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The impact of food advertising on children's daily energy intake: does it differ by advertising content, format, or participant characteristics? A cross-over randomised controlled trial

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ABSTRACT

Exposure to audiovisual advertising for unhealthy food products increases children's immediate food consumption and effects may persist to subsequent meals. The impacts of food advertising that is brand-only or in other formats is unknown. This study aimed to quantify the impact of unhealthy food advertising on children's immediate and later intake; and assess differences in impacts for different advertisement content (brand-only vs. product), format (audiovisual vs. visual vs. audio vs. static), or sociodemographic characteristics. A pre-registered cross-over randomised controlled trial was conducted in schools in Merseyside, UK. Across two sessions, child participants ($n = 240$, 7-15 years, $M = 11.0 \pm 2.0$) were exposed to 5-min of unhealthy food (intervention condition) and non-food (control condition) advertisements that were brand-only or product-based and in one of four media formats. Measurements included *ad libitum* intake of snacks and lunch, and height and weight. Area-level socioeconomic deprivation was calculated using home postcode. Data were analysed using linear mixed models. After food advertising (vs non-food), children consumed more energy at snack (+58.73 kcal; $p < .001$) and lunch (+72.93 kcal; $p < .001$). There was no statistically significant difference in effects by advertisement content, media format, or deprivation. This is the first study to show that brand-only food advertisements increase children's food intake, with effects not statistically different to that for product ads, and that impact is similar across advertising formats. Findings are theoretically informative and have implications for the design of restrictive food marketing policies in the UK and globally.

1. Introduction

Reducing rates of childhood obesity and associated non-communicable disease risk is a global public health priority (World Health Organization, 2017). Increased global prevalence of obesity in children, with disadvantaged groups disproportionately affected, has largely been attributed to changes in population diets towards increased consumption of unhealthy, ultra-processed foods and beverages (hereafter: food) (De Amicis et al., 2022; Swinburn et al., 2019). It has long been recognised that food marketing makes a significant contribution to childhood obesity (Harris, Pomeranz, et al., 2009; Norman et al., 2016) via a cascade of processes that transition, over time, through cognitive, affective, and behavioural stages to ultimately impact weight gain and diet-related disease (Boyland et al., 2024). Food cues, including those delivered through marketing, also cue immediate behavioural responses and there is substantial evidence that the promotion of unhealthy food products negatively impacts children's acute food preferences, choices, and consumption (Boyland et al., 2022a). Studies also show that food marketing takes advantage of youth neurocognitive, social, and emotional vulnerabilities (Boyland et al., 2023; Harris et al., 2021) and

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may be contributing to health inequalities (Backholer et al., 2021).

However, some notable research gaps remain. Firstly, it is unclear how long the intake-promoting effect of unhealthy food advertising persists for. To the authors' knowledge, only one study to date has directly measured the sustained effect of food advertising exposure on children's food consumption (Norman et al., 2018). In Australia, researchers measured children's snack intake immediately after food advertisement exposure (via TV and an advergame) and then again at lunch later in the day. They found children ate more snacks after exposure to food advertising compared with non-food advertising. Furthermore, this increased intake was not compensated for at lunch, leading to an additional daily food intake of 194 kJ (approximately 46 kcal) when exposed to food advertising. This lends support to the link between food advertising exposure and obesity, given that exposure appears to contribute to a positive energy-gap of sufficient magnitude to contribute to weight gain over time (Norman et al., 2016, 2018). However, this effect is yet to be replicated.

Secondly, most studies testing the impact of food marketing on children's eating behaviours have used food product-based stimuli (Boyland et al., 2022a), so the differential impacts of brand-only versus product-based food advertising are yet to be elucidated. Brand-only advertising can be defined as presentation of brand identity elements (e.g., logos, marks, characters, colours or straplines that are linked with an individual product, product range, or company) but with no identifiable product (Advertising Standards Authority, 2017). Globally, there is not yet a restrictive food marketing policy that prohibits brand-only marketing for food, yet recent evidence suggests that around 40% of food advertising is now for brands rather than specific products (Bandy et al., 2023). Indeed, there is evidence that brand-based marketing strategies are proliferating, particularly in digital media (Boyland et al., 2024). Food brand social media posts can reach billions of users (Potvin Kent et al., 2024), particularly among young people who frequently engage with brands and their online content (Fleming-Milici & Harris, 2020), and this is assumed to contribute to transfer of liking and changing beliefs via associative learning (Lutchyn & Faber, 2016; Neyens et al., 2017a). This tactic may be used by marketers to circumvent product-based restrictions (Harrison, 2022) and is seen as a major weakness of such policy approaches (Harris et al., 2025). However, while theoretical models purport that brand advertising can affect consumption (Folkvord et al., 2016) and cross-sectional associations between food brand recognition and child body mass index (BMI) have been identified (Harrison et al., 2017), experimental evidence of the impact of brand-only food marketing on children's eating behaviour is limited and of mixed quality (Boyland, Davies, et al., 2025).

Thirdly, we lack understanding of how children process and respond to different types and formats of advertising stimuli as the evidence base for the impact of unhealthy food advertising exposure is largely based on studies using television audiovisual advertising (Boyland et al., 2016; Russell et al., 2018). This is no longer reflective of the contemporary, diverse media landscape that children encounter (WHO Regional Office for Europe, 2016) as advertising expenditures increasingly shift to digital media (Potvin Kent et al., 2022) including in podcasts (Bezbaruah & Brahmbhatt, 2023). It is theoretically important to consider how the impact of marketing messages might differ when received in different formats from distinct media sources (such as television and radio) and also those processed using different or multiple *modalities* (such as auditory and visual processing) (Grewal et al., 2021) through testing under controlled conditions. While previous meta-analyses found no significant difference in the size of the effect on children's food intake between studies exploring food marketing on television, digital media, and food packaging, researchers did not compare the media types or advertising modalities directly (Boyland et al., 2022a). A recent theoretical model argues that the processing of key marketing elements is critical to its persuasive impact on behaviour (Maksi et al., 2024). Neuroimaging data appears to support this notion, as different advertising formats (static images such as banner or side bar ads compared with dynamic videos) had unique and differential effects on neural responding in 9-12 year old children (Yeum et al., 2023). While a variety of food advertising modalities are found across different contemporary media that children encounter, there is a lack of data comparing their relative impact on food intake among this age group.

