LETTERS
https://doi.org/10.1038/s41562-019-0586-6
nature human behaviour

A values-alignment intervention protects adolescents from the effects of food marketing

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Adolescents are exposed to extensive marketing for junk food, which drives overconsumption by creating positive emotional associations with junk food[1–6]. Here we counter this influence with an intervention that frames manipulative food marketing as incompatible with important adolescent values, including social justice and autonomy from adult control. In a preregistered, longitudinal, randomized, controlled field experiment, we show that this framing intervention reduces boys' and girls' implicit positive associations with junk food marketing and substantially improves boys' daily dietary choices in the school cafeteria. Both of these effects were sustained for at least three months. These findings suggest that reframing unhealthy dietary choices as incompatible with important values could be a low-cost, scalable solution to producing lasting, internalized change in adolescents' dietary attitudes and choices.

Unhealthy dietary choices are the leading cause of premature death and disease in the developed world, resulting in five times as many lost years of healthy life as physical inactivity[7,8]. In particular, the ever-increasing rate at which people are consuming 'ultra-palatable' processed foods high in sugar, fat and salt has led to a global obesity pandemic, with devastating human and economic consequences[6,9,10].

Somewhat counterintuitively given the scope of the problem, even a very small improvement in people's dietary habits has the potential to substantially reduce the incidence of diet-related death and disease. For example, a reduction in average energy consumption of as little as 20 kcal per day (less than a 1% change) would not just slow but reverse the growth of the obesity crisis and, within three years, prevent millions of new cases of diabetes, heart disease and cancer in the United States and United Kingdom alone, according to a recent high-profile estimate[10]. However, this is only true if two critical conditions are met: the changes must be sustained and they must be on a population scale[10–14].

Why must changes occur on a population scale? When risk is diffuse across the population, focusing prevention efforts on population-level risk factors ('universal prevention') is expected to have a much greater impact on the incidence of disease and mortality than attempts to identify and protect the specific group of individuals believed to be at greatest risk ('high-risk prevention'). This is because all are exposed to population risk factors and it is impossible to accurately predict which individuals will succumb[13,14]. By reducing the effect of those risk factors at the population level, the universal approach can prevent more cases of disease and death than any other known strategy. This is the logic behind such universal prevention interventions as immunization and seatbelts. The key to universal prevention's effectiveness is scale, not individual-level impact, which tends to be very small, on average[13,14].

To meet the pressing public health need, many investigators have developed and tested universal preventive interventions to encourage healthier diets, typically designed to be administered in schools[15]. Schools provide a unique opportunity to reach entire populations of young people, whose dietary preferences are still developing. Within the school-age years, adolescence may be a particularly opportune time at which to target interventions; this stage of life is increasingly recognized as an inflection point during which well-designed interventions have disproportionate potential to redirect a person's developmental trajectory in lasting ways[16,17]. However, to date, despite intense scientific effort, research has not identified a cost-feasible approach with clear potential to produce lasting, self-sustaining change in dietary preferences on a population scale[15,18]. For this and related reasons, some experts have become pessimistic about classroom-based obesity interventions[15,19].

We suggest that this pessimism about past interventions is warranted but misdirected. The problem is not with classroom-based universal prevention interventions per se. Rather, the traditional approach to such interventions, which typically involve teaching about nutrition and the importance of healthy choices in determining future health[15], is critically flawed: distant outcomes such as future health are known to have little motivational force—especially when pitted against the tempting appeal of unhealthy food[20]. Moreover, a focus on future health does nothing to counter the effect of the strong positive marketing messages about junk food that pervade children's and adolescents' daily lives. From a very young age, children are exposed to a relentless barrage of food industry marketing designed with the clear purpose of reinforcing strong positive associations with junk food in children's minds, to drive increased consumption. This includes not only advertising but also deliberately formulating junk food to be maximally rewarding, and strategically positioning it in stores to be difficult to resist[1–5]. This marketing is effective: leading experts have cited it as the single population risk factor most responsible for increasingly unhealthy diets[3–6].

In contrast with the traditional approach, we test a 'values-alignment' intervention aimed directly at neutralizing the positive emotional associations with junk food that marketing engenders, and portraying the rejection of unhealthy foods in favour of healthy alternatives as a way to live up to the values participants already care about deeply. The intervention seeks to do this by reframing food marketing and the eating of junk food as inconsistent with adolescent values—specifically: (1) the desire to be autonomous from adult control; and (2) the desire for social justice. Both of these values have been shown to be of heightened importance during the adolescent period[21–26].

The question of whether and how it is possible to change entrenched implicit associations (such as those created by food marketing) has been a major focus of leading researchers in the field of

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Table 1 | Representative excerpts of content from materials administered during session 1 of the exposé and control interventions

Exposé intervention	Control intervention
"Unhealthy foods—ones loaded with sugar, fat and salt—are more addictive than they've ever been, and companies are spending lots of money to find ways to make them even more addictive every day."	"Just like a car, our bodies need fuel in order to keep running, and nutrients are just like fuel for our bodies. We need nutrients to give us the energy to work, play and help our bodily systems stay in shape. Without proper fuel, a car will break down and so will our bodies."
"The most unfair part is that addictive, unhealthy foods hurt children and poor people the most—the people who have the least ability to defend themselves."	"It's important to check [the] nutrition labels on the foods we eat so we can make sure it's healthy before we put it into our bodies."
"They hire scientists to figure out the brain's blind spots. Then, they invent foods that trick the brain into craving more and more sugar and fat, whether you're hungry or not."	"…[T]oo much salt can lead to problems with increased blood pressure and cardiovascular disease. Processed foods like potato chips and cookies usually contain a lot of sodium, which is bad news!"
"You can kick the junk food habit mostly by staying away from these foods. If you avoid them in the store, and don't keep them in your home, you take away the food companies' power to keep sucking you in."	"The best plan is to keep eating a variety of healthy foods like fruits, vegetables and nuts, and stay active to keep your body healthy and strong."

See Methods for additional details.

social cognition for more than a decade[27–30]. Until now, an intervention that reliably produces any lasting change in these associations has not been discovered[27], but the approach we take here differs from most previous approaches. By altering adolescents' construal of junk food advertisements, the exposé intervention was designed to lessen the appeal of the environmental stimuli that support the existing problematic associations, making them easier to change[28,31].

