal options; serving fruit and vegetables first and presenting them in an attractive way; verbally cueing consumption (e.g. lunchtime supervisors asking, "Which vegetable would you like, or would you like both?" rather than, "Do you want vegetables?" where the answer could be, "No");

encouraging adults and older children to be healthy eating role models and providing catering staff with training in encouraging the consumption of fruit and vegetables through subtle nudges.

No changes were made to the children's classroom or dining room routines in the Control school.

Data collection at follow-up. Data were recorded over 4 consecutive days at follow-up for both the Intervention and Control schools in exactly the same manner as described for baseline. School dinner menus were matched across the two measurement occasions with the exception that, in the Intervention school, where the improved menus were introduced in Phase 2 of the Food Dudes Programme, the provision of fruit and vegetables was increased on two of the four testing days (named 'Special Energy' days), as vegetable-rich main courses and a choice of fruit-based desserts replaced the previously offered foods (e.g., starchy meals and cakes) for the children who bought school meals.

Data Processing and Coding

Determining the final sample. On each day, photographs were uploaded and labelled with the participant number and 'A' to denote pre-consumption and 'B' to denote post-consumption (for example, the post-consumption photograph of Participant 201 would be labelled "201B"). Following this, researchers were able to identify those participants from whom a full set of data (both a pre- and a post-consumption photograph) had been collected on each measurement day. To be included in the analysis, participants were required to have a full set of data collected for at least two days per time point (baseline and follow-up) including at least one 'normal' day (Mondays and Wednesdays) and one 'Special Energy' day (Tuesdays and Thursdays) in the Intervention school. Although there were no Special Energy days in the Control school, this procedure was applied equally, so children had to have data for the equivalent days.

Those participants from whom sufficient data had not been collected were removed from the sample, leaving 116 participants (58 participants from each school), 77% of the consented sample. In the Intervention school, 40% of the sample were female and 45% were key stage 1 (younger) children. In the Control school, 66% of the sample were female and 48% of children were from key stage 1.

Calculating children's consumption of each food in grams. Consumption of each food item was estimated to the nearest 10% increment on an 11-point scale (0% - 100%). An independent rater second-coded approximately 20% of the sample, and a high rate of inter-rater reliability was achieved (Cohen's k = .934, CI = .91 - .96). For school dinners, mean weights in grams for each food item had been collected from cafeteria staff. Food items that were available from the self-serve salad bar were estimated to the nearest 5g, with reference to target photographs of the food items. For lunchboxes, weight in grams for each food item was estimated by referring to product information published by the manufacturer (e.g. a snack pack of Jacobs Mini Cheddars ® cheese crackers weighs 25 grams according to published information, and so this was the weight recorded for this item and equivalent supermarket own brand varieties). For items where product information was unavailable (e.g. sandwiches, fresh fruit etc.), estimate weights were calculated from published product information of meal components and weighing standard samples. For example, for a ham sandwich, two medium slices of white bread weigh approximately 80 grams, and a slice of ham weighs approximately 20g. An average clementine weighs around 70 grams, less approximately 20% total weight for peel, leaving 56 grams of edible flesh. Grams of food item consumed were estimated by applying the percentage consumed to the weight of an average portion (e.g. if 20% of a portion of beans was consumed, and the average portion of beans weighed 86 grams, then it was estimated that 17.2 grams of beans were consumed).

Calculating children's overall consumption scores. Once consumption of each food item had been calculated, researchers calculated the nutritional content of the foods consumed using published product information, catering company recipes, and McCance and Widdowson's The Composition of Foods Seventh Summary Edition (Food Standard Agency, 2014), a comprehensive manual detailing the macro- and micro-nutrient content of the most regularly consumed food items in the UK. Following this, a 'global nutrient' score was calculated for each variable (grams of fruit and vegetable consumed, calorie, and macro- and micro-nutrients); the total amount consumed by that participant during the lunch period. These were averaged to produce average baseline and average follow-up consumption for each variable, which were used in all data analyses as dependent variables.

Preliminary analysis of data distribution. After testing the normality of the distribution of the main dependent variables, it was identified that much of the data were either skewed or kurtosed or both, and thus non-parametric analyses were conducted throughout.

Preliminary analysis of subsample differences. There were no gender differences in our sample concerning the main dependent variables, in either the baseline consumption or magnitude of the observed changes. Older children consumed more calories than their younger peers, but this difference was small, and our two samples were well matched in age.

Results

All within-groups data were analysed using a Related Samples Wilcoxon Signed Rank Test, and between-groups comparisons were analysed using Mann-Whitney U Tests, to account for non-normality of the distributions. Effect sizes were also calculated for each test by dividing the *z* score by the square root of the number of observations, with the subsequent *r* value indicating the magnitude of the effect (.1-.29 = small, .3-.49 = moderate, and ≥ .5 = large effect; Rosenthal, 1991). For each figure presenting box plots of the results, medians, interquartile ranges, and distributions of children's consumption in grams are shown at baseline and follow-up for the Intervention school and Control school. Key statistics for pairwise within- and between-condition tests are presented to aid interpretation of the data.

Changes in Children's Fruit, Vegetable, Protein, and Calorie Consumption

Figure 3.2 shows changes in children's fruit, vegetable, protein, and calorie consumption between the two measurement points.

Fruit. A significant increase in fruit consumption with a large effect size was observed in the Intervention school. By contrast, consumption remained stable over time in the Control school. At baseline, the two experimental conditions were not perfectly matched. Statistically, children in the Control school consumed significantly more fruit than the Intervention school, with a moderate effect size. At follow-up, children's consumption of fruit in the Intervention school was significantly higher than in the Control school, again with a moderate effect size.

Vegetables. A smaller but significant increase in vegetable consumption with a moderate effect size was identified in the Intervention school. This effect was not observed in the Control school, where there was no significant difference in consumption over time. Vegetable consumption was matched across the two conditions at baseline, but at follow-up children in the Intervention school consumed a significantly higher weight of vegetables than the Control school.

Protein. A significant decrease with a small effect size was observed in protein consumption in the Intervention school between baseline and follow-up. Protein consumption in the Control school remained stable over time. Children in the Intervention school consumed significantly less protein than those in the Control school at both time points, but the effect sizes were small and variability between individual children large, especially in the Control school. At follow-up, children in both schools consumed over one-third of their guideline protein daily intake of 28 grams (Intervention *Mdn* = 10.27, Control *Mdn* = 13.52), in line with recommendations to consume approximately 30% of your daily macronutrients with their lunchtime meal (Food Standards Agency, 2007).

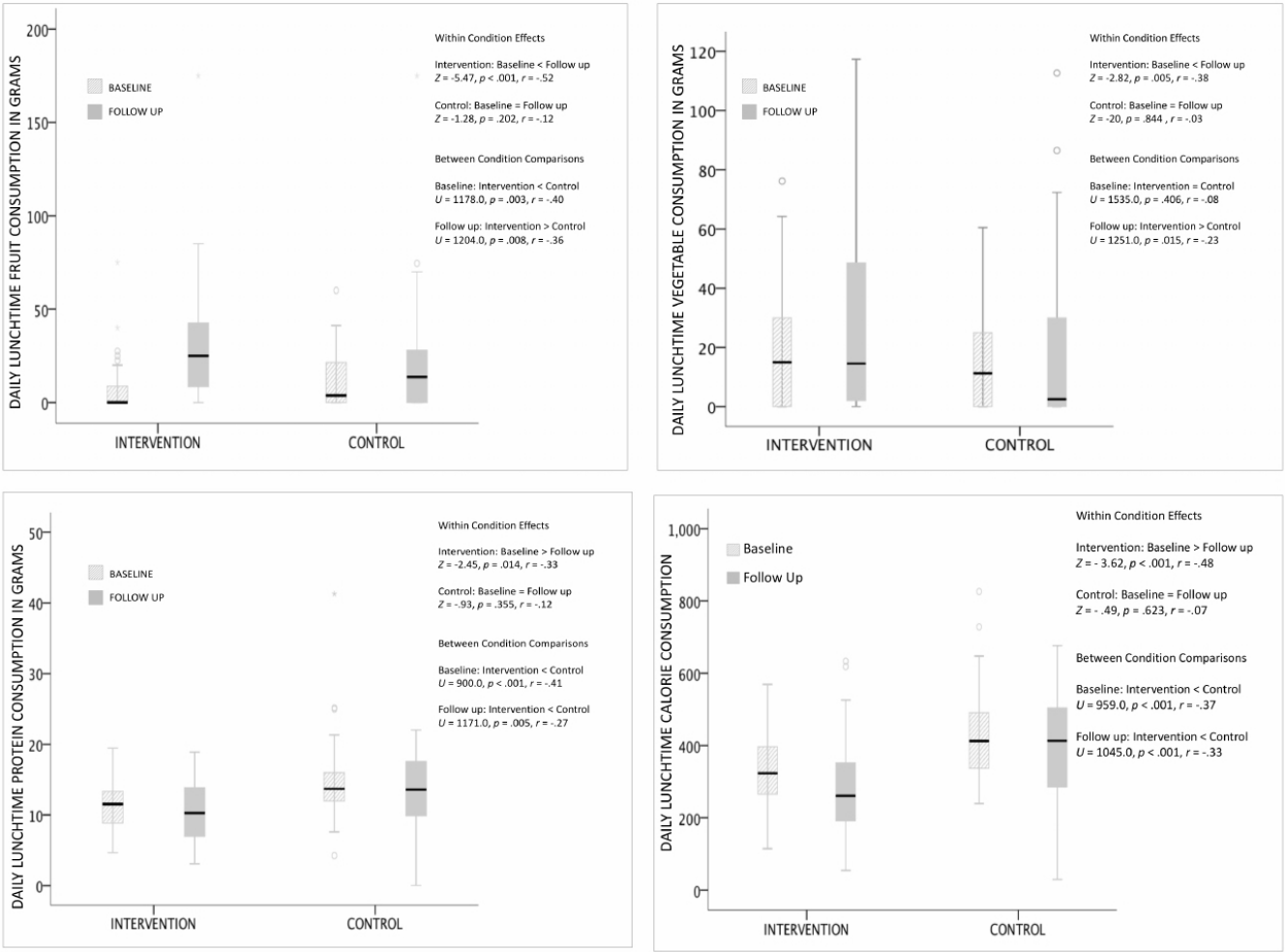

Figure 3.2. Boxplots showing children's daily consumption of FRUIT (top left), VEGETABLES (top right), PROTEIN (bottom left), and CALORIES (bottom right) at lunchtime.

Calories. A significant decrease in calorie consumption, with a fall in median values of 101 calories between baseline and follow-up and moderate effect size, was observed in the Intervention school. By contrast, calorie consumption in the Control school remained stable over time. Calorie consumption was not perfectly matched at baseline, with the Control school consuming significantly more calories than the Intervention school. The effect size for this difference was moderate – a 50 calorie difference between group medians. At follow-up, the Intervention school continued to consume significantly fewer calories than the Control school, with a moderate effect size.

Other Changes in Children's Macronutrient Consumption

Figure 3.3 shows changes in children's intake between the two measurement points, across the two conditions, for carbohydrates, sugar, fat, and saturated fat. Their intake of fibre was also analysed but this is not plotted.

Carbohydrates. There was a significant decrease in carbohydrate consumption observed in the Intervention school with the median score reducing by seven grams from baseline to follow-up observations, yielding a small effect size. No change was detected in in the Control school with consumption remaining stable over time. Carbohydrate consumption for the two conditions was matched at baseline, and was also statistically similar at follow-up (no significant difference), probably due to large variability and consequent overlap of distributions.

Sugar. Whilst no difference in sugar consumption was recorded over time in the Intervention school, a significant decrease in consumption was recorded in the Control school (small effect size). The latter was based on a 3 gram decrease in median consumption between observation points, which is not much different from the 2.4 gram difference in consumption observed over time in the Intervention school, representing 10% of recommended daily maximum intake (Food Standards Agency, 2016). As before, these results may be associated with large variability in the data set. Sugar consumption between conditions was matched at both baseline and follow-up observation points.

Fat. Typical fat consumption in the Intervention school decreased significantly over time with a large effect size, whilst consumption in the Control school remained stable over time. Fat consumption in schools was not matched at baseline (small effect size) where the median for the Control school was 4 grams higher than the Intervention school. A significant difference of 9.11 grams between schools was also observed at follow-up with a moderate effect size.

Saturated Fat. The decrease observed in saturated fat consumption in the Intervention school was significant with a large effect size. No changes were observed in saturated fat consumption in the Control school. Saturated fat consumption for each condition was matched at baseline. At follow-up, participants in the Intervention school consumed significantly fewer grams of saturated fat than participants in the Control school, with a moderate effect size.

Fibre. Finally, no significant within-groups differences in fibre consumption (not plotted) were observed over time for the Intervention school or Control school. The consumption of fibre was also matched across the two conditions at baseline and follow-up.

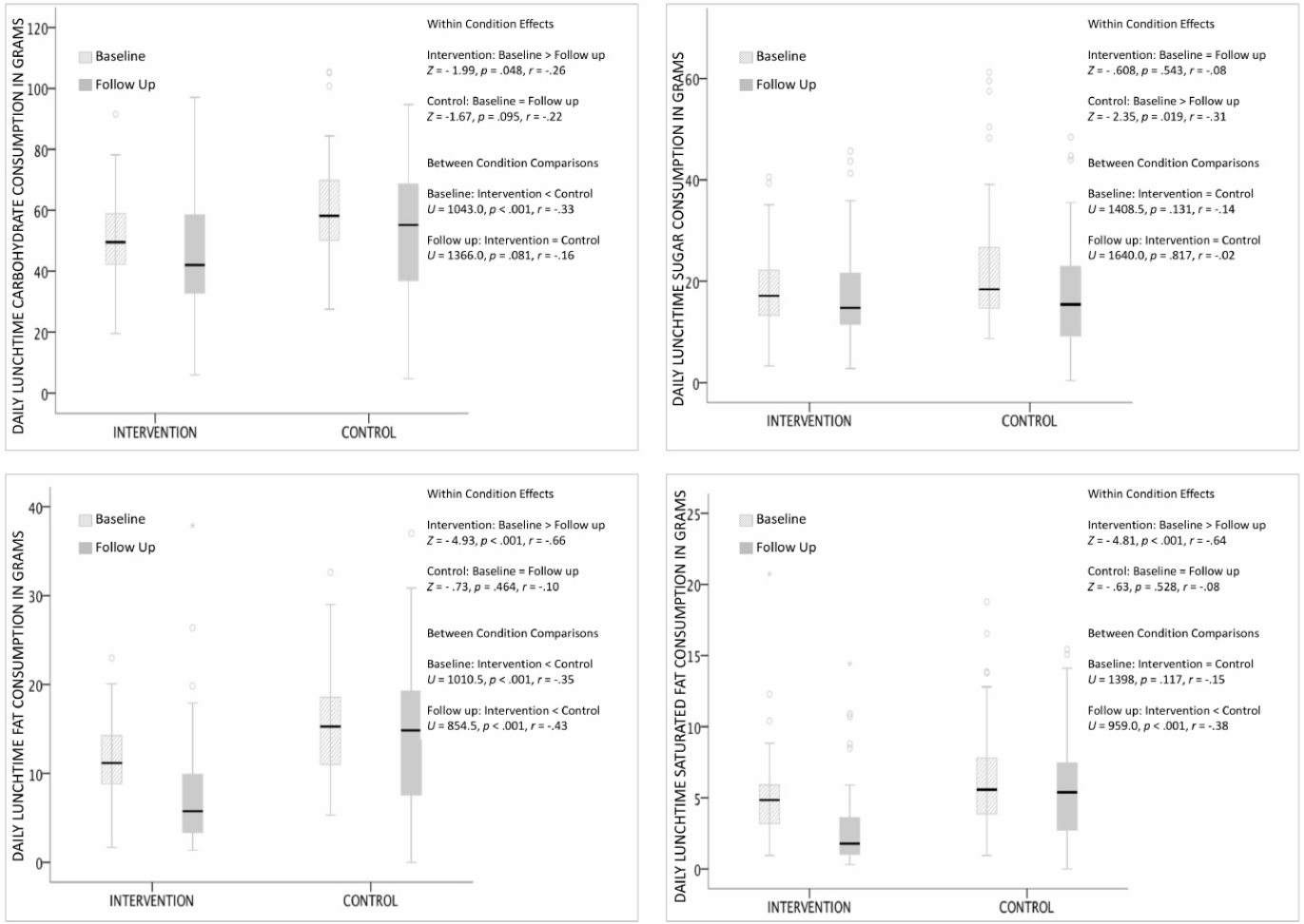

Figure 3.3. Boxplots showing children's daily consumption of CARBOHYDRATES (top left) , SUGAR (top right), FAT (bottom left), and SATURATED FAT (bottom right) at lunchtime.

Changes in Children's Micronutrient Consumption

Participants' consumption of sodium, potassium, vitamin C, and vitamin E were analysed. These micronutrients were chosen for multiple reasons. Sodium and potassium were chosen to monitor any differences in salt consumption; vitamin C was chosen due to its association with fruit and vegetables; and vitamin E was chosen due to research indicating that European children may be deficient in vitamin E consumption (Kaganov, Caroli, Mazur, Singhal, & Vania, 2015). Figure 3.4 shows changes in children's consumption of sodium, potassium, vitamin C and vitamin E between the two measurement points, across the two conditions.

Sodium. A significant decrease in sodium consumption with a moderate effect size was observed over time in the Intervention school, with median consumption reduced by 73 mg from baseline to follow-up. By contrast, a significant increase in sodium consumption with a moderate effect size was observed in the Control school, with median sodium consumption increasing by 93 mg. Sodium consumption was matched between groups at baseline. At follow-up, the Intervention school consumed significantly less sodium than did the Control school, with a large effect size. Indeed, Figure 3.4 demonstrates a 200 milligram difference in average consumption between groups at folllow-up, representing 100% of their daily recommended sodium intake (WHO, 2016).

Potassium. No significant differences in potassium intake were found over time in either condition. Potassium intake was matched between conditions at baseline and follow-up.

Vitamin C. A significant increase in vitamin C consumption was observed over time in the Intervention school, with a 22 mg increase, over two thirds of guideline minimum recommended intake (Food Standards Agency, 2007), recorded between baseline and follow-up observations (a large effect size). No significant difference was observed over time in the Control school. Vitamin C consumption was matched at baseline. At follow-up, the Intervention group consumed significantly more vitamin C than did the Control group, with a moderate effect size.

Vitamin E. Children's consumption of Vitamin E remained stable over time in both conditions. It was not perfectly matched at baseline, with the Intervention school consuming significantly less vitamin E than the Control school (a large effect size). However, no difference was detected at follow-up, with vitamin E consumption in the Intervention school increasing to match intake in the Control school. At follow-up, participants in each group consumed, on average, approximately one third of the recommended daily amount of vitamin E (NHS, 2017a).

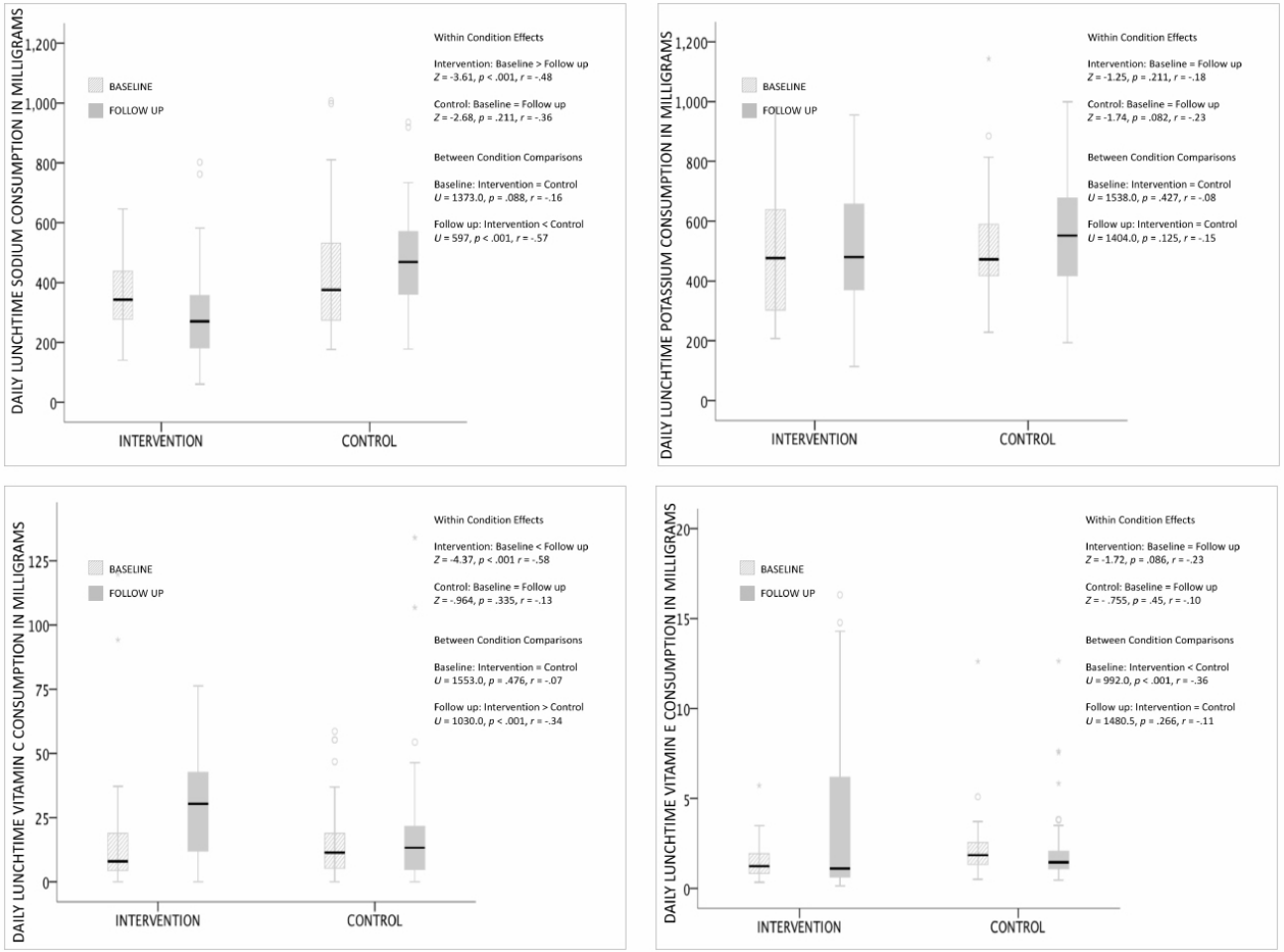

Figure 3.4. Boxplots showing children's daily consumption of SODIUM (top left), POTASSIUM (top right), VITAMIN C (bottom left), AND VITAMIN E (bottom right) at lunchtime.

Secondary Analyses: Main Effects by Lunch Type

Last, we investigated whether the consumption patterns differed between children who ate school lunches and those who brought their food from home. In the Intervention school, 73% of children brought their lunches from home and the remaining 27% had school dinners on most or all of their assessment days. In the Control school, 41% of children brought food from home and 59% were provided by school dinners.

Small samples and unequal group sizes necessitate cautious interpretation of the findings. Comparisons were made between groups at baseline, and in the magnitude of the changes over time (if any). We looked at fruit, vegetable, calorie, sodium, and vitamin C consumption - the key effects identified in the main analyses. The change over time was assessed by calculating the difference between baseline and follow-up observation points for each variable. These data are summarised in Table 3.1.

Table 3.1.

Significant within-groups differences by lunch type, according to the secondary analysis. Change = follow-up score - baseline score

	Baseline Difference	Magnitude of Change Difference
Fruit	-	I (U = 128, p = .030, r = -.20)
Vegetable	I (U = 131.5, p = .033, r = -.2) C (U = 313, p = .012, r = -.23)	-
Calorie	I (U = 71, p = .001, r = -.32) C (U = 193, p = .017, r = -.22)	-
Sodium	I (U = 106, p = .006, r = -.26) C (U = 79, p < .001, r = -.42)	I (U = 94.5, p = .003, r = -.28)
Vitamin C	I (U = 90, p = .002, r = -.29)	-

Note. I / C before parenthesis denote whether statistics apply to the Intervention (I) or Control (C.) school.

Fruit. Children in both schools were matched on their baseline fruit intake, but a lunch type difference was identified in the magnitude of change in consumption of fruit over time for the Intervention school. Indeed, those participants who consumed school dinners

increased their consumption of fruit significantly more than those participants who brought a lunch box to school (school dinner *Mdn increase* = 24.25; lunch box *Mdn increase*= 8.85). This may be because school lunch fruit provision was changed more readily than parental provision. No such effect was found over time in the Control school.

Vegetables. A difference in vegetable consumption between different lunch types was observed at baseline for both schools. In the Intervention school, participants who were provided with school dinners consumed significantly more vegetables (*Mdn* = 19.88) than those bringing lunch boxes from home (*Mdn* = 5.50). This may be because vegetables were provided with each school meal, but not in all lunch boxes. In the Control school, this trend was reversed, with participants who brought lunch boxes to school consuming more vegetables (*Mdn* = 20.00) than those provided with school dinners (*Mdn* = 0.00). This was unexpected. We noted that many lunchboxes in this school contained cucumber; it is quite possible that it was 'cool' in this school at the time of baseline testing to bring cucumber to school.

Calories. A significant difference in calorie consumption between lunch types was found in both the Intervention and Control schools at baseline. This was to be expected, with research consistently indicating that lunchbox food items are more likely to be high in fat, sugar and salt compared to their school dinner counterparts (Evans, Mandl, Christian & Cade, 2016).

Sodium. Significant differences were observed in sodium consumption between lunch types, with those participants who consumed food brought from home in lunchboxes consuming significantly more sodium than those participants who consumed school dinners in both conditions. A significant difference in the magnitude of change was observed between lunch types in the Intervention school, where those children who ate school dinners reduced their sodium intake more than those who brought lunchboxes from home.

Vitamin C. In the Intervention school participants who consumed school dinners consumed significantly more vitamin C than did those participants who brought their lunch from home.

Discussion

This study was the first to conduct a full nutritional analysis of the effects of the Food Dudes programme on children's lunches. The results show that the Food Dudes programme successfully increased fruit and vegetable consumption, whilst prompting a decrease in overall energy (calorie) intake, in the Intervention school. In-depth macro- and micro-nutrient analysis identified that these changes were associated with decreases in carbohydrates, fat, saturated fat, and sodium, as well as increases in vitamin C, supporting the notion that the increase in fruit and vegetable consumption elicited a displacing effect on the consumption of unhealthy snack food items. These positive changes were not identified in the Control school, suggesting that they can be attributed to the Food Dudes programme rather than seasonal differences in consumption between the two measurement points. These results have significant implications for national-level efforts to reduce the incidence of childhood obesity, and improve childhood nutrition, as recommended by the DOH (2011) and BMA (2015).

