Manipulated exposure to television-style healthy food advertising and children's healthy food intake in nurseries.

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1. Introduction

Many children do not consume daily recommended minimum amounts of vegetables, fruit, and whole-grain products, but exceed daily allowances sugar, salt, and fat (WHO, 2020a). Unhealthy eating patterns are estimated to account for 40% of non-communicable diseases in Europe, including childhood obesity (Lloyd-Williams et al., 2014; Public Health England (PHE), 2020). Childhood overweight and obesity affects a quarter of 4- to 5-year-olds in the UK (PHE, 2020). In Germany, the Robert Koch Institute (RKI) found 11% of 3- to 6-year-old girls and 7% of 3-to-6-year-old boys to be affected (RKI, 2018). The obesogenic environment with large amounts of advertising for readily-available, highly palatable, energy-dense, and ultra-processed foods with high sugar, salt, and fat content (HSSF), has been highlighted as a major contributor to unhealthy eating patterns and childhood obesity (Adams, Hofman, Moubarac & Thow, 2020; Lavriša & Pravst, 2019; Martínez-García, Trescastro-López, Galiana-Sánchez & Pereyra-Zamora, 2019; Smith, Kelly, Yeatman & Boyland, 2019; Swinburn et al., 2011).

Although digital HSSF cue exposure via novel information and communication technologies such as social media and streaming sites is increasing (Eurostat, 2017), television remains as the main advertising channel to reach children (Folkvord, 2020; Ofcom, 2016). Recent reviews and meta-analyses have produced strong evidence that acute and accumulative digital food advertising influences children's attitudes, preferences, and consumption of HSSF-products (Boyland et al., 2016; Cairns, Angus, Hastings & Caraher, 2013; Russell, Croker & Viner, 2019; Smith et al., 2019) while direct examinations of the effects of healthy food promotion on children's food intake are lacking (Folkvord & Hermans, 2020).

In contrast to HSSF-products, 'healthy foods' such as vegetables, fruit, and whole-grain products that contain high amounts of vitamins and minerals and low amounts of sugar, salt, and fat (DGE, 2020; NHS, 2020; PHE, 2020; WHO, 2020b) are rarely promoted (Russel et al., 2019; Smith et al., 2019) and rarely researched (Folkvord & Hermans, 2020; Naderer et al., 2018). The available research base on the effects of manipulated exposure to television-style food advertising for healthy foods and children's healthy food intake is currently restricted to four cross-sectional studies

(Dovey et al., 2011; Fox et al., 1980; Kaser-Boyd, 1978; Lemnitzer, Jeffrey, Hess, Hickey & Stroud, 1979), none of which provide recent insight into children's eating behaviour in rapidly evolving multimedia environments (Radesky, Chassiakos, Ameenuddin & Navsaria, 2020). In these studies, children viewed advertisements for healthy foods, HSSF foods, or non-food control advertisements embedded in children's programming before eating snacks from a selection of healthy and HSSF options (Dovey et al., 2011; Fox et al.,1980; Kaser-Boyd, 1978; Lemnitzer et al., 1979). None of these studies found evidence that television-style healthy food advertising increased healthy food intake in children, but HSSF advertisements did increase HSSF food intake (Dovey et al., 2011; Fox et al., 1980; Kaser-Boyd; 1978; Lemnitzer et al., 1979).

Some of these studies had methodological limitations, such as the use of recorded advertisements (Dovey et al., 2011; Fox et al.,1980; Kaser-Boyd, 1978; Lemnitzer et al., 1979), unequal numbers of healthy versus HSSF food options at the eating opportunity (Dovey et al., 2011), and the use of calories as the primary unit of measuring children's food intake (Dovey et al., 2011; Fox et al.,1980). The use of recorded advertisements poses issues regarding previous exposure levels and differences in advertising techniques across conditions that render HSSF advertising more familiar to children, and therefore more effective than healthy food advertising (Kraak, Rincon-Gallardo & Sacks, 2019). HSSF advertisements use themes of fun and fantasy, which make them more appealing to children than typical healthy food advertisements that target adult audiences with rational and cognitively demanding arguments (Calvert, 2008; Vilaro et al., 2017). Kaser-Boyd (1978) and Lemnitzer et al. (1979) attributed the lack of healthy food advertising effects on children's healthy food intake in their studies to the available healthy food advertisements being less sophisticated, less visually interesting, and of poorer technical quality due to the lack of funding compared to available HSSF-advertising. Offering more HSSF than healthy food options may have misrepresented children's food selection via variety effects (Brondel et al., 2009), majority food cue effects (which refers to increased intake of HSSF foods when the HSSF food option outnumber the healthy food options; Pechey & Marteau, 2018), and statistical probability which may explain the lack of healthy food intake despite exposure to healthy food advertisements in Dovey et al. (2011). Due to the relatively low caloric value of vegetables and fruit, increases

in healthy food consumption are harder to detect than changes in HSSF food consumption (Kaser-Boyd, 1978), and reporting children's changes in food intake in kilocalories only may bias outcomes. Despite frequent calls to improve children's diets (WHO, 2020a; PHE, 2020; RKI, 2018), to date no studies have investigated exclusively the effect of exposure to television-style, healthy food advertisements on children's healthy food intake. Research on children's healthy food intake in response to healthy food cues is inconclusive and in need of further investigation (Folkvord & Hermans, 2020) and this is particularly true for television-style food advertising.

Research on digital food cues including healthy food placements in cartoons (Binder et al., 2019, 2020; Gonçalves et al., 2018; Naderer et al., 2018), narrative media programmes (Horne et al., 2004, 2009; Lowe et al., 2004; Upton et al., 2013), and advergames (Folkvord, Anschütz, Buijzen & Valkenburg, 2012; Folkvord & Laguna-Camacho, 2019) complement the limited research base on television-style healthy food advertisements and children's healthy food intake. Although digital food cues differ from television-style advertising in terms of immersion, interaction, and embedment (Terlutter & Capella, 2013) the relevant studies used advertising stimuli that were specifically designed for their research (Binder et al., 2019, 2020; Folkvord & Laguna-Camacho, 2019; Folkvord, Anschütz, Buijzen & Valkenburg, 2012; Gonçalves et al., 2018; Horne et al., 2004, 2009; Lowe et al., 2004; Naderer et al., 2018; Upton et al., 2013).