To reframe food marketing and unhealthy dietary choices as inconsistent with adolescent values, our intervention provided an exposé of manipulative food marketing practices, perpetrated by self-interested adults and aimed at pushing adolescents and other vulnerable groups to buy and consume junk food[1,2]. It emphasized the social justice implications of the food companies' disproportionate targeting of vulnerable populations, including children and the poor, with their marketing for the unhealthiest foods[1–3,32]. The purpose of this framing was to portray the rejection of unhealthy foods in favour of healthier options as a way to reassert one's autonomy from adult control and to take a symbolic stand against the injustice perpetrated by food marketers.

Our past research provided support for the basic elements of our theoretical premise. We found that teaching adolescents about manipulative food marketing and its social justice implications caused them to view healthy dietary choices as consistent with widely shared adolescent values and, as a result, to make significantly healthier snack and drink choices, one day post-treatment, in what they believed was an unrelated situation[17]. Although these results were encouraging, they left the big question unanswered: can a values-alignment intervention that is brief and inexpensive enough to be implemented on a population scale produce sustained change in attitudes and dietary choices? Values alignment is expected to be more effective at producing sustained change in attitudes and choices than other approaches because it connects food marketing and dietary choices with stable values that are important to participants.

In a double-blind, longitudinal, preregistered field experiment, we tested whether a values-alignment intervention can produce enduring changes in: (1) adolescents' implicit affective associations with junk food marketing; and (2) adolescents' dietary choices as measured by their purchases in the school cafeteria for the rest of the school year (three months). Students in the eighth grade at a rural/suburban Texas middle school ($N=362$) were randomly assigned, at the individual level, to either the exposé intervention or an active placebo control intervention (see Supplementary Note 1 for details on the preregistered analysis plan). Both interventions were designed to be efficient—they were administered over two classroom sessions on consecutive days—to be compatible with the ultimate goal of universal prevention, which requires that an intervention be brief and inexpensive enough that it could plausibly be administered on a population scale.

The exposé (that is, values-aligned) intervention taught participants about deceptive food marketing and its social justice consequences (see Table 1). To reinforce the negative construal of food marketing, and in particular the junk food advertisements adolescents are exposed to in their daily lives, participants in the exposé condition completed an activity called 'Make it True.' In this activity, participants were shown images of food advertisements on tablet computers that allowed them to draw or write over the images. Instructions encouraged them to make changes (for example, cross out and replace words) that would make the advertisement 'true' (that is, no longer deceptive; see Fig. 1). The Make it True exercise was designed to evoke the subversive adolescent thrill of using graffiti to express rebellious opposition to adult-imposed injustice.

The placebo control intervention was based on existing middle school health curricula and the US government's healthy eating website. As with many past interventions, it taught participants about nutrition and the importance of a healthy diet for ensuring one's future health (see Table 1). In the second session, participants in the control condition completed an interactive activity that had been professionally developed as part of an existing nationwide health campaign, in which participants played a game designed to teach them how much of different types of physical activity it takes to work off the calories from various foods. The activity was introduced to participants with the title 'make it fun.'

All reported P values refer to two-sided tests, and all reported standardized mean differences (SMDs) are the treatment effect, using the unstandardized metric, divided by the control group's standard deviation, which is considered the most appropriate effect size index for intervention experiments[33]. Replicating the findings of our past research[17], the exposé intervention significantly increased the extent to which participants construed healthy eating as aligned with the adolescent values of autonomy from adult control and social justice relative to the control intervention ($M_{\text{exposé}}=3.52$; s.d.$=0.88$; $M_{\text{control}}=2.55$; s.d.$=0.86$; $t(338)=10.23$; $P<0.001$; SMD$=1.13$; 95% confidence interval of the SMD (CI_{SMD}): 0.90 to 1.33). Supporting our theoretical premise that this change in construal constituted a realignment of healthy dietary choices with widely shared adolescent values, the exposé intervention also increased the perceived social status appeal of