The effects of the Food Dudes programme may have substantial health implications for the children who take part. Increased fruit and vegetable consumption has consistently been associated with health benefits, such as having a protective effect against cancers, coronary heart disease, and stroke (Van Duyn & Pivonka, 2000). It has also been associated with children consuming fewer high energy snacks (Epstein et al., 2001), which was the trend observed in the present study, leading to a significant reduction in calorie intake. A decrease in calorie intake is associated with a decrease in incidence of, and a protective effect against, overweight and obesity (Barlow, & Dietz, 1998; Dehghan, Akhtar-Danesh, & Merchant, 2005). Indeed, the median calorie reduction recorded over time in the intervention group was 47 calories. Though predictions of weight change are subject to individual and environmental differences and cannot be confidently asserted (Hall et al., 2012), it has been suggested that a daily positive energy balance of 120 calories can result in a 50-kilogram weight increase over 10 years (Ebbeling, Pawlak, & Ludwig, 2002). The present effect, even if it was confined to lunchtime and did not transfer to home, would protect the children from a substantial weight gain. This evaluation ought to be replicated with measurements of children's consumption over the entire day, to confirm that children did not compensate by consuming more calories during other meals and snack times, and to ascertain whether further benefits of increased

fruit and vegetable consumption were obtained at their home - even if this has to be measured in a less direct and precise manner.

The present nutritional analysis also highlighted other potential health implications. The macronutrient decreases in fat, saturated fat, and carbohydrate consumption may themselves serve as protective factors against childhood obesity. High fat intake is associated with an increased likelihood of obesity in children (McGloin et al., 2002), whilst high carbohydrate intake is associated with a greater likelihood of an energy dense diet (Gibson, 2000) that could subsequently lead to a positive energy balance. When considering micronutrient changes, a 200 milligram between-groups difference in average sodium consumption was observed at follow-up between the two cohorts, totalling almost 100% of their daily recommended sodium intake (DOH, 2012). This represents a significant health implication for the Intervention group, as identified by Sacks et al. (2001) who reported that a decrease in dietary intake of sodium of this magnitude can result in a significant reduction in risk of hypertension. In addition, a 17mg difference in vitamin C consumption was observed between groups at follow-up, a difference of almost 50% of the daily recommended intake for vitamin C (NHS, 2017b), presenting potential implications for immune function (Maggini, Wenzlaff, & Hornig, 2010).

During the nutrient analysis, we also identified some unexpected effects. Protein consumption decreased in the intervention school, though the median decrease between time points was only 1.7 grams representing less than 5% of guideline daily recommended protein intake (NHS, 2017c). Considering this, we do not believe that this result is associated with any health implications. Due to increases in fruit and vegetable intake, we had anticipated an increase in fibre consumption, but none was found, possibly because other foods in children's lunches also contained fibre, and variability was large. We had expected a decrease in sugar consumption; however, no significant differences were identified. This may be because, although unhealthy snack items were displaced, the sugar from these foods was substituted with intrinsic sugars found in fruit. This would still present a favourable outcome. The WHO (2015) suggests that, since these sugars have not been associated with poor health effects, they should not be considered when assessing dietary sugar. Unfortunately, it was not possible to analyse the two types of sugar separately because of lack of sufficiently detailed information, but it seems likely that inclusion of intrinsic sugars in our nutrient analysis is masking significant decreases in free sugars, found in processed foods and naturally present in honey, syrup, and fruit juice.

Overall, the present results show that short-term changes in children's dietary habits, achieved over two months, can be robust and significant, and that increasing fruit and vegetable consumption engendered by the Food Dudes programme leads to displacement of less healthful foods from children's lunches, for both those children who were eating school lunches, and others (a majority) who brought their food from home. In the latter case, changes in provision that enabled children to enjoy a healthier diet was also indicative of parental support and habit change. Future research ought to provide a long-term tracking of these effects, because potential health benefits of dietary change can only be realised if this change is sustained over time.

The present study builds upon previous research in several ways. Existing research into the effectiveness of the Food Dudes programme has only estimated consumption of fruit and vegetables on a 5-point scale: 0; 25%; 50%; 75%; 100% (e.g., Horne et al., 2004). Using a previously-validated digital photography methodology (Marcano-Olivier et al., in submission), we were able to estimate food item consumption to a finer-grained scale, to the gram. Further to this, we were also the first to consider the impact of the Food Dudes programme on global nutrient consumption at lunchtime, rather than portion size consumption differences alone. These two factors allowed us to conduct a better and more detailed nutritional analysis of all food items consumed at lunchtime, yielding information regarding calorie, macro- and micro-nutrient consumption. This enabled us to assess the potential health benefits of participation in the Food Dudes programme, and verify a displacing effect of fruit and vegetable consumption on less healthy food items.

Conclusion

This study presented an in-depth evaluation of the Food Dudes programme, a school-based intervention designed to encourage healthy eating behaviour in children. Following implementation of the intervention, we observed significant increases in fruit, vegetable, and vitamin C consumption, as well as decreases in fat, saturated fat, carbohydrate and sodium consumption. No such changes were observed in the control school. These results show promise as a protective factor against childhood obesity.

Chapter 4

Using Nudges to Promote Healthy Food Choices in the School Dining Room: A Systematic Review of Previous Investigations

In chapter 3, we presented an analysis of an intensive, multicomponent healthy-eating programme. Such interventions have been reported to yield good results, but they need time, training, and resources to implement effectively, which makes them unaffordable in most settings. In many cases, the commissioners responsible for healthy eating resort to cheaper, social marketing campaigns and interventions, such as the 'Change for Life' in the UK (DOH, 2011), despite the lack of evidence for their effectiveness. This demonstrates a requirement for simpler interventions that can effectively promote healthy eating behaviour in schools, but without the associated cost.

One method of behaviour change characterised by relatively low cost and simplicity of execution is the modification of the choice architecture and utilisation of behavioural nudges (see Chapter 1, 'Key Approaches That Work' section). The following chapter describes a systematic review of school-based healthy eating interventions that employ behavioural nudges as the sole component influencing behaviour change. This paper was written for the attention of health professionals with a goal to promote healthy eating behaviour in schools, and researchers with an interest in developing interventions to improve school children's diets. The aims of this review were to highlight the potential for behavioural nudge interventions in promoting healthy eating behaviour, whilst also identifying areas where future research may build upon previous investigations.

This paper was submitted to the Journal of School Health, an indexed peer-reviewed, open access journal (IF=1.43) with a focus on promoting best practice for a healthy school environment. Their intended readership includes health professionals, physical educators, and school physicians and nurses, and hence is aligned with the intended audience for this review.

Authors' Contributions

MMO conducted the review, completed QATQS assessment, processed and analysed data, and drafted the manuscript. ME secured the funding, supervised the review process, completed QATQS assessment, and co-wrote the final manuscript. SV assisted with

methodological background and editing. PJH made an editing contribution. All authors have read and approved the final manuscript.

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Abstract

There is a growing interest in low-cost interventions that modify obesogenic environments to encourage positive behaviour change. We have conducted a systematic review of the studies that used behavioural nudges to promote healthful food consumption in school cafeterias. A focused literature search was conducted using five databases; out of 381 papers, 25 were included in the present review and assessed using the Quality Assessment Tool for Quantitative Studies.

Most studies used relatively small, convenience samples and data collection methods that could not be described as robust, necessitating cautious interpretation of their results. A range of behavioural nudges were employed. Seventeen studies reported positive effects on children's selection and 11 studies reported improvements in their consumption of target foods, effected by changing the order of serving; increasing the convenience, attractiveness, and normativeness of selecting healthy options; increasing the variety available; and attractive target food labelling.

Overall, this review identified the requirement for well-designed and well-controlled investigations into the effects of changing the choice architecture in school cafeterias, assessing short-, medium-, and long-term changes in individual children's consumption, utilising validated measures, and conducted across a variety of settings, including dining rooms of schools outside the US.

Keywords: choice architecture, nudge, obesity, school dining rooms, school canteens, school cafeterias, healthy eating interventions, behaviour change, children.

Introduction

Investigations into children's diets indicate that they have a preference for foods high in fat (Birch, 1992; Johnson, McPhee, & Birch, 1991), sugar (Cooke & Wardle, 2005; Waddingham, Stevens, Macintyre, & Shaw, 2015) and salt (Beauchamp & Cowart, 1990; Bouhlal, Issanchou, & Nicklaus, 2011). Children regularly indulge in these "junk food" items (Garemo, Lenner, & Strandvik, 2007) but fail to consume fruit and vegetables (Grimm, Kim, Yaroch, & Scanlon, 2014; McAloney et al., 2014; National Cancer Institute, 2015), in spite of being aware of the associated health benefits of a diet rich in those foods (Povey, Cowap, & Gratton 2016). Overeating and poor dietary choices significantly contribute to the high prevalence of overweight and obesity in children in the developed world. With research suggesting that dietary habits and weight in childhood and adolescence are significant predictors of dietary habits (Larson, Lasaka, Story, & Neumark-Sztainer, 2012) and weight related issues (Daniels, 2009) in later life, interventions promoting healthy eating during childhood could have the potential to protect against future weight related health issues (Tran, Ohinmaa, Kuhle, Johnson, & Veugelers, 2014).

A convenient setting for healthy eating interventions in childhood is the school dining room at lunchtime. Many schools allow pupils the option of bringing their own lunch to school from home or choosing hot or cold meals provided in the school canteen. It is these school cafeteria meals (i.e., school dinners) that offer the greatest potential for systematic intervention implementation as most aspects of the meal experience, from choice to environment and serving size, can be easily controlled, monitored, and measured. Many multicomponent interventions have been designed to target school lunch nutrition, but they can be time costly and require considerable resources and expertise to implement effectively (Sahota et al., 2001; Anderson et al., 2005), though the costings of such interventions are not typically published. As a result, funding bodies may be more likely to opt for cheaper, less effective interventions.

Could interventions that change the choice architecture (Thaler & Sunstein, 2008) of the lunchroom to promote healthy food choices yield significant and lasting changes in children's consumption, without the time and resource costs associated with more intensive interventions? Choice architecture refers to the ways that the environment presents certain behavioural options to an individual, and can be altered in order to increase the salience and convenience of target behavioural choices. Modifications to the environment to promote target behaviours are usually referred to as behavioural nudges. Some healthy eating programmes have incorporated such modifications, such as providing each child with

colourful “Fruit” and “Vegetable” containers to encourage them to take fruit and vegetables to school (Horne et al., 2009).

Whilst intensive, multicomponent programmes may utilise nudges to complement their intervention, a new generation of relatively simple, low-cost interventions entirely based around behavioural nudges have surfaced in the literature, and report promising results for behaviour change. Recent systematic reviews have examined the effects of nudges on eating behaviour in adults (Bucher et al., 2016; Wilson, Buckley, Buckley, & Bogomolova, 2016), the role of nudging as a part of a multi-component review of childhood healthy eating influencers (DeCosta, Møller, & Frøst, 2017), and whether nudging can help to increase children’s vegetable consumption (Nørnberg, Houlby, Skov, & Peréz-Cueto, 2016). The present paper adds to this literature by reporting the first systematic review of the effects of behavioural nudge interventions that have modified choice architecture of school canteens at lunchtime, to influence children’s food selection and consumption.

Method

Search Strategy

To identify interventions using only behavioural nudges to promote healthy food item choice or consumption in the school cafeteria, a literature search was conducted. Five databases for peer reviewed scientific literature and unpublished grey literature were used to retrieve articles published since 2000 (prior to which the cafeteria environment may have changed too significantly to draw comparison); these included Google Scholar, Science Direct, PubMed, PrePubMed, and Web of Science. The search terms used comprised of words and phrases associated with the phenomenon of interest: setting (e.g., school canteen, school cafeteria, school eating, and school dining); intervention type (e.g., nudges, choice architecture, environmental interventions, and environmental variables); and target behaviour (e.g, healthy eating, fruit/vegetable consumption, and healthy choices). Time was taken to ensure that different combinations of key terms were searched on each database. Following this, whenever we identified multiple papers as coming from the same authors, we also conducted a search of their lab website. Finally, for all identified relevant papers, we investigated which studies they cited, and who cited their work in turn. This mixed search methodology was successful in identifying several unpublished theses, reports, and papers

that used vague key words; it minimised the confound effects that may be caused by publication bias and “file drawer problem” (Littell, Corcoran, & Pillai, 2008).

Selection Process

This search yielded a total of 3681 potentially relevant studies, which were screened according to the postulated inclusion criteria (a) simple nudge-only interventions, (b) focused on increasing healthy food and drink choice, (c) conducted in school cafeterias at lunchtime (e.g. no breakfast clubs or snack time interventions), (d) reporting at least one outcome measure for food selection or consumption (e.g. studies where participant’s opinions about healthy food were the sole outcome measure were not included), (e) some form of experimental control was utilised (given the pilot nature of most studies, baseline vs. follow-up in a single sample was acceptable), and (f) had been published since 2000 (inclusive, to ensure comparable environments); however, no relevant studies prior to 2012 were identified. Studies were excluded if (a) changes were made to canteen provision to reduce choice (e.g. unhealthy options were no longer offered in the canteen), (b) the participants were not a typical school population sample, or (c) the nudge was a part of a multicomponent intervention.

Methodological Quality

All studies identified as appropriate for inclusion were assessed for quality using the Quality Assessment Tool for Quantitative Studies (QATQS; Effective Public Health Practice Project, 2003; see Appendix 14). This practice is recommended as an appropriate tool for use in the systematic review of intervention effectiveness (Armijo-Olivo, Stiles, Hagen, Biondo, & Cummings, 2010). Using this tool, studies were scrutinised and rated on a three-grade scale (i.e., weak, moderate, or strong) on six methodological and reporting dimensions: selection bias, study design, confounders, blinding, data collection methods, and withdrawals and drop-outs. However, it was agreed that this last category was not applicable, because in most of the reviewed studies individual consent and individualised data were not recorded.

A global rating was then calculated according to the QATQS guidelines. Those studies that had achieved at least a strong or moderate rating on the five dimensions merited a strong global rating; a moderate rating was given to those studies that obtained a weak rating on one of the dimensions; and a weak rating was given if two or more dimensions were rated as weak. To ensure inter-rater reliability, the first and the last authors of this paper

independently rated each study. Disagreements were discussed until a final verdict on study quality was reached.

Data Extraction and Synthesis

Data and QATQS results of the final sample of studies meeting the inclusion criteria were tabulated. Table 4.1 details QATQS scores for each study, in each category and overall. Table 4.2 summarises key features of studies examining influences on milk, fruit, and vegetable consumption. Table 4.3 presents these details for studies examining global nutrient change.

Results

Results Search Strategy

Of the 381 studies identified by the search strategy, 311 were eliminated based on titles and abstracts and the full text of 70 studies were retrieved and reviewed. Following this, 25 studies were included in the final review. Most excluded articles were removed on the basis of using nudges as one component of a complex multicomponent intervention. Such studies were deemed outside of the scope of the present review because the effectiveness of the nudge components alone could not be ascertained. The paper selection procedure is summarised in Figure 4.1.

Methodological Quality of Included Studies

Prior to discussions, independent raters reached agreement levels of 67% - 100% in each of the six QATQS categories. Following discussion, a final verdict was agreed for each rating; disagreements were small and related to different reading of study questions or the assessment tools. No third party was required to reach an agreement.

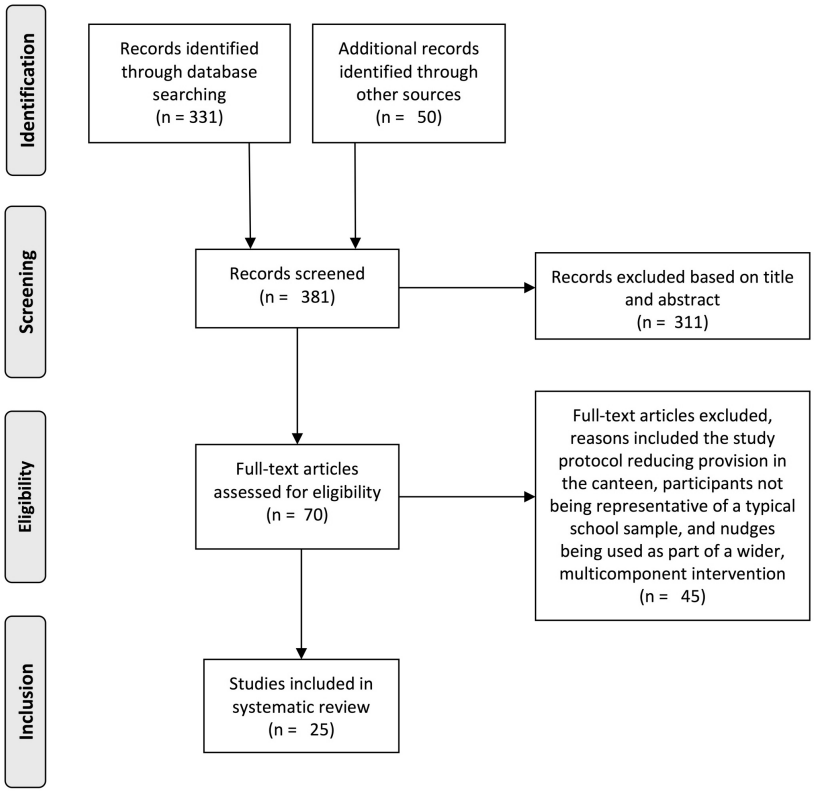

Figure 4.1. Selection protocol for studies included for review.

Table 4.1.

QATQS scoring results for studies included in this review.

Study/Country	Selection Bias	Study Design	Control for confounders	Blinding	Data collection	Global Rating
Elsbernd et al. (2016) [26]	**	**	***	**	**	***
Goto et al. (2013) [27]	***	**	***	**	*	**
Greene, et al. (2017) [28]	***	**	***	**	*	**
Hakim & Meissen (2013) [29]	**	**	***	**	*	**
Hanks et al. (2016) [30]	**	**	*	**	*	*

Keller (2017) [31]	**	**	***	**	*	**
Miller et al. (2015) [32]	**	**	***	**	*	**
Redden et al. (2015) [33]	**	**	**	**	*	**
Reicks et al. (2012) [34]	*	**	*	**	*	*
Samek (2016) [35]	***	**	*	**	*	*
Schwartz (2007) [36]	*	**	***	***	*	*
Swanson (2009) [37]	**	**	***	**	**	***
Wansink et al. (2013b) [38]	**	**	***	**	*	**
Wansink et al. (2012) [39]	**	**	***	**	*	**
Study/Country	Selection Bias	Study Design	Control for confounders	Blinding	Data collection	Global Rating
Wansink et al. (2012) [40]	***	**	***	**	*	**
Zellner et al. (2016) [41]	**	**	***	**	*	**
Zhuzhina (2016) [42]	*	**	***	**	*	*
Ensaff et al. (2015) [43]	**	*	*	**	***	*
Graham (2015) [44]	*	**	*	**	*	*
Hanks et al. (2013a) [45]	**	**	***	***	***	***

Hanks et al. (2013b) [46]	**	**	***	**	*	**
Hanks et al. (2012) [47]	**	**	***	**	*	**
Miller et al. (2016) [48]	**	**	*	**	***	**
Siegel et al. (2015) [49]	**	**	***	**	***	***
Wansink et al. (2013a) [50]	*	**	*	***	***	*

Note. * = Weak, ** = Moderate,*** = Strong

Hereafter, when referring to multiple studies included in the review in parenthesis, their associated study number (see Table 4.1) will be cited in superscript.

As can be seen from Table 4.1, four studies yielded a strong global rating [26,37,45,49]; the global rating of 12 studies were moderate (27-29,32,33,38-41,46-48); while the remaining nine studies were rated as weak (30,31,34-36,42-44,50).

Sample ("selection bias") was rated as weak in five studies (34,36,42,44,50); moderate in 15 studies (26,29-33,37-39,41,43,45-48,49); and strong in four studies (27,28,35,40). Issues negatively affecting ratings were generally associated with opportunity sampling (where local schools were used) or volunteer sampling (e.g., a small percentage of engaged parents consented to the intervention) whereby participants may not have been fully representative of the general population.

Twenty-four study designs were rated as moderate, with only one study rated as weak (Ensaff et al., 2015), that is, the design of the study was unclear. Due to the nature of the research, no studies were randomised controlled trials, as participants were assigned to intervention or control groups by cohort rather than by individual case. As a result, studies were either described as cohort (26,29,31-34,37,39-42,44,46,47,49) or cohort analytic (27,28,30,35,36,38,40,45,48,50). Of the 10 studies including a control group, seven described the group allocation procedure as randomised (27,28,30,35,36,38,45), however, only one paper described a randomisation procedure (Greene, Gabrielyan, Just, & Wansink, 2017).

Of those papers described as cohort analytic (includes a control group and pre- and post-test measures for comparison), no important differences were identified between groups

at baseline on key potential confounders in five papers [27, 28, 36, 38, 45], with four papers reporting notable differences between groups [30, 35, 48, 50], the one remaining paper did not report sufficient information to assess confounding factors between groups (Wansink, Just, Hanks, & Smith, 2013). Regarding blinding, the outcome assessors were aware of the participants' exposure status in every study except one (Zhuzhina, 2016), whilst only one paper (Siegel, 2015) reported whether or not participants were made aware (or blinded from) the purpose of the study.

Data collection methods were generally weak (27-36, 38-42, 44, 46, 47, 49) with most studies utilising visual observation methods without establishing their validity and reliability. One study (Greene et al., 2017) utilised visual observation methods and provided references to a previously validated protocol (Hanks, Wansink, & Just, 2014), however, a low rating was awarded due to coding errors resulting in a loss of a large quantity of the data. Another study (Swanson, Branscum, & Nakayima, 2009) utilised a reliable digital photography data collection method (Swanson, 2008), however, validity for this method was not reported, and so a moderate rating was awarded for data collection on this paper. One other paper (Elsbernd et al., 2016) achieved a moderate rating, whilst five studies yielded strong ratings (43, 45, 48-50).

Study Findings

The following summary of the findings of the studies included in the present review is sub-categorised by target outcome behaviour.

Healthy milk choice. Two of the included studies focussed on increasing white milk selection (see Table 4.2). Goto, Waite, Wolff, Chan, and Giovanni (2013) conducted their study using two interventions and one control school. The first intervention made selection of chocolate milk more "effortful" than the healthier white milk option, that is, students had to ask for chocolate milk rather than being able to select it from stands by the cafeteria tills. The second intervention for this study increased the "availability and prominence" of white milk by maintaining a three-to-one ratio of white milk to chocolate milk on the milk stands. In this study, the sole significant change was an increase in white milk selection for those participants in the "increased effort" condition.

Samek (2016) conducted his study using 90 6th grade classes. It employed two intervention groups and one control group. The first intervention encouraged children to take healthier white milk instead of chocolate milk by giving children a "gift" (a sticker) to thank them "in advance" for selecting white milk. The second intervention involved asking children to set themselves the "goal" of choosing white milk by filling in "goal setting cards" before entering the dining hall. In the control school, children were read an educational message about sugar in white and flavoured milk. Children were not obliged to take white milk in any condition and continued with their normal lunchtime routine. Results indicated that in the control condition, selection of white milk increased significantly from 11% at baseline to 47.8% on the day they received the educational message. White milk selection increased significantly compared to baseline selection and the control group in the "gift" and "goal" intervention groups (from 11% to 65.5% and 54.8%, respectively). It is not possible to assume that these effects would remain stable over time and have a lasting impact on children's milk choice due to a lack of follow-up observation. One key limitation of this research is the significant increase in milk consumption in the control group, indicating that there was a substantial influence of simply drawing children's attention to milk choices, but this impact was not addressed nor controlled for.

Fruit and/or vegetable consumption. Fifteen studies aimed to employ nudges to increase fruit and/or vegetable selection and/or consumption (see Table 4.2). Elsbernd et al. (2016) examined the influence of serving a portion of bell peppers in the dinner line on total vegetable consumption. Children were offered a portion of bell peppers "to eat right now" before they were served the rest of their meal. Although the mean weight of peppers consumed by students who took a serving of peppers did not significantly increase, a significant increase in total number of children eating peppers was identified, resulting in a significant increase in total vegetable consumption, compared to baseline.

Greene et al., (2017) tested the effectiveness of the Smarter Lunchroom programme. This paper reported that targeting fruit by several nudges, including increasing the choice and appearance of the servings, convenience of their selection, labelling, and information provision, led to significant increases in the selection and consumption of this target food, accompanied by some increases in the selection and consumption of vegetables and milk. These effects were recorded in the four intervention schools but not in the three control schools.

Hakim and Meissen (2013) attempted to increase fruit and vegetable consumption for those children served free or discounted school meals by introducing more active choice into the forced-choice paradigm. This intervention involved increasing the number of fruit or vegetables available to participants on alternating days. For example, on a “vegetable” day, students had a choice of five varieties of vegetable but were served the standard fruit available on that day. Results indicated that consumption of both fruit and vegetables increased significantly compared to baseline.

Hanks, Just, and Brumberg (2016) aimed to increase selection of vegetables from the salad bar using visual nudges. A control school and three treatment conditions were utilised. No changes were made in the cafeteria of the control schools. In the “banner” intervention group, a brightly coloured banner depicting cartoon vegetable characters was placed around the salad bar. In the “television” group, screens playing health education messages delivered by vegetable characters were placed in the cafeteria. In the “banner and television” group, both media prompts were utilised. Results indicated a significant increase in the number of salad and vegetable servings taken in the “banner and television” condition, but not in either condition where only one type of media was utilised, compared to baseline.

Keller (2017) assessed the effectiveness of three nudge techniques, utilised independently, on 6th grade students’ selection and consumption of fruit. Following a three-day baseline data collection period, on intervention day one, stickers were placed on whole pieces of the fruit available to buy at lunchtime (apple) by way of “branding”; on day two, the fruit available (banana) was digitally advertised on television screens in front of the dinner queue; on day three, two types of fruit were offered (grapes and kiwi), increasing the variety of fruit available. The branding intervention was found to have no impact on apple selection, and indeed was associated with a decrease in consumption, whilst digital advertisement intervention prompted an increase in banana selection, though banana consumption was significantly reduced. The most successful nudge was increasing the variety of fruit available, which was associated with a significant increase in fruit selection, though consumption remained constant.

Miller et al. (2015) increased portion sizes of fruit and vegetables served at lunchtime to investigate the subsequent effects on overall consumption. Following one day of baseline data collection, the portion sizes of baby carrots, oranges, and apple sauce were increased, though no other changes were made to the lunchtime routine. Results indicated a significant increase in mean consumption for apple sauce and oranges, but no significant increases in

baby carrot consumption. Researchers noted that this may be due to the low levels of vegetable selection, and difficulty eating a large portion of raw baby carrot compared with the ease of eating apple sauce or pre-sliced orange wedges.