In a best-choice-situation where only healthy foods were available, Horne et al. (2004, 2009), Lowe et al. (2004) and Upton et al. (2013) found that narrative media exposure increased children's vegetable and fruit intake while mere availability of vegetables and fruits led to a decline in intake over time (Horne et al., 2009; Upton et al., 2013). Gonçalves et al. (2018) offered unlimited access to healthy and HSSF snacks and found that viewing cartoons with healthy food cues increased children's intake of healthy options. Binder et al. (2019) and Naderer et al. (2018) showed children cartoons with healthy food cues and found that when children were asked to make discrete choices and pick either a fruit snack or a candy snack, children prioritized candy over fruit. Healthy food cues in advergames did not increase children's fruit intake (Folkvord et al., 2012), although the same advergame with

embedded HSSF cues increased HSSF snack intake (Folkvord et al., 2012). Even when only vegetables were available to eat, a healthy food cue advergame play did not increase children's vegetable intake compared to a non-food control advergame in Folkvord et al. (2019). Narrative media studies suggest that children benefit from a best-choice-situation where HSSF products (Horne et al., 2004, 2009; Lowe et al., 2004; Upton et al., 2013) are absent, but encouragement to eat the available healthy foods is still required to maintain or increase children's vegetable and fruit intake (Horne et al., 2009; Upton et al., 2013). Choice format played a role as Binder et al. (2019) and Naderer et al. (2018) found that when children were prompted to make exclusive choices, children picked candy over fruit. To date, healthy food advergames appear ineffective at increasing children's healthy food intake even in best-choice-situations (Folkvord et al., 2019), which may suggest that further research is required before being able to successfully apply HSSF food marketing strategies to healthy food promotion.

The interplay of evolutionary predispositions, learnt preferences and environmental conditions that make consumption of culturally celebrated (Albon, 2015) and physiologically pleasing HSSF products more rewarding than that of healthy alternatives (Folkvord, 2020) poses challenges for healthy food promotion (Cohen, 2008; Berridge & Kringelbach, 2015). The Promotion of Healthy Food Model (Folkvord, 2020) suggests that to compete with hedonic influences and existing reinforcing value of physiologically and psychologically rewarding HSSF food, it is important to increase the reinforcing value of healthy foods. This includes building a positive attitude towards healthy foods, reinforcing children's willingness to repeatedly try and taste healthy foods, increasing children's intention to make purchase requests for healthy foods or to buy and consume them, and supporting preferences for healthy foods over other foods (Folkvord, 2020). In line with Social Learning Theory (Bandura & McClelland, 1977) social endorsers including peer and parent models in digital media can increase the reinforcing value of healthy foods and increase healthy food intake in children (Scaglioni, Salvioni & Galimberti, 2008).

Priming children more often with digital healthy food cues through repeated advertising exposure and increased availability could increase children's healthy food consumption via familiarity processes automatically (Berridge & Kringelbach,

2015; Cohen, 2008). Children's healthy eating may therefore be supported by priming children more often with attractive digital healthy food cues that increase the appeal and status of healthy foods and automatically trigger familiarization processes to enhance the likeliness of children eating and enjoying healthy foods so that healthy food may become part of the children's regular diet (Berridge & Kringelbach, 2015; Cohen, 2008; Folkvord, 2020).

The present study aimed to overcome several limitations of existing research on food advertisements. First, most studies have measured the effect of television-style food advertising on food preferences, purchase requests, or behavioural intentions (see review by Smith et al., 2019) and have not assessed children's actual food intake. Second, studies that have measured actual food intake have only used advertisements that were recorded from television (Anschutz et al., 2009; Anschutz et al., 2010; Boyland et al., 2013; Dovey et al., 2011; Fox et al.,1980; Galst, 1979; Gilbert-Diamond et al., 2017; Gorn & Goldberg, 1980; Halford et al., 2004; Halford et al., 2007; Halford et al., 2008; Harris et al., 2009; Lemnitzer et al., 1979; Lorenzoni et al., 2017) rather than designed for the purpose of the study and matched across conditions.

Third, studies that assessed the effects of food advertisements on children's food intake have almost exclusively investigated children's intake of HSSF snacks (Anschutz et al., 2009; Anschutz et al., 2010; Boyland et al., 2013; Gilbert-Diamond et al., 2017; Gorn & Goldberg, 1980; Halford et al., 2004, 2007, 2008; Harris et al., 2009; Lemnitzer et al., 1979; Lorenzoni et al., 2017). Studies investigating exclusively television-style, healthy food advertisements and healthy food intake in children are non-existent. Despite the difficulty of detecting changes to healthy foods with very low caloric intake compared to HSSF-products with very high caloric content, changes in food intake have been reported in kcal only (Anschutz et al., 2009; Anschutz et al., 2010; Boyland et al., 2013; Dovey et al., 2011; Fox et al., 1980; Gilbert-Diamond et al., 2017; Gorn & Goldberg, 1980; Halford et al., 2008; Halford et al., 2007; Halford et al., 2004; Harris et al., 2009; Kaser-Boyd, 1978; Lemnitzer et al., 1979; Lorenzoni et al., 2017).

