Registered report

Sugary drinks devaluation with ~~executive control training~~~~food~~ response training helpss ~~to~~ to resist ~~to~~ their consumption

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Abstract

Food ~~executive control~~response ~~-~~training has been shown to reduce the ~~perceived~~ reported value of palatable food items. ~~This~~ These approaches may thus help to reduce unhealthy (over)consumption ~~behaviour~~behaviors and its related diseases. Yet, whether and how training-induced devaluation effects translate into reductions in the target items (over)consumption remains unclear.

We will address this issue by testing whether a combined food Go/NoGo and cue-approach ~~executive control~~ training targeting the participants' ~~favourite~~favorite sugary drinks can improve how many days they resist drinking them with a double-blind randomized controlled trial. We will further examine the association between the devaluation of the target food cues and the real-world effect of the training on adherence to the restrictive diet, and the impact of the length of the ~~presence of a dose-response effect to the~~ training intervention~~'s length~~.

Introduction

Unhealthy consumption ~~behaviours~~behaviors contribute to the development of most non-communicable diseases. In particular, overconsumption of energy-dense but nutrient-poor foods leads to diseases ranging from diabetes to cancer[1]. ~~Conventional reflective approaches to reduce overconsumption behaviours largely target conscious processes, which can lead to usually failing because they target conscious processes, whereasas (palatable) food consumption is largely directly driven by cues in the environment[2,3].~~

Interestingly, recent evidence indicates that the practice of tasks ~~tasks training~~ involving the execution or inhibition of motor~~ic~~ responses to~~ward~~ food cues ~~can~~ modulates their self-reported value, and ~~in turn~~ their consumption[2,3]. ~~Interestingly, recent evidence indicates that the automatic motivational processes driving unhealthy overconsumptions can be modulated by executive controlfood response training (ECT). In the eating domain, ECT response training indeed has been shown to robustly reduces the perceived value of the targeted cues[4,5]. 6,7~~

~~*Explication food GNG*~~

In the food Go/NoGo (GNG) task, participants have to ~~quickly~~ respond as fast as possible to healthy food cues, while withholding their ~~and withhold their~~ responses to ~~cues associated to~~ unhealthy food cues.[8] ~~, while in the CAT, participants have to respond as fast as possible to items when a Go cue is displayed and before it disappears[27]. The target items in this study are sugary drinks, an ideal target to~~

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~~study real-world consumption behaviours as they display highly recognizable brands with marked and stable interindividual preferences[28], and are rarely shared with peers.~~

The repeated inhibition of motor response to ~~problematic~~unhealthy cues is thought to reduce their ~~hedonic~~ reward value~~, an effect putatively driven by the individuals trying~~ to solve the conflict between the ~~training~~task demand for response withholding and their tendency to respond to palatable cues[4,5]. Other accounts suggest that the development of inhibition reflex to the unhealthy cues could also contribute to the reduction in valuation and consumption ~~(~~[6,7]~~).~~.

~~*Explication food CAT*~~

~~I~~In the Cue-Approach Training ~~AT~~(CAT)[9], participants have to respond as fast as possible to items when a Go-cue is displayed and before it disappears[8]. The practice of this task may modulate the valuation of the target ~~i~~items ~~associated with Go-cues have been shown to increase their hedonic value~~ by developing attentional biases toward or away from them

~~Likewise, i~~~~Instruction to withhold responses to cues may reduce their hedonic value by developing attentional biases away from them (see~~[9]~~.~~ There is, however, little evidence supporting real-life effects of cognitive bias modification (though see the work on alcohol approach bias modification in alcoholic patients~~,~~[10] ~~REF~~). ~~for details on the neurocognitive mechanisms involved in ECT-induced item devaluation).~~

Our previous work has demonstrated that ~~When~~ the combination of these task in a response training intervention~~s combined in our previous studies, both tasks have been shown to~~ robustly reduces the self-reported explicit liking of the targeted unhealthy food cues, alongside a potential ~~effects in~~ increas~~ing~~e in the healthy items value~~a~~tion and ~~in~~a decreas~~ing~~e in the unhealthy items self-reported consumption[11,12].