Reicks, Redden, Mann, Mykerezi, and Vickers (2012) studied the effect of visual prompts on the amount of green beans or carrots consumed. Data were collected on two days (control and intervention), spaced three months apart. No changes were made to the lunchtime routine on the control day, however, on the intervention day photographs of available vegetables were placed in the compartments of dinner trays designated for vegetable servings, so that children identified these areas as where vegetables “should go”. There was an increase in percentage of children who selected the target vegetables, but no overall increase in the average consumption of either vegetable; indeed, carrot consumption declined between control and intervention collection dates.

Redden et al. (2015) investigated the impact of serving a portion of vegetables in the dinner line on total vegetable consumption. In study 1, children were able to select a portion of baby carrots, a relatively well-liked vegetable, to eat in the dinner line. No other changes to provision or serving were made. This study was conducted on two days, spaced three months apart. Results showed that participants consumed significantly more carrots on the day when this option was available. Their second study was longitudinal, conducted over five days (one control day, three intervention days, one post-test control day) spaced two or three weeks apart. As before, children were able to select a vegetable portion, for instance a relatively disliked vegetable like broccoli, to consume in the dinner line. Results indicated that children consumed significantly more broccoli on intervention days compared to control days. A strength of this study manifests in the generalisability of results between relatively liked and relatively disliked vegetables.

Schwartz (2007) used verbal prompts to encourage fruit and fruit juice consumption. No changes were made at lunchtime in the control group; however, the intervention group were given one simple verbal prompt by cafeteria staff to encourage selection: “Would you like fruit or juice?”. Results indicated that, on the first day of the intervention, children in the intervention school selected more fruit following verbal nudges, and on the second day, children in the intervention school were more likely to take fruit or juice, although the difference between groups had decreased for fruit selection. Although they were not more likely to consume their fruit than the control school (approximately 80% of students in each group who selected fruit also ate it), increased selection still led to greater levels of

consumption. Unfortunately, data collection relied on visual counts from parents, rather than trained observers, with no means of establishing validity or reliability of this method.

Swanson, Branscum, and Nakayima (2009) investigated the impact of ease of consumption on selection and consumption of apples and oranges. Oranges and apples were either served as half of a piece of fruit sliced into three wedges (day 1, intervention), or as a whole piece of fruit (day 2, follow-up control) during the lunch period. Selection and consumption of sliced oranges were greater compared with when whole oranges were offered, though this effect was not observed for sliced apples, for which selection and consumption were comparable across intervention and control days.

Wansink et al. (2013a) also assessed the influence of serving sliced fruit on the selection and consumption of apples, in New York middle schools. Apples were either served whole (control schools) or pre-sliced using a commercial fruit slicer (intervention schools). Apple sales increased by 71% in the intervention school compared with the control school; however, there was no change in percentage of apples consumed. A strength of this research was a prior identification of barriers to fruit consumption. Using interview techniques, researchers discovered that whole pieces of fruit could be difficult to eat for young children, especially those with teeth missing or braces, and that older girls found eating whole fruit to be messy and unattractive in front of peers.

Wansink, Just, and Payne (2012) evaluated the influence of branding on apple consumption in seven school. This study took place over five days where children were given the option to choose either an apple and/or a cookie. On the control days (days 1 and 5), neither the apple nor the cookie were branded. On intervention days (days 2 - 4), children were either offered an apple branded with a sticker of a well-known cartoon character (Elmo), and/or an unbranded cookie; a branded cookie (as before) and/or an unbranded apple; or an apple branded with a sticker of an unknown character and an unbranded cookie. Selection of Elmo-branded apples significantly increased compared to control conditions, though no effect was found for branding on cookie selection, nor were any effects observed for apple selection when an unknown cartoon character sticker was used.

Wansink, Just, Payne, and Klinger (2012) investigated the use of attractively named vegetables to promote and maintain vegetable consumption. In their first study, children ate significantly more carrots when they were labelled “X-ray vision carrots” than when they were labelled “Food of the day” or were unlabelled. In Study 2, hot vegetables were given attractive names in the school cafeteria (e.g., “Power Punch Broccoli”), and data

automatically collected by cash registers indicated that students were much more likely to select a hot vegetable if they had an attractive label than students in the no-label control group.

Zellner and Cobuzzi (2016) investigated the influence of the order of serving fruit on the consumption of vegetables at school mealtime. On two separate days, more than two months apart, children were either served their portion of fruit with their meal (control condition), or after their meal as a separate dessert course. Results indicated that participants consumed significantly more target vegetable (kale) when fruit was served as a separate course, though "liking" ratings remained constant. This indicates that the mere presence of a more liked competing food item may reduce consumption of a less liked food item, even if the consumption of one does not require the displacement of another. Curiously, the authors did not report children's consumption of fruit in either condition.

Zhuzhina (2016) implemented a "Smarter Lunchroom Makeover". Following baseline data collection, the school lunch halls were modified to incorporate several behavioural nudges; signage featuring new names for fruit and vegetables along with personified images were displayed, decorative plastic bowls containing sliced fruit were placed on the salad bar, and wicker baskets containing whole pieces of fruit were also displayed. Results indicated that the intervention had been successful in increasing fruit and vegetable selection in only one of the intervention schools, compared to baseline, though the likelihood of students consuming a whole serving of fruit or vegetable, once they had selected it, increased in both schools during the intervention.

Table 4.2

A synopsis of the included studies that focus on healthy milk choice or fruit and/or vegetable consumption.

Study/Country	Study Design	Sample Characteristics	Duration/ Measurements	Outcomes	Main Results
Elsbernd et al. (2016); Minnesota, US [26]	Cohort	1 elementary school, Kindergarten – 5th grade classes, n = 575	1 day control; plus 1 day follow-up control; 3 day intervention. Visual observation, vegetable sales, and floor-waste.	Number of students eating peppers (NP), mean weight of peppers consumed (PC), mean weight of total vegetables consumed (VC).	NP: +++ PC: [=] VC: [=]
Goto et al. (2013); Northern California, US [27]	Cohort Analytic	3 elementary schools, 2 treatment groups (T1; T2), 1 control group (C) – T1 (Ask intervention, n = 247), T2 (Increase intervention, n = 153), C (control, n = 277).	5 day baseline; 5 day intervention. Milk selection recorded and milk waste weighed.	White milk selection (MS) and percentage of milk consumption (MC).	- T1 MS: +++ Ask MC: [=] - T2 MS: [=] MC: [=]
Greene, et al. (2017); New York, US [28]	Cohort Analytic	10 Middle schools; fruit intervention (n = 4); vegetable intervention (n = 3); control (n = 3)	1 month baseline; 2 month follow-up. Selection and plate waste recorded by observation.	Fruit selection (FS) and consumption (FC), Vegetable selection (VS) and consumption (VC), and milk selection (MS) and consumption (MC).	FS: +++ FC: +++ VS: +++ VC: +++ MS: +++ MC: [=]

Study/Country	Study Design	Sample Characteristics	Duration/ Measurements	Outcomes	Main Results
Hakim & Meissen (2013); Midwest, US [29]	Cohort	Plate waste was recorded for 2148 meals by direct observation (n = 2, 064) or objective weighing (n = 84).	1 month baseline; 1 month intervention. Selection and plate waste recorded by observation or direct weighed measure.	Consumption of fruit (CF) and vegetable (CV).	CF: ++ CV: ++
Hanks et al. (2016); New York, US [30]	Cohort Analytic	10 elementary schools - 1 control condition (C: n = 2), 3 treatment conditions (T1: n = 2; T2: n = 3; T3: n = 3, respectively). 22206 observations recorded.	2 weeks baseline; 4 week intervention. Food preparation records. Tallys of number of students taking a salad serving (visual observation).	Vegetable and salad selection (VS).	Food preparation records - T1 VS: [=] - T2 VS: [=] - T3 VS: + Tallys of selection - T1 VS: + - T2 VS: [=] - T3 VS: +++

Study/Country	Study Design	Sample Characteristics	Duration/ Measurements	Outcomes	Main Results
Keller (2017); Atlanta, US [31]	Cohort	1 school, 6th grade students.	3 day baseline; 3 day intervention (1 day treatment 1 [T1, branding], 1 day treatment 2 [T2, advertising], 1 day treatment 3 [T3, variety]). Data recorded by observation.	- Fruit selection (FS) and consumption (FC).	T1 - FS: [=] - FC: +++ (reduction) T2 - FS: ++ - FC : ++ (reduction) T3 - FS : +++ - FC : [=]
Miller et al. (2015); US [32]	Cohort	1 elementary school, Kindergarten – 5th grade classes, n = 758.	1 day baseline; 2 day increased portion size intervention. Pre-consumption weight estimates were compared to actual post-consumption weight.	- Carrot consumption (CC), apple sauce consumption (AC), and orange consumption (OC).	CC: [=] AC: +++ OC: +++

Study/Country	Study Design	Sample Characteristics	Duration/ Measurements	Outcomes	Main Results
Redden et al. (2015); Minnesota, US [33]	Cohort	1 elementary school; Kindergarten – 5th Grade. Study 1: n = 755. Study 2: n = 558.	Study 1: 1 day control; 1 day intervention. - Study days conducted 3 months apart. Visual estimation and average portion sized weights used to approximate consumption. Study 2: 2 day control; 3 day intervention. Study conducted over 3 months. Visual estimation and average portion sized weights used to approximate consumption.	- Study 1 - Carrot consumption (CC). - Study 2 – Broccoli c onsumption (BC).	Study 1 – CC: +++ Study 2 – BC: +++

Study/Country	Study Design	Sample Characteristics	Duration/ Measurements	Outcomes	Main Results
Reicks et al. (2012); Minnesota, US [34]	Cohort	1 elementary school; n = 800	1 day control; 1 day intervention. Consumption calculated from plate waste.	- Green bean consumption (GBC), and carrot consumption (CC).	GBC: = CC: I < C +++
Samek (2016); Chicago, US [35]	Cohort Analytic	8 schools (C n = 27 classrooms; Gift n = 30 classrooms; Goal n = 33 classrooms); n = 1,483.	1 day intervention; 1 day baseline. Milk sales records.	- Choice of white milk control (WCc), choice of white milk Gift condition (WC1), choice of white milk Goal condition (WC2).	WC1 > WCc: ++ WC2 > WCc: +
Schwartz (2007); New England, US [36]	Cohort Analytic	2 elementary schools; I and C; n = 646.	2 day baseline; 2 day intervention. Direct observation of fruit/fruit juice selection and consumption.	- Fruit/Fruit juice selection (FS/FJS) and consumption (FC/FJC).	Day 1 - IFS 4x more likely than CFS. - FJS: [=] No significance level reported.

Study/Country	Study Design	Sample Characteristics	Duration/ Measurements	Outcomes	Main Results
Swanson (2009); Kentucky, US [37]	Cohort	1 school, Kindergarten – 4th grade students; n = 491	1 day intervention; 1 day follow-up control. Observation via the digital photography method.	- Orange selection (OS) and consumption (OC), apple selection (AS) and consumption (AC).	OS and OC increased. AS: [=] AC: [=]
Wansink et al. (2013b); New York, US [38]	Cohort Analytic	6 middle schools; Control = 3, Intervention = 3.	1 month intervention. Recorded tray waste and calculated apple sales records.	- Apple selection (AS) and apple consumption (AC).	AS: +++ AC: [=]
Wansink et al. (2012); New York, US [39]	Cohort	7 schools; n = 209.	1 day baseline control; 1 day post-test control; 3 day intervention, 3 treatment groups; Elmo branded apple (T1), Elmo branded cookie (T2), unknown branded apple (T3). Unspecified data collection methods.	- Apple selection (AS) and cookie selection (CC).	T1 AS: [=] T2 CS: [=] T3 AS : [=]

Study/Country	Study Design	Sample Characteristics	Duration/ Measurements	Outcomes	Main Results
Wansink et al. (2012); New York, US [40]	- St1: Cohort - St2: Cohort Analytic	- Study 1: n = 147 - Study 2: Purchase observations for 1552 students.	Study 1: 3 day data collection. Selection and plate waste was recorded. Study 2: 20 day baseline data collection; 20 day intervention. Hot vegetable selection was recorded.	- Study 1 – Carrot consumption control (CCc), carrot consumption labelled (CC1), carrot consumption attractive label (CC2) - Study 2 – Hot vegetable selection (HVS).	Study 1 - - CC2 > CC1: + - CC2 > CCc: + Study 2 – - HVS: +++
Zellner et al. (2016); US [41]	Cohort	1 school, grades 3 and 4; n = 25.	1 day control, fruit served at the same time as vegetable; 1 day intervention, fruit served as a dessert, after vegetable. Consumption data recorded by trained observers.	- Consumption of kale (KC)	KC: ++

Study/Country	Study Design	Sample Characteristics	Duration/ Measurements	Outcomes	Main Results
Zhuzhina (2016); California, US [42]	Cohort	2 schools, grades 1 to 5.	2 or 3 days baseline data collection per school; 5 days intervention data collection per school. Data recorded using the digital photography method.	- Fruit selection (FS) and consumption of whole portion (FC), and vegetable selection (VS) and consumption of whole portion (VC).	School 1 (B.S): FS increased; VS increased; FC increased; VC increased. School 2 (W.P): FS decreased; VS decreased; FC increased; VC increased.

Note. For those studies that reported varying sized participant samples for different data collection days, the largest sample is reported. Significance noted as + = p = .05, ++ = p = .01, +++ = p = .001, [=] = no change

Global Nutritional Improvement. Eight studies assessed global nutritional improvement as an outcome measure, with interventions that aimed to target general healthful food selection and consumption (e.g., including whole grains and a reduction in less wholesome alternatives), as shown in Table 4.3. Ensaff et al. (2015) investigated the impact of changes to the choice architecture on students' selection of plant-based foods. Small changes were implemented in the cafeteria to make target foods more attractive, including (a) selling vegetarian daily specials in disposable plastic pots (b) placing stickers on sandwiches containing salad, (c) displaying promotional posters for sandwiches containing salad, (d) placing stickers on fruit pots, (e) creating attractive displays for whole fruit, and (f) displaying window stickers promoting whole fruit. Results indicated that these nudge strategies were associated with an increase of target food selection in the intervention school, while no changes were identified in the control school.

Graham (2015) assessed the influence of the presence of a "traffic light" system of nutritional coding (e.g. red-coded meals contain more fat) on pre-ordered entrée selection. A number of different pre-ordering systems were set up during a nine-week baseline data collection period, which was immediately followed by a short lesson on the meaning of the traffic light nutritional coding system. The remaining 23 days comprised the intervention data collection, where children pre-ordered their meals as before, but entrées were now coded with the traffic light system. Results showed minimal change in entrée selection associated with nutritional labelling, though selection of "green" entrées were more likely if there was more variety in "green" entrée choice.

Hanks, Just, and Wansink (2013b) also assessed the influence of pre-ordering lunch, although this investigation focussed on healthy entrée selection alone. Fourteen classes were randomly assigned to one of three conditions: continuous pre-ordering, pre-ordering with a week break, or discontinuing pre-ordering during the last week. Results indicated that those children who pre-ordered food were more likely to choose a healthy entrée (29.4%, compared with 15.3% when no pre-ordering was available). Unfortunately, although consumption data were collected, no reference was made to the data collection protocol, nor were these results reported.

Hanks, Just, and Wansink (2013a) assessed the impact of their "smarter lunchroom makeover" on selection of fruit, vegetables, healthy sandwiches, and starchy sides. This involved several nudge strategies that increased the convenience, attractiveness, and normativeness of target foods, and led to a significant increase in the selection and

consumption of fruit and vegetables (no changes were noted in the selection or consumption of other target food items).

The last experiment reported by Hanks, Just, Smith, and Wansink (2012) investigated the impact of a dedicated "convenience line" on selection and consumption of healthy foods and white milk. This involved changing the options in one of the convenience lines in the dining room so that only healthy foods and sandwiches were available. Results indicated that following this change, students selected significantly more healthy food items (although there was no difference in healthy food item consumption) and consumed significantly fewer unhealthy food items. Total milk sales also increased, albeit as the result of a significant increase in flavoured (comparably less healthy) milk selection.

Miller, Gupta, Kropp, Grogan, and Mathews (2016) investigated the influence of pre-ordering school lunches on selection of food items contributing to a nutritionally balanced meal, including all five lunch components (grain, entrée, fruit, vegetable, and dairy). Children were assigned to either a control group or one of two treatment groups. In both treatment groups, children pre-ordered their meal using a computer app which displayed all food items available in the appropriate lunch component categories. Children in the first intervention group were made aware of the five categories but selected and submitted their choices without further nudges. In the second intervention group, children who did not select a food item for each category received the message, "This does not look like a balanced meal," with the missing categories highlighted. Children then had the option to select more food items or continue with their order. Results showed that children in both treatment groups selected significantly more fruit, vegetables, and low-fat milk than children in the control group, whilst children in the second intervention group selected significantly more fruit, vegetables and low-fat milk than those in the first intervention group.

Siegel et al. (2015) investigated the use of "emoticon stickers" to promote white milk, fruits, vegetables, and healthy entrées. Following a two-month baseline data collection period, stickers with a green smiley face were placed on healthful food options, and cafeteria staff explained at the beginning of the intervention, and intermittently throughout, that this meant the food item was a healthy choice. This intervention lasted for two months, and no other changes were made to the cafeteria or the food service procedure during this time. Results showed a significant increase in white milk selection, displacing chocolate milk selection so that overall milk selection remained constant. Vegetable selection also increased, though no significant differences were observed for fruit or healthy entrée selection.

Wansink, Just, Patterson, and Smith (2013) investigated the use of “nutritional report cards”. Food selection information collected automatically by cash registers was sent via email to parents in the form of a nutritional report card. It was hypothesised that children would make healthier choices at lunchtime if they knew that their parents were aware of what they had chosen. However, no significant difference was recorded on any of the target food items, except for cookie selection, which significantly decreased from 14.3% to 6.5%.

Table 4.3

A synopsis of the included studies that focus on global nutritional improvement.

Study/Country	Study Design	Sample Characteristics	Duration/ Measurements	Outcomes	Main Results
Ensaff et al. (2015); Yorkshire, UK [43]	Unclear	2 Secondary schools; n = 980; 218,796 cafeteria transactions recorded	Baseline and post-intervention data extracted from cafeteria records from the academic year; 6 week intervention. Cashless electronic system automatically recorded purchase information.	- Selection of designated healthy food items - vegetarian daily specials (VDS), sandwiches containing salad (SS), fruit pots and whole fruit (F).	VDS: +++ SS: +++ F: +++
Graham (2015); Texas, US [44]	Cohort	1 elementary school, Kindergarten – 5th grade classes, n = 25 classrooms. 4 Treatment groups (T1; T2; T3; T4).	43 day baseline; 23 day intervention. Self reported food journals, monitored by direct observation of a selection of meals.	- Selection of nutritionally coded entrees according to a traffic coding system (e.g. red = unhealthy)	Minimal differences associated with nutritional labelling. "Green" entrée choices more likely with increased variety.

Study/Country	Study Design	Sample Characteristics	Duration/ Measurements	Outcomes	Main Results
Hanks et al. (2013a); New York, US [45]	Cohort Analytic	2 Elementary schools; n = 272	2 weeks baseline. 2 or 3 weeks intervention. Sales records were recorded.	- Selection of healthy entrée (HES) or unhealthy entrée (UES).	More likely to select a healthy entrée if pre-ordered.
Hanks et al. (2013b); New York, US [46]	Cohort Analytic	2 Junior-Senior High Schools; 3762 observations.	2 month baseline; 2 month intervention. Recorded tray waste.	- Selection and consumption of fruit (FS/FC) and vegetables (VS/VC).	FS: + VS: +++ FC: ++ VC: +++
Hanks et al. (2012); New York, US [47]	Cohort	1 High school; Control = 602 observations, Intervention = 482 observations.	8 week baseline period; 8 week intervention. Recorded tray waste.	- Selection of designated healthy food items (HFS). - Consumption of designated healthy food items increasing (HFC). - Consumption of unhealthy food items decreasing (UFC)	HFS: ++ HFC: [=] UFC: ++
Miller et al. (2016); Florida, US [48]	Cohort Analytic	Students in 5th and 6th grade.	2 week baseline; 2 week intervention. Control (C)– no treatment. Treatment 1 (T1) orders	- Selection of healthy meal components: meat/alternative (MAS), grain (GS), fruit (FS), vegetable (VS), and dairy (DS).	T1 > C for FS, VS & DS. (continued)

Study/Country	Study Design	Sample Characteristics	Duration/ Measurements	Outcomes	Main Results
(continued)			recorded via a web-based programme with no prompt, Treatment 2 (T2) or with prompt.		T2 > T1 for FS, VS & DS.
Siegel et al. (2015); Cincinnati, US [49]	Cohort	1 elementary school; n = 297	2 month baseline; 2 month intervention. Sales records from till receipts.	- Selection of white milk (MS), chocolate milk (CS), healthy entrée (HS), fruit (FS) and vegetables (VS)	MS: +++ CS: +++ (decrease) HS: [=] FS: [=] VS: > 8 data points above mean (sig.).
Wansink et al. (2013a); New York, US [50]	Cohort Analytic	1 School district; Control = 1460, Treatment = 35.	5 week intervention. Point of sale purchase information.	- Selection of fruits (FS), vegetables (VS), starch (SS), milks (MS), snacks (SnS) and a-la-carte items (ALCS).	FS/VS/SS/MS/ALCS: [=] SnS*: [=] *Cookie Selection: -

Note. For those studies that reported varying sized participant samples for different data collection days, the largest sample is reported. Significance noted as + = p = .05, ++ = p = .01, +++ = p = .001,[=] = no change

Discussion

This systematic review identified 25 papers reporting the results of simple behavioural nudges intended to promote healthy eating in the school cafeterias. The results of 17 studies indicated an increase in selection of a target healthy food ([27,28,30,31,34-38,40,42,43,45-49]) and 11 studies reported a significant change in target food consumption ([26,28,29,31-33,37,40-42,46]). One study reported no significant change in selection or consumption (Wansink et al., 2013b). Overall, it has been reported that selection of target healthy food items can be increased by making choosing unhealthy food items more effortful, displaying attractive posters and videos promoting target food selection in the lunch room, prompting children in the dinner line to select healthier options, and pre-ordering meals before joining the dinner queue. Consumption of target healthy food items has been increased through changing the order of serving for vegetables, increasing the convenience, attractiveness, and normativeness of selecting healthy options with "smarter" lunchrooms, increasing the variety of fruits and vegetables available, and renaming target food items with attractive, exciting names.

We have been surprised to find that the effectiveness of simple nudge-based interventions has not yet been explored outside of the US school environments. Only one of the reviewed studies was conducted in the UK (Goto et al., 2013). Within the US cohort, nine out of the 25 studies had been conducted by the same research team or their associates ([28,30,38-40,45-47,50]). The possible benefits of cafeteria-based dietary nudge interventions need to be explored in a wider range of schools in Europe, where school-provided lunches are common. Although the nutrition standards of these meals have been improving in most developed countries, children's diets consistently contain fewer fruit and vegetables than is recommended (Grimm et al., 2014; McAloney et al., 2014; National Cancer Institute, 2015).

We also found that, in around a third of included papers, the authors did not collect consumption data. Instead, effectiveness of the nudge interventions was evaluated using food item selection data. Whilst collecting purchase data at the point of sale may be reliable, provision and selection of food items does not necessarily equate to consumption. This resulted in poor internal validity; no conclusions could be drawn regarding the effectiveness of the assessed interventions in promoting healthy dietary habits. Further, for those studies that collected data on food item selection and consumption yet only identified a significant increase in selection of target food items, the parsimonious conclusions that may be drawn are that the intervention was successful in teaching children what observers expected of them

but not in influencing actual consumption behaviour. This may have led to results that manifest social desirability bias, to which children are particularly vulnerable (Klein, 1969; Hebert, Clemoq, Pbert, Ockene, & Ockene, 1995). Measuring effects in the longer term may be one way of establishing whether or not transient demand characteristics account for the changes recorded in these evaluations. Recording children's eating over multiple occasions can minimise the influence of novelty and present a better picture of children's typical behaviour in the school canteens.

Of those studies that did measure actual consumption of a target food item, most used measures that demonstrated only face validity. Only two of the reviewed studies employed a visual estimation protocol for nutritional data collection that had been validated for this purpose [28, 51; 37, 52], and reported reliability, albeit without giving much detail. Consumption was often estimated by comparing pre-consumption records, based either on visual observation or on target food item sales, with subsequent plate waste records, without reporting the validity or reliability of these measures. These limitations were reflected in the typically weak ratings on the QATQS component describing data collection methods. A weak methodology can only yield inconclusive results, and because reviewed studies did not employ sound data collection methods, no firm conclusions ought to be drawn. Our own exploration of the behavioural nutrition literature had revealed a scarcity of publications establishing validation of instruments that can be used for measuring food consumption in a fast-paced canteen setting.

None of the studies examined the changes in children's consumption on an individual level. This restricted the statistical tests they could deploy and limited the conclusions that could be drawn from the data. For example, we do not know whether some of the nudges may work with children who eat the least healthy diets at the outset, or are these effects restricted only to those who already choose to consume fruit, vegetables, or white milk at least some of the time. This information is needed before any changes to choose architecture could be recommended as a tool for combating poor nutrition in schools. Further, most of the reviewed studies measured immediate, short term effects of nudges on children's behaviour. However, only sustained, long-term changes to eating behaviour can be expected to impact on children's habits, health, and weight status.

We noted that none of the authors of the reviewed papers mentioned pre-registering their research. Pre-registering anticipated results protects the integrity of the research by implementing a barrier against the desire for researchers to cherry-pick data, analyses, and

results in order to generate the most seemingly significant data. This issue is evidenced by an increasing number of journals requesting (and indeed insisting) that submitted papers must provide evidence of pre-registering anticipated results prior to study commencement. This good practice should be adopted in consumption research so that, where appropriate, the null hypothesis can be objectively evidenced and correctly accepted.

In spite of their methodological weaknesses, the reviewed studies were generally published in established journals. With journal impact factors ranging from 0.596 to 4.396 at the time of publishing, it is evident that research into behavioural nudges to benefit nutritional intake is well regarded in the scientific community. This is not surprising considering the well-documented effects of obesogenic environments that children are exposed to. However, significant advances in our understanding of the environmental factors that can be harnessed to influence a positive change in children's eating behaviour can only be made by addressing the methodological limitations highlighted in the present review. A strength of the existing investigations is that they demonstrate that schools, cafeteria staff, and indeed children are willing to adapt to change and are open to implementing nudge interventions. This suggests that simple and inexpensive nudge interventions could have a place in improving children's food choices, with the possibility of good public health population impact upon an entire cohort.