Fourthly, it remains unclear the extent to which the impact of food advertising exposure on child food intake differs according to sociodemographic characteristics. A meta-analysis previously found that the effect was moderated by child weight status, whereby following food advertising exposure (compared with non-food adverts) children with overweight or obesity consumed an average of 45.6 kcal more than children with healthy weight (Russell et al., 2018). However, while childhood obesity has a marked social patterning, and deprived and ethnic minority groups are disproportionately exposed to unhealthy food marketing, there is limited evidence to describe how these characteristics moderate the impact of food marketing on behaviour (Backholer et al., 2021). Similarly, while differences in food advertising exposure have been observed based on child age (Potvin Kent et al., 2019), there is little direct evidence to support the claim that this leads to observed differences in behavioural outcomes (Chernin, 2008). Studies also suggest that boys have greater exposure to food advertising than girls, but the impact of exposure appears similar across the sexes (Castronuovo et al., 2021; Chernin, 2008). These effects warrant further exploration and clarification.

United Nations agencies have called on countries to take action to protect children from unhealthy food marketing as part of efforts to improve diet and health outcomes (UNICEF, 2018; World Health Organization, 2023), though progress and the scope of policies is variable (Kraak et al., 2016; World Health Organization, 2018). In January 2026 the UK Government implemented restrictions on advertisements for ‘less healthy’ products on television before 9pm and a total restriction on paid-for advertising online, though brand advertising which does not identify a less healthy product is exempt (Harris et al., 2025). It is important to generate robust data of the impact of food marketing to inform the development of stronger policies that can reduce health inequalities.

The objectives of the present study were to (i) quantify the impact of exposure to unhealthy food advertising (vs. non-food advertising) on children's immediate energy intake and intake across the day, and to determine any differences in effect (ii) for brand-only compared with product-based food advertising, (iii) by the advertising format, or (iv) by the child's sociodemographic characteristics or weight status.

2. Methods

2.1. Sample

Two-hundred and forty participants (128 female) aged 7-15 years (Mean = 11.0 ± 2.0) were recruited from nine schools (six primary and three secondary) in Merseyside, UK. School recruitment was conducted by email contact with schools who have participated in previous studies and snowball sampling. Young people in this age range have high levels of exposure to commercial media (Ofcom, 2024) and have previously been identified as requiring protections from food marketing in UK Government policies (Ofcom, 2007). A power calculation was conducted in G*Power using the ANOVA (within * between) interaction. We used a Cohen's f = .15, which is the equivalent of SMD = .30 based on Russell et al. (2018), with 90% power and alpha = .05. We included four groups (advertisement format) and two measures (advertisement condition) as per the design, described in full below. We chose a small correlation between measures ∼.35 as we had limited information, and smaller estimated correlations require larger sample sizes, therefore we aimed to overestimate the sample size to increase robustness, but also to keep our recruitment feasible. This determined a target sample size of n = 212 which we rounded up to 216 to give whole numbers per group (n = 27 per group for 8 groups). However, we sought to recruit up to an additional 20% to account for anticipated attrition and missing data.

Children were deemed eligible to participate if their parent confirmed they did not have (a) any food allergies, intolerances, medical or dietary restrictions, (b) a history of anaphylaxis or eating disorder, or (c) a dislike of any of the test foods to be used in the study. Informed consent from gatekeepers (school head teachers and parents) was established first, parents were informed of the study via school electronic communications (e.g., email or newsletter), which provided a link to an information sheet, consent form, and short sociodemographic survey. Children with parental consent to participate were given the opportunity to discuss the study with the researcher and asked to provide verbal assent if they wished to take part. No individual reimbursements were provided but book vouchers (£50) were issued to participating schools. The study protocol was preregistered on the Open Science Framework (https://osf.io/ypcux/) and approved by the University of Liverpool Central Research Ethics Committee D in October 2022 (ref: 11333). Data were collected between February and October 2024.

2.2. Design

The study was a cross-over randomised controlled trial (RCT) with eight parallel arms for advertisement type varying by advertisement content (brand-only *vs.* product) and format (audio, visual, audiovisual, *vs.* static). See Fig. 1. Participants were randomly allocated to intervention arm and sequence of advertisement condition (food *vs.* non-food) by clusters; specifically, eating groups. Eating groups (12 children per group) refer to the groups of children who participated in the study at the same time and therefore ate together at the snack and lunch sessions. These groups did not pre-exist; they were constituted by school year based on availability at the time of testing. Randomisation was conducted by the lead researcher using www.randomizer.org prior to the first testing session and continued until the required sample size was met. A two-week washout period was imposed between testing sessions to minimise spill over and order effects. Neither participants nor those assessing the outcomes were fully blinded to intervention arm or advertisement condition assignment because of the need to receive or enable the relevant exposures, respectively. However, the true aims of the study were concealed to participants using a cover story.

2.3. Materials and measures

2.3.1. Advertising stimuli and manipulation

Advertisements were obtained from a variety of official sources including social media and company websites. For the purposes of experimental control, the study focused on the *type* of advertising (brand vs product-based) rather than the source of the advertisements. Some of the advertisements required editing using Canva software (i.e., to create a brand-only version by removing product imagery). Video and audio-visual stimuli were saved as.mp4 files and compiled using Corel Video Studio 2022. Audio-only stimuli were comprised of radio and podcast advertisements and were gathered from an existing database (https://database.radiocentre.org/). Where an original radio or postcast advertisement could not be sourced for a particular brand, audio content was extracted from the relevant audiovisual advertisement. Audio-only advertisements were saved as.mp3 files and compiled using Audacity (https://audacityteam.org/). Static stimuli consisted of existing static advertisements or still images taken from the audiovisual media content.