Fourth, research locations and settings of studies assessing children's healthy food intake in response to television-style healthy food advertisements have been limited to classrooms in schools (Boyland et al., 2013; Dovey et al., 2011; Halford et al., 2008, 2007, 2004; Harris et al., 2009; Lorenzoni et al., 2017), classrooms that were made to look like a living room ('semi-naturalistic setting', Anschutz et al., 2009, 2010), mobile research laboratories (Fox et al., 1980; Kaser-Boyd, 1978), research laboratories (Gilbert-Diamond et al., 2017; Kaser-Boyd, 1978), and summer camps (Gorn & Goldberg, 1980; Harris et al., 2009), none of which necessarily reflect children's naturalistic eating behaviour (Anschutz et al., 2009, 2010).

The present research study extends the existing literature by applying a cluster randomized, controlled pre/post-test design to investigate children's actual intake of exclusively healthy foods in response to healthy food advertisement exposure in five nurseries in Germany. Uniquely, the present study used specifically designed advertising stimuli that were similar in design, advertising techniques, and target group across conditions. The stimuli were modeled on key success factors commonly used in commercial food marketing and healthy food marketing to children specifically (Aschemann-Witzel et al., 2012). Additionally, to avoid previous methodological issues discussed above, the present study provided children with a wide selection of healthy foods to avoid potential bias from children's food dislikes, and food intake was reported in standardised portions (see section 2.3.2) and in calories based on information provided by manufacturers.

It was hypothesised that children who viewed the healthy food advertisement would increase their healthy food intake from pre-test (T1) to post-test (T2), and that healthy food intake would be greater at T2 compared to children who viewed control advertisements. It was hypothesised that children in the control condition would not change their healthy food intake between T1 and T2.

2. Methods

2.1 Design

A cluster randomised 2 (condition: healthy food advertising, control) X 2 (time point: pre-test, post-test) mixed design was used with condition as a between-subjects

factor and time point as a within-subjects factor. Block randomisation of nursery groups was used to allocate children to condition via toss of a coin (Gelman & Nolan, 2002). The study was comprised of two test days, including one test day for pre-test (T1) and one test day for post-test (T2) measurements, with a two-day break in between test days. Food intake in items and energy (kcal) were the main outcome measures. Test sessions took place in nursery activity rooms, which were large, bright and child friendly rooms. Although the activity rooms were not children's usual eating place, children were familiar with the rooms and the size of the activity rooms allowed for all aspects of the experiment to take place in one room (see Figure 1), which facilitated compliance with the nursery schedule and safeguarding procedures. Experimental areas included a viewing area, a buffet area and an eating area. The time of day when testing took place was standardised across test sites. Experiments were carried out between 9.30am and 11.30am, which was children's usual breakfast and snack time, at T1 and at T2. Experiments were carried out at the same time of day to control for energy, hunger and attention levels (Dovey et al., 2011; Gorn & Goldberg, 1980; Harris et al., 2009).

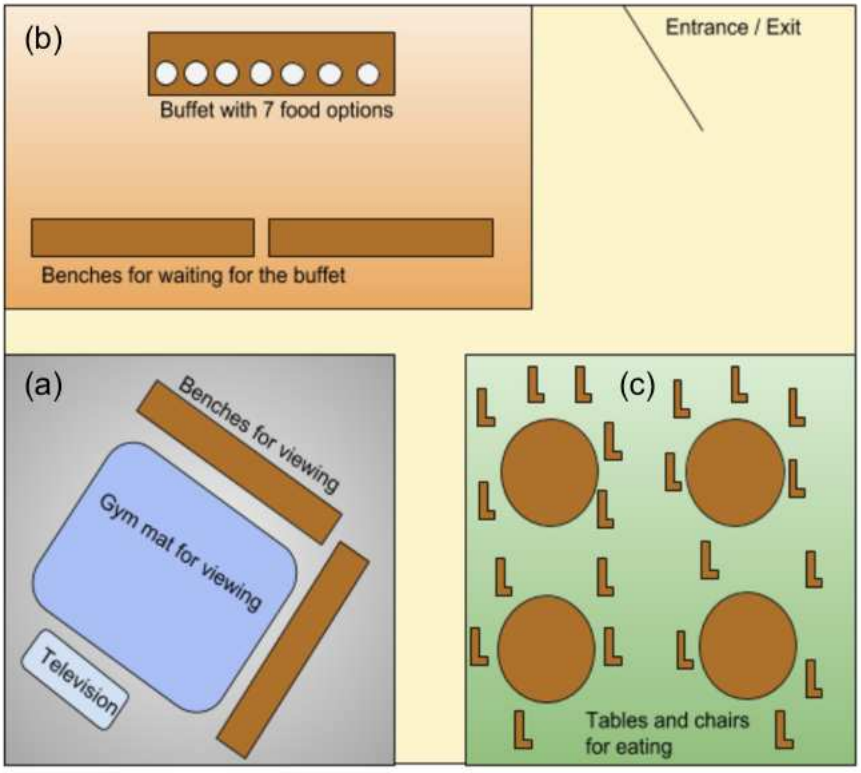


Figure 1. Plan of research setting which included (a) viewing area, (b) food selection area, and (c) eating area.

2.2 Participants

An opportunity sample of 172 children was recruited from five nurseries in the neighboring cities of Frankfurt and Offenbach in Germany. Given the influence of the early years of life on food preferences and eating behaviour (Cooke, 2007) and the lack of studies on children younger than eight years of age conducted in nurseries, the sample included children aged 3 to 7 years (*M*: 4.72 ± 0.99). After an initial telephone call confirming interest to participate in the study, each nursery was visited by the first author to explain the research aims and procedures. Nurseries and parents were aware that the research was carried out and approved by a UK-based university. Nursery management and staff distributed study information and obtained consent from parents for their children to participate. Nursery management and staff were briefed to communicate information about the study in a clear and accessible way. To prevent bias parents were asked not to share any information about the study with their child. Children were told that they would participate in a movie screening followed by a buffet to find out what children liked to eat. Children with food allergies, intolerances or special dietary requirements related to the foods used in the study were excluded from participation. Oral assent was obtained from the children on the day of the experiment by asking if they would like to watch a children's programme. The study was approved by the Ethics Committee of the Department of Psychology at the University of Sheffield (Reference number: 011950).