Conclusion

This review has examined school cafeteria-based interventions that have utilised behavioural nudges as the sole influencing factor for behaviour change. It was found that many of these interventions were effective in increasing children's healthier menu choices, and in some cases their consumption of target foods, although procedural limitations that included the absence of control groups and lack of independently validated measures limited the conclusions that could be drawn from the data. Nevertheless, even these tentative results indicate a promising area for positive behaviour change, with the potential for mass implementation at low cost and significant benefits for public health. Overall, this review ultimately identified the requirement – a gap in the literature – for well- designed, and well-controlled investigations into the effects of changing the choice architecture in the school cafeterias, assessing short-, medium-, and long-term changes in individual children's

consumption, utilising validated measures, and conducted across a variety of settings, including dining rooms of schools outside the US.

Chapter 5

A Low-Cost Behavioural Nudge and Choice Architecture Intervention Targeting School Lunches Increases Children's Consumption of Fruit.

The following describes a pilot study of a behavioural nudge based choice architecture intervention, which was designed to fill the gap in the literature identified by systematic review presented in Chapter 4. This paper will be of interest to fellow scientists, educational professionals, and caterers interested in setting up affordable yet effective measures to increase children's consumption of healthful foods at lunchtime.

The present paper describes the utilisation of five nudges, identified through systematic review (see Chapter 4) to promote healthful consumption behaviour: *Advertisements* (brightly coloured posters advertising fruit and vegetables); fruit and vegetable items being re-labelled with *attractive names*; *Food labels* (drawing attention to the food with its attractive name and an exciting picture); *Attractive servings* (sliced fruit, placed into colourful plastic bowls*; and Fruit and veg first* (the order of service was changed so that vegetables were served first). It was anticipated, due to its success in previous interventions, that re-ordering service, and slicing fruit into bite-sized pieces and serving them in brightly coloured "take away" bowls, would be the nudge that would be most likely to elicit significant behavior change, whilst the remaining three nudges would aid in drawing children's attention to this new presentation style. These more simple "advertisement" nudges were cheap to implement, and may not have been highly effective if implemented alone, but utilized together may have a cumulative influence on the children's attention towards fruit and vegetables, resulting in the "presentation" nudges being more impactful.

This paper was submitted to the International Journal of Behavioural Nutrition and Physical Activity, a peer reviewed, indexed, open access journal (IF=4.39) with a focus on promoting the understanding of the behaviours associated with diet and physical activity, and the subsequent implications on well-being. Indeed, at the annual meeting for the International Society for Behavioural Nutrition and Physical Activity, in 2017, Dr. Jago (Editor-in-Chief) implored researchers to submit papers exploring the influence of behavioural nudges on consumption behaviour, exemplifying the relevance of the present study.

Authors' Contributions

MMO designed and coordinated the study, processed and analysed data, and drafted the manuscript. RP contributed with data collection, inputting, and second coding. AR contributed with data collection and inputting. PJH contributed with editing. SV advised on statistical analysis and results. ME obtained funding, supervised all aspects of the research, and co-wrote the final manuscript. All authors have read and approved the final manuscript.

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Abstract

Research has consistently indicated that most children do not consume sufficient fruit and vegetables to provide them with a healthy, balanced diet. This study set out to trial a simple, low-cost behavioural nudge intervention to encourage children to select and consume more fruit and vegetables with their lunchtime meal in a primary school cafeteria. Four primary schools were randomly allocated to either the control or the intervention condition and baseline data were collected over two days in each school. Following this, changes were made to the choice architecture of the school cafeterias in the intervention schools and maintained over a three-week period. The intervention included improved positioning and serving of fruit, accompanied by attractive labelling of both fruit and vegetables on offer. Next, data were collected over two days in each school, with menus matched in each instance between baseline and follow-up. We employed a validated and sensitive photographic method to estimate individual children's (N=176) consumption of vegetables, fruit, vitamin C, fibre, and total sugars. Significant increases were recorded in the intervention schools for children's consumption of fruit, vitamin C, and fibre, accompanied by a small increase in sugar intake. No significant changes were observed in the control condition. The increases in fruit consumption were recorded in a large proportion of individual children, irrespective of their baseline consumption levels. No changes in vegetable consumption were observed in either condition. These results are the first to show that modest improvements to the choice architecture of school catering, and inclusion of behavioural nudges, can significantly increase fruit consumption, rather than just selection, in primary-age children. This has implications for the development of national and international strategies to promote healthy eating in schools.

Keywords. Choice architecture; behavioural nudges; fruit; plant-based foods; consumption; school lunch; cafeteria; healthy eating; children

Introduction

It is well established that a balanced diet high in fruit and vegetables supports positive developmental and health outcomes in children and adults, and ought to be promoted (WHO, 2005). However, investigations into typical childhood eating patterns have consistently identified deficiencies in fruit and vegetable intake compared to international and local recommendations (Grimm et al., 2014; McAloney et al., 2014; National Cancer Institute, 2015). The UK Department of Health (DOH, 2011) has continued to advocate national-level efforts to encourage healthier childhood eating patterns, pledging to support healthy food provision in schools. While this is a positive step, provision does not equate to consumption, and structured behavioural programmes may be necessary to increase fruit and vegetable uptake.

Multicomponent interventions targeting school lunch nutrition have shown success (Anderson, 2005; Sahota et al., 2001), but they are time costly and require substantial resources to implement effectively. This limits their potential for national-level support. Despite disappointingly few positive behaviour effects and poor intervention engagement (Croker, Lucas, & Wardle, 2012), information-based interventions and social marketing campaigns, such as the 'Change for Life' (DOH, 2011), continue to receive governmental support and funding. It is perhaps not surprising that, at present, despite being familiar with the health benefits associated with a plant-rich diet (Povey, Cowap, & Gratton, 2016), many primary-age children in the UK do not eat their recommended five portions of fruit and vegetables each day (Hayter et al., 2015).

There is an emerging literature showing how low-cost interventions can improve dietary choices of adults and teenagers in a variety of canteen settings (Butcher et al., 2016; Ensaff et al., 2015). These interventions alter the choice architecture of dining rooms to encourage healthy food selection, by increasing the salience of target foods and their convenience (Thaler & Sunstein, 2008). Such modifications to the environment are referred to as behavioural nudges. A smaller number of studies have examined the effectiveness of nudge interventions with younger children, in elementary school cafeterias (Hanks, Just, &

Wansink, 2013; Siegel et al., 2015; Wansink et al., 2013b). Whilst many of these interventions reported success in increasing selection of target healthy food items, consumption was seldom measured, resulting in poor internal validity. For those studies that did measure consumption, procedural issues limited the conclusions that could be drawn from the data (Miller et al., 2015; Redden et al., 2015). Their methodological shortcomings included the absence of a control group; lack of independently validated measures; single-day data collection; and use of group data (Marcano-Olivier, Horne, Viktor & Erjavec, in submission).

The present study addressed these shortcomings and extended the existing literature to the UK school settings, where the mid-day meal is consumed by all children in a dining room. Caterers prepare and/or serve a choice of foods to those children whose carers pay for school meals, and to children with low-income families who receive meals for free.

To our knowledge, this was the first controlled experimental evaluation of the changes in individual children's consumption that may be engendered by a low-cost behavioural nudge intervention in primary-school dining environments. Schools were randomly allocated to experimental conditions, and striated sampling ensured that participants' ages spanned the primary-school range. Individual children's consumption was measured using an independently validated digital photography method (Marcano-Olivier, Viktor, Horne, Pearson & Erjavec, in submission), which yielded fine-grained estimates of the weight of fruit and vegetables that the children consumed, and the nutrient content of their lunches as a whole. Pre- and post-measures were taken over two days in each instance, to accommodate variability of children's daily choices and menu differences.

Method

Aim

This study was designed to investigate the effectiveness of a behavioural nudge intervention encouraging children to consume more fruit and vegetables with their lunchtime meal in the school cafeteria.

Ethics

Approval to conduct this investigation was granted by the School of Psychology Ethics and Research Governance Committee at Bangor University (approval number:

2014000089). Opt-out consent forms were distributed to participants two weeks prior to study commencement.

Participants

Following institutional ethical approval and the distribution of opt-out consent forms (see Appendix 15), teacher information sheets (see Appendix 16), and caterer information sheets (see Appendix 17) one week prior to study commencement, 176 children from four primary schools in Llandudno, North Wales took part (intervention $n = 86$, control $n = 90$). No parent opted-out, and every child contributed data to the final sample. Both conditions were gender balanced (40 females in the intervention condition and 49 in the control condition) and represented the full primary school age span (with 33 children in year 1; 45 in year 2; 22 in year 3; 21 in year 4; 46 in year 5; and 9 in year 6). Participants were of a predominantly Caucasian origin, reflecting the demographics of the region. Schools were randomly allocated to conditions prior to any data collection.

Materials

Four digital cameras (Fujifilm Finepix, 16 mega pixels, Model no. AX650), positioned on tripod stands (Tiffen Davis and Sanford, Vista EXPLORERV 60-Inch Tripod), with tape measures and protractors to ensure correct setup, were used to collect consumption data. Food items were displayed on plastic school dinner trays. White self-adhesive participant identification labels were attached to red metallic wrist bands given to each participant to wear during lunchtime, and to the tray for later coding of the food and waste in each photograph.

Intervention Procedure

Behavioural nudges. Several changes were made in the cafeterias of the intervention schools; no changes were made in the control schools. The choice architecture of the cafeteria was changed to include five behavioral nudges that have been used in previous research.

1. *Advertisements*. Brightly coloured posters advertising, “A Spring of Fruit and Vegetables”, displaying fruit and vegetables and cartoon characters of children enjoying these foods, were placed around the dinner hall, encouraging children to, “Let fruit and vegetables put a spring in your step”. At the beginning of the dinner queue, a further wipe-

clean poster advertised the "vegetable of the day", using new attractive names. All materials were presented bilingually in English and Welsh (see Appendix 18).

2. *Attractive names*. For each fruit or vegetable available to buy over the data-collection and intervention period, a new and exciting name was created. Examples included "Dinosaur Tree Broccoli", "Anti Sneeze Peas", and "Superpower Satsumas".

3. *Food labels*. Every fruit and vegetable was labeled. These wipe-clean labels were placed in or on the associated serving bowl, drawing attention to the food with its attractive name, an exciting picture, and a cartoon character (see Appendix 19).

4. *Attractive servings*. Whole fruit servings (available daily instead of, or in addition to, desserts in both schools) were replaced by sliced fruit, placed into colourful plastic bowls, and displayed on a cake stand at the end of the dinner queue.

5. *Fruit and veg first*. Where possible, the order of service was meant to be changed so that vegetables were served before the entrée or starchy side, and fruit was offered before the provided dessert. Catering staff were asked to encourage children to take a serving of vegetable and fruit with their meal.

Implementation. Following the initial visits to schools, it became apparent that the caterers already provided verbal encouragement for children's selection of vegetables, and served salad daily, but did not do the same with fruit. Indeed, on most days, fruit was given only to those children who explicitly requested it, instead of their daily dessert, and hidden from children's view, as it was selected so seldom that displaying it was considered an unnecessary use of canteen space. Therefore, the present intervention mostly targeted children's fruit choices and consumption. Because of space limitations, the fruit stand had to be placed at the end of the dinner queue.

Prior to implementation, the intervention was discussed with caterers. Throughout the intervention, a researcher was present in the cafeteria at lunchtime to ensure intervention fidelity, and to minimise any disturbance for the catering staff. We established that typical daily provision of fruit consisted of bananas, satsumas, apples, or pears. These foods were therefore used in the intervention; we brought some extra when children's consumption grew significantly, to avoid running out.

The intervention was implemented in two schools over a period of three weeks. It commenced in the week following the initial baseline data collection, and stopped after the follow-up data were collected. Throughout, we noted how many students took fruit from the

stand. Daily selection of fruit pots ranged from 47 - 84 (out of a maximum of 132 students eating school dinners on any one day) over the course of the intervention. In some cases students helped themselves to fruit in addition to dessert; in others, the fruit replaced the dessert. The pots were available to all children who took school dinners, including those not participating in data collection.

Data Collection Procedure

Data were recorded over two days at baseline and two days at follow-up in each school. Schools were either visited on a Monday and a Wednesday, or a Tuesday and a Thursday. On these days, researchers arrived at the school around one hour before the lunch period to set up a data collection area in the school cafeteria. One researcher visited participating classrooms to distribute identification stickers and wristbands, and to explain the research to the children. Neutral statements were used to avoid cueing social desirability.

The protocol we used to measure consumption was validated in our previous research (Marcano-Olivier, Viktor, Horne, Pearson, & Erjavec, in submission). Average food portion weights were calculated based on five servings of every food item available in the cafeteria on each day. At lunchtime, participants were instructed to come to researchers after they had been served their lunch, and again after they finished eating, so that pre- and post-consumption photographs could be recorded for each child.

Data processing and Coding

Consumption estimates from digital photographs. The first author of this paper estimated, using an 11-pont scale (0 – 100%), how much of each individual food item had been consumed for each child's lunch. This was then converted into estimated weight consumed (e.g. if 90% of a 56-gram portion of baked beans was consumed, then the total weight consumed was calculated as 50.4 grams). Total lunchtime fruit, vegetable, fibre, vitamin C, and sugar consumption were then calculated for each participant. An experienced second coder independently calculated consumption for approximately 20% of the data set, to

determine inter-rater reliability. Near-perfect levels of inter-rater agreement were achieved (Cohen's k = .939, *CI* = .88 -.93).

Preliminary data analyses. All data were inputted into the IBM Statistical Package for the Social Sciences (SPSS) version 22, including participant number, food item, estimated pre- and post-weight records, estimated weight consumed, first rater percentage estimations, second rater estimations, and agreed estimated weight consumed. Where the first and second coder disagreed on how much of a food item was consumed by 10% or less, the estimation from the first coder was taken, and where they disagreed by more than 10%, the middle value was used.

Statistics and Sample Size Calculations

Within groups comparisons. Consumption estimates were compared for differences over time using distribution-free Mann Whitney U analyses. Using an alpha of 0.05, a sample of 176, and two tails, it was identified that a medium effect size (d = 0.5) would be detected at a power of 1.

Between groups comparisons. Differences between groups were calculated using distribution-free Wilcoxon Signed Ranks tests. Using an alpha of 0.05, a sample of 86 (intervention) and 90 (control), and two tails, it was identified that a medium effect size (d = 0.5) would be detected at a power of 1.

Effect size calculations. Effect sizes were calculated for each test by dividing the *z* score by the square root of the number of observations, with the subsequent *r* value indicating the magnitude of the effect (.1-.29 = small, .3-.49 = moderate, and ≥ .5 = large effect; Rosenthal, 1991).

Results

Daily fruit, vegetable, fibre, vitamin C, and sugar consumption at lunchtime were calculated for each participant, for the two measurement points (baseline and follow-up).

Changes in Children's Fruit Consumption

Figure 5.1 shows changes in children's consumption of fruit between the two measurement points. A significant increase in fruit consumption with a moderate effect size was observed in the intervention condition. By contrast, median consumption did not change in the control condition. The two conditions were matched at baseline; however, at follow-up, the intervention group consumed significantly more fruit.

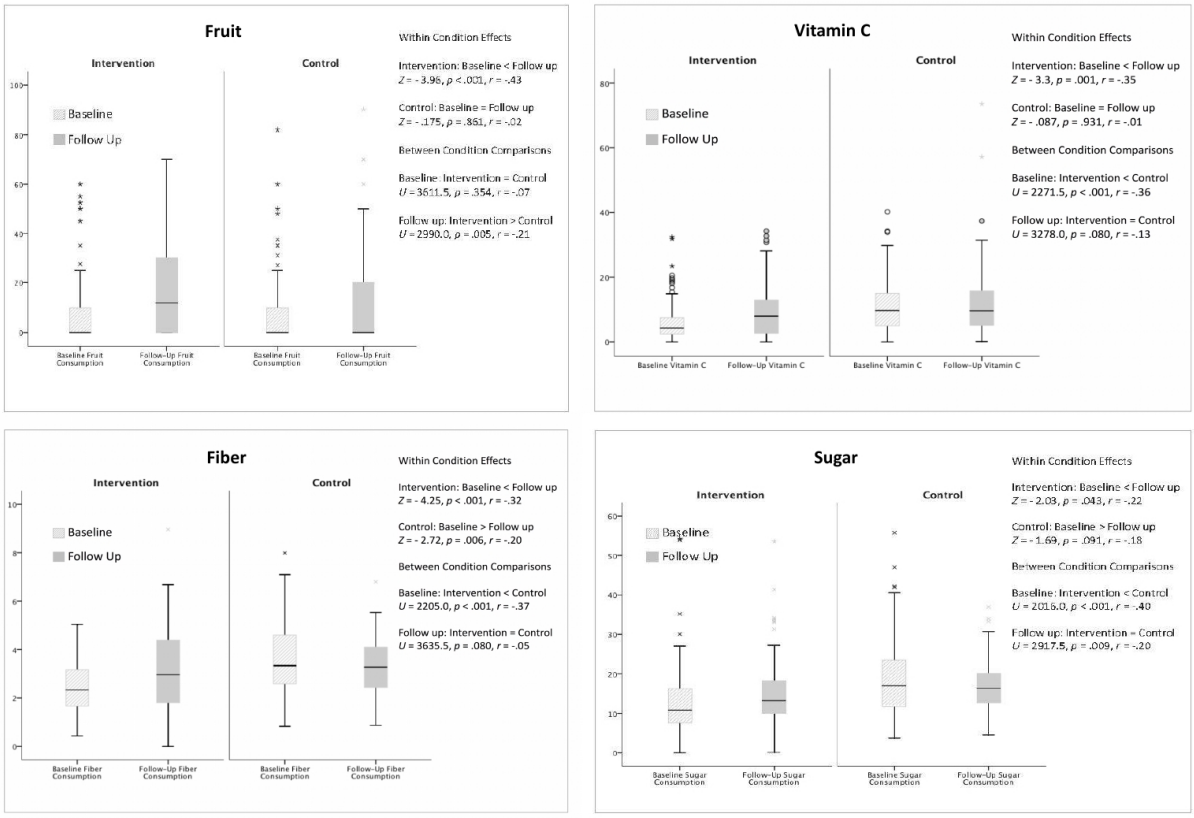

Figure 5.1. Boxplots showing children's daily consumption of fruit, vitamin C, fiber, and sugar at lunchtime. Medians, interquartile ranges, and distributions of children's consumption in grams for fruit, fiber and sugar, and milligrams for vitamin C are shown at baseline (striped bars) and follow-up (solid bars) for the intervention and control condition. Key statistics for pairwise within- and between-condition tests are presented to aid interpretation of the data.

We grouped individual children's data into three categories: those who ate no fruit; those who consumed less than half of a child-sized portion (20g); and those who ate more than a half-portion. Table 5.1 confirms that the increase in fruit consumption due to intervention can be observed across categories.

Table 5.1.

Number of children in each fruit consumption category, condition, and measurement point.

	Intervention		Control	
Fruit Consumed	Baseline	Follow-up	Baseline	Follow-up
None	63	35	57	58
Less than half a portion (< 20g)	19	39	29	24
More than half a portion (> 20g)	6	12	4	8

We examined individual children's data to establish how many children changed their consumption between baseline and follow-up measurements. Table 5.2 shows a fairly constant consumption in the control group, where most children ate the same at the two measurement points and small comparable numbers ate either more or less fruit. In the intervention condition the pattern is different, with many more children eating more in the follow-up and fewer eating less. Although not all children benefited from the intervention, many did.

Table 5.2.

Number (and percentage) of children in each condition whose fruit consumption increased, remained the same, and decreased, between baseline and follow-up measurements.

	Changes in Fruit Consumption		
Children	Increase	No Change	Decrease
Intervention (*N*=86)	40 (46.5 %)	38 (44.2 %)	8 (9.3 %)
Control (*N*= 90)	17 (18.9 %)	57 (63.3 %)	16 (17.8 %)

Children's Vegetable Consumption

Vegetable consumption was matched at both baseline (U = 3608.5, p = .437, r = -.06) and follow-up (U = 3279.5, p = .079, r = -.13), with no significant changes recorded in the intervention schools (Z = -.896, p = .370, r = -.10) or control schools (-.175, p = .861, r = -.02) over time. Median consumption across measurement points and conditions varied from 22.45 to 29.73 grams, with the individual children consuming between 0 and 231 grams of vegetables per day.

Changes in Children's Nutrient Intake

The two groups were not matched at baseline, with participants in the control condition consuming significantly more fibre, vitamin C, and sugar than their intervention condition counterparts. This was a result of a higher uptake of nutrient-dense self-serve salad, and additional helpings of leftover food items. Although menus were largely matched at baseline (both pairs of schools were catered by the same company), catering staff in one control school were observed to be comparably more encouraging for children to select self-serve salad, whilst catering staff in the other control school were more likely to encourage second and third helpings of leftovers, than were those in other schools.

Figure 5.1 shows that a significant increase in vitamin C consumption with a moderate effect size was observed between measurement points for the intervention condition, but not the control condition. Levels of vitamin C consumption were matched at follow-up, with consumption levels in the intervention condition rising to the same level as the control condition. A significant increase in fibre consumption with a moderate effect size was observed over time in the intervention condition, whilst a small but significant decrease in fibre consumption was observed in the control condition (though significant due to the highly powered analysis, the median decrease in fibre was .06 of a gram, probably reflecting weekly random variance in consumption). Levels of fibre were matched at follow-up, with consumption levels of the intervention condition rising as the level of consumption in the control condition fell. Finally, significant increase in sugar consumption with a small effect size was observed in the intervention condition, but not in the control condition. This was somewhat expected due to the significant increase in fruit consumption; however, the median increase in sugar was small, only 2.35 grams, and sugar consumption remained significantly less than the control condition at follow-up.

Discussion

This study is the first to present a controlled evaluation of a behavioural nudge intervention designed to increase fruit and vegetable consumption of primary-age children in UK school cafeterias. Within and across condition comparisons based on individual children's data revealed that their fruit consumption, vitamin C, and dietary fibre intake increased in the intervention schools, but not in the control schools. This finding has significant implications for national-level efforts to improve children's diets, as recommended by the DOH (2011), and for international drives to improve childhood nutrition.

The present study builds upon the existing research in several ways. Many previous investigations situated in the school cafeterias have assessed intervention success using food item selection data, often at the point of sale (Ensaff et al., 2015; Hanks, Just, & Wansink, 2013; Wansink, Just, & Payne, 2012). This method is convenient and reliable, but without measuring consumption it cannot be ascertained that the intervention was successful. Indeed, some papers reported an increase in target food item selection, but not consumption (Greene et al., 2017; Wansink, Just, & Payne, 2012). The present study was the first to measure children's consumption using a validated data collection protocol (Marcano-Olivier, Viktor, Horne, Pearson & Erjavec, in submission), and thus conclusions of effectiveness could be confidently asserted.

It also is the first evaluation of a behavioural nudge intervention in the school cafeteria to measure changes in children's food consumption at an individual level. We identified that the intervention was successful in increasing fruit consumption from the poorest eaters to those who already consumed adequate levels of fruit. This was manifest in the decreased percentage of children consuming no fruit, whilst the percentage of children eating up to half a portion, and over half a portion, doubled. In addition, we are the first to report nutrient changes over time, with previous nudge studies simply reporting weight or portion changes for target foods. The significant increase in vitamin C consumption recorded in this study has implications for immune system strength (Weber, Bendich, & Schalch, 1996), whilst increases in fibre promote digestive health (Anderson et al., 2009). A small but significant increase in sugar accompanied the increase in fruit consumption. However, the WHO (2015) suggest that intrinsic sugars, such as those found in whole fresh fruit, should

not be considered in efforts to reduce sugar intake, as no research evidence links intrinsic sugar consumption with adverse health effects.

The intervention was effective for fruit but not for vegetable consumption. There could be multiple reasons for this finding. First, some nudges we employed may have been more effective than others. Participants were visibly enthusiastic about the brightly coloured pots with a selection of different fruits cut into bite-sized chunks, arranged on tiered stands more commonly associated with cake displays. Due to environmental constraints, no such prompts could be used to encourage selection of vegetables and salad. Conversely, re-branding of the fruit and vegetables and colourful advertisements of the "vegetable of the day" may have been much less effective because of the already stimulating nature of the environment. Primary school cafeterias are typically loud and busy, and attractively named vegetables, posters, and "food spikes" may not have been salient. In future studies, we plan to introduce brightly coloured pots with a variety of salad options (e.g., halved cherry tomatoes, cucumber slices, and bell peppers) cut into bite sized chunks, to investigate the effects of this nudge on children's vegetable consumption. We consider it unlikely that the present vegetable results were due to ceiling effects, because fairly low consumption, about half a child-sized portion on average per day, was recorded in all schools at baseline.

More generally, changes to the choice architecture can only be expected to enable those children who already eat fruit and vegetables to make healthier day-to-day lunchtime choices, but nudges are unlikely to change the behaviour of the remaining children who have not learned to like the target foods. Indeed, looking at the individual children's data, some children in the intervention schools continued to choose no fruit with their lunch, even though we know that taste preferences for sweet foods favour fruit consumption over vegetable choices that may be bitter in taste (Mennella & Bobowski, 2015). In future interventions, acceptability of a variety of vegetables and fruit could possibly be increased by repeated tasting sessions organised by the school catering team (Lakkakula, Geaghan, Zanovec, Pierce, & Tuuri, 2010).

Another consideration for future development of this intervention is its sustainability. A close engagement with the catering teams is necessary to engender a sense of ownership, which promotes intervention fidelity (Van Daele, Van Audenhove, Hermans, Van den Bergh, & Van den Broucke, 2012). Our interactions with the school caterers indicated that the time needed to slice and serve the fruit, and wash the pots afterwards, presented a manageable and acceptable additional workload. However, a large and sustained increase in demand for fruit

would present them with an additional cost, which is at present not covered by any national scheme or payment. We are continuing to work in partnership with the school caterers from several boroughs to find solutions to this obstacle to wider implementation, and to develop a simple intervention pack that would enable the other schools to follow suit without the need for involvement of the research team.

Conclusion

This study presented a low-cost intervention to encourage the consumption of fruit and vegetables in primary-age children. Following changes to the choice architecture of intervention school cafeterias, we observed a significant increase in children's lunchtime consumption of fruit, vitamin C, and fibre, accompanied by a small increase in sugar. No changes were observed over time in the control condition, or for children's consumption of vegetables. These results can be used to inform decision makers, schools, and caterers about simple yet effective behavioural nudge strategies that can improve the poor fruit intake typical of children's diets.