~~Opposite~~In contrast to conventional reflective approaches to reduce overconsumption behaviors primarily ~~which~~ targeting ~~ineffective conscious~~deliberate processes[13,14], these food response trainings ~~rely~~target ~~on~~ automatic ~~motivational~~reward processes. As a result, these approaches do not require acquiring dietary knowledge or exerting effortful self-control overeating impulses and may thus represent an advantageous complementary approach ~~, and thus a new promising approach to~~ ~~solve~~reduce the unhealthy overconsumption ~~problem~~behaviors ~~(~~[13]~~).~~

~~*The combination of both tasks into a single intervention have been shown similar effects on trained items explicit liking than when isolated.*~~

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~~The repeated inhibition of motor response to problematic cues is thought to reduce their hedonic reward value, an effect putatively driven by the individuals trying to solve the conflict between the training demand for response withholding and their tendency to respond to palatable cues[6]. Likewise, instruction to withhold responses to cues may reduce their hedonic value by developing attentional biases away from them (see[7,8] for details on the neurocognitive mechanisms involved in ECT-induced item devaluation).~~

However, whether and how ~~these 'action-to-valuation' mechanisms~~tasks~~they~~response training intervention ~~of action~~ impact~~s on~~ consumption ~~behaviour~~behaviors ~~remains~~remain largely unresolved. Current evidence for a reduction in food consumption after ~~ECT~~ food response training relies either on self-reported consumption outcomes such as food frequency questionnaires or food journals[15–17], or on laboratory tasks such as food buffets or bogus taste tests[18–23]. While these studies observed modulations in consumption, they do not directly demonstrate real-world effects. Indeed, the effect of ~~ECT~~ food response training remains mixed on physiological parameters (e.g., BMI, body fat)[11,16,24–28], self-report measures are intrinsically biased because of memory and social confounds[29], and laboratory settings only partly mimic ecological situations. To our knowledge, the only study reporting real-world effects focused on eating disorder symptoms and were thus potentially confounded by the clinical condition of the population of interest[30].

We aim to bridge this gap by testing with a double-blind randomized controlled trial whether a gamified food ~~ECT-intervention~~response training intervention combining a Go/NoGo and CAT can improve adherence to a restrictive diet focusing on the participants' ~~favourite~~favorite sugary drinks. Adherence to a restrictive diet ~~constitutes a robust and valuable dependent variable~~is valuable to index the real-world effect of food ~~ECT~~ response training because: i) it is easier to report and ~~not~~ less biased by memory or the relationship with the experimenter; ii) it represents an important use-case ~~of ECT~~ for conditions such as diabetes or food intolerance; improving the success rate of restrictive dieting will demonstrate the relevance of ~~food ECT~~such intervention as an adjuvant approach to conventional interventions in (sub-)clinical populations; and iii) letting the participant stop their training whenever they want in a ~~one~~two-week~~s~~ window enables to investigate the ~~dose-dependence of ECT~~link of the intervention's length on its real-world effect size, thereby allowing to formulate recommendations for its use in applied settings.

The intervention will ~~consist of a combination of a Go/NoGo (GNG) and Cue-Approach Training (CAT) training tasks~~ be implemented in an online gamified smartphone app, to capitalize on our replicated result showing a robust 20% reduction in the valuation of the target food items ~~with this specific ECT~~[11,12]. The target items in this study are sugary drinks, an ideal target to study real-world

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consumption ~~behaviours~~behaviors as they display highly recognizable brands with marked and stable interindividual preferences[31], and are rarely shared with peers. ~~In the GNG task, participants have to withhold their responses to cues[6], while in the CAT, participants have to respond as fast as possible to items when a Go cue is displayed and before it disappears[27]. The target items in this study are sugary drinks, an ideal target to study real-world consumption behaviours as they display highly recognizable brands with marked and stable interindividual preferences[28], and are rarely shared with peers.~~