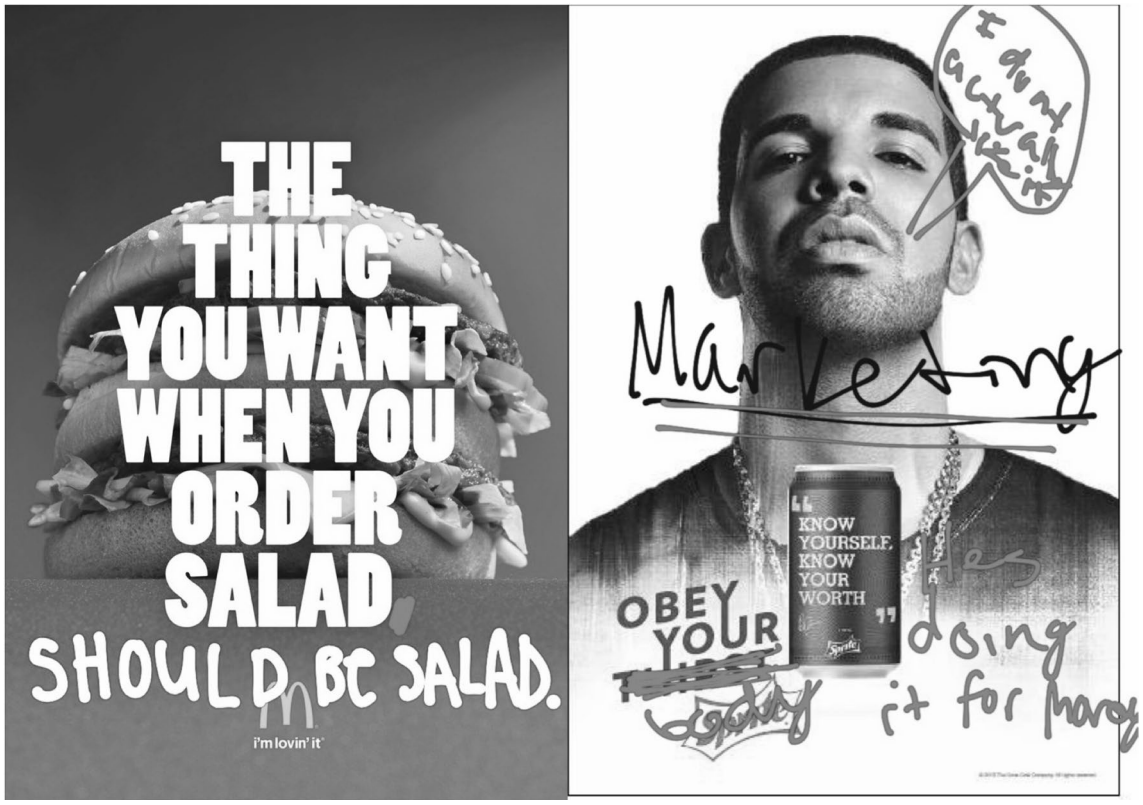

Fig. 1 | Examples of modifications to junk food advertisements produced by exposé intervention participants during the Make it True exercise administered in session 2 of the exposé intervention. In the image on the right, the speech bubble says "I do not actually like it"; the text below Drake's face says "Marketing"; and the text in the bottom, right corner says "Hes [sic] doing it for money". In the bottom, left corner, the student crossed out the word "thirst" and wrote in the word "body". These images are adaptations of what participants produced. The original images were in colour.

healthy choices ($M_{\text{exposé}} = 3.49$; s.d. = 0.87; $M_{\text{control}} = 3.04$; s.d. = 0.93; $t(339) = 4.66$; $P < 0.001$; SMD = 0.49; 95% CI_{SMD}: 0.28 to 0.70), and this effect was statistically mediated by the increased construal of such dietary choices as autonomy- and social-justice-oriented behaviour ($b_{\text{indirect effect}} = 0.64$; $P < 0.001$; 95% $CI_{\text{indirect effect}}$: 0.53 to 0.76), with 100 bootstrapped samples (see Supplementary Results 1 for details). These status appeal results all replicate findings of our previous research[17]. Also replicating our past research[17], the exposé intervention significantly increased participants' self-reported level of anger in response to images of junk food advertisements they were shown immediately after the intervention ($M_{\text{exposé}} = 2.28$; s.d. = 1.16; $M_{\text{control}} = 1.34$; s.d. = 0.85; $t(303) = 8.00$; $P < 0.001$; SMD = 1.09; 95% CI_{SMD}: 0.82 to 1.37), and significantly reduced their self-reported desire to consume the products depicted in those advertisements ($M_{\text{exposé}} = 2.45$; s.d. = 1.29; $M_{\text{control}} = 2.87$; s.d. = 1.33; $t(304) = -2.85$; $P = 0.005$; SMD = 0.32; 95% CI_{SMD}: 0.10 to 0.55) (see Supplementary Fig. 1).

We measured participants' affective associations with junk food advertisements using the affect misattribution procedure (AMP)—a validated and widely used measure of implicit affective associations in which participants indicate whether an unfamiliar and affectively neutral character feels pleasant or unpleasant to them after a very brief (75 ms) exposure to images of the true target of measurement[34,35]. We also used the AMP to measure affective associations with healthy foods, both to serve as a contrast category with the junk food advertisements and to test the possibility that the exposé intervention would also increase positive associations with those foods. We administered the AMP two weeks postintervention, and again three months postintervention, immediately before the end of the school year. Note that we also administered the AMP immediately postintervention, during the second classroom session, but a problem with the school Wi-Fi connection caused most of those data not to be saved. The 57 participants whose data were saved showed marginally significant evidence of the same condition effect (see Supplementary Results 1).

Compared with the control intervention, across the two measurement points, the exposé intervention caused participants' implicit affective reactions to junk food advertisements to become significantly more negative ($b = -0.068$; s.e. = 0.026; $t(348.729) = -2.65$; $P = 0.009$; SMD = 0.26; 95% CI_{SMD}: 0.06 to 0.45) and their implicit affective reactions to healthy food to become significantly more positive ($b = 0.047$; s.d. = 0.021; $t(347.112) = 2.283$; $P = 0.023$; SMD = 0.20; 95% CI_{SMD}: 0.02 to 0.38) (see Fig. 2, Supplementary Results 1, and Supplementary Table 1). There was no significant evidence that these effects weakened over that period—that is, neither of those effects interacted significantly with variables representing the time of assessment (see Supplementary Table 1).

The second key outcome was participants' choices of snacks and drinks in the school cafeteria. The cafeteria uses an electronic debit system, linked to students' school ID cards, to charge students for food purchases. The school provided us with the complete purchase records for the academic year for every participant in the study. The cafeteria's accounting system differentiates among the snacks and drinks on offer and the options for both include healthy items (for example, fruit, milk and water) and unhealthy items (for example, chips, cookies and sugary juice). Cafeteria staff were blind to the intervention content and to students' condition assignments, and the purchase records are not subject to bias due to non-response or misreporting. Using these cafeteria purchase data, we compared the changes in purchases, from before to after the interventions were