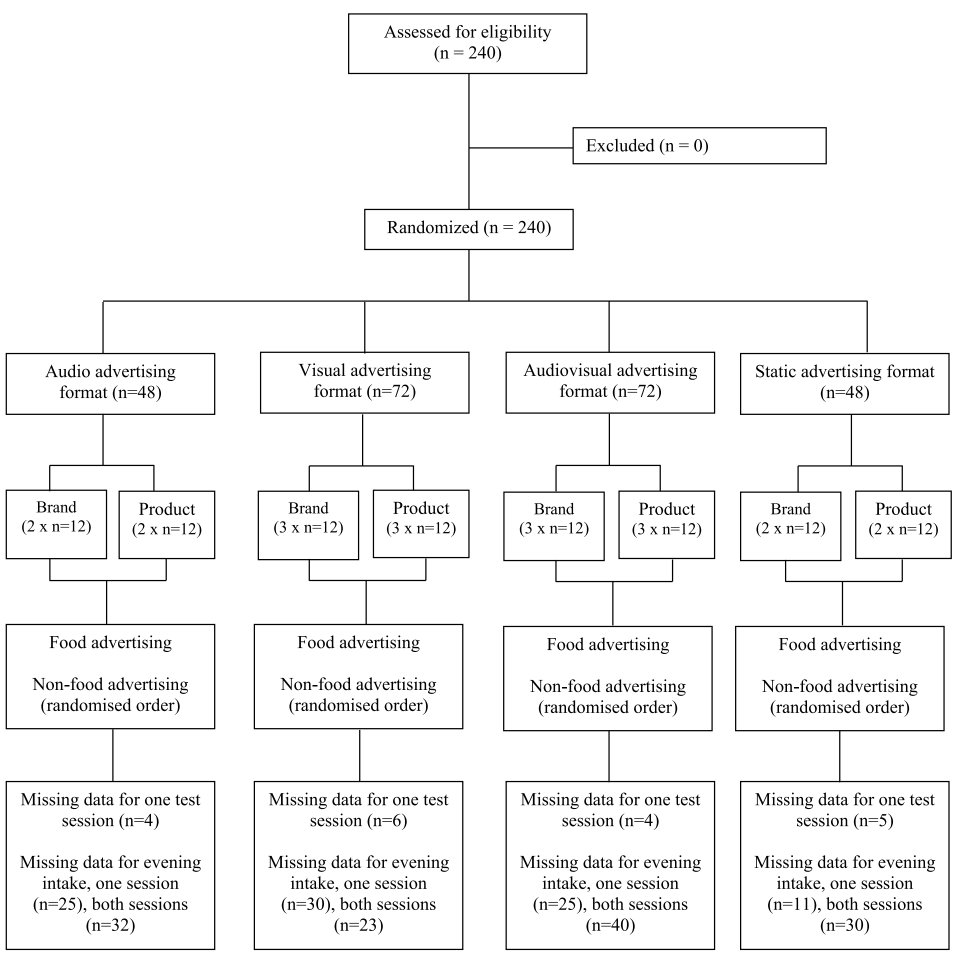

Fig. 1. Consort flowchart and study design.

Advertisements were selected on the basis that they featured brands/products familiar to the UK population and would appeal to children and/or families, based on the creative content of the advertising (e.g., fantasy themes, depictions of family life). For the food advertisements, brands and products deemed to be synonymous with unhealthy foods were used (e.g., fast-food brands). A pilot study (n = 24 child participants, aged 7-15y) was conducted via an online survey in November 2023 to ensure children were familiar with the advertised brands and products, that the brand-only food advertising represented brands synonymous with unhealthy food products, and the audio-only food advertising content was recognisable as food advertising. Advertisements were matched for the brands and, where relevant, products depicted across the media formats.

A complete list of the advertised brands for each condition is provided in Table 1. A brief description of each advertisement is provided in the online supplement.

Audio, visual and audiovisual stimuli were presented to children on an iPad (10th Generation) with headphones, where relevant. Static stimuli were printed on A4 paper, laminated, and presented as physical copies in a bound booklet. Participants were exposed to the same number of advertisements (n = 10) in each condition (unhealthy food and non-food) for a total of 5 min (30 s per advertisement). This is consistent with a meta-analysis revealing the mean advert duration found to trigger a cued consumption effect in children was 4.4 min (Russell et al., 2018). In the static condition children were asked to view each advertisement for 30 s to match exposure duration across conditions.

2.3.2. Sociodemographic characteristics survey

Prior to children taking part in the study, parents were invited to complete an online survey, which gathered data on children's age, gender, ethnicity, and home postcode. Home postcode was used to calculate area-level neighbourhood socioeconomic deprivation for each participant via the 2019 English Index of Multiple Deprivation (IMD) (Ministry of Housing Communities & Local Government, 2019), which is the most recent available indicator for deprivation in the UK. IMD is a multidimensional index that ranks small areas based on their composite features across seven domains: income, employment, health deprivation and disability, education, crime, barriers to housing and services, and living environment. Participants were assigned to deciles ranging from "least deprived" (decile 10) to "most deprived" (decile 1) based on population data.

2.3.3. Awareness of study aims

Participants' awareness of the aims of the study were measured at the end of the study with a brief paper questionnaire that asked, "What do you think the project was about?". Children provided their answers in a free text response box. One participant was coded as having awareness of the study aims and their removal did not influence findings reported below.

Table 1
Brands featured in advertisements (ads) in each condition.

Experimental (Food Ad Condition)	Control (Non-Food Ad Condition)
Burger King	Lego
McDonalds	Dove
Subway	Xbox
Dominos	EE
Kellogg's	Sony PlayStation
Cadburys	Apple
Walkers	Nintendo
Ben and Jerry's	Nike
Coca-Cola	Adidas
KFC	Google

2.3.4. Body Mass Index (BMI)

Participants' height and weight measurements were taken in person at the end of the second testing session to minimise the likelihood of any emphasis on body weight affecting eating behaviour. Weight was measured to the nearest .1 kg using a calibrated weighing scale (Seca 770) and height was measured to the nearest .5 cm using a stadiometer (Leicester Portable Height Measure). BMI was calculated as weight (kg)/height (m)^2 and this was used to classify child weight status (healthy weight, overweight, obesity) based standardised international cut-offs (Cole & Lobstein, 2012).

2.3.5. Foods and objectively measured snack and lunch session caloric intake

To measure *ad libitum* intake (kcal) of snack foods and lunch foods, an individual tray of foods was provided per child at each session. Children were instructed that they could eat as much or as little as they liked of each item on their tray and would be given more of any food item if requested. They were informed that they should not consume foods from trays other than their own. The tray offered six different snack foods (snack session)/lunch foods (lunch session) in six separate coloured dishes and were presented without any packaging or branding information. Details on test foods provided, with weights and nutritional information, are in the online supplement. The weight of food served was such that the quantities in each bowl were visually similar. Test foods were different to the products and brands advertised, to ensure the data captured generic (not brand-specific) advertising exposure effects on intake. Children had 15 min to consume their foods at each session. This approach is consistent with several published studies (Coates et al., 2019a, 2019b; Norman et al., 2018).