The effect of the intervention will be contrasted with a mechanistic control group only differing in the active 'ingredient' of the training: the cue-response mapping rules will be 100% in the experimental and 50% in the control group. This contrast will allow us to control for the confounding factors ~~of cue exposure and of expectations developed by the participants on the effects of the intervention~~developed by food cue exposure and cognitive training. We expect that: Hypothesis H1) the participants in the experimental training group will maintain more days of successful sugary drinks restrictive dieting than in the control training group; H2) that the amplitude of the reduction in the targeted items' explicit liking will be positively associated with number successful days of adherence to the diet in the experimental group; H3) that the more a participant in the experimental group will train, the larger the effect of the intervention will be on their dieting ~~behaviour~~behavior.

A detailed design table detailing the hypotheses and their rationales can be found at the end of the method section (Table 1).

Method and Materials

All materials, including scripts, data, and stimuli, can be accessed via and will be uploaded to our Open Science Framework (OSF) project page (view-only link: https://osf.io/s4trh/?view_only=4934c0215f2943cfb42e019792a30b53).

Sampling plan

Our rationale for the sampling plan is to try and detect at minimum the smallest effect that would be relevant to a daily living or clinical setting, instead of searching for the minimal effect expected with the current literature. As such, when possible, the population parameters (e.g., differences in means) are used as effect sizes instead of relative indexes (e.g., Cohen's d).

For H1, the estimated smallest effect size of interest that would be relevant to an applied setting is a difference in means of 5 days more of restrictive dieting in the experimental than control training groups, with an estimated standard-deviation of 10 (Cohen's d = 0.5). A-priori power analysis using G*Power[32] shows that a sample size of 140 (70 per group) is needed to reach 90% power with an alpha

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of .05 for a one-sided independent t-test and this effect size. Any smaller effect will not be interpreted as relevant even if significant.

~~For H1, a priori power analysis using G*Power[31] shows that a sample size of 72 (36 per group) is needed to reach 90% power with an alpha of .05 for a one-sided independent t-test testing the smallest effect size of interest of a 7 days difference in successful restrictive dieting that we considered of interest, with an estimated standard deviation of 10 (Cohen's d = 0.7).~~

For H2 and H3, which only considers the experimental group, the smallest effect size of interest was estimated to be small (r = 0.4) based on clinical subjectivity.~~a~~ A-priori power analysis using the pwr R package[33] indicates that a sample size of 50 is needed to reach 90% power with an alpha of .05 for a one-sided correlation with ~~the smallest effect size of~~ r = .~~4 that we considered of interest on principled grounds~~. Any smaller effect will not be interpreted as relevant even if significant.

Overall, a total of 140 participants will be needed for the analysis of H1, and 50 participants will be needed for the analyses of H2 and H3. If exclusions to comply with the positive controls reduce the sample size below these thresholds (see Statistical Analysis section), new participants will be recruited .

~~Overall, a total of 72 86 participants will be recruited for the study: 36 for the group control, and 50 for the experimental group.~~

Recruitment and screening

Participants will be recruited via public advertisement.

We will include ~~18 to 45 year old~~18- to 45-year-old healthy individuals willing to follow a sugary drink restrictive diet. ~~Non-healthy~~Unhealthy participants include self-report of past or current eating disorders, any visual or hearing disability preventing gamified training, and any olfactory or gustative impairment (including smokers consuming ≥10 cigarettes daily). We will also exclude ~~We will exclude~~ participants with ~~past or current eating disorders,~~ previous participation in a food executive control training study, and- pregnant participants or participants planning to be pregnant~~olfactory or gustative impairments~~.

General procedure

Participants will sign a consent form and be screened for eligibility criteria through a custom-made health questionnaire. They will then be given access to our online training software – The Diner – via an app store and fill out in-app analogue scales of items' drinking frequency and explicit liking.