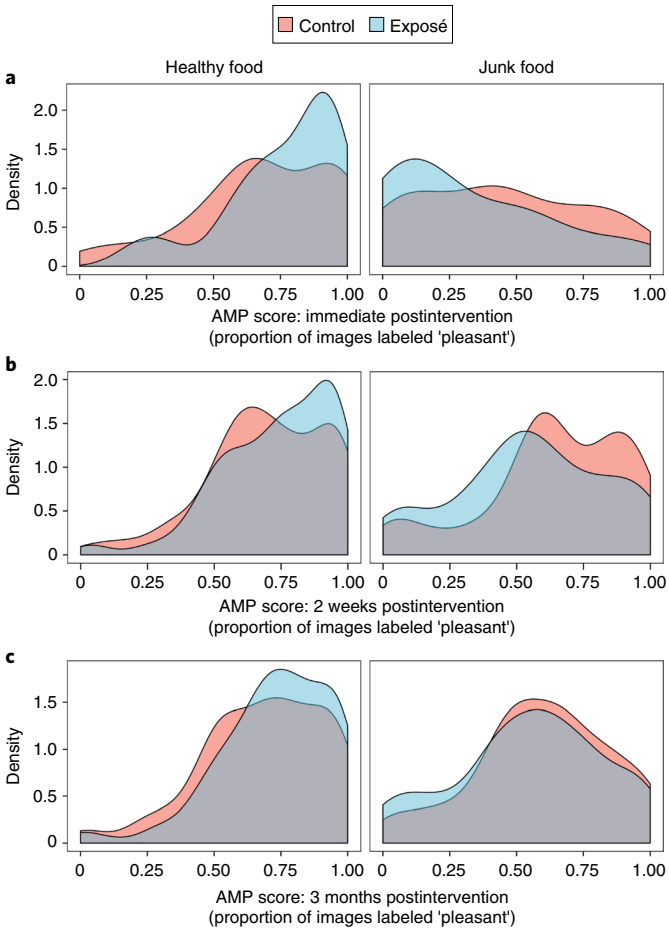

Fig. 2 | Distributions of participants' responses to junk food marketing and healthy food images following intervention. Responses to healthy food images are shown on the left, and responses to junk food marketing are shown on the right. **a**–**c**, The AMP was used to measure responses on day 2 of the intervention (**a**), at two-week follow-up (**b**) and at three-month follow-up (**c**). Values represent the proportion of images labelled 'pleasant'.

administered, among those in the exposé and control intervention groups (see Methods and Supplementary Results 1). Compared with participants in the control condition, those in the exposé condition made significantly healthier snack and drink purchases in the remaining three months of the school year after the intervention was administered than they did in the roughly 6.5 months before. This change was evident whether we looked at effects on healthy purchases or unhealthy purchases (healthy purchases: $b_{\text{time}\times\text{condition}} = 0.002$; s.e. = 0.001; $t = 2.06$; $P = 0.039$; odds ratio (OR) = 1.49; 95% CI: 1.02 to 1.97; unhealthy purchases: $b_{\text{time}\times\text{condition}} = -0.012$; s.e. = 0.005; $t = 2.21$; $P = 0.027$; OR = 0.92; 95% CI: 0.85 to 0.99) (see Supplementary Table 2 and Supplementary Results 2).

Exploratory analysis revealed that the above-reported effects of the exposé intervention on cafeteria snack and drink purchases were driven entirely by changes in boys' purchases (healthy purchases: $b_{\text{time}\times\text{condition}\times\text{gender}} = -0.011$; s.e. = 0.003; $t = -4.476$; $P < 0.001$; $\text{OR}_{\text{boys,healthy}} = 2.16$; 95% CI: 1.66 to 2.67; $\text{OR}_{\text{girls,healthy}} = 0.92$; 95% CI: 0 to 3.2; unhealthy purchases: $b_{\text{time}\times\text{condition}\times\text{gender}} = 0.062$; s.d. = 0.011; $t = 5.603$; $P < 0.001$; $\text{OR}_{\text{boys,unhealthy}} = 0.74$; 95% CI: 0.66 to 0.83; $\text{OR}_{\text{girls,unhealthy}} = 1.14$; 95% CI: 1.02 to 1.26) (see Supplementary Results 1 and Supplementary Table 3). In pre- versus postintervention comparisons, the health profile of girls' purchases actually improved slightly (and, in some tests, significantly) more following the control intervention than following the exposé intervention (see Supplementary Table 3). The relative advantage of the control intervention for girls, although significant in some tests, was much smaller than (that is, 32% the size of) the relative advantage of the exposé intervention for boys. Among boys, the exposé intervention caused a 31% reduction in daily purchases of unhealthy snacks and drinks (for example, sugary drinks, chips and cookies) and a 35% overall improvement in the health profile of their daily snack and drink purchases in the three months postintervention, relative to participants in the control condition (see Supplementary Results 2 for details). The moderation of the intervention's effect on cafeteria purchases by gender appears highly robust. That is, the relatively large sample and very low *P* values for the interactions with gender suggest that the moderation by gender is unlikely to be a spurious finding (see Supplementary Results 2 for an additional check of the robustness of the gender moderation finding).

Importantly, boys' and girls' psychological responses to the intervention (including values-aligned construal of healthy eating, explicit emotional reactions to junk food marketing, and implicit affective associations) were the same—all of these effects were in the same direction and of similar size for boys and girls (all gender interaction *P* values > 0.05; see Supplementary Table 5). We suggest that the gender moderation of the cafeteria purchase effects is probably driven by increased behavioural responsiveness among girls to the bodyweight implications of the control intervention, which was composed almost exclusively of content generated by professional public health and communications experts that is currently being employed on a national scale with the purpose of improving adolescent health decisions. For girls, an emphasis on calories, for example, might trigger sociocultural pressures to be thin, which are much greater for them than they are for boys[36].

Indeed, for many adolescent girls, being thin might be a more important value than autonomy and social justice. So, although girls' psychological responses to the exposé intervention are identical to those of boys, their food choices might be driven more strongly by a concern with the effects of their diets on their physical appearance. It is also important to remember that the finding of a slight relative advantage of the control intervention in improving the health profile of girls' food choices does not imply that the exposé intervention was ineffective for that purpose. Thus, future research should investigate whether the exposé intervention, by avoiding the traditional emphasis on cues related to bodyweight, can achieve similar health results with fewer negative psychological side effects for girls.

Each of the two major findings of this experiment—enduring change in boys' and girls' implicit affective reactions to junk food marketing messages and in boys' daily real-life dietary choices, over three months—represents an important scientific advance in its own right. We do not believe it is a coincidence that these advances were achieved together. Rather, our theory of long-term behaviour change was predicated on being able to undermine the positive affective associations with junk food that are created and maintained by food marketing. Indeed, by explicitly linking our exposé message with the junk food advertisements adolescents are continually exposed to, the Make it True exercise may even have allowed us to co-opt the ubiquity of such advertisements to serve as continual reminders of our exposé message. A test of this hypothesis would require accurate data on adolescents' levels of exposure to food marketing. Examining this should be a high priority for future research.