Chapter 6

General Discussion

The present thesis grew out of the work that had been done over the past three decades at the School of Psychology in Bangor, where late Prof Fergus Lowe and Prof Pauline Horne first set up a programme of research leading to development of the Food Dudes intervention. My own reading and research have confirmed that development and implementation of healthy eating interventions which can make a difference to the diet of children remain important topics, presenting interesting scientific and practical challenges.

The body of research into methods to improve children's diet began in the 1980s, with school-based healthy eating interventions beginning to emerge in the literature (Parcel, Simons-Morton, O'Hara, Baranowski, & Wilson, 1989; Perry, Mullis, & Maile, 1985). However, four decades later, research continues to indicate that children do not consume sufficient amounts of fruit and vegetables, and that their narrow taste preferences continue to bias their food choices towards those foods that are energy-dense, but nutrient-poor (see Chapter 1). The maintenance of such behaviour suggests that poor childhood diet is a pervasive, systematic issue, and that the wealth of research that has been conducted into this problem has not been sufficient to promote lasting change.

Brownell and Roberto (2015) suggest that this lack of progress may be the result of insufficient engagement between researchers and policy makers; scientific findings are communicated within our community, but seldom applied outside of research. They advise that, to bridge this gap, tighter interaction must exist between researchers and policy domains, including four steps: (i) *identify agents of change*, those individuals or institutions that have influence over policy advances; (ii) *develop strategic questions*, working with policy makers to identify questions that need to be addressed; (iii) *scholarship*, complete strategic research; and (iv) *communicate*, shortening the time between research conclusion and peer-reviewed article publication by directly communicating results summaries to policy makers and explaining how these can help to address strategic questions identified. Following these steps, it is suggested, will promote the impact and subsequent application of research by beginning to break down some of the barriers to progress, such as the resistance of government to implement policy, and the lack of pressure to implement policy from civil society (Roberto et al., 2015).

However, though progression is slow, the evidence that many countries are increasing their focus to address unhealthy diets (such as having government teams dedicated to

reducing non-communicable diseases [WHO, 2013]), should provide researchers with hope for the future. Such efforts are supported by the development of the NOURISHING framework by the World Cancer Research Fund International (Hawkes, Jewell, & Allen, 2013), based on a consensus from the scientific community and practice, which describes how policy actions may best promote healthy diets (see Figure 6.1).

Domain		Policy area	Examples of potential policy actions
Food environment	N	Nutrition label standards and regulations on the use of claims and implied claims on foods	eg, nutrient lists on food packages; clearly visible "interpretive" and calorie labels; menu, shelf labels; rules on nutrient and health claims
	O	Offer healthy foods and set standards in public institutions and other specific settings	eg, fruit and vegetable programmes; standards in education, work, health facilities; award schemes; choice architecture
	U	Use economic tools to address food affordability and purchase incentives	eg, targeted subsidies; price promotions at point of sale; unit pricing; health-related food taxes
	R	Restrict food advertising and other forms of commercial promotion	eg, restrict advertising to children that promotes unhealthy diets in all forms of media; sales promotions; packaging; sponsorship
	I	Improve the nutritional quality of the whole food supply	eg, reformulation to reduce salt and fats; elimination of trans fats; reduce energy density of processed foods; portion size limits
	S	Set incentives and rules to create a healthy retail and food service environment	eg, incentives for shops to locate in underserved areas; planning restrictions on food outlets; in-store promotions
Food system	H	Harness the food supply chain and actions across sectors to ensure coherence with health	eg, supply-chain incentives for production; public procurement through "short" chains; health-in-all policies; governance structures for multi-sectoral engagement
Behaviour-change communication	I	Inform people about food and nutrition through public awareness	eg, education about food-based dietary guidelines, mass media, social marketing; community and public information campaigns
	N	Nutrition advice and counselling in health-care settings	eg, nutrition advice for at-risk individuals; telephone advice and support; clinical guidelines for health professionals on effective interventions for nutrition
	G	Give nutrition education and skills	eg, nutrition, cooking/food production skills on education curricula; workplace health schemes; health literacy programmes

Figure 6.1. The World Cancer Research Fund International NOURISHING framework.

The relevance of the present thesis to the current literature is manifest in its alignment with the policy areas to 'Offer healthy foods and set standards in public institutions and other specific settings' and to 'Give nutrition education and skills.' Although we would consider that information provision is not the most effective of behaviour change tools, there is certainly a case to be made for teaching caterers and school staff about simple changes that can maximise healthy choices of children in their dining rooms.

Though we are presently limited in our capacity to yield national-level change, we hope that the present research may inspire future research directions that ultimately influence national policy to promote healthier childhood eating behaviour. Right now, our team at the Centre for Activity and Eating Research (CAER, see http://caer.bangor.ac.uk/) is planning to extend the collaboration with local school caterers, established through the research described

in this Thesis, to further develop and trial a flexible behaviour-nudge intervention that can be sustained and rolled out in many schools.

Overview and Evaluation

Throughout this thesis, we have argued that, in order to suggest improvements for childhood eating behaviour, we must first be able to accurately measure this behaviour, to establish what is being eaten and – following any interventions – to identify where improvements were made and how these were achieved. Using digital photography as a method of nutritional data collection, taking photographs of individually coded meals before and after consumption, may help us to achieve this. After Gemming, Utter, and Mhurchu (2015) conducted a systematic review of image-assisted nutritional data collection methods, they concluded that better validation studies were required for those protocols investigating a free-living sample. Considering this, we have developed a comparably simple protocol for the collection of nutritional data in free-living cafeteria environments. Following this, we were able to report that this protocol resulted in accurate estimates of consumption for most food types (see Chapter 2).

This was the first time that a digital photography method of nutritional data collection had been validated in situ, against weighed measures, and with high levels of inter-rater reliability. Its success between settings, lunch types, and ages indicates high levels of generalisability and ecological validity. This is a significant contribution to the literature, providing nutritional researchers with a validated measure for recording intake in free-living settings. This may, in turn, increase the validity of conclusions drawn from intervention evaluations which have previously typically relied on indirect measures or observational measures that may have had no more than face validity (see Chapter 4). By providing a more objective, scientific method, we have contributed to the integrity of nutritional evaluation research.

The added value of the measure to the literature is further manifest in its flexibility; it may be utilised to analyse any food item or macro-/micro nutrient of interest. For example, there has been a growing concern recently concerning the specific sources of children's sugar consumption (Farajian, Risvas, Panagiotakos, & Zampelas, 2016), with the WHO (2015) recommending a significant reduction in the consumption of "free" sugars (those which are added to foods to make them more palatable, or naturally present in syrups). However, this recommendation does not include a reduction in the consumption of sugars naturally present

in whole fruit or vegetables. The digital photography measure could be used to assess both sources of dietary sugar with no change to the data collection method, simply by coding fruit and vegetables in the data set so that they may be selected/deselected, and independently analysing sugar consumption from “free” versus “fruit and vegetable” sources. The ability to measure different sources of dietary sugar through simple coding, and subsequently promote an intervention as being able to reduce free sugars whilst increasing fruit content, is simply one example of how the digital photography measure can contribute to investigating current trends, and gaps in the literature.

Though successful, this study was also subject to limitations. Whilst the digital photography measure could be used to accurately estimate most food item types, the results of a Bland-Altman analysis and PRE calculation suggested that the subcategory of fruit and vegetables was associated with lower reliability than other food subcategories, due to a systematic overestimation bias. This may have implications for the use of this protocol in research investigating fruit and vegetable consumption. However, no published guidelines exist on the acceptability levels of the PRE statistic when assessing nutritional consumption in a free-living sample, and so whilst lower levels of reliability were identified for fruit and vegetable food item consumption estimates, no acceptability assumptions were violated. Indeed, the observed bias was small, representing an overestimation of consumption of less than two grams on average, and was attributed to high variability in portion sizes provided to children by catering staff. Future research into the validation of data collection methods in free-living samples may benefit from exploring acceptable levels of bias, to remove ‘judgement call’ decisions on measure acceptability, promoting measure integrity.

With the availability of a validated protocol, we were able to consider applying it to the evaluation of healthy eating interventions, and identify if this protocol is effective at detecting changes in children’s consumption to a macro- and micro-nutrient level. There are many types of intervention, from simple, information-based initiatives, such as the ‘Change for Life’ campaign (DOH, 2011), to intensive, multicomponent interventions (Anderson, 2005; Horne et al., 2004; Sahota et al., 2001). We use our digital photography data collection method to evaluate the effectiveness of a complex, multi-component school-based intervention, designed to promote healthy eating by targeting fruit and vegetables: the Food Dudes programme (see Chapter 3). Results indicated that the Food Dudes programme had been successful in increasing fruit and vegetable consumption, whilst decreasing unhealthy food item consumption. This nutritional shift has significant health implications (Emmett &

Jones, 2015; Maynard et al., 2003; Pearson, Biddle, & Gorely, 2009). However, such positive health implications cannot be confidently asserted in the absence of supportive long-term follow-up observations.

Though associated with significant behaviour changes, complex, multicomponent interventions are seldom commissioned due to their relatively high associated cost, and so we moved on to consider more simple intervention approaches. Disregarding the simplest information-based approaches because there is a lack of evidence that they can change actual eating behaviour (Croker, Lucas, & Wardle, 2012), we have examined comparably simple behavioural nudge interventions. These interventions have been used to promote healthy eating behaviour and have featured prominently in discussions of cost-effective approaches to improving eating. However, there was no systematic review describing the influence of such interventions that modified the choice architecture of school cafeterias at lunchtime to promote healthy food selection and consumption.

Chapter 4 met this gap in the literature by presenting a review of 25 school cafeteria based behavioural nudge investigations, and concluded that these interventions showed the potential to promote healthy eating behaviour. Whilst this paper contributes to the current literature by identifying areas for methodological improvement, the absence of a meta-analysis means that we were not able to draw general conclusions of statistical results. A meta-analysis would provide future researchers with the ability to objectively compare the results of their intervention with those that are typical in the present literature. Unfortunately, high variability in research design, data type collected, and depth of results reported severely limited the sample of studies appropriate for inclusion, and thus our ability to conduct a meaningful statistical analysis.

The paper presented in Chapter 5 aimed to satisfy the gap in the literature identified by systematic review for a well-designed, well-controlled, UK based investigation into the influence of a behavioural nudge intervention in the school cafeteria, employing validated data collection protocol. Results indicated that the intervention had been successful in promoting healthy eating behaviour. These results indicate that even simple, low-cost, behavioural nudge interventions can yield a positive difference in children’s consumption, however, further research into behavioural nudges that encourage vegetable consumption is required to develop this intervention, and increase its effectiveness.

The interventions presented in Chapters 3 and 5 are associated with different triumphs and shortcomings, and so it is difficult to postulate which was the most successful. A cost-

benefit analysis would indicate that the behavioural nudge intervention was the most successful, as the nudge intervention yielded comparable results to those reported for the Food Dudes intervention, with far fewer costs associated with intervention implementation. However, the Food Dudes intervention was unique in its success in increasing vegetable consumption, where the nudges intervention was unable to influence vegetable consumption. This result is likely associated with the increased focus of the Food Dudes programme on vegetable consumption, where role models specifically highlight the benefits of vegetables, and rewards are contingent upon consuming a portion of both fruit *and* vegetables (see Chapter 3). The nudge intervention did not utilise rewards, relying instead on subconscious motivations which may be sufficient to increase fruit consumption, but not vegetable consumption, as children find fruit more intrinsically rewarding than vegetables due to fruit being naturally sweeter (Mennella & Bobowski, 2015). Indeed, in our experience, caterers are already trying to encourage children to select and consume more vegetables, and so our subtle nudges did not significantly contribute to the effectiveness of these efforts. Further research is required to investigate which behavioural nudges might significantly increase children's vegetable intake in the school dining room, so that behavioural nudge interventions yield similar results to those from the intensive, multicomponent Food Dudes intervention.

Future Directions

Future research may build from the findings of the studies presented in several ways. A basic protocol of the photographic method had been made available on our Research Gate pages, and a more detailed manual is in development. This will assist those researchers interested in establishing details of children's present consumption at school, and measure effects of any changes and interventions. With the recent recognition of the importance of monitoring and evaluation of initiatives in Public Health circles (Bowen, Barrington, & Beresford, 2015), this method may have application beyond academia. For example, as part of the present research, we have sent feedback to caterers and schools showing that nutrient composition of school meals is superior to that of home-packed lunches; they were able to (proudly) share this information – not otherwise available in Wales – with their parents and governors. This also made the caterers happy to partner up with our research team in the long run.

In Chapter 3, we presented results showing that participation in the Food Dudes programme has the potential to yield significant health benefits. However, further investigation is required to replicate and extend these results. The sample size for the present

study was relatively small (n = 112) and follow-up data were collected only 2 months from intervention implementation. Future research would benefit from replicating this investigation with a larger sample, to promote generalisability, and with longer-term follow-up observations, to ensure that changes in eating behaviour are maintained over time, since only sustained dietary changes can be expected to yield significant health and weight changes. Recent US-based research indicates that such an investigation would likely be successful; Morrill, Madden, Wengreen, Fargo, and Aguilar (2016) analysed the effectiveness of the Food Dudes programme with a large sample (n = 2, 292) and a six month follow-up, and reported that significant improvements in eating behaviour were maintained when compared to a control sample. However, this study did not include a full nutritional analysis, nor can results be generalised to a UK sample. Therefore, UK replication is still necessary.

In Chapter 5 we presented research describing a low-cost, simple, school-based healthy eating intervention, and results indicated that this was effective in promoting fruit consumption, suggesting a promising direction for interventions focussing on nutritional improvement. However, no changes were observed in vegetable consumption. Whilst children continue to consume insufficient amounts of vegetables (Grimm et al., 2014; McAloney et al., 2014; National Cancer Institute, 2015), improving vegetable intake must remain a priority. As discussed earlier in this chapter, it may be that subconscious motivators, such as re-ordering the order of serving so that vegetables are served first, are not sufficient to override children's innate dislike of bitter foods (Cashdan, 1994; Steiner, 1977), and so more influential nudges must be utilised to see improvements in children's vegetable consumption. Considering this, future research may benefit from building upon the success of the study presented in Chapter 5, and developing school-based behavioural nudge interventions that utilise those nudges that have been associated with encouraging fruit consumption (e.g. could salad items such as sliced cherry tomatoes and bell pepper be served in colourful salad pots?). Further, the potential impact of the intervention can be extended by working in alliance with school catering services, to further develop the intervention protocol in order to ensure that the intervention is versatile and affordable in the long run. This would increase the potential for mass implementation of the intervention in schools, and thus increase the potential for the intervention to yield a significant impact on public health.

Finally, the research reviewed and presented in this thesis focussed on the nutritional aspects of child health; however, nutritional intake is not the sole influencer of children's

health and weight status. It is considered that lifestyles characterised by low levels of physical activity (in addition to poor diet) are most commonly associated with incidences of obesity (Monasta et al., 2010). However, the influence of activity level on incidence of overweight and obesity in a primary-age population is far from substantial. Harris, Kuramoto, Schulzer and Retallack (2009) conducted a meta-analysis of the effect of physical activity interventions on the Body Mass Index (BMI) of primary age children in the United States (US). During this investigation, 18 school-based interventions were analysed for their effectiveness on improving BMI, body fat percentage, waist circumference and/or total lean mass. Of the interventions scrutinised, none reported any significant intervention effects on BMI, whilst only three identified intervention effects in other anthropomorphic variables (including BF%, total lean mass, and waist circumference [in male participants only]). This trend has also been observed in the UK. The Health and Social Care Information Centre (2014) report that, whilst 64% of primary-age children report participating in at least three hours of high-quality exercise per week, there was no significant variation in BMI category between those who met recommended levels of physical activity, and those who were considered to engage in moderate or low activity. This indicates that, whilst physical activity has many benefits, the association between physical activity and weight may be insufficient to impact upon incidence of overweight and obesity. However, when combined with an effective dietary intervention, physical activity initiatives may promote lasting change. This is supported by Khambalia, Dickinson, Hardy, Gill, and Baur (2012), who reviewed and synthesised the results of eight systematic reviews and meta-analyses describing school-based interventions, and identified that those studies associated with the greatest outcomes were those with combined physical activity and healthy eating components. Therefore, future directions for the present research could benefit from including the development of school-based combined healthy eating and physical activity intervention – such as the recent development of the Dynamic Dudes programme by Prof Horne and her colleagues at CAER in Bangor (Horne, Lowe, & Whitaker, 2017; Sharp, 2017).

A Reflection Note at the End

As I studied for my PhD, there have been areas that have stood out to me as being particularly successful. Though my papers are currently under review, I have been able to directly observe the reception of my research at several conferences, and these experiences have supported my belief that the research I present in this thesis is of relative importance. At

the ISBNPA Annual Meeting in Vancouver, Canada in 2017, I met Isobel Contento, a researcher from Columbia University whose work has been cited in my thesis. She had seen my presentation on the validation of digital photography measure and requested a copy of the protocol to use in her own research. I believe that this act shows how in demand a methodology such as the one described the first paper presented in this thesis is, and how important it is to promote the continuous development of high-quality data collection methods in nutritional research. Conversely, I have concerns regarding the application of the measure to nutritional research. Whilst I am confident that the digital photography measure is able to yield valid and reliable data concerning food intake, we were not able to further develop this measure to include beverages. Unfortunately, I doubt this will ever be achieved through digital photography methods (a cup of diet cola is identical to a cup of full sugar cola when photographed, though the macronutrient differences are substantial), and so I have had to accept that accurately recording beverage intake at lunchtime through direct observational methods will not be achieved by myself. At least for now.

The experimental research that I conducted was also successful. However, these papers yield further questions that I was not able to answer, in particular, the influence of healthy eating programmes on sugar intake. Indeed, in Chapter 5, we observed a significant increase in sugar intake, whereas in Chapter 3 no change in sugar intake was identified over time. We concluded that it was likely that sugar consumption from fruit was responsible for this observed increase, and so this result should not be considered to be a limitation of the research. However, in the absence of the ability to analyse sub-categories of sugar, this conclusion was simply an assumption, and I believe my research would benefit from objective evidence.

To conclude, the present thesis describes my effort to measure and promote healthy eating behaviour in children. I hope that this research may go some ways to influencing larger-scale research that has the potential to inform national-level policy.

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Appendices

Appendix 1: Consent Form for Pilot Study

COLEG GWYDDORAU IECHYD AC YMDDYGIAD
COLLEGE OF HEALTH & BEHAVIOURAL SCIENCES

YSGOL SEICOLEG
SCHOOL OF PSYCHOLOGY

PRIFYSGOL
BANGOR
UNIVERSITY

Dear Parent/Guardian,

Recent studies into the quality of children's diets have highlighted that children do not always get the key nutrients they require for optimum growth and development. As nearly a third of children's food intake is consumed in school, the lunch period is an ideal setting in which to identify where diet could be improved. This study involves measuring food consumption in the cafeteria during the children's lunchtime.

Lunch Boxes: Researchers will weigh each food item provided in your child's lunch box, and photograph the contents before and after lunch.

School Dinners: Photographs will be taken of each child's lunch tray before and after eating. The left-overs will also be weighed.

After the measures, a feedback information pack will be provided to your child's school detailing the nutritional values of what the children are consuming at lunchtime. No children will be visible in the photographs taken and all data will be kept anonymous and confidential. All researchers have been Disclosure and Barring Checked (DBS/CRB) and are well trained.

If you are happy with your child participating in this research, there is nothing you need to do. If you do not wish your child to participate, please complete the slip below by Friday 30th January and return to your child's teacher. If at any time you wish to discontinue your child's participation, please inform the Head Teacher who will inform us immediately. If you would like any further information, please contact lead researcher Mariel Marcano-Olivier (email: psp525@bangor.ac.uk) who will be happy to provide more information about the research.

Thank you for your support, and kind regards,
Dr. Mihela Erjavec
Lecturer in Child Development and Learning

Should you have any complaints regarding the research, please direct these to the School Manager at Bangor University, Mr. Hefin Francis, School Manager, School of Psychology, Adeilad Brigantia, Penrallt Road, Gwynedd LL57 2AS, United Kingdom.

PRIFYSGOL BANGOR
ADEILAD BRIGANTIA,
FFORDD PENRALLT,
BANGOR,GWYNEDD, LL57 2AS

FFÔN: (01248) 382211
FFACS: (01248) 382599

BANGOR UNIVERSITY
BRIGANTIA BUILDING,
PENRALLT ROAD,
BANGOR, GWYNEDD, LL57 2AS

TEL:(01248) 382211
FAX:(01248) 382599

www.bangor.ac.uk www.bangor.ac.uk/psychology

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Annwyl Riant/Gwarcheidwad,

Mae astudiaethau diweddar i ansawdd diet plant wedi dangos nad ydy plant bob tro yn cael y maetholion allweddol sydd eu hangen ar gyfer twf a datblygiad gorau posibl. Fel bron i draean o gymeriant bwyd plant yn cael ei fwyta yn yr ysgol, mae amser cinio yn lleoliad delfrydol i nodi lle y gellid gwella'r diet. Mae'r astudiaeth hon yn cynnwys mesur defnydd fwyd yn y ffreutur yn ystod amser cinio'r plant.

Bocsys Cinio: Bydd ymchwilwyr yn pwyso a mesur pob eitem bwyd ym mlwch cinio eich plentyn, a thynnu lluniau'r cynnwys cyn ac ar ôl cinio.

Cinio Ysgol: Bydd lluniau yn cael eu cymryd o hambwrdd cinio pob plentyn cyn ac ar ôl bwyta. Bydd y gwastraff bwyd yn hefyd cael eu pwyso.

Ar ôl y mesurau, bydd pecyn gwybodaeth adborth yn cael ei ddarparu i ysgol eich plentyn yn manylu'r gwerthoedd maethol o beth mae'r plant yn bwyta yn ystod amser cinio. Ni fydd unrhyw blant yn weladwy yn y lluniau a bydd yr holl ddata yn cael eu cadw'n ddienw a chyfrinachol. Mae'r holl ymchwilwyr wedi bod yn Ddatgeliad a Gwahardd Gwiriwyd (DBS/CRB) ac wedi cael eu hyfforddi'n dda.

Os ydych yn hapus gydag eich plentyn yn cymryd rhan yn yr ymchwil hyn, nid oed unrhyw beth mae angen i chi gwead. Os nad ydych chi am eich plentyn cymryd rhan, llenwch y slip isod erbyn Dydd Gwener 30 Ionawr a dychwelyd i athro eich plentyn. Os ar unrhyw adeg byddwch yn dymuno cyfraniad eich plentyn, plîs rhowch wybod i'r Pennaeth a fydd yn rhoi gwybod i ni ar unwaith. Os hoffech unrhyw wybodaeth bellach, cysylltwch â'r ymchwilwyr Mariel Marcano-Olivier (e-bost: psp525@bangor.ac.uk) neu Anne Fraser (psp444@bangor.ac.uk) a fydd yn hapus i roi mwy o wybodaeth am yr ymchwil..

Diolch i chi am eich cefnogaeth, a chofion caredig,
Dr. Mihela Erjavec
Darlithydd mewn Datblygiad Plant a Dysgu

Pe bai gennych unrhyw gwyn (sy'n annhebygol) ynghylch yr ymchwil a gynhelir ym meithrinfa eich plentyn, cysylltwch â Mr Hefin Francis, Rheolwr, Ysgol Seicoleg, Prifysgol Bangor (e-bost: h.francis@bangor.ac.uk neu weler y manylion cyswllt isod)

PRIFYSGOL BANGOR
ADEILAD BRIGANTIA,
FFORDD PENRALLT,
BANGOR,GWYNEDD, LL57 2AS

FFÔN: (01248) 382211
FFACS: (01248) 382599

BANGOR UNIVERSITY
BRIGANTIA BUILDING,
PENRALLT ROAD,
BANGOR, GWYNEDD, LL57 2AS

TEL:(01248) 382211
FAX:(01248) 382599

www.bangor.ac.uk www.bangor.ac.uk/psychology

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Appendix 2: Headteacher Study Information Sheet for Pilot Study

Headteacher Study Information Sheet

We are working with Food Dudes Health Limited, developed by behaviour change experts at Bangor University over the last 20 years. Recent studies into the quality of children's diets have highlighted that children do not always get the key nutrients they require for optimum growth and development. As nearly a third of children's food intake is consumed in school, the lunch period is an ideal setting in which to identify where diet could be improved. This study involves measuring food consumption in the cafeteria during the children's lunchtime.

Our focus for this study is on children in classes Year 1, Year 3 and Year 5 who will all be sent consent forms. These forms will work on an "opt out" basis, and so it is of great importance that children are prompted to give these letters to their parents. If at any time during the study parents/guardians wish to discontinue their children's participation, they can inform the Headteacher who should inform us immediately.

On 3 separate days (on agreed dates with the Headteacher) 4 researchers will be present, all having been Disclosure Barring Checked (DBS/CRB). In order to protect the study data from any bias, the dates of the study should be withheld from parents where possible (although, should the dates be requested by a parent, they may be disclosed to that individual).

Lunch Boxes: Researchers will weigh each food item provided in children's lunch boxes, and photograph the contents before and after lunch.

School Dinners: Photographs will be taken of each child's lunch tray before and after eating. The left-overs will also be weighed. 5 reference portions from caterers of each individual portion of served food, on the menu that day, will also be weighed prior to children's serving time, meaning individual children's trays will not need weighing pre consumption.

No children will be visible in the photographs taken and all data is kept anonymous and confidential.

Researchers will visit the dining room on the day of the Headteacher meeting to familiarise themselves with the dining room routine, and will arrange a meeting with the caterer to clarify preparation and menu information. Any disruption will be kept to a minimum.

After data collection, a feedback information pack will be provided to the school detailing the nutritional values of what the children are consuming at lunchtime. As detailed data coding and analysis may take some time, this feedback will not be immediate, but will be as soon as possible after study cessation.

The researchers for this study are Mariel Marcano-Olivier (email: psp525@bangor.ac.uk) or Anne Fraser (psp444@bangor.ac.uk) who will be happy to provide more information.

Appendix 3: Caterers Information Sheet for Pilot Study

Caterer's Information Sheet

We are working with Food Dudes Health Limited, developed by behaviour change experts at Bangor University over the last 20 years. Recent studies into the quality of children's diets have highlighted that children do not always get the key nutrients they require for optimum growth and development, often due to a discrepancy between what a child is served, and what they actually consume. As nearly a third of children's food intake is consumed in school, the lunch period is an ideal setting in which to identify where diet could be improved. This study involves measuring food consumption in the cafeteria during the children's lunchtime.

Our focus for this study is on children in classes Year 1, Year 3 and Year 5.