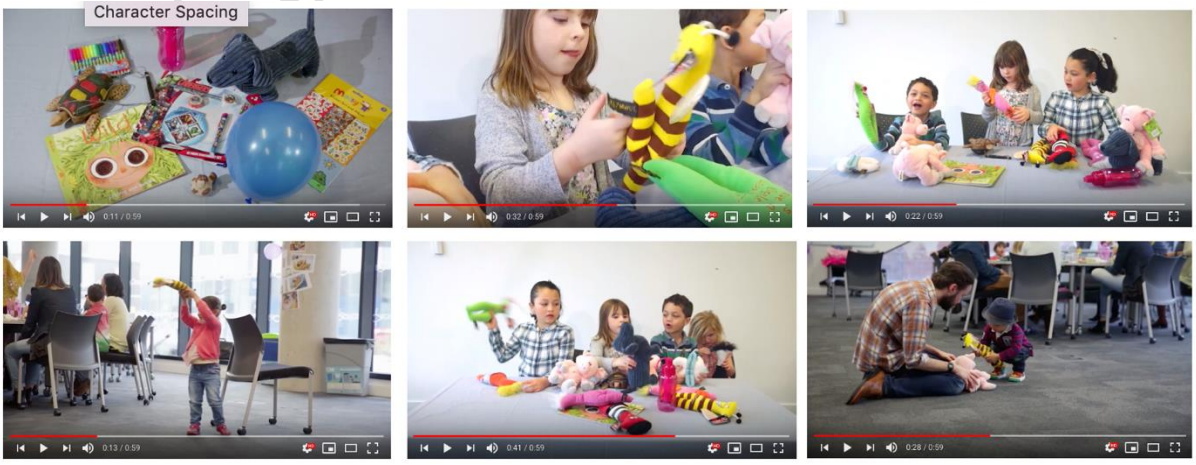
2.3 Materials

2.3.1 Advertising stimuli and children's programme

The advertising stimuli were specifically designed and recorded for the purpose of the present study. Advertising stimuli included a healthy food advertisement for the experimental condition (see Video still 1) and a toy advertisement for the control condition (see Video still 2). To ensure that advertisements were comparable across conditions, the healthy food advertisement and the control advertisement were identical in setting, story, actors, music, lighting, special effects, length, and logo.

The healthy food advertisement showed children and parents enjoying healthy foods. The advertisement for healthy eating was informed by nutrition guidelines on healthy and balanced eating as outlined by WHO (2020b), NHS (2020), PHE (2018) and DGE (2020) and included the promotion of water, vegetables and fruits, and whole-grain products. No explicit health claims were made to avoid possible interference with the advertisements (Raghunathan, Naylor & Hoyer, 2006). The toy advertisement showed children and parents playing with a variety of toys. The advertisements can be viewed in German via https://tinyurl.com/KinderundLebensmittelstudie and in English via https://tinyurl.com/FoodAdvertisingStudy. Children in Germany viewed the advertisements in German.

Video still 1. Healthy food advertising clip (experimental condition).



Video still 2. Toy advertising clip (control condition).

Incorporating themes of magic and fantasy (Calvert, 2008), both advertisements showed a selection of products (vegetables, fruit, whole-grain bread and water in the healthy food advertisement; toys in the toy advertisement) 'magically' pop up on a table. In the healthy food advertisement, children use cucumbers as swords in play fighting and carrots as vampire teeth. In line with peer (Aschemann-Witzel, Perez-Cueto, Niedzwiedzka, Verbeke & Bech-Larsen, 2012; Birch, 1980; Kim, Chen & Cheon, 2019) and parent modeling (Nicklas, Baranowski, Baranowski, Cullen, Rittenberry & Olvera, 2001) both advertisements showed children and parents positively interacting with the products through playing, tasting, and eating.

Based on findings suggesting that children are more likely to imitate behaviours of role models they perceive to be similar to themselves (Zmyj & Seehagen, 2013), amateur actors from the local community were used to create a relevant and realistic viewing experience. Uplifting music without lyrics was used to create a positive mood. Voice-overs were adapted to promote either healthy foods or toys. The advertising messages were pitched at an age-appropriate level by using voice overs of children using children's terminology, such as 'yummy' for the healthy food advertisement or 'so much fun' for the control advertisement. Both advertisements were informed by food advertising techniques and key success factors for healthy food promotion outlined by Aschemann-Witzel et al. (2012) and Calvert (2008) such as repetition and attention-grabbing features including action, magic, movement, sound effects, music and song (Calvert, 2008). There was no branding or packaging, to reduce the potential impact of brand preferences acting as confounding variables (Dial & Musher-Eizenman, 2020). A logo distinguished advertising from programme.

The same advertisement, for either healthy food or for toys, was embedded at the beginning, end and middle of an animated children's programme, 'Shaun the Sheep', adding up to three exposures or three minutes of advertising in total. The total advertising exposure in this study is in line with previous research on children's food intake in response to food advertising (Kaser-Boyd, 1978; Lemnitzer et al.,1979). A logo was used at the beginning and end of the advertising clips to mark the difference between the children's programme and the advertising break. Two 7-minute episodes of 'Shaun the Sheep' were used as an age-appropriate children's programme in terms of content and length. The episodes contained no explicit