The finding that this intervention's effect on dietary choices appears to have been specific to boys is notable in light of the fact that past interventions, to the extent they have had any effect, have only worked for girls. The meta-analytical effect of past behavioural interventions—including expensive and involved ones—on boys has repeatedly been found to be indistinguishable from zero[15,18]. (Note that this is consistent with indications in the present experiment

that the control intervention, which mimicked the traditional intervention approach, seems to have been at least somewhat effective for changing girls' behaviour.) The discovery of an effective method for influencing the dietary preferences of boys is, itself, a significant advance with important public health implications.

Although the improvements the exposé intervention produced in boys' daily snack and drink choices in the school cafeteria are substantial, one might question whether they extended to contexts beyond the cafeteria. For example, did the changes in dietary choices extend to contexts in which opposing forces might have been present (for example, parents' control of what is available to eat at home, or pressure from untreated peers outside school)? It is possible that they did not, but this would not diminish the theoretical importance of our finding. The data make clear that, even if there were countervailing forces at work in other contexts, the intervention's effect on participants' internalized preferences was strong enough to withstand them. Boys continued to make healthier selections in the cafeteria, even in the face of any such outside influences, for the full three months of the school year that remained after the intervention was complete.

The effects of the exposé intervention in this study are particularly striking given that, for reasons of methodological rigour, we opted to use individual-level random assignment. This meant that the intervention protocol could not include any group discussion, social media campaigns or other features that might have fostered a 'social movement' within the school. An intervention that deliberately taps into socially shared values would be expected to have even stronger and longer-lasting effects if it had an overtly collective social dimension. The present results underscore the need for large-scale trials using classroom- or school-level randomized designs that could test these theoretical predictions directly.

More broadly, these findings constitute a major advance in the science of behaviour change, showing how a values-alignment approach can lead to scalable interventions that successfully change behaviour in domains where traditional approaches have been unsuccessful. Values alignment is expected to be particularly effective in domains where, despite understanding the importance of responsible choices, people regularly face temptation to make irresponsible ones (for example, with regard to distracted driving or environmental conservation). In light of the present findings, the current dominant focus on long-term self-interest as a way to motivate behaviour change should be carefully re-evaluated[24]. Rather than urging people to prioritize their long-term material interest over short-term temptations, policymakers and programme designers might consider what other goals or values already feel important and immediate to the relevant population, and whether behavioural appeals can be framed to harness this existing source of motivation. Because values alignment creates change by fostering internalized motivation, it may be particularly useful when, as with diet, regulatory solutions to behaviour problems (for example, strong legal restrictions on food marketing) face political opposition or are impractical. For the same reason, values alignment might also be an especially useful approach when contextual 'nudges'[37] cannot offer a comprehensive solution because behavioural decisions are repeated and occur in a wide range of different contexts.

We caution that this research does not imply that the specific exposé approach employed in this research will be effective in all situations—or even in all adolescent school contexts. As with any psychologically sophisticated behavioural intervention, the details should be tailored to the nuances of the context and population in question[38,39]. However, these findings do suggest the urgent need for a major new scientific initiative to explore the potential of values-alignment approaches to 'move the needle' on the large number of personal behaviours that contribute to some of society's most persistent problems.

Methods

The institutional review board at the University of Chicago approved the study. This experiment was conducted as a programme evaluation carried out at the request of the participating school district. Parents were informed of the programme evaluation in advance and given the opportunity to withdraw their children from the study. Informed student assent was obtained from all participants.

Participants. All students attending the eighth grade at a middle school serving families living in rural and suburban areas were invited to participate in the study, and 362 of them did (85.6% of registered eighth-grade students). This sampling plan was determined in advance and included in the preregistered analysis plan (available at https://osf.io/7krnt/) to make clear that the sample size decision was not influenced in any way by its implications for experimental results. There were 400 students enroled in the eighth grade at the start of the school year. By that count, our sample comprised 90.1% of enrolled students. By the end of the year, however, enrolment in the eighth grade was 423 students. Since we do not know how many of the additional 23 students began before the start of our study, we make the conservative assumption and report the participation rate based on a denominator of 423 students. The participants ranged in age from 13–15 years (44% were 13 years old, 52% were 14 years old, and 4% were 15 years old). They were 51% white, 44% Latinx, and 5% black/African-American or of mixed race. A total of 38% were officially designated as economically disadvantaged based on their family's income.

Procedure. Participants and teachers were fully blinded to the goals of the study and the condition assignments (that is, the study was not described to participants or teachers as an experiment with different conditions that would be compared, but rather as an opportunity for the researchers to obtain feedback from students about various sets of draft material for use in future eighth-grade health classes). The researchers who facilitated data collection were also kept blind to experimental condition.

Participants were randomly assigned at the individual level, automatically on logging into Qualtrics software, to either the exposé ($n=184$) or placebo control ($n=178$) condition. Both interventions were administered on 2 consecutive school days during a single 50-min class period each day.

Overview of manipulation and survey. The first experimental session in both conditions involved a brief, condition-specific, narrated informational reading exercise (completed using laptop computers with disposable earphones), followed by a condition-specific paper-and-pencil writing exercise. Paper materials were distributed in coded envelopes to preserve researchers' blindness to the conditions. The randomized Qualtrics program was linked to the envelope codes to allow research assistants to provide condition-appropriate envelopes to each participant without learning participants' condition assignments. Participants then completed a survey of psychological process variables, completed on paper; these were identical across conditions (see the section 'Summary of measurement time points', below). Students completed all activities privately and quietly at their desks. Research assistants, who were blind to the students' experimental condition assignment, introduced the activity as an opportunity to provide feedback on novel curricula for schools. Assistants, working with teachers, maintained a quiet and focused atmosphere until all students had completed the activities. All manipulated content was delivered either in written materials or via audio using earphones (or both) so that participants in different conditions could participate in the same classroom.

In session 2 (the experimental session), both conditions consisted of a brief (five-minute), condition-specific video summary of the previous day's content (viewed on laptop computers with disposable earphones), a short survey of explicit attitudes about junk food marketing (identical across conditions), a condition-specific game-like interactive activity completed on a tablet computer, and finally an implicit associations measurement task, which was identical across conditions and completed on a tablet computer.

All intervention materials were developed through an iterative process of prototyping and piloting to ensure the material was clear, evocative and age appropriate.