Individual intake was quantified by weighing each item pre- and post-intake to the nearest 0.1g (Model BP8100; Sartorius, Epsom, United Kingdom). Data were later converted to kcal using nutrition information from the manufacturer's website.

2.3.6. Parent-reported evening food intake

Following the testing session, participants' parents were asked by email to complete an online measure of their child's intake for the remainder of the day (from after school until the time they went to bed) using Intake24, a validated open-source dietary assessment research tool (https://intake24.co.uk/).

2.4. Procedure

Children were provided with age-appropriate information about the study and asked to provide verbal assent to participate, which was documented by the researcher. Participants took part in the study in groups of 12 during normal school hours within quiet unused classrooms, devoid of any associations with food intake or advertisement exposure. Each session lasted approximately 30 min, with the snack intake session taking place between 10 and 10:30am and the lunchtime intake session between 12 and 12:30pm.

Children were instructed that they would be viewing/listening to a series of advertisements (5 min) and that they should pay close attention because they would later be asked about them in a memory game (cover story). After viewing the advertisements, children were served their tray of six pre-weighed snacks and a bottle of water. Children were asked to wait until everyone had their trays before they could start eating. Afterwards the trays were removed, and children completed the memory game asking non-food related questions about the advertisement content, such as how many flags appeared (data not analysed). Children were then accompanied back to their classrooms and asked to refrain from discussing the study with their peers. All food items were weighed and recorded.

The above procedure was followed for the lunchtime session with the exceptions that children were not exposed to advertisements on this occasion, and that lunch foods were served in place of snack foods. In the afternoon, the lead researcher emailed participants' parents requesting completion of the Intake24 measurement. At the end of their second, and final, testing session, participants' height and weight measurements were recorded in private. Children were verbally debriefed by the researcher after all participating children within the school had completed the study.

2.5. Data reduction and analyses

Data were analysed using linear mixed models (Brown, 2021), using the 'lme4' package in R. The loglikelihood ratio test was used to determine the best fitting model, based on nesting. Random slopes were allowed for eating groups, as it was expected that the advertisement effect would vary by eating group (Gelman & Brown, 2024). The best fitting model for snack calories was a three-level model of individuals nested within eating groups nested within schools (X2(1) = 13.49, p < .001), with a random slope for eating group. A two-level model (participants within eating groups, with a random slope for eating groups) was the best fit for the lunch calories (and combined snack and lunch calories (X2(1) = 13.31, p < .001)). Normality of residuals and linearity were checked using the 'performance' package. Any outliers in intake were identified using boxplots, and sensitivity analyses were conducted with these outliers removed. Findings were robust against outlier removal, as such these outliers were retained in the models to improve generalisability. BMI was converted to age adjusted z-scores based on UK-90 reference data using the 'sitar' package (Cole, 2023). Height and/or weight data was missing for 40 participants. Those with missing height and/or weight data did not significantly differ from those with complete data on demographic variables (age, gender, deprivation), or other covariates (TV exposure, test food liking).

Adjusted models including covariates of z-score BMI (both raw z-scores and normal weight vs overweight/obesity categorisation), age, gender, and socio-economic status were examined, as well as cross-level interactions between advertisements and BMI/deprivation. Given the large number of possible models with the inclusion of covariates and interactions, a more conservative p-value was used for statistical significance for any effect in these models (p < .01). Finally, parent-report data for evening intake was obtained for 135 testing occasions (n = 78 after food ad exposure and n = 57 after control ad exposure). As such we present this information descriptively due a considerable loss of statistical power for any models using this information.

For each outcome we first fit a model with only the main effect of advertisement condition (food vs control), then in a second model we added in advertisement content (brand vs product), and in a third model we removed advertisement content, and included media format (audio vs visual vs audio visual vs static). We also examined adjusted models (including age, socioeconomic status and gender, as well as interactions). For snack and lunch calorie descriptives and contrasts we computed estimated marginal means based on covariate adjusted models using the 'emmeans' package (Lenth, 2025), and the 'eff_size' function to compute effect sizes for the individual contrasts.

Finally, we also included models adjusted for hunger and liking for the snack food and lunch food (reported in online supplement). For each model, the marginal and conditional R2 values were computed using the 'tab_model' function from the sjPlot package (Lüdecke, 2024). Marginal R2 values represent the variance explained by the fixed effects (predictors and covariates) and conditional R2 values represent the total variance explained by the model (fixed effects and random effects). Main effects and interaction plots were created using the 'cat_plot' function from the 'interactions' package (Long, 2024) and 'ggplot2' (Wickham, 2016). Multiple imputation was conducted for missing hierarchical data on our outcomes, using the 'mitml' (Grund et al., 2023) and 'mice' (van Buuren & Groothuis-Oudshoorn, 2011) packages. We imputed 10 data sets. We noted no difference in findings so retain complete case analyses and report multiple imputation analyses in the online supplement, along with summary information on the structure of the confirmatory models described above.

3. Results

The average BMI z-score of participants was .55 (SD = 1.15, min = −2.07, max = 3.43), and 123 children were of healthy weight while 77 were living with overweight or obesity. Summary statistics for key participant characteristics are presented in Table 2 (split by advertisement format in supplement).

Overall, 19 participants missed one or more test sessions due to being: absent from school, engaged in an alternative event at school (e.g. exam, sports competition), or engaged in activities off the school premises (e.g. field trip) at the time of testing.

3.1. Effect of advertisement condition on snack intake

There was a main effect of advertisement condition on snack intake (B = 58.03 [95%CI: 21.99 to 94.11]; p = .002). On average, exposure to food advertisements increased snack intake by 58 kcal compared with exposure to non-food advertisements (Fig. 2 and Table 3). The overall model (both fixed and random effects) predicted 51% of variance (Conditional R^2 = .51).

Including covariates in an adjusted model did not change the significance nor the magnitude of the effect (see Table 4). BMI z-score was a significant predictor (B = 17.00 [95%CI: 2.99 to 31.00]) indicating that increased BMI was associated with increased snack intake. Interactions between advertisement exposure, BMI z-score, and deprivation were non-significant (ps > .415). Removal of outliers did not substantially impact the main effect of advertisement condition (B = 54.12 [95%CI: 17.27 to 90.97], p = .004).