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They will then complete a combined gamified GNG and ~~AMB~~ CAT tasks for 20 minutes per day (10min for each task), for a minimum of 7 days and a maximum of ~~14~~ 20 days. The trained Go items will be water pictures, and the NoGo items will be only the participant's 8 most drunk sugary items. Participants have the option to stop the study at any time ~~after having completed at least 7 days of training~~through an "End training" button appearing in the software after the minimum 7 days of training, which in turn blocks the game and triggers the post-training measures.~~.~~

After training, participants will complete the post-training analogue scales of explicit liking and will be asked to avoid their trained sugary drinks (i.e~~t~~., those selected as their most consumed) for as long as possible. Their adherence to the diet will be measured with weekly questionnaires asking if their diet was successful, and if not, the exact earliest day they again consumed one of the target sugary drinks, for a maximum of two months. A debriefing questionnaire will assess whether they consumed other types of sugary drinks as a compensatory strategy for exploratory purposes.

Stimuli

The stimuli will be sugary drinks as they have shown a robust reduction in self-reported consumption after training in our previous study[12], have marked individual preferences and their consumption is easier to track than for solid snacks.

53 pictures of sugary drinks and 7 pictures of water bottles will be used as items. They represent the most popular drinks marketed in Switzerland (they can be downloaded on our OSF page https://osf.io/s4trh/?view_only=4934c0215f2943cfb42e019792a30b53).

Analogue scales

In-app analogue scales of drinking frequency will be used to personalize the training with participants' 8 most drunk items. The question "How much do you drink this?" will be asked for all sugary drink items in a randomized order, with a scale ranging from "Never" to "Very often" (0 and 100 points respectively), with a marker in the middle (neutral 50 points).

The within-app analogue scales of explicit liking are the same as in our previous studies[11,12]. Before and after the training, participants will rate in a random sequence their 8 most drunk items as well as the water items, from 0 ('not at all') to 100 ('very much') according to the question 'Imagine drinking this, how much do you like it?'.

Training tasks

The GNG and CAT training tasks are the same as in [11,12] to ensure reproducibility and to capitalize on our robust and replicated findings for an effect of this ECT on item valuation.

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A demonstration of the app and its training tasks can be found on our OSF page (https://osf.io/s4trh/?view_only=4934c0215f2943cfb42e019792a30b53).

In both tasks, the participants must complete as many trials as they can in one block. Each correct response awards points to the participant. After five correct responses, the reaction time threshold (RTT) is increased of a level (Table 2). After making a certain number of accuracy or speed errors (5 without powerups), as indicated by two distinct life gauges, the run is over. This process is repeated until the participants reach 10 minutes of training for each task. The participant's highest score for a session is used as ranking in the game's anonymous scoreboard, as to maximize motivation to the training. At the end of a session, the score is also transformed to in game currency to be exchanged with task-independent power-ups, such as bigger life gauges or a double points temporary boost, to prevent repetition-induced boredom.

Table 2. *Difficulty parameters at each level for all tasks (in seconds)*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
GNG (RTT)	1.1	1	.9	.8	.725	.675	.625	.575	.55	.525	.5	.475	.452	.43	.407	.387	.36	.33
CAT (1.25-GSD; see Table 3)	0.88	.81	.74	.67	.62	.57	.53	.49	.455	.42	.39	.36	.335	.31	.29	.27	.26	.25

Table 3 summarizes the task parameters. Table 4 depicts the percentages of healthy (water) and unhealthy (sugary drinks) items based on the trial condition and task.

Go/NoGo

For the GNG task (Fig. 1), the participants will be presented with drink pictures and instructed to drag the pictures that are circled in green as fast as possible to the bottom of the screen; they must not touch the pictures circled in red that are accompanied. A correct response is defined either by responding to green-cued pictures (hit) below the reaction time threshold (RTT) or not responding to red-cued pictures (correct rejection [CR]). In these situations, a positive green feedback (i.e., the points obtained) is displayed with a rewarding sound. In the case of a hit above the RTT, a negative orange ('too late') feedback is displayed. If they respond to a red-cued picture (false alarm [FA]) or withhold response to a green-cued picture (miss), a negative red cross is displayed as feedback. The Go and NoGo cues are delayed by 50 ms after stimulus onset for the picture to be treated by the participants'

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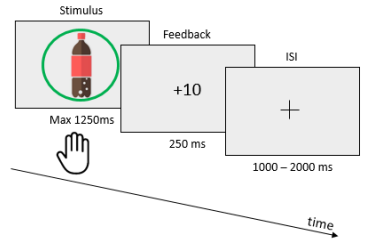
visual system before they see the item's condition. This delay prevents the participants from only treating the cue without giving attention to the item.