Exposé treatment. *Session 1.* The narrated informational reading exercise in the exposé intervention described recent journalistic works exposing the deceptive and manipulative marketing practices of food companies and the harmful effects of these practices on society, with a particular emphasis on harm to young children and the poor. For example, the exposé described how companies invest millions of dollars in scientific research with the explicit goal of maximizing its addictiveness (or 'craveability'), using deceptive labels and product names to create the perception that unhealthy products are healthy, and disproportionately targeting very young children and the poor with marketing of unhealthy products. To activate adolescents' desire to assert autonomy from adults and tap into the stereotype of the controlling, hypocritical adult, the article included pictures of four specific food industry executives or consultants (all white, middle-aged men in business attire) and described their hypocritical behaviour (for example,

"[Name] is a former tobacco executive who oversaw Kraft. He calls himself 'a bit of a fitness freak'. So, he avoids the sweet drinks and fatty snacks that his company sells."). Finally, the informational reading exercise included a series of quotes that contributed to the perception of widespread outrage and suggested how that outrage could be channelled to take a stand against the injustice perpetrated by food companies by eating less unhealthy—and more healthy—food.

To increase the likelihood that participants would internalize this information, this informational exercise was followed by a reading and writing exercise that incorporated two techniques that have become standard practice in psychological interventions[40]. First, to create the perception of a descriptive norm in support of the treatment message[41], participants read a brief report from an ostensible survey of older students in their own school district, conducted in an earlier year, that suggested that most such students felt outraged about food company practices and planned to change their behaviour in response to having learned about it (for example, "…**almost all** ninth graders said they planned to **fight back** against the companies by **buying and eating less processed food**." [bold in original]). Second, students were asked to write a short statement explaining why other students like them were outraged and how they might fight back against the companies—a so-called 'saying is believing' exercise[40,42].

Session 2. The second classroom session, held on the following day, began with a five-minute video that provided an overview of how junk food companies unjustly target children. Next, participants were shown images of real junk food advertisements along with real quotes from morally outraged ninth-grade students (the previous year's eighth graders)—edited for clarity and concision—that described how they intended to fight back by not purchasing junk food. Students were then asked to write a short statement representing what they would tell a younger child about the advertisements.

Next, to reinforce this new values-aligned construal of food marketing, participants completed an interactive activity, called Make it True. They were shown images of food advertisements on tablet computers in a software program that allowed them to draw or write over the images. They were instructed to make whatever changes (for example, cross out and replace words) they thought were needed to make the advertisement 'true' (that is, no longer deceptive; see Fig. 1). This exercise intentionally simulated the subversive adolescent thrill of using graffiti to express rebellious opposition to adult-imposed injustice and thus to reinforce the association in participants' minds between healthy diets and the powerful symbolic reward that comes from living up to the important values they share with their peers.

Traditional health education (active placebo control). The control activities were designed to mimic the current standard approach to health and nutrition education and behaviour change in this population, almost exclusively using content and communication approaches designed by relevant experts and currently in use on a national scale (for example, textbooks, government educational websites, and national non-governmental health education and behaviour change programmes).

Session 1. The narrated informational reading exercise in the control intervention was based directly on published eighth-grade health textbooks and conveyed information about how the body processes foods, and how this relates to weight and health in general. It included colourful, appealing pictures of healthy foods, informative tips about reading nutrition labels, and specific recommendations for eating a healthy and balanced diet. Finally, the informational reading exercise included a series of purported quotes from adults (for example, parents and health educators) expressing praise for the material and encouraging students to read and follow the recommendations.

Next, participants were asked to write essays explaining why it is important to make healthy eating choices. They were also asked to describe some active steps that they might take in order to follow the advice of the article and of the adults who endorsed it. Hence, like the exposé treatment, it involved active interaction with the messages, as well as elements of psychological intervention[40].

Session 2. The second classroom session began with a five-minute video that detailed how to use the federal government's MyPlate guidelines to make healthy food choices. Participants then completed an interactive tablet-computer-based activity, developed by an academic laboratory with specific expertise in media and communication as part of a national foundation-funded programme to encourage young people to adopt healthy lifestyles. Called 'Make it Fun' (to roughly match the name of the corresponding activity in the exposé condition), it invited participants to spin a virtual (Wheel-of-Fortune-style) wheel to learn how much physical activity it takes to work off the calories from various foods. An instructional packet encouraged participants to think about how long they would need to spend doing their favourite activity to burn off calories from their favourite foods.

In summary, the active placebo control was substantially more informative about the science of health and nutrition, and provided more self-interest-based reasons why it is important to eat healthily than the exposé intervention did. It also included explicit appeals to drink water, avoid food high in salt, fat and sugar, eat fruit, and make other healthy dietary choices. For these reasons, it was a strong active placebo control and allowed for a conservative test.

Measures. *Self-reports.* Six survey items, presented in a single randomly determined order, assessed the three focal constructs outlined below.

Alignment of healthy eating with adolescent values (Session 1). Four items assessed adolescents' construal of healthy eating as addressing social justice concerns. These were: "When I eat healthy, I'm doing my part to protect kids who are being controlled by food companies"; "When I choose to eat healthy, I'm helping to make the world a better place"; "By not buying products from junk food companies, I'm helping others in need"; and "What I choose to eat makes a difference to others". Participants responded to each item using a five-point scale (1 = not at all true; 2 = slightly true; 3 = somewhat true; 4 = very true; 5 = extremely true).

Next, three items assessed individuals' construal of healthy eating as independent and autonomy-assertive behaviour. These were "Eating healthy is a way to stand up to people who are trying to control us"; "Eating healthy is a way to be independent"; and "When I eat healthy, I really feel like I'm taking control of my food choices". Participants responded to each item using a five-point scale (1 = not at all true; 2 = slightly true; 3 = somewhat true; 4 = very true; 5 = extremely true).

The items assessing values-aligned construals of healthy eating were averaged into a single index. The results are substantively identical when the autonomy items are averaged into one index and the social justice items are averaged into another index (see Supplementary Results 1).

Social status appeal of healthy eating (Session 1). Three items assessed the social status appeal of healthy eating: "I like the idea of being a healthy eater"; "I respect healthy eaters more than unhealthy eaters"; and "I want to think of myself as a healthy eater". Participants responded to each item using a five-point scale (1 = not at all like me; 2 = slightly like me; 3 = somewhat like me; 4 = very like me; 5 = extremely like me). These items were averaged into a single social status appeal index.