There was no statistically significant interaction between advertisement condition and the advertisement content (brand *vs* product: B = 63.53 [95%CI: −4.79 to 131.86], p = .068). Effect sizes from estimated marginal means (see Table 3) demonstrate that the effect was larger for product vs brand condition, and the confidence intervals for the brand condition overlapped zero. The overall model (both fixed and random effects) predicted approximately 51% of variance (conditional R2 = .51). Including covariates in the model did not change the significance. There was no significant interaction with BMI z-score. There was a significant three-way interaction with deprivation; however, this was not robust to outlier removal (p = .083) and was not explored further.

There were no significant interactions between advertisement condition and advertising format (ps > .519). Effect sizes from estimated marginal means were all small-to-moderate in favour of food advertisements increasing consumption in the audio, audiovisual and visual conditions, but negligible in the static condition (see Table 3). Covariates did not influence the findings, and there were no significant interactions with BMI or deprivation.

Table 2
Participant characteristics for sample and split by brand vs product condition. Values are mean and standard deviation for continuous data and N for categories.

	Overall	Brand	Product
Age (months)	135.07 (28.20)	135.08 (29.23)	135.06 (27.01)
BMI (z-score)	.56 (1.13)	.36 (1.17)	.78 (1.04)
SES (IMD)	4.54 (2.99)	4.05 (2.89)	5.15 (3.01)
TV Weekday	3.82 (2.13)	4.02 (2.13)	3.58 (2.11)
TV Weekend	4.33 (1.88)	4.38 (1.90)	4.28 (1.87)
Commercial TV (VAS)	20.69 (19.66)	18.68 (19.66)	23.11 (23.74)
Internet Weekday	4.44 (2.15)	4.44 (2.12)	4.44 (2.20)
Internet Weekend	5.29 (2.14)	5.23 (2.14)	5.35 (2.14)
Gender (F:M)	128:112	85:47	65:43

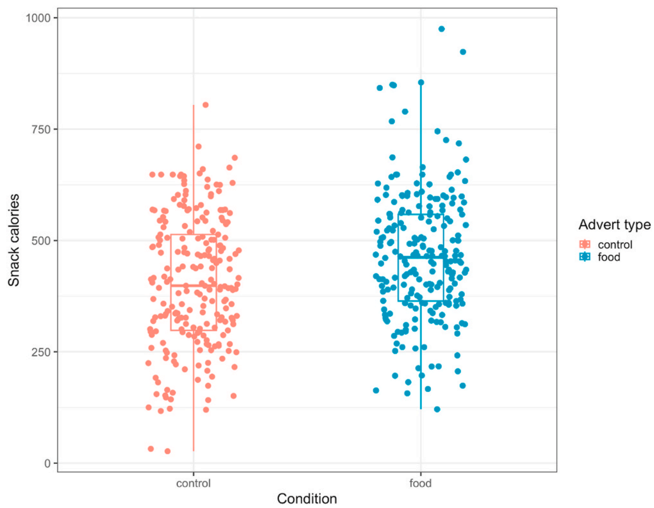

Fig. 2. Main effect and interaction of food advertisement (vs control) on calories from snacking.

Table 3
Estimated marginal means and effect sizes (95% CIs) for contrasts adjusting for covariates for snack food intake.

Contrast	EMM	95% CI	Effect size	95% CI
Brand vs Product				
Control Advert + Brand	418	363 - 473	d = .249	−.127 - .626
Food Advert + Brand	453	403 - 503		
Control Advert + Product	385	324 – 446	d = .599	.186 – 1.012
Food Advert + Product	471	415 – 526		
Media Type				
Control Advert + Audio	399	323 – 475	d = .359	−.212 - .933
Food Advert + Audio	451	383 - 518		
Control Advert + Audiovisual	400	326 – 474	d = .586	.058 – 1.113
Food Advert + Audiovisual	484	417 - 550		
Control Advert + Static	440	354 – 525	d = .098	−.545 - .742
Food Advert + Static	454	379 - 529		
Control Advert + Visual	379	299 – 459	d = .489	−.097 – 1.076
Food Advert + Visual	449	377 - 521		

Legend: EMM = estimated marginal mean; a positive d indicates greater calories consumed in the food advert vs control advert condition for the contrast by brand vs product or media type.

3.2. *Effect of advertisement condition on lunch intake*

There was a main effect of advertisement condition on lunch intake (B = 72.50 [95%CI: 30.01 to 114.99; p = .001; Fig. 3 and Table 5). On average, exposure to food advertisements increased lunch intake by 72 kcal compared with exposure to non-food advertisements.

The overall model (both fixed and random effects) predicted approximately 45% of variance (conditional R2 = .449). Including covariates in an adjusted model did not change the significance (Table 6) nor the magnitude of the effect. BMI z-score was a significant predictor (B = 35.61 [95%CI: 16.90 – 54.31], p < .001) indicating that increased BMI was associated with increased lunch intake. There were no significant interactions with BMI or deprivation. Removal of outliers did not significantly impact the main effect (B = 73.08 [95%CI: 30.77 to 115.39], p < .001).

There was no significant interaction between advertisement condition and advertisement content (brand *vs* product: B = 29.85 [95%CI: −56.61 to 116.30, p = .498). The effect size was larger for product vs brand contrasts, but in both cases the 95% confidence intervals did not overlap zero (see Table 5). The model (both fixed and random effects) predicted approximately 45% of variance (Conditional R2 = .455). Inclusion of covariates did not significantly influence the model (Table 4), and there were no interactions with BMI or deprivation (ps > .304).

There were no significant interactions between advertisement condition and format (ps > .198). Effect sizes for the individual contrasts were all small-to-moderate, except for visual adverts which demonstrated no effect (see Table 5). Covariates did not influence the findings, and there were no significant interactions with deprivation.

Fig. 3. Main effect of food advertisement (vs control) on lunch time calories consumed.

Table 4
Adjusted analysis including age, BMI and gender to main effect of food advertisement (vs control: left panel) and interaction between food advertisement (vs control) and product (vs brand: right panel) on snack intake).