On 3 separate days (on agreed dates with the Headteacher) 4 researchers will be present, all having been Disclosure Barring Checked (DBS/CRB). In order to protect the study data from any bias, the dates of the study should be withheld from parents where possible (although, should the dates be requested by a parent, they may be disclosed to that individual).

Lunch Boxes: Researchers will weigh each food item provided in children's lunch boxes, and photograph the contents before and after lunch.

School Dinners: Photographs will be taken of each child's lunch tray before and after eating. The left-overs will also be weighed. 5 reference portions from caterers of each individual food item served, on the menu that day, will also be weighed prior to children's serving time, meaning individual children's trays will not need weighing pre consumption.

No children will be visible in the photographs taken and all data is kept anonymous and confidential.

After data collection, a feedback information pack will be provided to the school detailing the nutritional values of what the children are consuming at lunchtime.

The researchers for this study are Mariel Marcano-Olivier (email: psp525@bangor.ac.uk) or Anne Fraser (psp444@bangor.ac.uk) who will be happy to provide more information.

Appendix 4: CAER Bangor Protoc ol for Digital Photography Measure

PRIFYSGOL BANGOR UNIVERSITY

Protocol for the Digital Photography Method of Measuring Consumption in the School Cafeterias (2016)

Centre for Activity and Eating Research CAER BANGOR

Author Contact Details

Mariel Marcano-Olivier

Email: psp525@bangor.ac.uk

Other Contributors

Dr Mihela Erjavec

Ruth Pearson

Web: http://caer.bangor.ac.uk/

Brief Description of Resource

This resource details the protocol for collecting nutritional data using the digital photography method in school cafeterias, including the training protocol for observers.

Materials

- Four digital cameras with four tripods and four memory cards.
- White paper plates.
- White self-adhesive participant identification labels.
- Wrist bands.
- Small white participant lunchbox identification tags.
- Non-latex gloves.

Preparing Participant Identification Materials

Participant identification labels must be prepared in advance. For each participant ID, two white self-adhesive identification labels and one identification tag should be prepared. One of these participant identification labels should be attached to a participant wrist band, the remaining label will be attached to their dinner tray OR the identification tag will be attached to their lunchbox. Both lunch options should be prepared for all participants, as lunch type may change day by day or at the last minute. Due to the fast paced and unpredictable nature of the school canteen environment, it is important that these are prepared in advance to protect against participant attrition.

Procedure

- Prior to study commencement:
    - The researcher should have the opportunity to assess the dining room set-up, observe a standard lunchtime routine, and familiarise with the lunchtime staff.
    - Researchers should also assess the positioning of the waste disposal areas in the dining hall. If several bins are situated around the hall, researchers should ask for all bins to be situated in one area for the duration of data collection, to protect against attrition from children disposing of waste in an "unsupervised" area.
    - The nutritional information of the food items provided by the school for school dinners should be requested from the school catering company, to inform data analysis.
- Researchers arrive at the school at 8:30 a.m. to unpack equipment and prepare the designated study area.

- At 9 a.m., the school day begins, and one researcher enters each classroom, collects lunch boxes (and removes items intended to be consumed during morning snacktime), distributes numbered participant wrist bands to each participant and attaches the corresponding tag to their lunch box. Participants who consume school dinners are told that they would receive another sticker at lunchtime for their dinner tray. Researchers then describe to participants what they will be asked to do at lunchtime.
- Following this, lunchboxes are taken to the study area, where the contents of each lunchbox are placed on a white paper plate, along with a participant identification number label, to be photographed. Photographs of food items are standardised so that the camera was positioned on a tripod, between 45-60 centimetres from the centre of the plate, at a 45 degree angle (see Figure 1 for an example of pre- and post-consumption lunchbox photographs). In photographs, it is ensured that all food items are clearly visible, and all items that can be unwrapped (e.g. sandwiches wrapped in tin foil or cling film) are unwrapped for the purpose of the photograph.

Figure 1. Pre- and post-consumption photographs of a participant's lunchbox contents.

- For those participants consuming school dinners, estimate food measurements are calculated by asking caterers to serve researchers five portions of every food item available to children. Each portion is

weighed on a plastic dinner tray (or whatever school dinner is served on in the cafeteria) and from this a mean is calculated for each food item. The portion served that is closest to the mean for that food item is then photographed for reference purposes during consumption/ nutrient analysis. All food item weights are recorded on data collection sheets (see 1).

- At this point, catering staff and lunchtime staff are asked to instruct children wearing participation wrist bands to bring all lunchbox and tray waste back to researchers at the back of the dinner hall when they had finished eating.
- This is immediately followed by the school lunchtime.
- Two researchers are positioned at the end of the canteen queue to collect pre-consumption school dinner photographs; one researcher identifies participants by their wrist bands, and places a corresponding participant identification label on their tray, before the second researcher takes the pre-consumption photograph of their dinner tray (set-up as before, see Figure 2). The children then sit down to eat as normal.

Figure 2. Pre- and post-consumption photographs of a participant's school dinner tray.

- Once the participants finish eating, they hand their dinner trays and lunchboxes to the remaining two researchers positioned at the back of the hall by the waste bins, to protect against attrition from children

disposing of waste food before it had been photographed. Researchers then photograph each dinner tray and the contents of each lunchbox (as before).

- Following this, food items from lunchboxes are returned to their boxes that are, in turn, returned to participant's classrooms, and plate waste from dinner trays is disposed of, and dinner trays are returned to the school cafeteria.

Data Processing and Coding

Determining the Final Sample

- On each day, photographs collected are uploaded and labelled with the participant number and "A" to denote pre-consumption and "B" to denote post-consumption (for example, the post-consumption photograph of Participant 201 would be labelled "201B").
- Following this, researchers are able to identify those participants from whom a full set of data (both a pre- and a post-consumption photograph) have been collected on each measurement day. Those participants from whom sufficient data had not been collected are removed from the sample.

Creating Typical Food Database

- For school dinner items, average food weights are taken for each food item available on the day of data collection.
- For items in lunch boxes, data should be assessed for commonly provided items, such as sandwiches, crisps, cake bars etc. The standard weight of shop-bought items can be recorded from packaging or the manufacturers published information. For home made items (e.g. sandwiches), researchers make five standard

examples of the food item presented and from this can calculate an average weight.

- All weights should be recorded in a database. This process takes approximately two days, depending on variability in the foods provided in the sample.

Calculating Children's Consumption of Each Food in Grams

- The percentage consumed for each food item presented is estimated by the lead researcher to the closest 10% increment using the pre- and post-consumption photographs for reference. Approximately 40 – 50 participants can be coded in an hour, depending on rater experience. An independent rater second-codes 20% of the meals presented each day.
- Should raters disagree on percentage consumed by 10%, the estimation of the lead researcher is taken. Should raters disagree by 20%, the middle value is taken (e.g. lead researcher estimates 10%, second coder estimates 30%, 20% is taken as consumed weight). If raters disagree by more than 20% this is considered to be failed agreement and the food item is reassessed.
- The weight in grams for each food item in lunchboxes is estimated by referring to product information published by the manufacturer (e.g. a Nutri-grain ® soft baked fruit cereal bar weighs 37g according to published product information, and so this was the weight recorded for Nutri-grain bars and supermarket own-brand varieties). Where this information is unavailable (e.g. for sandwiches), an average sandwich weight is calculated from published product information (e.g. the average "medium" slice of bread weighs 40g, the average "small" bread roll weighs 60g), and weighing samples (e.g. making 5 cheese sandwiches and weighing the components independently to conclude

an average sandwich filling weight for commonly presented food items). For example, the average cheese sandwich on sliced bread is estimated to weigh 100g in total, with additional fillings (e.g. cheese and ham) increasing the estimated weight by 20g per filling, or 5g per salad filling (e.g. cheese and lettuce). Participants are also often presented with pieces of fruit, and so estimates were calculated from an average sized piece of fruit (e.g. an average apple weighs 70g [60g edible flesh, minus 10g for core], an average "snack size/kids size" apple weighs around 50g [40g edible flesh, minus 10g for core]).

- For school dinner food items, average weights are taken from five reference portions of each food item available, served and weighed on school dinner trays by the lunchtime catering staff. Food items that are available from the self-serve salad bar are estimated to the nearest 5g, with reference to target photographs of the food items.
- In the few incidences that a serving of a food item for school dinners for one participant is visually very different from that of the photographed reference portion (see above), then the weight of this food item can be estimated using the reference photograph using the following steps:
    - Estimate the approximate percentage the served portion represents of the reference portion (e.g. a small portion of beans may appear to be around 50% of that of a standard portion).
    - Calculate the weight of this independently (e.g. 50% of an average 84g portion of beans may be 42g).
    - Use this as the pre-weight and continue using standard protocol (e.g. 90% of 42g was consumed, 38g consumed).

- Following this protocol, it is possible to estimate the weight of each food item that children consumed in grams. For example, if a participant consumed 70% of a Nutri-grain ® bar then 26g was consumed, or if a participant consumed 80% of a 64g portion of carrots then 51g was consumed.

Calculating Children's Overall Consumption Scores

- Once the amount of each food item consumed had been estimated in grams, researchers are able to calculate the macro- and micro-nutritional content of the foods consumed using published product information or, where this was not available, McCance and Widdowson's The Composition of Foods Seventh Summary Edition (Food Standard Agency, 2014), a comprehensive manual detailing the macro- and micro-nutrient content of the UK's most commonly consumed foods.

Photographic Assessment Training

The lead researcher and a second coder are trained in assessing, to the nearest 10%, the amount of each food item consumed from pre- and post-consumption digital photographs.

Creating the training materials for your sample

- Following data collection, data is analysed and regularly presenting food items are identified. This generally includes sandwiches, crisps, fruit, chocolate bars, and crisps for lunchboxes, and composite meals/wet foods (such as stews or beans), meat portions, vegetables, potatoes, and puddings for school dinners.
- An example food item from each of these categories is subsequently photographed (as it would be served on a plate or tray) as a "full" portion, and then in 10% decrements of consumption. For example, if

an average portion of baked beans weighed 80 grams, then 80g of beans is photographed as a "full portion", then 8g of the food item would be removed, leaving 72g of beans remaining for the 10% consumed (90% remaining) photograph example. This is repeated for every 10% decrement until the final photograph, leaving 8g of beans and representing the 90% consumed (10% remaining) photograph example. This protocol is then repeated for the key example food items in your sample, resulting in sample photographs of the regularly presenting food item chosen in 10% decrements of consumption.

- Whilst every single food item that may be presented cannot be predicted (or a full database is unrealistic to achieve), items of similar texture and weight present similarly on a tray and in a photograph, and so may be grouped together for the purpose of training (e.g. stews and baked beans; wet foods; cereal bars, chocolate bars and cake bars; snack bars).
- See Appendix 2 for example.

Training Raters

- Once photographs of sample food items have been recorded, these are printed as "flashcards" with the picture of the food item on the front and the percentage consumed written on the back.
- Training sessions last half an hour, and include six five-minute exposures and six five minute breaks. Multiple sessions can be undertaken in one day (and there is no limit to how many), however, time must be allowed for the trainee to recuperate and be distracted by other tasks in order to protect against fatigue.
- During the exposures, the trainee is given the "full portion" examples of each food item for reference. They are then shown a "**%

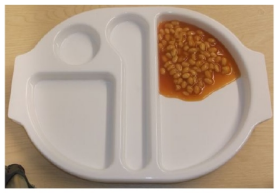
consumed" photograph and must estimate how much of that food item has been consumed.

- Correct and incorrect estimations are tallied to track trainee progress.
- After several sessions, when the trainee feels confident about estimating food consumption and is showing increases in correct assessment, then the trainee should be given a random selection of pre- and post-consumption examples from the sample of data collected.
- This gives the trainee an opportunity to practise their skills on a real-life sample, and allows researchers to calculate the inter-rater reliability of multiple trainees and monitor trainee progress on real-life data.
- Once "perfect" inter-rater agreement has been achieved on more than 80% of food items in the sample file, trainees are considered to be "trained observers".

Appendix 1. - Example of data collection sheet for school dinner items.

School Dinner items average weight		
Food Type	Pre- weight	Other Notes
Average		
Average		
Average		
Average		
Average		
Average		
Average		

Appendix 2. - Observer training: Food that can be seen on plates or trays - in grams.



Baked beans: Full portion (86g)

Baked beans: 30% consumed (50g)

Crisps: Full portion (16g)

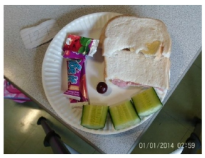
Crisps: 20% consumed (13g)

Apple: Full (edible) Portion (120g)

Apple: 20% consumed (96g)

Appendix 3. - Example of a lunchbox consumption estimated using digital photography method.

Pre-Consumption



Post-Consumption

- Ham sandwich: 10% consumed; Cucumber: 0% consumed; Biscuit: 100% consumed; Yogurt 1: 100% consumed; Yogurt 2: 40% consumed; White grapes: 100% consumed; Red grapes: 80% consumed.

Food Item	Pre-Consumption Weight (g)	Total weight Consumed (g)
Ham sandwich	100	10
Cucumber	45	0
Biscuit	25	25
Yogurt 1	22	0
Yogurt 2	22	9
White Grapes	8	8
Red Grapes	16	3

Appendix 4. - Example of a school meal consumption estimated using digital photography method.

Pre-Consumption

Post-Consumption

- Sausages: 100% consumed; Courgette 100% consumed; Cabbage: 0% consumed; Mashed potato: 10% consumed; Bread: 0% consumed; Tomato: 0% consumed; Cake: 100% consumed.

Food Item	Pre-Consumption Weight (g)	Total weight Consumed (g)
Sausages	53	53
Courgette	20	0
Cabbage	20	0
Mashed Potato	47	5
Bread	10	0
Tomato	5	0
Cake	37	37

Appendix 5: Conference Presentation for Validation Study

Estimates of Food Consumption in a School Cafeteria Setting: A Validation Study of the Use of Digital Photography

Mariel Marcano-Olivier, Mihela Erjavec, Pauline Horne, Simon Viktor, Ruth Pearson-Blunt

Background

- Suboptimal childhood nutrition
  - Excess calories – fat and carbohydrates. [1]
  - Insufficient iron, iodine, and folate. [2,3]
- Health impacts
  - Obesity, heart disease, type 2 diabetes, bone and joint problems etc.
  - Fatigue, poor immune function and stunted growth (iron [4]); inadequate thyroid function resulting in atypical neurological development, and poor growth (iodine [5]); poor growth, cognition, social development, and depressive symptoms (folate [6]).

Methodologies

- Indirect
  - Diet diaries.
  - 24 hour recall interviews.
  - Poor agreement (64%) identified when comparing maternal reporting of dietary intake [7].
  - Insensitive to small but significant changes [8].
- Direct
  - Gold-standard is intrusive.
  - Food preparation records can be insensitive/lack ecological validity.

Digital Photography Method

- Many different methods
  - Diet apps etc.
- Remote method/Mobile phone method
  - Shows promise but subject to bias and study conditions very controlled [9]
- Yet to be successfully evaluated in fast-paced canteen setting.
  - Some research has shown strong inter-rater reliability but not compared to known weights [10]
  - Some research has shown good agreement between photography and weighed measures but in a contrived setting such as simulated plate waste [11], or "typical" sandwich lunches [12].
  - One study compared photography and weighed estimates but with faulted methodology/analysis and over-generous accuracy criteria.

Aims and Hypothesis

- The present study had been designed to validate a simple but versatile protocol for collection of nutritional consumption data in
  - Free-living cafeteria environments
  - Primary and secondary school settings
  - For meals provided both by caterers and by parents

Methodology

- **Participants**
  - 131 children from Primary (North Wales), 127 children from Secondary (West Midlands, UK).
  - Both samples were well gender balanced.
  - Represented a wide range of ages.
  - Predominantly Caucasian origin, reflecting the demographics of their regions (rural Wales and urban England, respectively).
- **Materials**
  - 4 digital cameras, tripod stands, tape measures and protractors.
  - Food items were either displayed on paper plates for lunchbox meals, or plastic dinner trays for school dinners.
  - Plain white paper participant identification tags, white self-adhesive participant identification labels, wrist bands.
  - Non-latex gloves.

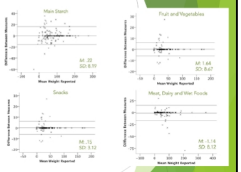
Methodology

- *Lunchboxes.* Participants' lunchboxes were collected during registration and taken to the study area to be photographed. The contents of each box were spread on a paper plate. They were clearly visible and any items that could be unwrapped (e.g. sandwiches in tin foil or cling film) were exposed for the purpose of the photographed and weighed. Lunchboxes were restored and returned to participants after morning break time.
- *School dinners.* Estimate food measurements were calculated by asking caterers to serve researchers five portions of every food item available to children. The portion that was closest to the mean for that food item was photographed. At lunchtime, participants were told to come to researchers after they had been served their lunch, but before they sat down to eat, so that a pre-consumption photograph could be recorded for each child.
- At lunchtime, all children sat down to eat as usual. Then, researchers photographed the dinner trays or contents of each lunchbox, and weighed each remaining food item individually (in the same manner as the pre-consumption data collection).

Example

Data Analysis and Results

- The results of the Bland-Altman analysis indicate that the estimated consumption of food items derived from digital photographs presented an acceptably small bias for the categories Main Starch; Snacks; and Meat, Dairy and Wet Foods.
- Percentage relative error.
- This results reflects a comparably higher variation in Fruit and Vegetable serving sizes.
- Catering staff did not always follow instruction to serve standard portions, leading to disparities between the pre-consumption estimated weights and the actual weights of the portions served.
- The actual differences were very small: The average consumed portion weighed 47.91 grams and this was overestimated via photography by 1.64 grams on average.



Inter-Rater Reliability

Category	Full Agreement	10% Disparity	20% Disparity	> 20% Disparity
Main Starch	81.00	7.60	2.50	8.90
Fruit and Vegetables	83.60	11.00	2.70	2.7
Meat, Dairy and Wet	95.20	4.80	-	-
Snacks	94.10	2.90	1.50	1.50

Conclusion

- We have found that photographic estimates can be equivalent to those recorded using objective weighed measures for most food types, and that a high level of inter-rater agreement can be achieved using the present protocol.
- This has significant implications for the collection of nutritional data in children.

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Appendix 6: Conference Poster for Validation Study

Estimates of Food Consumption in a School Cafeteria Setting: A Validation Study of the use of Digital Photography .

Mariel Marcano-Olivier, Mihela Erjavec, Pauline Horne, Simon Viktor, & Ruth Pearson
Centre for Activity and Eating Research (CAER) & Bangor University.

PROBLEM: Poor nutrition during childhood is a significant issue in the developed world. School lunchtime provides an opportunity for observational research into children's diet, however, the "gold standard" of weighing every food item pre- and post-consumption is invasive and time consuming. This study aims to validate the use of digital photography as a non-invasive, time-effective and accurate alternative.

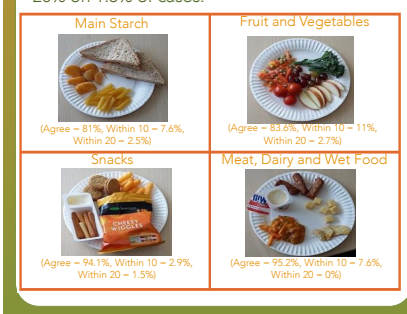
THE USE OF DIGITAL PHOTOGRAPHY

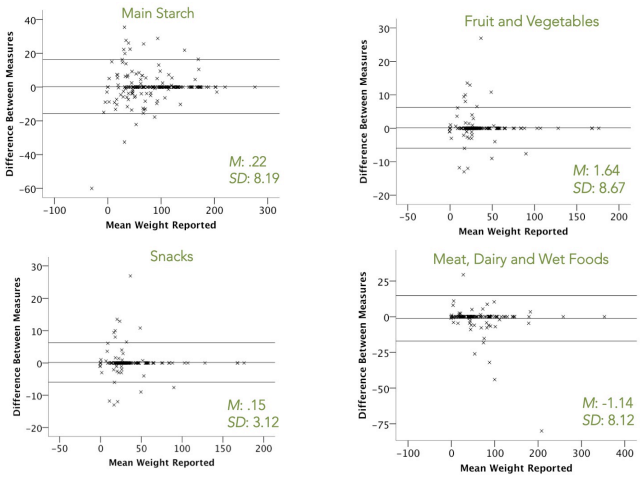
- Previous research indicates that digital photography can be utilised in multiple settings, including university settings and remotely (using self report images from participants homes via smartphones).
- These studies have consistently achieved high levels of inter-rater agreement.
- The use of this method has never been validated in a fast-paced school cafeteria environment.

METHOD: A validation study was conducted in one primary school in North Wales and one secondary school in the West Midlands, to compare objective weighed measures of food item consumption to estimates derived from digital photographs.

- We measured consumption of pupils from years one, two, three, four and five (5-10 years old; n = 116) in the Primary school and years seven, eight, nine, ten and thirteen (11 – 18 years old; n = 123) in the secondary school.
- Data were collected over two consecutive school weeks, with five days of data collection conducted in the primary school and four days of data collection in the secondary school.
- For children who ate food brought from home, lunchbox contents were photographed and each food item individually weighed pre- and post-consumption.
- Estimate portion weights for each food item available in the canteen were calculated.
  - For children who ate school dinners, photographs of each plate were taken pre-consumption (at the end of the cafeteria line), estimate average weights were used as a pre-consumption weighed measure. Photographs of each dinner tray were taken post-consumption, and any remaining food items were individually weighed.
- The digital photographs recorded were used to estimate the amount of each food item consumed to the nearest 10%.
- Each food item was categorised into one of four categories: Main Starch, Fruit and Vegetable, Snacks, and Meat, Dairy and Wet Foods in order to analyse accuracy on different types of food items
- A Bland-Altman analysis was then conducted in order to compare estimates of food consumption from digital photographs to objective weighed measures.

AGREEMENT ESTIMATES: Approximately 30% of food items were recoded by a trained second-coder. Raters agreed on amount of each individual food item consumed on 88% of cases. Raters agreed to within 10% of consumption on 6.7% of cases, and within 20% on 1.8% of cases.





For more information, email: psp525@bangor.ac.uk
Or visit our website: http://caer.bangor.ac.uk

These results show that digital photography can be used as a method of collecting accurate and reliable nutritional data in a fast-paced lunchtime cafeteria setting.

Appendix 7: Consent form for Validation Study (Primary)

COLEG GWYDDORAU IECHYD AC YMDDYGIAD
COLLEGE OF HEALTH & BEHAVIOURAL SCIENCES

YSGOL SEICOLEG
SCHOOL OF PSYCHOLOGY

PRIFYSGOL BANGOR UNIVERSITY

Dear Parent/Guardian,

Recent studies into the quality of children's diets have highlighted that children do not always get the key nutrients they require for optimum growth and development. As nearly a third of children's food intake is consumed in school, the lunch period is an ideal setting in which to identify where diet could be improved. This study involves measuring food consumption in the cafeteria during the children's lunchtime.

Lunch Boxes: Researchers will weigh each food item provided in your child's lunch box, and photograph the contents before and after lunch.

School Dinners: Photographs will be taken of each child's lunch tray before and after eating. The left-overs will also be weighed.

After the measures, your child will be entered into a prize draw to win "Love2Shop" vouchers, as a thank you for taking part. No children will be visible in the photographs taken and all data will be kept anonymous and confidential. All researchers have been Disclosure and Barring Checked (DBS/CRB) and are well trained.

If you are happy with your child participating in this research, there is nothing you need to do. If you do not wish your child to participate, please complete the slip below by 20th June and return to your child's teacher. If at any time you wish to discontinue your child's participation, please inform the Head Teacher who will inform us immediately. If you would like any further information, please contact lead researcher Mariel Marcano-Olivier (email: psp525@bangor.ac.uk) who will be happy to provide more information about the research.

Thank you for your support, and kind regards,
Dr. Mihela Erjavec
Lecturer in Child Development and Learning

Should you have any complaints regarding the research, please direct these to the School Manager at Bangor University, Mr. Hefin Francis, School Manager, School of Psychology, Adeilad Brigantia, Penrallt Road, Gwynedd LL57 2AS, United Kingdom.

Child's name:……..

PRIFYSGOL BANGOR
ADEILAD BRIGANTIA,
FFORDD PENRALLT,
BANGOR,GWYNEDD, LL57 2AS

FFÔN: (01248) 382211
FFACS: (01248) 382599

BANGOR UNIVERSITY
BRIGANTIA BUILDING,
PENRALLT ROAD,
BANGOR, GWYNEDD, LL57 2AS

TEL:(01248) 382211
FAX:(01248) 382599

www.bangor.ac.uk www.bangor.ac.uk/psychology

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Annwyl Riant/Gwarcheidwad,

Mae astudiaethau diweddar i ansawdd diet plant wedi tynnu sylw at y ffaith nad yw plant bob amser yn cael y maetholion allweddol y maent eu hangen ar gyfer y twf a'r datblygiad gorau posib. Gan fod plant yn bwyta bron i un rhan o dair o'u holl fwyd yn yr ysgol, mae amser cinio'n gyfle delfrydol i nodi lle gellid gwella diet. Mae'r astudiaeth hon yn ymwneud â mesur y bwyd sy'n cael ei fwyta yn y neuadd ginio yn ystod amser cinio'r plant.

Bocsys Bwyd: Bydd ymchwilwyr yn pwyso pob eitem o fwyd sydd ym mocs bwyd eich plentyn, ac yn tynnu llun cynnwys y bocs cyn ac ar ôl cinio.

Cinio Ysgol: Bydd lluniau o hambyrddau cinio pob plentyn yn cael eu tynnu cyn ac ar ôl iddynt fwyta'u cinio. Bydd y bwyd sydd ar ôl hefyd yn cael ei bwyso.

Ar ôl gorffen y gwaith mesur, bydd enwau'r plant yn cael eu rhoi mewn het i geisio ennill talebau "Love2Shop", i ddiolch iddynt am gymryd rhan. Ni fydd modd gweld unrhyw blentyn yn y ffotograffau a dynnir, a bydd yr holl ddata'n cael ei gadw'n ddienw ac yn gyfrinachol. Mae'r holl ymchwilwyr wedi cael eu gwirio o safbwynt Datgelu a Gwahardd (DBS/CRB) ac wedi eu hyfforddi'n dda.