Explicit marketing attitudes (Session 2). Explicit attitudes towards unhealthy food marketing were measured by showing participants two junk food advertisements (one for a Gatorade sports drink and one for Cheetos-brand corn puffs). Participants were asked to rate the extent to which the advertisements made them feel angry (1 = not angry at all; 2 = slightly angry; 3 = somewhat angry; 4 = very angry; 5 = extremely angry) and want to consume the product (1 = not at all; 2 = slightly; 3 = somewhat; 4 = very much; 5 = a great deal). These items were analysed separately because they measure conceptually distinct constructs.

Implicit affective associations. AMP (Session 2, two weeks and three months postintervention). We measured participants' implicit affective associations with junk food marketing and healthy foods using the AMP—a thoroughly validated and widely used measure of implicit affective associations in which participants indicate whether an unfamiliar and emotionally neutral character feels pleasant or unpleasant to them (relative to similar such characters) after a very brief (75 ms) exposure to images of the true target of measurement[34,35]. The AMP was administered with tablet computers using Inquisit software and each administration lasted three to five minutes. The AMP measured students' implicit attitudes towards three types of food: healthy foods (fruits and vegetables), popular unhealthy foods depicted in the context of advertisements (for example, Doritos and Coca-Cola) and unhealthy foods available in the school cafeteria (for example, Snapple 100% Natural, Oven-Baked Lays and chocolate chip cookies). Our preregistered hypotheses were limited to the first two of these three categories, but we included the third for exploratory purposes. The results for the third (exploratory) category were substantively identical (that is, in magnitude and significance level) to those using the popular unhealthy items, so they are not discussed further. The procedure comprised 150 trials (50 per food category). Students were asked to make a dichotomous rating of each of the series of 150 target Chinese characters as 'pleasant' or 'unpleasant'. The instructions made clear that this rating was intended to be relative to other similar characters. We administered the AMP during Session 2 of the intervention, but a problem with the school's Wi-Fi connection prevented us from saving the data from the majority of participants. We corrected the technical issue in time to re-administer the AMP two weeks postintervention and again three months postintervention (at the end of the school year). The analysis of the AMP data described in the main text refers to a mixed-effects repeated-measures analysis with time points nested within individuals.

Behaviour. Cafeteria purchases. The school district provided data on all purchase choices by participating students for the entire school year. Before the researchers had access to the cafeteria purchase data, each snack and drink item was classified either as healthy or unhealthy. The preregistered analysis focused on the change in healthy and junk food choices from pre- to postintervention, by condition. The reported effects of intervention condition on cafeteria purchases in the main text refer to the results of a multilevel mixed-effects linear probability model with days nested within individuals (see Supplementary Results 1).

Snack pack order form (one week postintervention). Before the intervention, the school principal announced that eighth graders would have the opportunity to

select their own snack pack as a reward for completing the state-wide standardized tests. Students completed the snack pack order forms in their homerooms (a different setting from the one in which they had received the treatment). Teachers instructed students to complete the snack pack order forms with no discussion and without looking at any other students' forms. Students completed the forms immediately after arriving at their first-period class.

In contrast with the initial evaluation study[17], in which the order form was distributed the day after the intervention, in the present study, the form was administered one week after the intervention (because the present intervention required two class periods rather than one and the school administration expressed a preference that we not take up class time in three consecutive days in the same week). No condition differences were observed on students' snack pack choices in the present study. This is the only preregistered hypothesis that was not supported (see Supplementary Results 1 for further discussion of this topic).

Summary of measurement time points. Below is a brief summary of the study's measurement timeline in chronological order.

Pre-intervention period (baseline). We obtained a pre-intervention measure of cafeteria purchases. Those data comprise records of all eighth-grade students' daily cafeteria purchases from the start of the school year through to the day before the intervention began. We also obtained information about students' demographic characteristics and pre-intervention body mass index from the school's administrative data system.

Intervention session 1. After completing the intervention activities in Session 1, participants completed the measures of perceived alignment of healthy eating with adolescent values and the social status appeal of healthy eating.

Intervention session 2. After completing the intervention activities in Session 2, participants completed the measures of explicit affective reactions to junk food marketing and the AMP. As is noted above, data from this first administration of the AMP were only successfully saved for a small number of participants due to a problem with the school's Wi-Fi connection.

One week postintervention. One week after the intervention was over, participants completed the snack pack order form.

Two weeks postintervention. Two weeks after the intervention was over, participants completed the AMP for the second time.

Three months postintervention (single time point). Three months after the intervention was over, participants completed the AMP for the third and final time.

Postintervention period (three months, continuous). Daily cafeteria purchases were measured beginning the day after the intervention was over, through to the end of the school year.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

The data that support the findings of this study are available on request from the Population Research Center at the University of Texas at Austin. Researchers must agree to the terms of data use, including analysis on a secure server and prohibitions against any analysis that risks exposing the identity of the participating students (that is, deductive disclosure). Requests for data should be directed to E. Johnson at ejohnson@prc.utexas.edu.

Code availability

The syntax used to produce all of the results reported in this article is available at https://osf.io/2wuh3/.

Received: 11 October 2018; Accepted: 7 March 2019;
Published online: 15 April 2019

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Acknowledgements

The authors are grateful to C. Dweck, R. Dahl, J. Risen, B. Bonikowski, G. Cohen, S. James, K. Wysen and K. Pathakis for helpful feedback on previous drafts, A. Audette, Q. Hirschi, F. (N.) Medrano and members of the Adolescent Development Research Group for help with data collection, and A. Kim and staff in the participating school district for partnership and support. Financial support to develop the intervention and carry out data analysis was provided in part by grants from the Character Lab (principal investigator: C.J.B.; co-investigator: D.S.Y.), Templeton Foundation, via the University of Chicago New Paths to Purpose project (principal investigator: C.J.B., co-investigator: D.S.Y.), William T. Grant Foundation (principal investigator: D.S.Y.) and National Institute of Child Health and Human Development (grant numbers 10.13039/100000071 R01HD084772-01 (principal investigator: D.S.Y.) and P2C-HD042849 to the Population Research Center at the University of Texas at Austin). Preparation of this manuscript was supported by a fellowship from the FMC faculty research fund at the University of Chicago's Booth School of Business (to C.J.B.), a fellowship from the Center for Advanced Study in the Behavioral Sciences at Stanford University (to C.J.B.) and a William T. Grant Scholars award (to D.S.Y.). The funders had no role in study design, data collection and analysis, decision to publish or preparation of the manuscript.