325 references to food, nutrition, body weight or health. ‘Shaun the Sheep’ is based
326 entirely on music and sounds without any language or speech, so the programme
327 made little cognitive demand, and could be enjoyed by children irrespective of their
328 language skills.
329
330 Screenings took place in a viewing area (Figure 1a) which consisted of a gym mat
331 and chairs or benches for children to sit on. The children watched the
332 advertisements and programme on a large flat-screen television placed on a table in
333 good view of all the children. Screenings took place in groups ranging from five to 15
334 children, depending on the size of the individual nursery and the number of children
335 available on a particular test day.
336
337 Research materials including the research setting, advertising stimuli, children’s
338 programme, and similar food buffet and food intake monitoring materials were piloted
339 in one small study ($N = 11$) and used in two previous studies ($N = 26$; $N = 34$) (Von
340 Nordheim, 2021). The advertising stimuli were created in collaboration with a
341 volunteer group of local children and parents which contributed to the design and
342 production of the advertisements.
343
344 2.3.2 Food buffet and food intake monitoring materials
345
346 The food buffet included seven healthy food options cut into standardised, bite-size
347 portions (‘items’) and presented in ways that have been shown to be appealing to
348 children such slices and sticks (Olsen et al., 2012). Buffet options included apples
349 cut into eighths, orange segments, carrot sticks, cucumber wheels, pepper slices,
350 cherry tomatoes, and half slices of whole-meal bread, presented on medium-sized,
351 white plates that children usually ate from. The food portions in this study were
352 similar to methods used by Gonçalves et al. (2018) where children’s food intake
353 following food cue exposure was measured in the number of grapes and baby
354 carrots consumed rather than portions in weight. The researcher refilled the test
355 foods in between participants to ensure consistent available portion sizes for each
356 child. Each child received a medium-size, white plate to use at the buffet. A clipboard
357 and monitoring sheets with a picture of a table displaying all the food options were
358 used by the researcher to record a child’s food selection at the buffet, any leftovers,

and a child's total food intake. The researcher stood by the side of the buffet and observed children unobtrusively. Children's food intake was recorded in items and later converted into caloric value using the product information provided by the manufacturer.

2.4 Procedure

At pre-test (T1) and post-test (T2), groups of children were accompanied by one to two familiar nursery teachers to the activity room and sat down in the viewing area (see Figure 1). Children were welcomed by the researcher, who introduced herself to the children and explained the procedure. Children were given a brief summary of the 'Shaun the Sheep' episode prior to viewing. At T2, children were also told that there would be advertising breaks.

At T1, children viewed one episode of 'Shaun the Sheep' and selected healthy foods from the buffet, which they then consumed in the eating area. At T2, children viewed another episode of 'Shaun the Sheep' interrupted by the same one-minute advertising clip for either healthy foods (experimental) or toys (control) inserted at the beginning, middle, and end of the episode followed by food selection at the buffet and intake in the eating area.

After viewing the programme, the children were told to sit on the benches in front of the buffet. The benches were positioned at a sufficient distance from the queuing children so that children could not observe the exact food choices of their peers, while still being able to observe one another at the buffet to ensure all the children followed the procedure the same way. Children were told that they could eat what and how much they wanted, that they could return to the buffet for more, and that they did not have to take anything at all. There was no time limit on children's individual food selection at the buffet.

Children ate their food in the eating area, which consisted of group tables with four to five chairs each for children to sit down together (see Figure 1). Drinking water was provided at all tables. Drinking water intake was not measured. Children were told not to swap or share foods, and to leave any food they did not want to eat on their

plate. Children who had finished eating were asked once if they wanted more and were then allowed to return to their nursery groups to avoid distracting children still eating. Each group was allocated 30 minutes in the eating area. Children were not aware of the time limit, and most of the children finished within the 30 minutes. Children who were still eating after 30 minutes were gently told to finish their plate or leave leftovers and return to their nursery group. Children were able to follow the instructions, and this is most likely because the food selection and intake procedures were in line with the typical procedures at the nurseries. For instance, children were used to self-serving at their usual breakfast buffet and were used to eating in small groups.

3. Analysis

G*Power calculations (Faul, Erdfelder, Lang & Buchner, 2007) with a conservative effect size (f = 0.10), error probability of 0.05, and power of 0.80 indicated that 160 participants were required to detect significant differences in intake between groups across the two time points. Allowing for an estimated 30% attrition rate, we aimed to recruit at least 208 children. Children's food intake at pre-test (T1) and post-test (T2) was calculated as the sum of all foods consumed and analyzed as caloric (kcal) and item consumption (measured portions). Data across the five nurseries were merged as a one-way ANOVA showed that there were no significant differences between nurseries in item consumption at T1, $F(4, 167) = 1.89$, $p = .11$, or caloric consumption at T1, $F(4, 167) = 0.37$, $p = .83$. Data are presented as means ± standard deviation and 95% confidence intervals (CI) unless specified. Multiple comparisons were adjusted for by dividing the standard significance level of $p<0.05$ by four comparisons. Results were considered significant if $p<.01$. Partial eta squared (η^2) is reported for effect sizes and interpreted as 0.01 small, 0.06 moderate and 0.14 as large (Field, 2005). We conducted a mixed ANOVA for the overall model. For follow-up tests, we used the overall estimate of residual within-cell error from the ANOVA to compute an experiment-wide SED for t-tests. The hypothesis was tested by the delta (T1-T2) in the control group versus delta in the experimental group (T1-T2).

4. Results

In total, 267 children were recruited at T1, and of those 172 completed both T1 and T2 measures (*M*: 4.7 ± 0.1 years; healthy food advertisement n = 103; control n = 69). Children's absence at T2 was due to illness or to other commitments, none of the children declined participation.

An independent t-test showed that there was no significant difference in age between the healthy food advertisement group (*M*: 4.8 ± 1.01) and the control group (*M*: 4.7 ± 1.0), t(159) = -.94, p = .30. A Chi-squared test showed that there was no significant difference in gender between conditions, X^2(1, N = 172) = 1.05, p = .31 (healthy food advertisement: females n = 50, males n = 53; control: females n = 39, males n = 30).