Os ydych yn fodlon i'ch plentyn gymryd rhan yn yr ymchwil hwn, does dim angen i chi wneud unrhyw beth. Os nad ydych yn dymuno i'ch plentyn gymryd rhan, a fyddech cystal â llenwi'r bonyn isod a'i ddychwelyd i athro/athrawes dosbarth eich plentyn erbyn 20 Mehefin. Os byddwch yn dymuno i'ch plentyn dynnu'n ôl o'r astudiaeth unrhyw bryd, rhowch wybod i Bennaeth yr ysgol, a fydd yn rhoi gwybod i ni ar unwaith. Os hoffech gael rhagor o wybodaeth am yr ymchwil, cysylltwch â Mariel Marcano-Olivier, y prif ymchwilydd (ebost: psp525@bangor.ac.uk), a fydd yn hapus i roi mwy o wybodaeth i chi.

Diolch yn fawr am eich cefnogaeth, a chofion caredig,
Dr. Mihela Erjavec
Darlithydd Dysgu a Datblygiad Plentyn

Os oes gennych unrhyw gwynion am yr ymchwil, dylech eu cyfeirio at y Rheolwr Ysgol ym Mhrifysgol Bangor, Mr Hefin Francis, Rheolwr Ysgol, Ysgol Seicoleg, Adeilad Brigantia, Ffordd Penrallt, Bangor, Gwynedd LL57 2AS.

PRIFYSGOL BANGOR
ADEILAD BRIGANTIA,
FFORDD PENRALLT,
BANGOR,GWYNEDD, LL57 2AS

FFÔN: (01248) 382211
FFACS: (01248) 382599

BANGOR UNIVERSITY
BRIGANTIA BUILDING,
PENRALLT ROAD,
BANGOR, GWYNEDD, LL57 2AS

TEL:(01248) 382211
FAX:(01248) 382599

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Appendix 8: Consent form for Validation Study (Secondary)

COLEG GWYDDORAU IECHYD AC YMDDYGIAD
COLLEGE OF HEALTH & BEHAVIOURAL SCIENCES

YSGOL SEICOLEG
SCHOOL OF PSYCHOLOGY

PRIFYSGOL
BANGOR
UNIVERSITY

Dear Parent/Guardian,

Recent studies into the quality of children's diets have highlighted that children do not always get the key nutrients they require for optimum growth and development. As nearly a third of children's food intake is consumed in school, the lunch period is an ideal setting in which to identify where diet could be improved.

This study involves measuring food consumption in the cafeteria during the children's lunchtime. Photographs and weights of each individual food item will be recorded of the contents of each child's lunchbox or dinner tray before and after eating.

After the measures, your child will be entered into a prize draw to win £50 worth of "Love2Shop" vouchers, as a thank you for taking part. No children will be visible in the photographs taken and all data will be kept anonymous and confidential. All researchers have been Disclosure and Barring Checked (DBS/CRB) and are well trained.

If you are happy with your child participating in this research, there is nothing you need to do. If you do not wish your child to participate, please complete the slip below by 27th June and return to your child's form teacher, head of house, or reception staff, for the attention of Mr. Sedgwick. If at any time you wish to discontinue your child's participation, please inform the head teacher, Mr. Mountney, or Mr. Sedgwick who will inform us immediately. If you would like any further information, please contact lead researcher Mariel Marcano-Olivier (email: psp525@bangor.ac.uk) who will be happy to provide more information about the research.

Thank you for your support, and kind regards,
Dr. Mihela Erjavec
Lecturer in Child Development and Learning

Should you have any complaints regarding the research, please direct these to the School Manager at Bangor University, Mr. Hefin Francis, School Manager, School of Psychology, Adeilad Brigantia, Penrallt Road, Gwynedd LL57 2AS, United Kingdom.

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ADEILAD BRIGANTIA,
FFORDD PENRALLT,
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Registered charity number: 1141565

Appendix 9: Staff Information Sheet Validation Study (Primary)

Staff Information Sheet

We are working with the Centre for Activity and Eating Research laboratory at Bangor University. Recent studies into the quality of children's diets have highlighted that children do not always get the key nutrients they require for optimum growth and development. As nearly a third of children's food intake is consumed in school, the lunch period is an ideal setting in which to identify where diet could be improved. This study involves measuring food consumption in the cafeteria during the children's lunchtime.

Our focus for this study is on children in classes Year 1, Year 2,Year 3, Year 4 and Year 5 who will all be sent consent forms. These forms will work on an "opt out" basis, and so it is of great importance that children are prompted to give these letters to their parents. If at any time during the study parents/guardians wish to discontinue their children's participation, they can inform the Headteacher who should inform us immediately.

On 5 consecutive days (on agreed dates with the Headteacher) 5 researchers will be present, all having been Disclosure Barring Checked (DBS/CRB).

Lunch Boxes: Researchers will weigh each food item provided in children's lunch boxes, and photograph the contents before and after lunch.

School Dinners: Photographs will be taken of each child's lunch tray before and after eating. The left-overs will also be weighed. 5 reference portions from caterers of each individual portion of served food, on the menu that day, will also be weighed prior to children's serving time, meaning individual children's trays will not need weighing pre consumption.

No children will be visible in the photographs taken and all data is kept anonymous and confidential.

After data collection, your school will be provided with "Love2Shop" vouchers as a "thank you" for those staff that took part, and children who participated will be entered into a prize draw to win £20 "Love2Shop" vouchers.

The lead researcher for this study is Mariel Marcano-Olivier (email: psp525@bangor.ac.uk) who will be happy to provide more information.

Taflen Wybodaeth i Staff

Rydym yn cydweithio â labordy'r Ganolfan Ymchwil Bwyta a Gweithgaredd ym Mhrifysgol Bangor. Mae astudiaethau diweddar i ansawdd diet plant wedi tynnu sylw at y ffaith nad yw plant bob amser yn cael y maetholion allweddol y maent eu hangen ar gyfer y twf a'r datblygiad gorau posib. Gan fod plant yn bwyta bron i un rhan o dair o'u holl fwyd yn yr ysgol, mae amser cinio'n gyfle delfrydol i nodi lle gellid gwella diet. Mae'r astudiaeth hon yn ymwneud â mesur y bwyd sy'n cael ei fwyta yn y neuadd ginio yn ystod amser cinio'r plant.

Byddwn yn canolbwyntio ar blant dosbarthiadau Blwyddyn 1, Blwyddyn 2, Blwyddyn 3, Blwyddyn 4 a Blwyddyn 5 ar gyfer yr astudiaeth hon, a byddant i gyd yn cael ffurflenni cydsynio. Bydd y ffurflenni hyn ar sail "optio allan", felly mae'n bwysig iawn sicrhau bod y plant yn rhoi'r llythyrau hyn i'w rhieni. Os bydd rhieni/gwarcheidwaid yn dymuno i'w plentyn dynnu'n ôl o'r astudiaeth unrhyw bryd, dylent roi gwybod i Bennaeth yr ysgol, a fydd yn rhoi gwybod i ni ar unwaith.

Bydd pum ymchwilydd yn bresennol ar bum diwrnod yn olynol (dyddiadau y cytunwyd arnynt gyda'r Pennaeth), a byddant i gyd wedi cael eu gwirio o safbwynt Datgelu a Gwahardd (DBS/CRB).

Bocsys Bwyd: Bydd ymchwilwyr yn pwyso pob eitem o fwyd sydd ym mocs bwyd y plant, ac yn tynnu llun cynnwys y bocs cyn ac ar ôl cinio.

Cinio Ysgol: Bydd lluniau o hambwrdd cinio pob plentyn yn cael eu tynnu cyn ac ar ôl iddynt fwyta'u cinio. Bydd y bwyd sydd ar ôl hefyd yn cael ei bwyso. Bydd pum hambwrdd ychwanegol, wedi'u darparu gan yr arlwywyr ac yn cynnwys yr union fwyd sydd ar y fwydlen y diwrnod hwnnw, hefyd yn cael eu pwyso cyn i'r plant gael eu bwyd, fel na fydd angen pwyso hambyrddau unigol y plant cyn iddynt fwyta'u bwyd.

Ni fydd modd gweld unrhyw blentyn yn y ffotograffau a dynnir, a bydd yr holl ddata'n cael ei gadw'n ddienw ac yn gyfrinachol.

Ar ôl casglu'r data, bydd eich ysgol yn cael talebau "Love2Shop" i ddiolch i'r staff a gymerodd ran yn yr astudiaeth, a bydd enwau'r plant a gymerodd ran yn cael eu rhoi mewn het i geisio ennill gwerth £20 o dalebau "Love2Shop".

Mariel Marcano-Olivier yw prif ymchwilydd yr astudiaeth hon ebost: psp525@bangor.ac.uk), a fydd yn hapus i roi mwy o wybodaeth i chi.

Appendix 10: Staff Information Sheet for Validation Study (Secondary)

Staff Information Sheet

We are working with the Centre for Activity and Eating Research laboratory at Bangor University. Recent studies into the quality of children's diets have highlighted that children do not always get the key nutrients they require for optimum growth and development. As nearly a third of children's food intake is consumed in school, the lunch period is an ideal setting in which to identify where diet could be improved. This study involves measuring food consumption in the cafeteria during the children's lunchtime.

Our focus for this study is on children in classes Year 7, Year 8, Year 9, Year 10 and Year 11 (or, alternatively, year 10 on two days if year 11 are not available) who will all be sent consent forms. These forms will work on an "opt-out", and so it is of great importance that children are prompted to give these letters to their parents. If at any time during the study parents/guardians wish to discontinue their children's participation, they can inform any member of staff who should inform us immediately.

On 5 consecutive days (June 27th – July 1st) 5 researchers will be present, all having been Disclosure Barring Checked (DBS/CRB). Photographs will be taken of the contents of each child's lunch box before and after consumption, and each individual item will also be weighed before and after consumption (should there be any waste).

No children will be visible in the photographs taken and all data is kept anonymous and confidential.

After data collection, those staff that took part in our research will be given vouchers as a "thank you" for taking part. Those children who took part will be entered into a prize draw within your school to win £50 worth of Love2Shop vouchers.

The lead researcher for this study is Mariel Marcano-Olivier (email: psp525@bangor.ac.uk) who will be happy to provide more information.

Appendix 11: Caterer Information Sheet for Validation Study (Primary)

Digital Photography Validation Study

What we plan to do

8:30 – Arrive at school.

9:00 – 9:10 – Be present during registration in Year 1, Year 3 and Year 5 to distribute participant stickers to pupils, ask pupils to remove any break time snacks from their lunchboxes, and to collect lunchboxes for assessment.

9:15 – 11:45 – Take "before" photographs of lunchbox contents and return lunchboxes to classrooms (or other designated area) before lunchtime.

11:45-12:00 – Set up data collection areas in the dinner hall, take estimate weights and photographs of "typical" school meal portions.

12:00 – 1:00 - Take before and after photographs of children's school dinner trays, and collect lunchboxes when the children have finished eating.

1:00-2:00 - Take "after" photographs of lunchbox contents and return lunchboxes.

2:00 – Leave school

What we hope you will help us with

- Return any returned "non-consent" slips to us, so we know who not to observe
- Prompting children to remember out instructions, such as "take your snack out of your lunchbox", "make sure you have a photo taken of your dinner tray", "please give your tray/lunchbox to us after you have finished your meal" and, very important (!!) "please do not throw anything away"

Astudiaeth Achos Ffotograffiaeth Ddigidol

Ein bwriad

8:30 – Cyrraedd yr ysgol.

9:00 - 9:10 - Bod yn bresennol yn ystod cyfnod cofrestru Blwyddyn 1, Blwyddyn 3 a Blwyddyn 5 i ddosbarthu sticeri i'r disgyblion sy'n cymryd rhan yn yr astudiaeth, gofyn i'r disgyblion dynnu unrhyw fyrbrydau amser chwarae o'u bocsys bwyd, a chasglu'r bocsys i'w hasesu.

9:15 – 11:45 – Tynnu lluniau "cyn bwyta" o gynnwys y bocsys bwyd a dychwelyd y bocsys i'r dosbarthiadau (neu le dynodedig arall) cyn amser cinio.

11:45-12:00 – Trefnu lleoedd penodol i gasglu data yn y neuadd ginio, amcangyfrif y pwysau a chymryd lluniau o bryd ysgol nodweddiadol.

12:00 - 1:00 - Tynnu lluniau "cyn bwyta" ac "ar ôl bwyta" o hambyrddau cinio ysgol y plant, a chasglu'r bocsys bwyd ar ôl i'r plant orffen bwyta.

1:00-2:00 - Tynnu lluniau "ar ôl bwyta" o gynnwys y bocsys bwyd a dychwelyd y bocsys i'r plant.

2:00 - Gadael yr ysgol

Rydym yn gobeithio y byddwch yn ein helpu gyda'r canlynol

- Dychwelyd unrhyw fonion "dim cydsynio" i ni, fel ein bod yn gwybod pa ddisgyblion i beidio'u harsylwi.

Appendix 12: Caterer Information Sheet for Validation Study (Secondary)

Digital Photography Validation Study

What we plan to do

8:30 – Arrive at school.

Your morning registration – Be present during registration in the selected class/es for that day to distribute participant stickers and wristbands to pupils, explain who we are and what we will be doing at lunchtime.

9 - lunchtime – Set up data collection areas in a designated area to weigh and photograph individual food items pre-consumption.

Lunchtime – Collect lunchboxes from participants post-consumption (it would be a fantastic help if the children choosing to participate would agree to eat their dinner in a designated room on that day, as we will only be collecting data from one class per day [years 7 – 11throughout the week, one year per day]).

After lunch – Weigh lunchbox waste and return lunchboxes to a designated area.

Leave school

What we hope you will help us with

- An area to sit and work to weigh and photograph food items before and after lunchtime.
- Return all consent forms back to us.
- Allowing us an unused room/area to ask participants to sit and eat their lunch so we can take their lunchboxes back, collect our data, and return them with relative ease.

Appendix 13: Data Recording Sheets

Lunch Boxes / School Dinners (Please circle)

Ppt No.	Food type	Pre or Post weight?	Other Notes

Appendix 14: Quality Assessment Tool for Quantitative Studies

QUALITY ASSESSMENT TOOL FOR QUANTITATIVE STUDIES

EPHPP
Effective Public Health Practice Project

COMPONENT RATINGS

A) SELECTION BIAS

(Q1) Are the individuals selected to participate in the study likely to be representative of the target population?

1 Very likely
2 Somewhat likely
3 Not likely
4 Can't tell

(Q2) What percentage of selected individuals agreed to participate?

1 80 - 100% agreement
2 60 – 79% agreement
3 less than 60% agreement
4 Not applicable
5 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

B) STUDY DESIGN

Indicate the study design

1 Randomized controlled trial
2 Controlled clinical trial
3 Cohort analytic (two group pre + post)
4 Case-control
5 Cohort (one group pre + post (before and after))
6 Interrupted time series
7 Other specify _____
8 Can't tell

Was the study described as randomized? If NO, go to Component C.

No Yes

If Yes, was the method of randomization described? (See dictionary)

No Yes

If Yes, was the method appropriate? (See dictionary)

No Yes

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

C) CONFOUNDERS

(Q1) Were there important differences between groups prior to the intervention?

1 Yes
2 No
3 Can't tell

The following are examples of confounders:

1 Race
2 Sex
3 Marital status/family
4 Age
5 SES (income or class)
6 Education
7 Health status
8 Pre-intervention score on outcome measure

(Q2) If yes, indicate the percentage of relevant confounders that were controlled (either in the design (e.g. stratification, matching) or analysis)?

1 80 – 100% (most)
2 60 – 79% (some)
3 Less than 60% (few or none)
4 Can't Tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

D) BLINDING

(Q1) Was (were) the outcome assessor(s) aware of the intervention or exposure status of participants?

1 Yes
2 No
3 Can't tell

(Q2) Were the study participants aware of the research question?

1 Yes
2 No
3 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

E) DATA COLLECTION METHODS

(Q1) Were data collection tools shown to be valid?

1 Yes
2 No
3 Can't tell

(Q2) Were data collection tools shown to be reliable?

1 Yes
2 No
3 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

F) WITHDRAWALS AND DROP-OUTS

(Q1) Were withdrawals and drop-outs reported in terms of numbers and/or reasons per group?

1 Yes
2 No
3 Can't tell
4 Not Applicable (i.e. one time surveys or interviews)

(Q2) Indicate the percentage of participants completing the study. (If the percentage differs by groups, record the lowest).

1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell
5 Not Applicable (i.e. Retrospective case-control)

RATE THIS SECTION	STRONG	MODERATE	WEAK	
See dictionary	1	2	3	Not Applicable

G) INTERVENTION INTEGRITY

(Q1) What percentage of participants received the allocated intervention or exposure of interest?

1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell

(Q2) Was the consistency of the intervention measured?

1 Yes
2 No
3 Can't tell

(Q3) Is it likely that subjects received an unintended intervention (contamination or co-intervention) that may influence the results?

4 Yes
5 No
6 Can't tell

H) ANALYSES

(Q1) Indicate the unit of allocation (circle one)

community organization/institution practice/office individual

(Q2) Indicate the unit of analysis (circle one)

community organization/institution practice/office individual

(Q3) Are the statistical methods appropriate for the study design?

1 Yes
2 No
3 Can't tell

(Q4) Is the analysis performed by intervention allocation status (i.e. intention to treat) rather than the actual intervention received?

1 Yes
2 No
3 Can't tell

GLOBAL RATING

COMPONENT RATINGS
Please transcribe the information from the gray boxes on pages 1-4 onto this page. See dictionary on how to rate this section.

A	**SELECTION BIAS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
B	**STUDY DESIGN**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
C	**CONFOUNDERS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
D	**BLINDING**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
E	**DATA COLLECTION METHOD**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
F	**WITHDRAWALS AND DROPOUTS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	Not Applicable

GLOBAL RATING FOR THIS PAPER (circle one):

1	STRONG	(no WEAK ratings)
2	MODERATE	(one WEAK rating)
3	WEAK	(two or more WEAK ratings)

With both reviewers discussing the ratings:

Is there a discrepancy between the two reviewers with respect to the component (A-F) ratings?

No Yes

If yes, indicate the reason for the discrepancy

1 Oversight
2 Differences in interpretation of criteria
3 Differences in interpretation of study

Final decision of both reviewers (circle one):

1 STRONG
2 MODERATE
3 WEAK

Appendix 15: Consent form for Nudges Study

COLEG GWYDDORAU IECHYD AC YMDDYGIAD
COLLEGE OF HEALTH & BEHAVIOURAL SCIENCES

YSGOL SEICOLEG
SCHOOL OF PSYCHOLOGY

PRIFYSGOL
BANGOR
UNIVERSITY

Dear Parent/Guardian,

Recent studies into the quality of children's diets have highlighted that children do not always get the key nutrients they require for optimum growth and development. As nearly a third of children's food intake is consumed in school, the lunch period is an ideal setting in which to encourage change in dietary habits. Your child's school has been invited to participate in a study examining the impact of a simple healthy eating intervention. This study involves measuring food consumption in the cafeteria during the children's lunchtime using digital photography on two days in May and again in June. No children will be visible in the photographs taken and all data will be kept anonymous and confidential. All researchers have been Disclosure and Barring Checked (DBS/CRB) and are well trained.

If you are happy with your child participating in this research, there is nothing you need to do. If you do not wish your child to participate, please complete the slip below by 15th May and return to your child's teacher. If at any time you wish to discontinue your child's participation, please inform the Head Teacher who will inform us immediately. If you would like any further information, please contact lead researcher Mariel Marcano-Olivier (email: psp525@bangor.ac.uk) who will be happy to provide more information about the research.

Thank you for your support, and kind regards,
Dr. Mihela Erjavec
Lecturer in Child Development and Learning

Should you have any complaints regarding the research, please direct these to the School Manager at Bangor University, Mr. Hefin Francis, School Manager, School of Psychology, Adeilad Brigantia, Penrallt Road, Gwynedd LL57 2AS, United Kingdom.

PRIFYSGOL BANGOR
ADEILAD BRIGANTIA,
FFORDD PENRALLT,
BANGOR,GWYNEDD, LL57 2AS

FFÔN: (01248) 382211
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BRIGANTIA BUILDING,
PENRALLT ROAD,
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TEL:(01248) 382211
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COLLEGE OF HEALTH & BEHAVIOURAL SCIENCES

YSGOL SEICOLEG
SCHOOL OF PSYCHOLOGY

PRIFYSGOL
BANGOR
UNIVERSITY

Annwyl Riant/Gwarcheidwad,

Mae astudiaethau diweddar i ansawdd diet plant wedi tynnu sylw at y ffaith nad yw plant bob amser yn cael y maetholion allweddol y maent eu hangen ar gyfer y twf a'r datblygiad gorau posib. Gan fod plant yn bwyta bron i un rhan o dair o'u holl fwyd yn yr ysgol, mae amser cinio'n gyfle delfrydol i annog newid mewn arferion diet. Mae ysgol eich plentyn wedi cael ei gwahodd i gymryd rhan mewn astudiaeth yn edrych ar effaith ymyriad bwyta'n iach syml. Mae'r astudiaeth hon yn ymwneud â mesur y bwyd sy'n cael ei fwyta yn y ffreutur yn ystod amser cinio'r plant gan ddefnyddio ffotograffau digidol ar ddau ddiwrnod ym mis Mai ac eto ym Mehefin. Ni fydd modd gweld unrhyw blentyn yn y ffotograffau a dynnir, a bydd yr holl ddata'n cael ei gadw'n ddienw ac yn gyfrinachol. Mae'r holl ymchwilwyr wedi cael eu gwirio o safbwynt Datgelu a Gwahardd (DBS/CRB) ac wedi eu hyfforddi'n dda.

Os ydych yn fodlon i'ch plentyn gymryd rhan yn yr ymchwil hwn, does dim angen i chi wneud unrhyw beth. Os nad ydych yn dymuno i'ch plentyn gymryd rhan, a fyddech cystal â llenwi'r bonyn isod a'i ddychwelyd i athro/athrawes dosbarth eich plentyn erbyn 15 Mai. Os byddwch yn dymuno i'ch plentyn dynnu'n ôl o'r astudiaeth unrhyw bryd, rhowch wybod i Bennaeth yr ysgol, a fydd yn rhoi gwybod i ni ar unwaith. Os hoffech ragor o wybodaeth, cysylltwch â'r prif ymchwilydd Mariel Marcano-Olivier (e-bost: psp525@bangor.ac.uk <mailto:psp525@bangor.ac.uk>) a fydd yn hapus i roi rhagor o wybodaeth am yr ymchwil i chi.

Diolch yn fawr am eich cefnogaeth, a chofion caredig,
Dr Mihela Erjavec
Darlithydd Dysgu a Datblygiad Plentyn

Os oes gennych unrhyw gwynion am yr ymchwil, dylech eu cyfeirio at y Rheolwr Ysgol ym Mhrifysgol Bangor, Mr Hefin Francis, Rheolwr Ysgol, Ysgol Seicoleg, Adeilad Brigantia, Ffordd Penrallt, Bangor, Gwynedd LL57 2AS.

PRIFYSGOL BANGOR
ADEILAD BRIGANTIA,
FFORDD PENRALLT,
BANGOR,GWYNEDD, LL57 2AS

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BANGOR UNIVERSITY
BRIGANTIA BUILDING,
PENRALLT ROAD,
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Appendix 16: Staff Information Sheet for Nudges Study

PRIFYSGOL BANGOR UNIVERSITY

Staff Information

Your headteacher has kindly volunteered for your school to take part in some exciting research into how small changes in the cafeteria can may impact on children's diets.

This will involve:

- A team of 5 DBS checked researchers being present for 2 days in May and 2 days in June.
- Participating pupils (those in selected classes who eat school dinners) will receive participation stickers just before lunchtime.
- At lunchtime, pupils who have school dinners will be given a matching participant sticker for their dinner tray.
- After eating, the children take their trays to the researchers, who will take photographs before returning dinner trays.

All data recorded will be anonymous and confidential.

If you have any questions regarding this research, please feel free to contact Mariel Marcano-Olivier by email: psp525@bangor.ac.uk, or by phone: 01248388478.

Thank you in advance for your help and support with this research.

kess
Ysgoloriaethau Sgiliau Economi Gwybodaeth
Knowledge Economy Skills Scholarships

ESF
Llywodraeth Cymru
Welsh Government
Ewrop & Chymru: Buddsoddi yn eich dyfodol
Cronfa Gymdeithasol Ewrop
Europe & Wales: Investing in your future
European Social Fund

PRIFYSGOL BANGOR UNIVERSITY

Gwybodaeth i Staff

Mae pennaeth eich ysgol wedi gwirfoddoli'n garedig i'ch ysgol gymryd rhan mewn ymchwil cyffrous i sut y gall newidiadau bach yn y ffreutur effeithio ar ddiet plant.

Bydd hyn yn cynnwys:

- Tîm o bum ymchwilydd fydd wedi cael gwiriadau DBS yn bresennol am ddau ddiwrnod ym mis Mai a dau ddiwrnod ym Mehefin.
- Bydd disgyblion sy'n cymryd rhan (y rhai mewn dosbarthiadau a ddewiswyd sy'n bwyta cinio ysgol) yn derbyn sticeri i ddangos eu bod yn cymryd rhan ychydig cyn amser cinio.
- Amser cinio, bydd disgyblion sy'n cael cinio ysgol yn cael sticer cymryd rhan cyfatebol ar gyfer eu hambwrdd cinio.
- Ar ôl bwyta, bydd y plant yn mynd â'u hambyrddau at yr ymchwilwyr, a fydd yn cymryd lluniau o'r hambyrddau cinio cyn eu dychwelyd.

Bydd yr holl ddata a gofnodir yn ddienw a chyfrinachol.

Os oes gennych unrhyw gwestiynau am yr ymchwil hwn, mae croeso i chi gysylltu â Mariel Marcano-Olivier drwy e-bost: psp525@bangor.ac.uk, neu dros y ffôn: 01248388478.

kess
Ysgoloriaethau Sgiliau Economi Gwybodaeth
Knowledge Economy Skills Scholarships

ESF
Llywodraeth Cymru
Welsh Government
Ewrop & Chymru: Buddsoddi yn eich dyfodol
Cronfa Gymdeithasol Ewrop
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Appendix 17: Caterer Information Sheet for Nudges Study

Caterer's Information Sheet

Recent studies into the quality of children's diets have highlighted that children do not always get the key nutrients they require for optimum growth and development, often due to a discrepancy between what a child is served, and what they actually consume. As nearly a third of children's food intake is consumed in school, the lunch period is an ideal setting in which to implement dietary change interventions. This study involves making small changes to the children's lunchtime eating environment with the hope of encouraging selection and consumption, and then measuring fruit and vegetable intake.

Data Collection. On 4 separate days (2 days in May and 2 days in June, on agreed dates with the Headteacher) 5 researchers will be present at lunchtime, all having been Disclosure Barring Checked (DBS/CRB). Five reference portions from caterers of each individual food item served, on the menu that day, will be photographed and weighed prior to children's serving time, meaning individual children's trays will not need weighing pre consumption.