To ensure response potency (i.e., a high pre-activation of motoric response), 70% of the trials consist of Go items, and 30% of NoGo items.

Figure 2. *Schematic GNG task timeline*



Attentional bias modification

In the CAT (Fig. 2), pictures appear on the screen one after another at random locations on a grid. When a green cue is presented around the picture, accompanied by a bell sound, the participants have to click on the item before its offset occurs. If the participant responds between the cue onset and the item offset, a positive green feedback (the points obtained) is displayed with a rewarding sound. If they respond to a cued picture after the item's offset, a negative orange ('too late') feedback is shown. If they do not respond to a cued picture or respond to a non-cued item, a negative red cross appears as feedback. In the case of correct response withholding, dark grey-green feedback is displayed with a neutral non-ascending sound, and a third of the hit point is awarded to avoid creating attentional bias during NoGo trials.

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Figure 3. *Schematic CAT timeline*

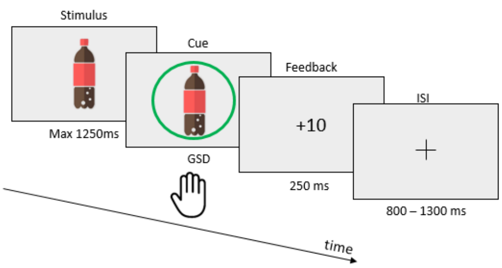

Table 2. *Task-specific parameters*

	GNG	**CAT**
Go/NoGo rate	70% Go 30% NoGo	25% Go (cued items) 75% NoGo (non-cued items)
Stimulus duration	1.25 second maximum and disappearing after the response	
Feedback duration	250 ms	
Visual cue duration	Until item offset	
Visual cue delay	50 ms	Go Signal Delay (GSD): based on difficulty level (see Table 2)
Auditory cue duration	300 ms	NA
Auditory cue delay	100 ms	NA
Interstimulus interval (ISI)	1000 – 2000 ms	800 – 1300 ms*

**Since the participants only respond to 25% of the trials during the CAT, we reduced its ISI to prevent boredom.*

Table 3*. Proportion of item categories displayed for each trial condition and group*

Experimental group		
Item type / Trial condition	Healthy	Unhealthy
Go trials	100%	0%
NoGo trials	0%	100%

Control group		
Item type / Trial condition	Healthy	Unhealthy
Go trials	50%	50%
NoGo trials	50%	50%

~~A demonstration of the app and its training tasks can be found on our OSF page (https://osf.io/s4trh/?view_only=4934c0215f2943cfb42e019792a30b53).~~

Questionnaires

Screening and demographic data will be collected with a 10-items custom-made questionnaire about the participant's health and willingness to follow a sugary drink restrictive diet.

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a mis en forme : Couleur de police : Bleu, Anglais (États-Unis)
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a mis en forme : Anglais (États-Unis)

At the end of the training phase, participants will receive a weekly questionnaire asking if they succeeded in not drinking the trained sugary drinks and if not, the exact date of the first consumption. After reporting a drop-off, or at the two-months maximum, they will be asked if they drank more of other (non-selected) sugary drinks than before the diet, to assess compensatory strategies. Expectation on the study's hypothesis will also be rated using two 5-items Likert scales at the same time, asking the participants: "Do you think the researchers of this study expect that your maintenance of the diet has been improved because of the training?" and "Do you think your maintenance of the diet has been improved because of the training?" with 1 (Not at all) and 5 (Absolutely) as the anchors.

All questionnaires translated from French can be read via our OSF page under the "PROTOCOL" folder: https://osf.io/s4trh/?view_only=4934c0215f2943cfb42e019792a30b53~~link~~.