Predictors	Snack kcal			Snack kcal		
	Estimates	CI	p	Estimates	CI	p
Ad condition [food]	**58.39**	**21.75–95.03**	**0.002**	35.67	−12.75 – 84.09	.148
BMI z-score	**17.00**	**2.99–31.00**	**0.017**	**17.19**	**3.06–31.32**	**0.017**
SES 1 10	−1.19	−7.79 – 5.41	.724	−1.07	−7.73 – 5.59	.753
Age in months	.52	−.42 – 1.46	.276	.51	−.46 – 1.47	.303
Gender 1 male [male]	**45.13**	**3.68–86.57**	**0.033**	**44.61**	**2.89–86.33**	**0.036**
Brand Product [product]				−32.79	−96.11 – 30.52	.309
Ad condition [food] × brand product [product]				50.08	−21.73 – 121.90	.171
N	198 $_{participant\_no}$ 20 $_{group\_no}$ 9 $_{school\_1\_9}$			198 $_{participant\_no}$ 20 $_{group\_no}$ 9 $_{school\_1\_9}$		
Observations	396			396		
Marginal R^2/Conditional R^2	.095/.524			.099/.528		

Table 5
Estimated marginal means and effect sizes (95% CIs) for contrasts adjusting for covariates for lunch food intake.

Contrast	EMM	95% CI	Effect size	95% CI
Brand vs Product				
Control Advert + Brand	441	396 - 485	d = .316	.008 - .624
Food Advert + Brand	509	450 - 568		
Control Advert + Product	443	395 – 491	d = .355	.018 – .693
Food Advert + Product	520	456 – 584		
Media Type				
Control Advert + Audio	414	357 – 471	d = .414	.016 - .817
Food Advert + Audio	505	423 - 586		
Control Advert + Audiovisual	432	381 – 483	d = .535	.166 – .905
Food Advert + Audiovisual	549	476 - 623		
Control Advert + Static	482	419 – 545	d = .306	−.152 - .765
Food Advert + Static	549	459 - 640		
Control Advert + Visual	451	392 – 510	d = −.006	−.424 – .412
Food Advert + Visual	450	366 - 533		

Legend: EMM = estimated marginal mean; a positive d indicates greater calories consumed in the food advert vs control advert condition for the contrast by brand vs product or media type.

3.3. Effect of advertisement condition on combined snack and lunch intake

There was a main effect of advertisement condition on combined snack and lunch intake (B = 128.39 [95% CI: 60.78 to 196.03]; p < .001). On average, exposure to food advertisements increased the combined snack and lunch intake by 128.39 kcal compared with exposure to non-food advertisements (Fig. 4). The overall model (both fixed and random effects) predicted approximately 59% of variance (conditional R2 = .587). Including covariates in an adjusted model did not change the significance nor the magnitude of the effect. There were no significant interactions with BMI or deprivation (ps > .161).

There was no significant interaction between advertisement condition and advertisement content (brand *vs* product: B = 95.57 [−36.52 to 227.68], p = .156). The model (both fixed and random effects) predicted approximately 59% of variance (Conditional R2 = .593). Inclusion of covariates or interactions did not influence the effects.

There was no significant interaction between advertisement condition and format (p > .493). Covariates or interactions did not influence the effects.

3.4. Effect of advertisement condition on overall intake across the day

The average energy consumed later in the day after food advertisements was 1334.50 kcal (±492.70), and after the non-food advertisements was 1295.93 kcal (±500.91). As such, from the available data the combined intake (snack + lunch + evening) on the food advertisement day was 2327.14 kcal (±580.94) and on the non-food advertisement day was 2227.56 kcal (±630.85). Descriptively, this is a difference of 99.57 calories (∼ $d = -.22$).

4. Discussion

The current study sought to quantify the impact of unhealthy food advertising exposure, compared to non-food advertising, on children's immediate energy intake and intake across the day. A secondary aim was to determine if any observed effect differed by advertising content (brand vs. product), format (audio, visual, audiovisual, static), or by the child's sociodemographic characteristics or weight status. We found that following exposure to food advertising, children consumed significantly more kilocalories at both the snack (+58.7 kcal) and lunch (+72.9 kcal), and at these eating occasions combined (+129.6 kcal), compared with following non-food advertising. There was no statistically significant difference in effects by the advertisement content, format, participant BMI or deprivation.

4.1. Effect of food advertising exposure on immediate energy intake and intake across the day

The finding that food advertising increased immediate snack intake was consistent with numerous previous studies and meta-analyses (Boyland et al., 2016, 2022a, 2025b; Russell et al., 2018). As with several prior studies, the advertised foods were not offered for consumption, so this is further evidence of a generic stimulatory effect of food advertising on intake. The finding that children also consumed significantly more at lunch in the food advertising condition is consistent with the previous study testing this sustained effect of advertising (Norman et al., 2018). Given the lack of statistical power, the data on evening intake is provided as a descriptive analysis only. However, tentative interpretation of these findings suggest that increases in intake during the day following food advertisement exposure were not compensated for by reduced intake in the evenings. The findings of this study further demonstrate how food advertising could make an substantial contribution to children's dietary energy imbalance, which could lead to weight gain over time (van den Berg et al., 2011).

4.2. Effect of brand-only food advertising exposure on energy intake

This is the first study globally to show that exposure to brand-only food advertising increases children's food intake. Here increased intake after brand-only food advertising was found at the lunch meal but the effect size for brand advertising was not statistically different to that for product-based advertising at either measured eating opportunity. The latter observation may reflect insufficient power (discussed further under limitations) given the effect size of d = .25 is similar to what we

Table 6
Adjusted analysis including age, BMI and gender to main effect of food advertisement (vs control: left panel) and interaction between food advertisement (vs control) and product (vs brand: right panel) on lunch intake.