A mixed ANOVA for the overall model showed that the main effect of time F(1, 170) = 2.17, p =.14, η_p^2 =.01, and the main effect of condition were not significant F(1, 170) = 1.81, p =.18, η_p^2 =.01. However, the condition x time interaction was significant, F(1,170) = 26.91, p<.001, η_p^2 =.14.

Paired t-tests showed that the healthy food advertisement group significantly increased item consumption from T1 (*M*: 6.2 ± 4.4) to T2 (*M*: 9.5 ± 7.1), t(102)= -4.90, p<.001, and significantly increased caloric consumption from T1 (*M*: 90.3 ± 72.3) to T2 (*M*: 119.0 ± 81.7), t(102)= -3.33, p =.001). The control group significantly decreased item consumption from T1 (*M*: 7.6 ± 6.9) to T2 (*M*: 5.9 ± 4.6), t(68) = 2.73, p =.008, and change in calorie consumption was not significant, T1 (*M*: 79.7 ± 66.7); T2 (*M*: 81.7 ± 58.1), t(68)= -0.23, p =.82 (see Figures 2 and 3).

Independent t-tests showed that at T1 food intake did not significantly differ between groups (item: t(170)= 1.59, p =.11; kcal: t(170)=-0.97, p =.33). Comparing delta (T1-T2) in the control group versus experimental group, independent t-tests showed that the increased item intake in the healthy food advertising group was significantly greater than the change between T1 and T2 in the control group, i.e. compared to the control group, the increase in healthy food items between T1 and T2 was significantly greater for the healthy food advertising group (items: 9.4 ± 7.1 vs 5.9 ±

4.6, t(170) = 5.19, *p<.001, CI* = 3.01, 6.70). Cohen's effect size value (d=.81) suggested a high practical significance. Comparing delta (T1-T2) in the control group versus experimental group, independent t-tests showed that caloric change scores were not significant between the control group and experimental group when applying the adjusted *p*<.01 (kcal: 119.0 ± 81.7 vs 81.1 ± 58.1, t(170) = 2.07, *p* =.04, *CI* = 96.0, 1.18, 52.18]. Cohen's effect size value (d=.32) suggested a moderate practical significance.

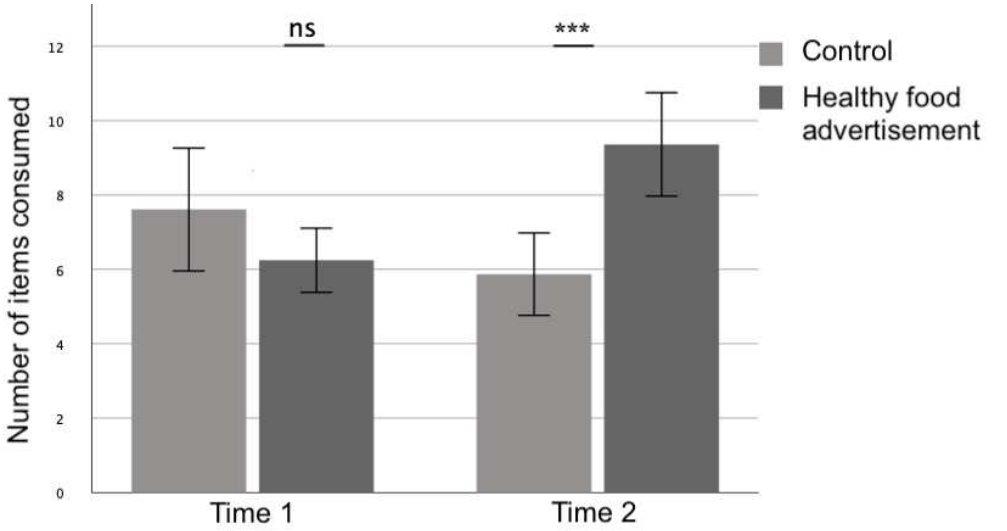


Figure 2. Consumption of items before (T1) and after (T2) exposure to healthy food or control advertisements. Error Bars: 95% CI.
***p<.001

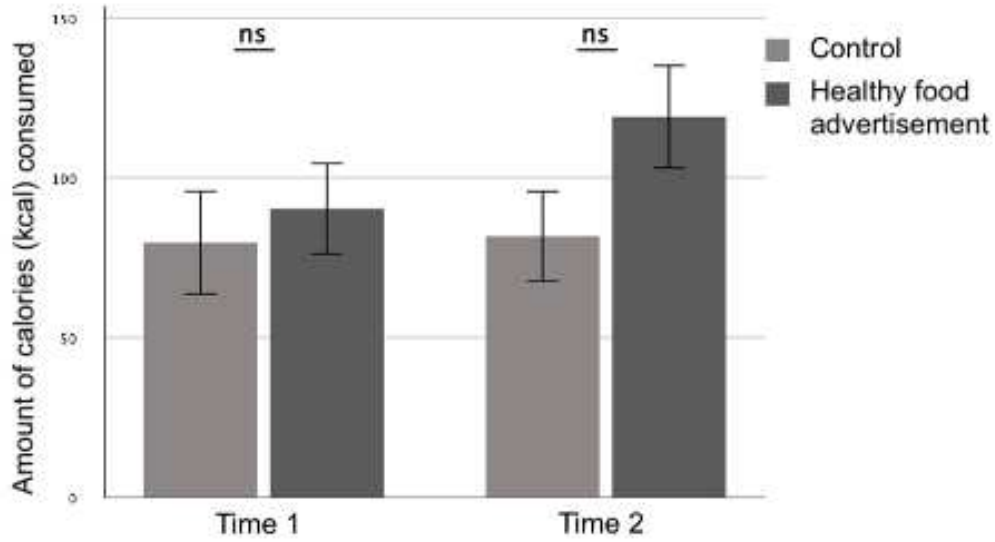


Figure 3. Caloric consumption before (T1) and after (T2) exposure to healthy food or control advertisements. Error Bars: 95% CI. Please note, non-significant when *p* was adjusted $p < .01$.