Author contribution

C.J.B., D.S.Y. and C.P.H. developed the concepts and designed the intervention. C.P.H., C.J.B. and D.S.Y. collected the data. C.P.H. managed and curated the data, D.S.Y. and C.J.B. analysed the data. C.J.B. and D.S.Y. wrote the manuscript.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information is available for this paper at https://doi.org/10.1038/s41562-019-0586-6.

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Software and code

Policy information about availability of computer code

Data collection	The narrated informational exercises were administered using Qualtrics Survey Software (Copyright 2017); the AMP was administered using Inquisit Player (Version 5.8.0 build 4000, iOS.2 Build 14C92); the Make it true activity used SnapPen (Version 1.1.3); the Make it fun activity used Eat-And-Move-O-Matic (Copyright 2014, NMSU Board of Regents).
Data analysis	Data were analyzed using R (Version 3.5.1 for Mac, 64-bit), Rstudio (Version 1.1.456 for Mac) and Stata (Version 15.1 for Mac, 64-bit).

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Behavioural & social sciences study design

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Study description	This is a pre-registered, 3-month longitudinal, randomized, behavioral intervention experiment (N = 362) testing a novel approach to providing adolescents with lasting protection against food marketing, a major environmental risk factor for obesity. The intervention reframed how manipulative junk food marketing and the unhealthy diets it is designed to encourage are perceived, portraying them as misaligned with adolescents' developmentally-heightened values. Data are quantitative.
Research sample	Our sample size was based on theoretical reasoning and practical constraints; given those, we sought to obtain the most statistical power possible. That is, for theoretical reasons, we targeted adolescents in the 13- to 15-year-old range (the youngest age when most would be expected to have reached puberty). Given the target age range, we determined that the best way to maximize our sample would be simply to recruit every participant in the 8th grade at the participating middle school. We then maximized statistical power by using individual-level random assignment rather than cluster random assignment.
Sampling strategy	See Research sample section, immediately above.
Data collection	Participants and teachers were fully blinded to the goals of the study and the condition assignments (i.e., the study was not described to participants or teachers as an experiment with different conditions that would be compared but rather as an opportunity for the researchers to obtain feedback from students about various sets of draft material for use in future 8th-grade health classes). The researchers who facilitated data collection were also kept blind to experimental condition. Participants were randomly assigned at the individual level, automatically upon logging into Qualtrics software, to either the exposé or the placebo control condition. Both interventions were administered on two consecutive school days during a single 50-minute class period each day. Overview of manipulation and survey. The first experimental session in both conditions involved a brief, condition-specific, narrated informational reading exercise (completed using laptop computers with disposable earphones), followed by a condition-specific paper-and-pencil writing exercise. Paper materials were distributed in coded envelopes to preserve researchers' blindness to condition. Participants then completed a survey of psychological process variables, completed on paper; these were identical across conditions. Students completed all activities privately and quietly at their desks. Research assistants, blind to students' experimental condition assignment, introduced the activity as an opportunity to provide feedback on novel curricula for schools. Assistants, working with teachers, maintained a quiet and focused atmosphere until all students had completed the activities. All manipulated content was delivered either in written materials or via audio using earphones (or both) so that participants in different conditions could participate in the same classroom. In Session 2, the experimental session, in both conditions, consisted of a brief (5-minute), condition-specific video summary of the previous day's content (viewed on laptop computers with disposable earphones), a short survey of explicit attitudes about junk food marketing (identical across conditions), a condition-specific game-like interactive activity completed on a tablet computer, and finally an implicit associations measurement task, which was identical across conditions and completed on a tablet computer.
Timing	This was a longitudinal study. The intervention sessions took place of Feb 14-15, 2017. Snack form data were collected on Feb 23, 2017. The 2-week AMP follow-up data were collected on March 1, 2017. The 3-month AMP follow-up data were collected on May 25-26, 2017. Daily cafeteria purchase data, provided to us directly from the school, span the period from Aug 23, 2016 through May 31, 2017 (inclusive).
Data exclusions	No data were excluded. All participants who provided complete data for a particular analysis were included in that analysis. We did employ listwise deletion of cases with missing data for any given analysis and report a detailed sensitivity analysis in our online supplement demonstrating that missing data pose no threat to internal validity.
Non-participation	No participants dropped out or declined to participate. All students who were in school on the days data were collected participated in the study.
Randomization	Participants were automatically randomly assigned to experimental conditions by Qualtrics software when they began the first intervention session.

Reporting for specific materials, systems and methods

Materials & experimental systems		Methods	
n/a	Involved in the study	n/a	Involved in the study
☒	☐ Unique biological materials	☒	☐ ChIP-seq
☒	☐ Antibodies	☒	☐ Flow cytometry
☒	☐ Eukaryotic cell lines	☒	☐ MRI-based neuroimaging
☒	☐ Palaeontology		
☒	☐ Animals and other organisms		
☐	☒ Human research participants		

Human research participants

Policy information about studies involving human research participants

Population characteristics	Characteristics of the participating sample of students. Here are the demographic characteristics of the participating students: • Age: 13 years old = 44% (n = 158), 14 years old = 52% (n = 189), 15 years old = 4% (n = 15) • Gender: Male = 49% (n = 165), Female = 51% (n = 175) • Race: White, non-Hispanic = 51% (n = 183), Other racial/ethnic group membership = 49% (n = 179) • Economic disadvantage status: Reduced-price lunch = 31% (n = 104), Free lunch = 7% (n = 24) • Overweight (BMI>85th %ile): 26% (n = 66) • Obese (BMI>95th %ile): 11% (n = 28)
Recruitment	No student who was present on the day of the intervention declined to participate in the study, and so these values match the characteristics of the school as a whole.