Photographs will be taken of each child's lunch tray before and after eating.

No children will be visible in the photographs taken and all data is kept anonymous and confidential.

The researchers for this study are Mariel Marcano-Olivier (email: psp525@bangor.ac.uk) or Anne Fraser (psp444@bangor.ac.uk) who will be happy to provide more information.

Equipment and provisions

Researchers will bring their own equipment, where possible. This will include:

- 4 x digital cameras
- 4 x tripods
- Placemat to standardise plate/tray placement in photographs
- Measuring equipment (4 x weighing scales, 2 x protractors, 2 x tape measures, plastic cups)
- Food hygiene materials (non-latex gloves)

Thank you for your participation in the running of this study. If you have any questions, concerns, or additional information you would like to provide, please feel free to contact lead researcher Mariel Marcano-Olivier (email: psp525@bangor.ac.uk) who will be happy to provide more information..

Taflen wybodaeth i arlwywyr

Mae astudiaethau diweddar i ansawdd diet plant wedi tynnu sylw at y ffaith nad yw plant bob amser yn cael y maetholion allweddol y maent eu hangen ar gyfer y twf a'r datblygiad gorau posib, yn aml oherwydd yr anghysondeb rhwng yr hyn a roddir i blentyn, a'r hyn y mae'n ei fwyta mewn gwirionedd. Gan fod plant yn bwyta bron i un rhan o dair o'u holl fwyd yn yr ysgol, mae amser cinio'n gyfle delfrydol i weithredu ymyriadau i newid diet. Mae'r astudiaeth hon yn ymwneud â gwneud mân newidiadau i amgylchedd bwyta plant amser cinio gyda'r gobaith o annog dewis a bwyta, ac yna mesur y ffrwythau a'r llysiau sy'n cael eu bwyta.

Casglu Data. Bydd pum ymchwilydd yn bresennol ar bedwar diwrnod gwahanol (dau ddiwrnod ym mis Mai a dau ddiwrnod ym Mehefin, ar ddyddiadau y cytunwyd arnynt gyda'r Pennaeth), a byddant i gyd wedi cael eu gwirio o safbwynt Datgelu a Gwahardd (DBS/CRB). Bydd lluniau yn cael eu tynnu o'r pum hambwrdd ychwanegol, wedi'u darparu gan yr arlwywyr ac yn cynnwys yr union fwyd sydd ar y fwydlen y diwrnod hwnnw, a hefyd yn cael eu pwyso cyn i'r plant gael eu bwyd, fel na fydd angen pwyso hambyrddau unigol y plant cyn iddynt fwyta'u bwyd.

Bydd lluniau o hambwrdd cinio pob plentyn yn cael eu tynnu cyn ac ar ôl iddynt fwyta'u cinio.

Ni fydd modd gweld unrhyw blentyn yn y ffotograffau a dynnir, a bydd yr holl ddata'n cael ei gadw'n ddienw ac yn gyfrinachol.

Offer a deunyddiau

Bydd yr ymchwilwyr yn dod â'u hoffer eu hunain, lle bo'n bosibl. Bydd hyn yn cynnwys:

- 4 x camera digidol
- 4 x stand drithroed
- Mat i safoni lleoliad y plât/hambwrdd yn y lluniau
- Offer mesur (4 x clorian pwyso, 2 x onglydd, 2 x tâp mesur, cwpanau plastig)
- Deunyddiau hylendid bwyd (menig sydd ddim yn rhai latecs)

Diolch i chi am gymryd rhan yn yr astudiaeth hon. Os oes gennych unrhyw gwestiynau, pryderon neu wybodaeth ychwanegol yr hoffech ei rhoi, mae croeso i chi gysylltu â'r ymchwilwyr Mariel Marcano-Olivier (e-bost: psp525@bangor.ac.uk) a fydd yn hapus i roi rhagor o wybodaeth.

Appendix 18: Nudges Posters

@_CAER Bangor University 2017

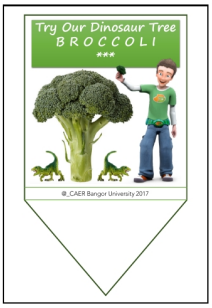
@_CAER Prifysgol Bangor 2017

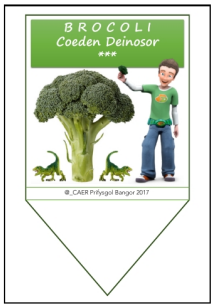
@_CAER Bangor University 2017

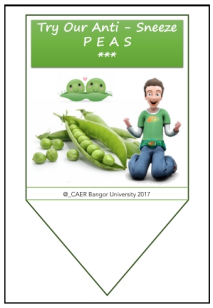
@_CAER Prifysgol Bangor 2017

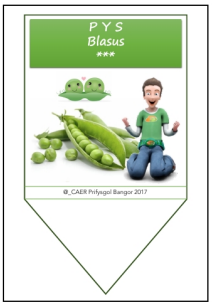
Appendix 19: Nudges Food Labels

3/25/18









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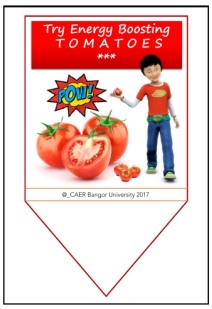

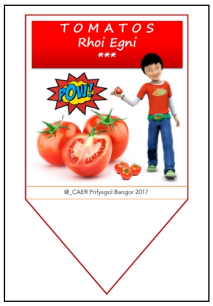

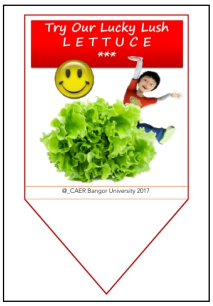

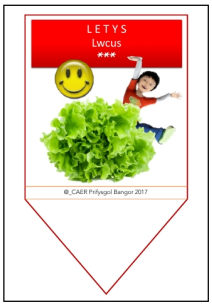

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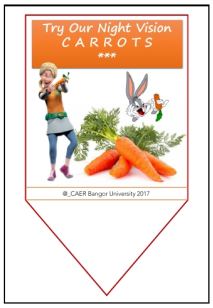
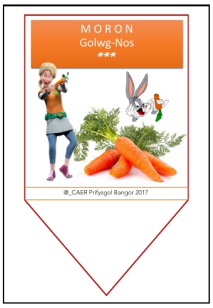
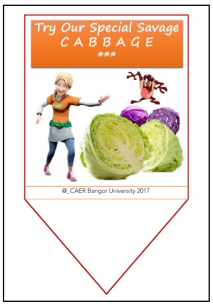
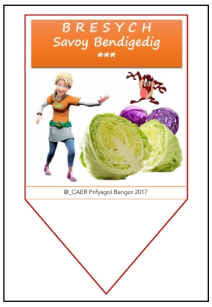
3/25/18









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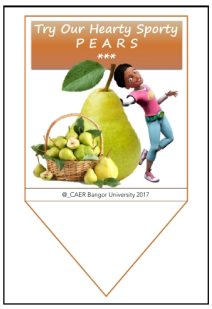

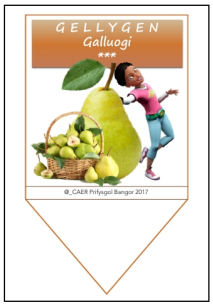

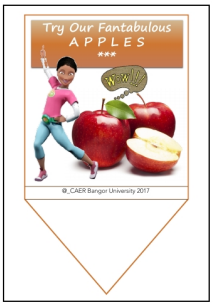

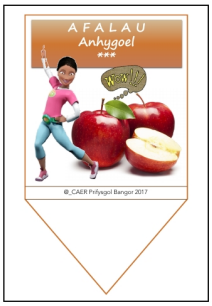

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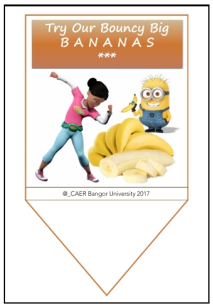
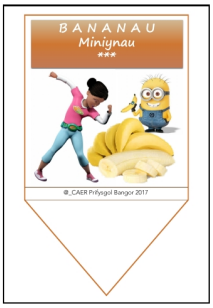




6

Appendix 20: Conference Poster for Food Dudes Evaluation

Centre for Activity and Eating Research
CAER
BANGOR

PRIFYSGOL BANGOR UNIVERSITY

kess
Ysgoloriaethau Sgiliau Economi Gwybodaeth
Knowledge Economy Skills Scholarships

ESF
Llywodraeth Cymru
Welsh Government
Ewrop & Cymru: Buddsoddi yn ein dyfodol
Cronfa Gymdeithasol Ewrop
Europe & Wales: Investing in your future
European Social Fund

Shall I have an apple, or cake, or both? Measuring the changes in the nutritional composition of children's meals after Food Dudes.

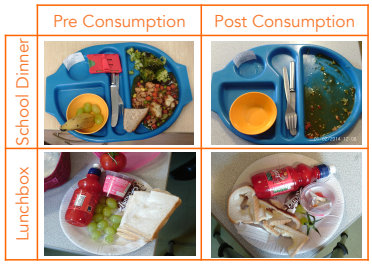
Mariel Marcano-Olivier, Mihela Erjavec, Pauline Horne, Simon Viktor, Jake Sallaway-Costello & Ruth Pearson-Blunt
Centre for Activity and Eating Research (CAER), Bangor University & Food Dudes Health Ltd.

PROBLEM: Childhood obesity has been associated with excessive consumption of foods high in fat, sugar and salt (HFSS). Can the Food Dudes Programme increase fruit and vegetable consumption *and* displace HFSS foods?

THE FOOD DUDES

- Young heroes who get special energy powers from eating lots of fruit and veg. They fight General Junk and his Junk Punks. They always win!
- An award-winning programme that teaches children aged 2-11 years to enjoy eating fruit and veg. It produces large increases in consumption and demand for fruit and veg.

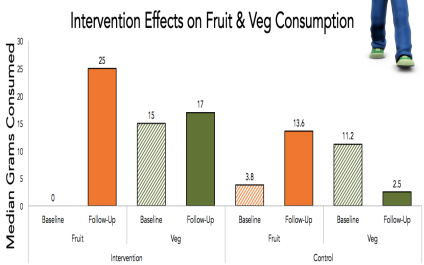
- A controlled trial was conducted in two primary schools in Leeds (one intervention and one control school) to identify the displacement effects of the Food Dudes Programme on consumption of HFSS food items.
- The intervention school received the Full Force Food Dudes Programme, whilst the control school received no treatment.
- We measured consumption of pupils from years one, three, and five (5-10 years old; N=172).
- Data were collected over a four-day baseline and at four-day follow-up two months into the Programme.
- For children who ate from lunchboxes brought from home, contents were photographed following registration (pre-consumption) and immediately after lunchtime (post-consumption).



- For children who ate the school meals, digital photographs of each dinner tray were collected pre- and post-consumption at lunchtime.
- Individual portion weights (in grams) were estimated by averaging from weight measurement for school meals and by using standard tables for lunchbox foods.
- The digital photographs recorded were then used to estimate the percentage of each food item consumed to the closest 10%.
- Twenty per cent of the sample was second-coded and a high agreement was achieved (>85%).
- Following this, a full macronutrient analysis was conducted.

Intervention Effects

- FRUIT: 250%+ increase
- VEG: 13% increase



Significant increases in fruit and veg consumption (both $p<.001$) were observed in the intervention school, but there was no significant change from baseline to follow-up in the control school ($p>.05$).

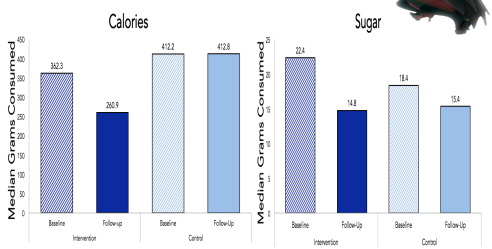
Macronutrient Effects

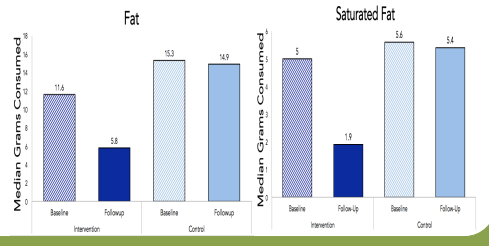
Intervention school:

- Calories: 28% decrease
- Sugar: 34% decrease
- Fat: 50% decrease
- Saturated Fat: 62% decrease
- (all $p<.001$)

Control school:

- No change (all $p>.05$)



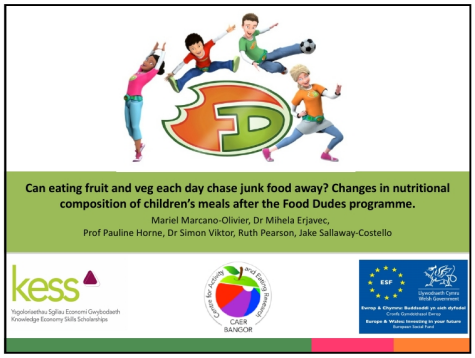


These results show that the Food Dudes Programme was successful in increasing fruit and veg consumption and in displacing the HFSS foods, manifesting in significant decreases in calorie, sugar, fat and saturated fat consumption.

For more information please email: psp525@bangor.ac.uk
Or visit our website: www.fooddudes.co.uk

Appendix 21: Conference Presentation for Food Dudes Evaluation (15 minute)

25/03/2018



Background: Childhood Obesity

- Developing countries have consistently reported increasing levels of obesity (Gupta, Goel, Shah, & Misra, 2012)
- Research indicates that obesity levels have plateaued at a high rate (Ogden, Carroll, Kit, & Flegal, 2014)
- Approximately 1/3 of children in the UK are overweight or obese (Public Health England, 2012)
- This fat is generally stored around the mid-region, and is associated with increased incidence of heart disease (Griffiths, Gately, Marchant, & Cooke, 2013), as well as having a negative impact on childhood psychosocial wellbeing (Bell & Morgan, 2000; Irving, 2000)
- Variables associated with childhood obesity include poor diet and a sedentary lifestyle (Monasta, 2010)

Background: The Food Dudes

- Principle of the 3 R's
  - Role Modelling
  - Repeated Tasting
  - Rewards
- Phase 1
  - 16 days
  - Fruit and vegetable pairings
  - Daily rewards

Background: The Food Dudes

- Phase 2
  - Dining Room Experience
  - Dining room monitors
  - Reduced reward schedule
- Food Dudes Forever
  - Online rewards
  - School environment changed
  - Full force intervention for incoming cohorts.

Aim

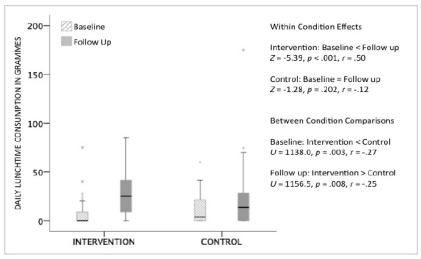
- To evaluate the effectiveness of the Food Dudes Intervention to a macro/micronutrient level – a depth of analysis that had not yet been attempted by the CAER laboratory
- To identify whether fruit and vegetable consumption had a displacing effect on the consumption of high fat, sugar and salt food items.

Evaluation Methodology

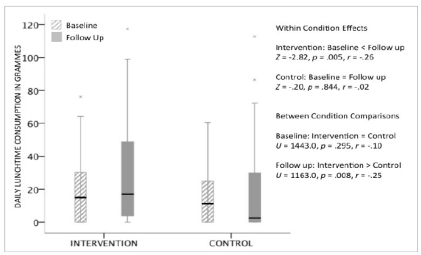
- Two schools: intervention vs. control
- Two phases: Baseline vs. Follow-Up
- Digital photography method of collecting nutritional data
- Data Analysis

25/03/2018

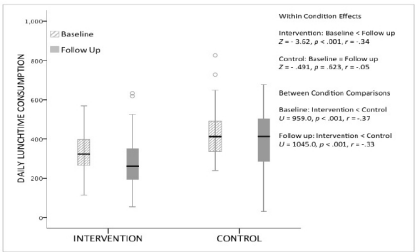
Results - Fruit



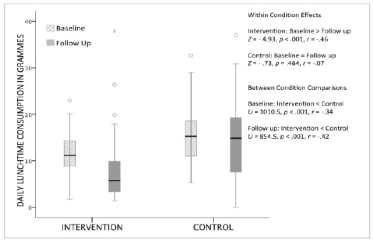
Results - Vegetables



Results - Calories

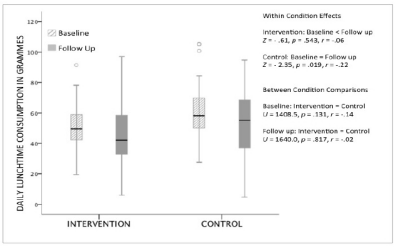


Results - Fat



25/03/2018 Food Dudes Health Ltd. 10

Results – Sugar



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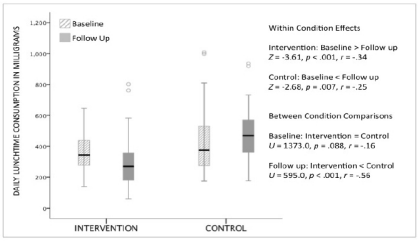
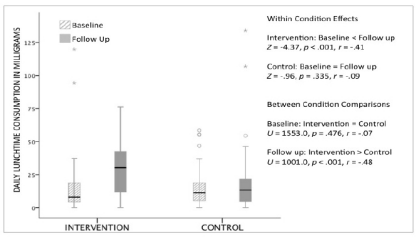
Results – Sodium



25/03/2018

Results – Vitamin C



Conclusion and Applications

- The Food Dudes intervention was effective in increasing fruit and vegetable intake and subsequently significantly increased consumption of vitamin C, whilst concurrently decreasing calorie, fat, and sodium intake.
- These results indicate that, over time, participation in the Food Dudes intervention may boost immune function and decrease risk factors to some diseases associated with overweight and obesity (e.g. heart disease).
- The intervention has run with success in Sicily and Ireland, and plans for the intervention to run in Austria are in discussion.

Validation of Methodology

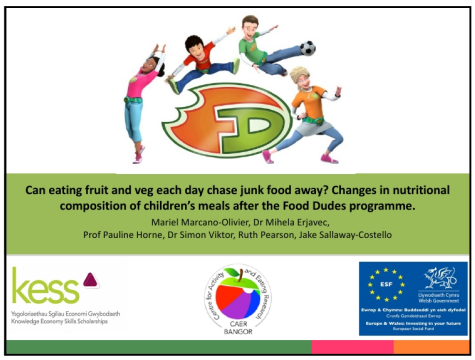
- Validation study conducted this summer
- High levels of inter-rater reliability achieved
- High levels of agreement with objective weighed measure
- Poster presentation for this research scheduled for this evening

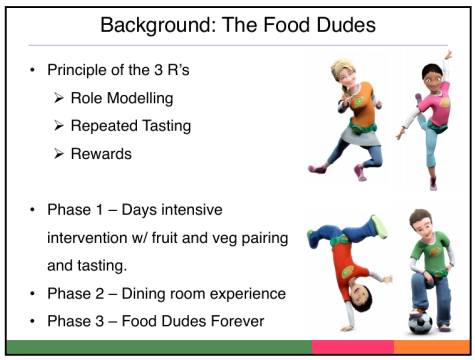
Thank you for listening

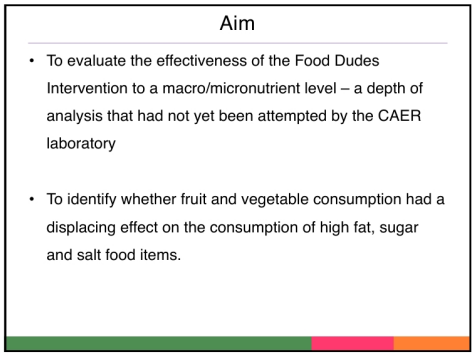
Any Questions?

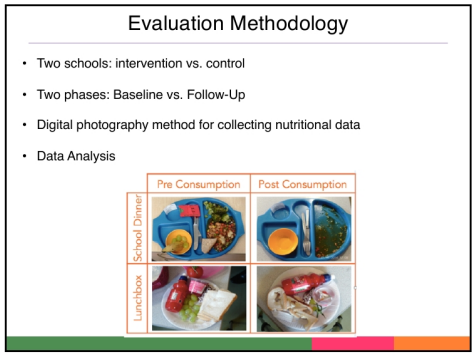
Appendix 22: Conference Presentation for Food Dudes Evaluation (5 minute)

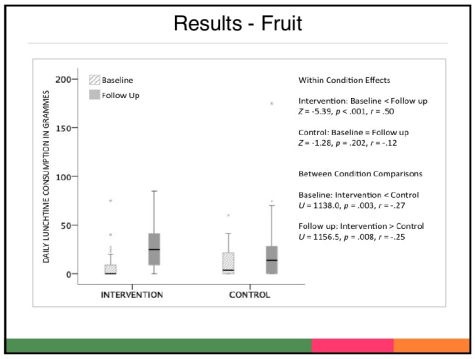
25/03/2018

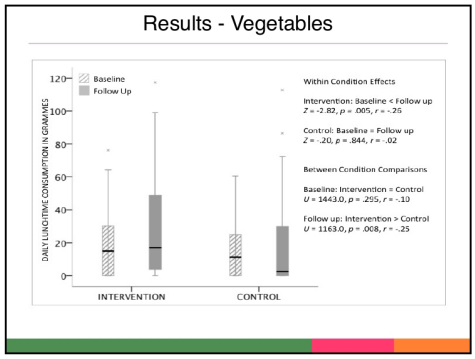












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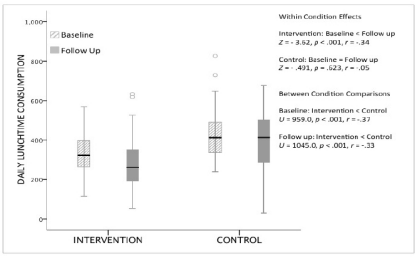
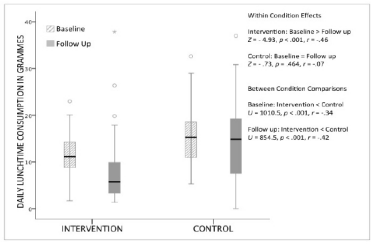
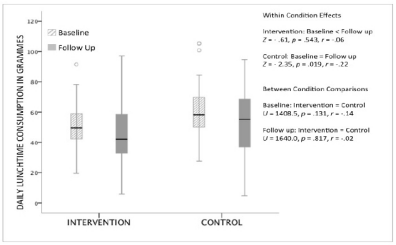
Results - Calories



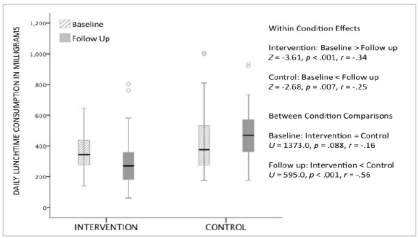
Results - Fat



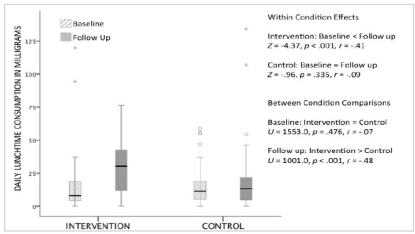
Results – Sugar



Results – Sodium



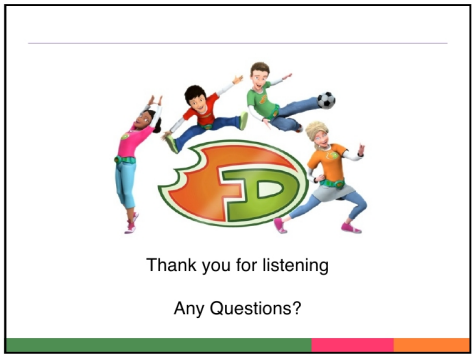
Results – Vitamin C



Conclusion and Applications

- The Food Dudes intervention was effective in increasing fruit and vegetable intake and subsequently significantly increased consumption of vitamin C, whilst concurrently decreasing calorie, fat, and sodium intake.
- These results indicate that, over time, participation in the Food Dudes intervention may boost immune function and decrease risk factors to some diseases associated with overweight and obesity (e.g. heart disease).
- The intervention has run with success in Sicily and Ireland, and plans for the intervention to run in Austria are in discussion.

25/03/2018



Appendix 23: Consent form for Food Dudes Evaluation

COLEG GWYDDORAU IECHYD AC YMDDYGIAD
COLLEGE OF HEALTH & BEHAVIOURAL SCIENCES

YSGOL SEICOLEG
SCHOOL OF PSYCHOLOGY

PRIFYSGOL
BANGOR
UNIVERSITY

Dear Parent/Guardian,

Recent studies into the quality of children's diets have highlighted that children do not always get the key nutrients they require for optimum growth and development. As nearly a third of children's food intake is consumed in school, the lunch period is an ideal setting in which to identify where diet could be improved. Your child's school has been invited to participate in a study examining children's diets research as an "Intervention" school, ready to start the Food Dudes healthy eating programme in April. This study involves measuring food consumption in the cafeteria during the children's lunchtime using digital photography on four consecutive days in April and again in July.

Following this, a feedback information pack will be provided to your child's school early next academic year, detailing the nutritional values of what the children are consuming at lunchtime, and any dietary changes following the Food Dudes healthy eating intervention, early in the next academic year. No children will be visible in the photographs taken and all data will be kept anonymous and confidential. All researchers have been Disclosure and Barring Checked (DBS/CRB) and are well trained.

If you are happy with your child participating in this research, there is nothing you need to do. If you do not wish your child to participate, please complete the slip below by 27th April and return to your child's teacher. If at any time you wish to discontinue your child's participation, please inform the Head Teacher who will inform us immediately. If you would like any further information, please contact lead researcher Mariel Marcano-Olivier (email: psp525@bangor.ac.uk) who will be happy to provide more information about the research.

Thank you for your support, and kind regards,
Dr. Mihela Erjavec
Lecturer in Child Development and Learning

Should you have any complaints regarding the research, please direct these to the School Manager at Bangor University, Mr. Hefin Francis, School Manager, School of Psychology, Adeilad Brigantia, Penrallt Road, Gwynedd LL57 2AS, United Kingdom.

PRIFYSGOL BANGOR
ADEILAD BRIGANTIA,
FFORDD PENRALLT,
BANGOR,GWYNEDD, LL57 2AS

FFÔN: (01248) 382211
FFACS: (01248) 382599

BANGOR UNIVERSITY
BRIGANTIA BUILDING,
PENRALLT ROAD,
BANGOR, GWYNEDD, LL57 2AS

TEL:(01248) 382211
FAX:(01248) 382599

www.bangor.ac.uk www.bangor.ac.uk/psychology

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