5. Discussion

The present study investigated the effects of healthy food advertisements versus toy advertisements on children's intake of healthy foods. Children who viewed healthy food advertisements ate significantly more healthy food items following healthy food advertising exposure than did children in the control condition who viewed toy advertisements, but these significant differences were not evident in caloric consumption. Exposures to a one-minute-advertisement for healthy food were sufficient to increase children's healthy food intake by as much as three portions, helping children to meet daily recommended amounts of vegetables, fruit, or whole-grain (NHS, 2020; PHE, 2020). In contrast, children in the control group who were exposed to toy advertising decreased their healthy food intake by approximately two portions.

Differences in children's food intake outcomes depending on the measurement units used for analysis have been reported in previous studies. For example, Halford et al. (2007) found that when children's food intake was measured in energy (kcal), the food item with the greatest intake was chocolate. However, when measured in weight (g), children's intake was greatest for grapes. Since energy (kcal) entails no information about the nutritional composition of foods such as vitamins, minerals, or fibre, (Carels, Harper & Konrad, 2006), other researchers have prioritised the use of portions as a unit to measure children's food intake (Gonçalves, et al., 2018). We therefore report that as predicted, children who viewed advertisements for healthy foods increased the intake of healthy food items.

Findings from the present study contradict previous research that found no links between exposure to television-style healthy food advertising and increases in children's healthy food intake (Dovey et al., 2011; Fox et al., 1980). Dovey et al. (2011) found that exposure to healthy food advertisements only decreased unhealthy food intake but did not affect healthy food intake. Fox et al. (1980) reported no changes to healthy food intake in response to healthy food advertisements. The

difference in outcomes between the present study and Dovey et al. (2011) and Fox et al. (1980) may be due to previous research using recorded advertisements for healthy foods that were less appealing or relevant to children. A novel aspect of the present study was that the healthy food advertisements were specifically developed in line with key success factors of commercial marketing (Aschemann-Witzel et al., 2012). Such advertisements may have successfully created a desire for the healthy foods that were offered, especially without the presence of HSSF-alternatives. For instance, the healthy food advertisements included the use of peer and adult role models, uplifting music, and encouraging voice-overs. As such, the current findings align with the first assumption of the Promotion of Healthy Food Model (Folkvord, 2020) which suggests that directing attention toward fruit and vegetables through food promotion may increase their reinforcing value, which is a child's liking for and wanting the advertised fruit and vegetables.

Future research using longitudinal designs is required to assess the remaining assumptions in the Promotion of Healthy Food Model (Folkvord, 2020) relating to the creation of a reciprocal relationship between desire for healthy foods, eating healthy foods, and experiencing improvements in health and wellbeing following dietary improvements, which in turn lead to increased eating of healthy foods until this behaviour becomes automatic and habitual. Folkvord (2020) highlighted the role of individual and societal factors in individual susceptibility to food marketing (Folkvord, 2020) and future researchers could explore the impact of such factors.

In addition to using specifically designed advertisements, differences between the present findings and Dovey et al. (2011) may be explained by methodological variation in the eating opportunity. In contrast to Dovey et al. (2011) where offering more unhealthy than healthy snacks may have accounted for the lack of healthy food intake despite healthy food advertisements, the present study offered healthy food options only. The lack of healthy food intake in Fox et al. (1980) might be explained in the same way, namely the use of recorded advertisements and offering healthy as well as unhealthy foods to children. Additionally, Fox et al. (1980) recorded food intake in calories only, which makes it harder to detect changes in healthy food intake compared to unhealthy food intake. In contrast, the present study recorded food intake in calories and in items.

559

560 Contrary to predictions made in the present study, children's intake of healthy foods
561 did not remain stable in the control group. When measured in food items, children
562 who viewed toy advertisements and were therefore not encouraged to eat
563 vegetables, fruit, and whole grain by digital peers and parents, reduced their healthy
564 food intake. This supports Lowe et al (2004) and Upton et al (2013) who also offered
565 healthy foods only and found that exposure to narrative media with healthy food cues
566 increased children's vegetable and fruit intake while mere availability of vegetables
567 and fruits led to a decline in intake over time (Horne et al., 2009; Upton et al., 2013).
568 The Promotion of Healthy Food Model (Folkvord, 2020) suggests that the
569 consumption of healthy foods is experienced as less physiologically and
570 psychologically rewarding than HSSF food consumption. Therefore, mere availability
571 of healthy foods without advertising aiming to increase their reinforcing value may
572 account for decreases in healthy food intake in the control group. Findings from the
573 present study suggest that mere availability of healthy foods is not sufficient to get
574 children to eat healthy foods, and that children benefit from digital food advertising
575 promoting healthy food intake.
576

577 This study assessed the immediate effects of healthy food advertisements on food
578 intake. Future researchers could assess the long-term effects of healthy food
579 advertisements on children's healthy food intake. As described in the Promotion of
580 Healthy Food Model (Folkvord, 2020), once advertisements successfully establish
581 attention to healthy foods and increase children's liking and wanting for those
582 products, a reciprocal relationship emerges that leads to normalisation,
583 automatization and habit formation (Folkvord, 2020).
584

585 The present findings suggest that digital food advertising for unbranded healthy
586 foods are an effective way of increasing children's vegetables, fruit, and whole-grain
587 intake in an environment restricted to healthy food options. The findings from this
588 study highlight the value of further research to develop targeted healthy food
589 advertisements that expose children to appealing images of vegetables, fruit and
590 whole-grain products, provide peer and parent role models for healthy eating, and
591 present healthy eating in a fun, rather than in a dogmatic manner. Learnt food
592 preferences and environmental conditions can be altered (Cohen, 2008; Berridge &

Kringelbach, 2015) and television advertisements may change norms relating to food and eating through positive role models (Cruwys, Bevelander & Hermans, 2015; Monahan, Murphy & Zajonc, 2000; Nairn & Fine, 2008).