Predictors	Lunch kcal			Lunch kcal		
	Estimates	CI	p	Estimates	CI	p
Ad condition [food]	**72.56**	**27.93–117.20**	**0.002**	**67.67**	**23.79–111.56**	**0.003**
BMI z-score	**35.61**	**16.90–54.31**	**<0.001**	**36.25**	**17.13–55.36**	**<0.001**
SES 1 10	2.27	−6.22 – 10.76	.599	1.52	−7.24 – 10.27	.734
Age in months	**1.06**	**0.05–2.07**	**0.040**	**1.19**	**0.12–2.26**	**0.030**
Gender 1 male [male]	**106.50**	**59.39–153.61**	**<0.001**	**99.28**	**49.75–148.81**	**<0.001**
Brand Product [product]				2.57	−62.22 – 67.37	.938
Ad condition [food] × brand product [product]				12.34	−52.23 – 76.91	.707
Random Effects						
N	$197_{\text{participant\_no}}$ $20_{\text{group\_no}}$			$197_{\text{participant\_no}}$ $20_{\text{group\_no}}$		
Observations	394			394		
Marginal R^2/Conditional R^2	.184/.454			.183/.393		

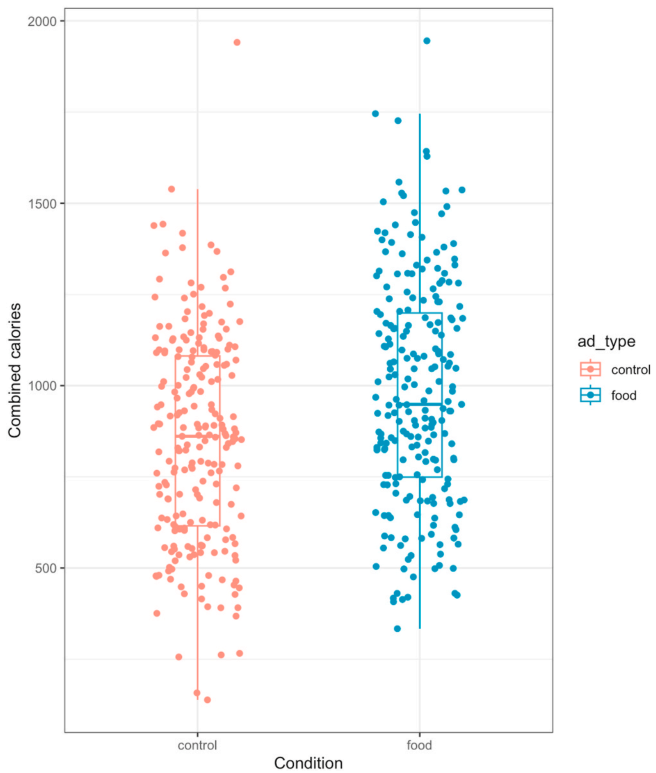

Fig. 4. Main effect of food advertisement (vs control) on combined calories (snack + lunch) consumed.

powered for based on published data, and the confidence intervals are wide. Future studies are warranted to more conclusively determine if such a difference exists.

Our findings have implications for research into the role of associative learning as a mechanism for advertising effect. Foods are a highly branded commodity (Story & French, 2004) and brands are powerful because of the societal, cultural, and ideological meaning and value they hold (Schroeder, 2017). Food marketers repeatedly pair brand imagery with attractive, entertaining and salient stimuli and, in so-doing, create positive emotional responses that transfer to the brand (Keller, 2003; Neyens et al., 2017b). Indeed, in an Australian study children displayed physiological arousal to their favourite food brands (Smith et al., 2019) and brain areas relating to emotional processing (as well as visual processing and sensorimotor activity) show consistent activation in response to food brand exposures in both children and adults (Boyland et al., 2023). Drawing on evaluative conditioning, there is considerable evidence that consistent pairing of brands with positive stimuli (e.g., music, humour, attractive imagery) results in positive brand attitudes and overt preference (Lutchyn & Faber, 2016). The Reactivity to embedded food cues in advertising model (REFCAM) builds on this, hypothesising that consumption experiences of a food brand (for example, at a positive event such as a celebration) influence brand affect and that exposure to marketing for a specific brand would influence consumption of foods generally (Boyland et al., 2024; Folkvord et al., 2016). The findings from the current study provide some support for these hypothesised processes and identify potential lines of inquiry for subsequent research, for example the extent of association that is required to drive behavioural responding to brands and the implications of differential cognitive processing and brand cue integrations for the observed effects.

Previous studies have demonstrated that branding (Boyland, Davies, et al., 2025; Forman et al., 2009; Robinson et al., 2007) and branding elements such as promotional characters (Packer, Russell, et al., 2022) on food packaging affect eating-related outcomes in children such as liking, choice, preference, and may – dependent upon weight status - affect intake (Forman et al., 2009). However, brand advertising is often considered through the marketing funnel model which has three stages (exposure, influence, conversion), and, within this, brand advertising is deemed to be concerned with the upper level of the funnel – exposure and publicity targeting outcomes of increased awareness, salience and loyalty (Ehrenberg et al., 2002) – to maximise the opportunity for conversion (behavioural responding) at later stages (Bite Back, 2025). The results of the current study appear to challenge this interpretation of the model and suggest that brand advertising can indeed elicit immediate consumption, which warrants further empirical testing.

4.3. Effect of food advertising via different formats on energy intake

This is also the first study, to the authors' knowledge, to directly test the impact of food advertising delivered by different advertising formats on children's food intake. We found that the effects were not statistically different across audio, visual, audiovisual, and static advertising formats, despite being processed via different modalities. However, there was some variability in the magnitude of effect sizes for the contrasts (see Tables 3 and 5), with some close to zero (no effect). Three of the advertising formats used in this study (audio, visual, static) relied only on a single form of processing (i.e., auditory or visual processing, respectively) whereas the fourth format (audiovisual) relied on both auditory and visual processing. The use of multiple modalities, relative to a single modality, is thought to enhance the processing of presented media into mental representations (Mayer, 2002), and each modality contributes to the assemblance of meaning from the message by providing context for the other (Grewal et al., 2021). Visual referents are thought to be important in influencing food perception and desire to eat (Koubaa & Eleuch, 2021), and so visual reactions and attention have been implicated in theoretical models of the mechanism of food advertising impact (Folkvord et al., 2016). Similarly, the importance of audio features to advertising effectiveness is known, though not well understood (Barnes & Wang, 2024). Nevertheless, our data do not support the notion that the effectiveness of marketing communications varies across media formats though the lack of significance must be interpreted with caution given the potential for insufficient statistical power. It is clear that the food marketing to which children are exposed is becoming increasingly diverse, as the digital environment and associated technologies support the use of sophisticated algorithms, analytics, artificial intelligence, and graphic design to deliver creative, compelling and personalised commercial messages primarily to mobile devices (Boyland et al., 2024). Specific platforms – such as videogame livestreaming platforms – also facilitate the presentation of multiple marketing elements concurrently (e.g., static display adverts, video adverts) leading to a highly saturated digital environment that may enhance marketing effects (Maksi et al., 2024; Evans et al., 2024). However, this is additional to extensive static and visually dynamic digital food advertising in outdoor spaces (Chung et al., 2022; Finlay et al., 2022) and in sporting contexts (Ireland et al., 2024; Pauzé et al., 2025), continued audiovisual television advertising (Potvin Kent et al., 2023), and industry trends showing increasing investment in podcast (Internet Advertising Bureau, 2024) and radio advertising (Radiocentre, 2025).

4.4. Differences in effect of food advertising on energy intake by sociodemographic characteristics or weight status

In the current study, neither the sociodemographic characteristics of the children nor their body weight moderated the impact of food advertising on their energy intake though again, the study may have had insufficient statistical power to detect such differences. A small number of previous studies have demonstrated that children with heavier weight status have heightened food intake responses to television food advertising (Halford et al., 2008; Russell et al., 2018) though this has not been found consistently (Boyland et al., 2016). Child gender also did not moderate the effect of food marketing on food intake, which is consistent with previous studies – though concerns have been raised about the use of gender constructs in research as being equivalent to biological sex (Castronuovo et al., 2021). However, there is some evidence that for other eating-related outcomes, including food preferences (Chernin, 2008), behavioural intentions (Castonguay & Bakir, 2019), and purchase requests (Kaur & Vohra, 2013; Marquis et al., 2005), boys are more affected by food advertising than girls. The differences in findings for food intake and preference may be explained, in part, by the observation that while food preferences strongly predict food intake in earlier childhood (5-11 years), the predictive power wanes – among girls in particular – during preadolescence (Rollins et al., 2011).

The finding that food marketing impact did not differ based on participant deprivation is consistent with most, but not all, previous studies (Backholer et al., 2021; Kearney et al., 2021). It might be expected that such an effect would be related to the links between deprivation, critical literacy skills, and their psychological correlates (e.g., stress) (Romeo et al., 2022). Related to this, there is some evidence that behavioural responding to food advertising is moderated by nutritional knowledge (Boyland et al., 2015; Tarabashkina et al., 2016), but this effect requires replication and further exploration. The role of literacy in these effects is also brought into question by the finding that age did not moderate food advertising impact in this study. Early theoretical frameworks, that have seemingly influenced the design of many restrictive food advertising policies to focus exclusively on children under 12 years of age (Boyland et al., 2022b), purported that a key aspect of vulnerability to food marketing was young children's limited 'advertising literacy' (i.e., understanding of advertising intent and persuasive tactics) (Harris, Brownell, & Bargh, 2009). More recent evidence suggests that these critical reasoning abilities are not fully developed even during adolescence, and, regardless, are not protective against advertising impact (Packer, Croker, et al., 2022). The current study supports this notion.

4.5. Strengths and limitations

The current study has several strengths that should be acknowledged, including the pre-registered RCT design and the diversity of the sample, such as the participant age range including adolescents which addresses a noted gap in the literature (Truman & Elliott, 2019) and inclusion of participants from highly deprived areas. It is also important to acknowledge the limitations. Neither the participants nor the researchers were fully blind to conditions, which may have introduced bias. Interactions modelled in G*Power are cross-over interactions which typically require less power than other types of interactions (Sommet et al., 2023), as such it is possible that our power analysis was too small to detect different shaped interactions. Due to the need to match stimuli across conditions, not all brand-only advertisements were 'real world' examples, some were created using edited product advertisements. With an opportunity sample, we may not have achieved representativeness for the UK child population. While it is not appropriate to formally test for baseline differences in RCTs (de Boer et al., 2015) and we included BMI in models as an adjustment, we acknowledge that due to chance we did not achieve optimal gender or BMI balance across groups. We cannot rule out other influences on eating behaviour that we did not measure or that children may have compensated for their increased intake later in the day (where this data was not provided by parents) or in subsequent days where we did not capture it, either by reducing food intake or engaging in other compensatory behaviours (e.g., increased physical activity). That we only received data on evening intake for less than a quarter of participants in each condition highlights the limitations and challenges of collecting dietary intake data among free-living populations – including the participant burden, as well as the potential for a lack of accuracy and for the act of reporting to alter usual habits (Magarey et al., 2011).

4.6. Conclusions and implications

This study explored the effect of food advertising on children's energy intake. We contribute to the literature by assessing different advertising content and formats, exploring potential differences in behavioural responding by sociodemographic characteristics and weight status, and by measuring both immediate energy intake and intake across the day. Our findings show that food advertising exposure does impact children's immediate and later energy intake and suggest that this effect does not differ by the other measured factors – though replication in an adequately powered study would be required to draw firmer conclusions. With this replication, our findings could suggest that restricting children's exposure to brand-only food marketing as well as product-based promotions would be evidence-based, as both types of advertisement promote food intake in children. This would present a clear challenge to existing regulatory frameworks, which typically apply nutrient profile models to distinguish which products should and should not be advertised, based on levels of key nutrients (Boyland et al., 2022b). However, an evidence-based method for brand classification was recently developed that governments may find useful (Jordan et al., 2024). Our findings also raise the question of whether advertising restrictions should extend beyond television and digital media, to ensure potential sources of exposure to static food marketing and to audio promotions are also limited, in order to make meaningful reductions in children's overall food marketing exposures. Such restrictions would be aligned with the promotion of children's rights to good health, wellbeing and development, as represented in the UN Convention on the Rights of the Child (UNICEF, 2018).

CRediT authorship contribution statement

Emma Boyland: Writing – review & editing, Writing – original draft, Supervision, Project administration, Conceptualization. **Anna E. Coates:** Writing – review & editing, Supervision, Investigation. **Mark Green:** Writing – review & editing. **Bridget Kelly:** Writing – review & editing. **Simon Russell:** Writing – review & editing, Conceptualization. **Rahul Savani:** Writing – review & editing. **Russell Viner:** Writing – review & editing. **Rebecca Evans:** Writing – review & editing, Investigation. **Beverley Burbridge:** Writing – review & editing. **Andrew Jones:** Writing – review & editing, Formal analysis, Conceptualization.

Ethical statement

The study received ethical approval from the University of Liverpool Central Research Ethics Committee D in October 2022 (ref. 11333) and was pre-registered on the Open Science Framework (https://osf.io/ypcux/, DOI: 10.17605/OSF.IO/YPCUX).

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Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2026.108566.

Data availability

The data and code needed to replicate the analyses are available on the Open Science Framework (https://osf.io/ypcux/, DOI: 10.17605/OSF.IO/YPCUX).

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