The advertisements in this study modeled popular advertising techniques from commercial food marketing such as repeated exposure, positive associations, themes of fun and fantasy, special effects, music, voice-overs, and peer- and parent-models. Future research may wish to systematically test these advertising elements to specify the most effective ones for improving children's diets. Effective healthy food advertisements could then be used to counteract the overwhelming imbalance in children's media and advertising environments which favour HSSF-foods over healthy products (Russel et al., 2019; Smith et al., 2019). Even if television should cease to be the main medium to reach children, the video format can be used on other media devices such as tablets and smartphones, through novel channels including television-on-demand, streaming sites, and social media. Future researchers could test the effectiveness of video-based healthy food advertisements on a range of media devices.

Although food selection at the buffet was individual, the present study was conducted in groups and procedures included children eating in groups. Viewings were supervised by nursery staff and the researcher, but children's attention to the screen was not systematically measured. It is possible that some children may have been distracted by others during the group viewings, and this may have affected exposure times to the advertisements. Food selection and food intake in the present study followed the nursery's breakfast routine, which included children freely selecting breakfast from a buffet that they could return to for refills and eating in groups. The design of the food selection and eating area may have influenced children's food intake, but this design of these areas was chosen to reflect children's eating behaviour in a naturalistic setting.

Since the present study did not contain any other food advertisement condition, the mere presence of any food cue rather than the presence of healthy food cues specifically may have caused increases in children's healthy food intake. Food cue exposure suggests that exposure to food cues triggers desire to eat and ultimately,

increases food consumption (Boyland et al., 2016). Food cue exposure as an alternative explanation for the current findings is unlikely because previous research outcomes on television-style food advertisement exposure and children's food intake have found no evidence for food cue reactivity in response to healthy food cues. In Halford et al (2007) exposure to HSSF food cues in television-style advertisements increased children's intake of all processed foods (high-fat savoury, low-fat savoury, high-fat sweet, low-fat sweet), but not fruit. In Halford et al (2008) exposure to the same HSSF-advertisements as in Halford et al (2007) increased intake of all available foods, but most increases were reported for HSSF-options (chocolates, jellies, crisps, snack-a-jacks) and least increases for fruit (grapes).

Findings from Halford et al (2007, 2008) may suggest that food cue reactivity may not be present for healthy foods or may be less pronounced. Even studies that have exposed children to healthy food cues in televison-style advertising have found little to no evidence for increases in healthy food intake (Dovey et al., 2011; Fox, 1980; Kaser-Boyd, 1978; Lemnitzer et al., 1979) suggesting that food cue reactivity in response to healthy food cues is unlikely. In Dovey et al (2011) healthy food advertisements decreased children's intake of HSSF-options in children with low neophobia levels only, but healthy food advertisements did not increase healthy food intake. In Fox (1980), HSSF-advertisements increased HSSF-intake in boys, but healthy food advertisements had no effect on snack intake on either gender. In Kaser-Boyd (1978) and Lemnitzer et al (1979) HSSF food cues increased HSSF intake, but healthy food advertisements did not lead to healthier eating. Since healthy food cues in previous television-style food advertisements studies did not increase children's intake of healthy of HSSF-options, it is unlikely that increases in children's healthy food intake in the present study were due to food cue reactivity.

Rather, we believe that increases in children's healthy food intake in the present study can be attributed to the use of professional, specifically designed television-style healthy food advertisements and to limiting children's food choice to a best-choice-situation with healthy food options only. While future researchers may wish to investigate and compare the effects of various food advertising conditions for healthy foods as well as HSSF-products and assess the intake of individual foods as well as food categories, we believe that explorative studies focussing exclusively on healthy

food advertisements and healthy food intake are needed. A large number of television-style food advertising studies have investigated exclusively HSSF-advertisements and children's HSSF-intake (Anschutz et al., 2009; Anschutz et al., 2010; Boyland et al., 2013; Gilbert-Diamond et al., 2017; Gorn & Goldberg, 1980; Harris et al., 2009), but studies of television-style healthy food advertisements and children's healthy food intake are restricted to the present study. To confirm which explanation is most likely, researchers could examine the effects of television-style food advertising for healthy versus HSSF foods on children's intake of healthy and HSSF foods.

Since healthy food advertisements in the present study increased children's healthy food intake when only healthy foods were available, future researchers could assess at what point exposure to healthy food advertisements can increase healthy food intake even when other HSSF-options are available to better equip children in their food abundant environments. Until then, caregivers might aim to create best-choice-environments filled with healthy food options where children are encouraged to consume the healthy foods that are available to them.

In conclusion, the present study responded to calls for further research on healthy food cues and children's healthy eating (Folkvord & Hermans, 2020). The present study is a first exploration into children's eating behaviour in the context of healthy food advertising and healthy food availability, and as such, this study is a unique contribution to the existing evidence base on food advertising effects and children's eating. Findings from the present study suggest that exposure to as little as three healthy food advertisements can help children achieve above the daily recommended minimum amounts of vegetables, fruit, and whole-grain (NHS, 2020; PHE, 2020), which may positively affect weight status, dietary health, and overall wellbeing (NHS, 2020; PHE, 2020). The present study showed that digital healthy food advertising was required to get children to consume the healthy foods that were available. Without healthy food advertising exposure, children's healthy food intake declined, which may suggest that digital healthy food marketing is not only effective, but also needed.

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Author contributions

Laura von Nordheim reviewed the research literature, developed the research study, designed and produced the advertisements, recruited nurseries, conducted the experiments, analysed the data, and wrote the manuscript.
Nicola Buckland supported data analysis and edited and reviewed the manuscript.
Mark Blades supervised the research study and reviewed the manuscript.
Caroline Oates supported the development of the research study and edited and reviewed the manuscript. All authors agreed the final version of the manuscript.

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Data statement

Data is available upon request.

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