Analysis plan

All tests will be performed using R base functions if not specified otherwise.

Only participants who completed at least 7 sessions of training will be considered. Dropouts and participants with missing data will not be accounted for in ~~be excluded from~~ their respective analyses.

All positive controls are checked from the raw data before any processing (see "positive controls" section), including the potential exclusion of participants to respect them. Participants excluded this way will be replaced only if their exclusions result in a sample size below the planned threshold.~~All positive controls are checked from the raw data before any processing (see "positive controls" section), including the eventual exclusion of participants to respect them. Participants excluded this way will be replaced only if their exclusions result in a sample size below the planned threshold.~~

All results will be interpreted using ~~the~~ frequentist statistics, with Bayes Factors reported as a supplementary manner to support ~~any eventual~~ null results.

H1) Participants in the experimental training will report more successful days of high sugary drinks restrictive dieting than the control training.

For this hypothesis, only the number of successful days of diet for the experimental and control groups will be considered.

After the eventual exclusion of participants to respect the positive controls, participants outside a 2.5*MAD (median average deviation; conservative criterion) range around the median of successful days of diet will be excluded.

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a mis en forme : Couleur de police : Bleu, Anglais (États-Unis)

a mis en forme : Couleur de police : Bleu, Anglais (États-Unis)

a mis en forme : Couleur de police : Bleu, Anglais (États-Unis)

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a mis en forme : Couleur de police : Bleu, Anglais (États-Unis)

a mis en forme : Anglais (États-Unis)

a mis en forme : Couleur de police : Bleu

a mis en forme : Couleur de police : Bleu

Then, we will test the homoscedasticity assumption using the car R package[34]. If the assumption is violated (Levene test with p<0.05), we will apply the Greenhouse–Geisser correction using the rstatix R package[35].

We expect more successful days of diet in the experimental than control training condition, as assessed by a one-sided independent t-test. This result will be interpreted as relevant only if the difference between both conditions is at least of 57 more days of successful dieting, even with a p-value below 0.05.

A Bayes Factor against the null hypothesis will be computed using the BayesFactor R package[36] in case of non-significant result (p > 0.05).

H2) The reduction in the explicit liking of trained items in the experimental group will correlate positively with the number of days of successful dieting.

For this hypothesis, only the pre-post reduction in sugary drinks explicit liking and the number of days of training in the experimental group will be considered.

When computing the average explicit liking of each participant, we will exclude items with a reaction time shorter than 300 ms to ensure a thorough filling of the analogue scales. Then, the pre-post-training differences are computed.

After the eventual exclusion of participants to respect the positive controls, participants outside a 2.5*MAD range around the median of both variables will be excluded.

We expect a positive linear link between the number of successful diet days and the pre-post reduction in the trained sugary drinks' explicit liking, as assessed by a one-sided correlation test. If the correlation is below 0.4, the results will be considered non-relevant even if significant (p < 0.05)

A Bayes Factor against the null hypothesis will be computed using the BayesFactor R package[36] in case of non-significant result (p > 0.05).

H3) The amount of days of training in the experimental condition will correlate positively with the number of days of successful dieting

For this hypothesis, only the number of successful days of diet and the number of days of training in the experimental group will be considered.

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a mis en forme : Couleur de police : Bleu

a mis en forme : Couleur de police : Bleu, Anglais (États-Unis)

a mis en forme : Couleur de police : Bleu

After the eventual exclusion of participants to respect the positive controls, participants outside a 2.5*MAD range around the median of both variables will be excluded.

Based on previous data showing a uniform distribution of the number of training days across participants[12], we expect a one-sided correlation between the number of successful days of diet and the number of days of training to be applicable as our confirmatory test. If the correlation is below 0.4, the results will be considered non-relevant even if significant ($p < 0.05$).

A Bayes Factor against the null hypothesis will be computed using the BayesFactor R package[36] in case of non-significant result ($p > 0.05$).

~~All tests will be performed using R base functions if not specified otherwise. Our alpha threshold is set to 0.05. Cohen's d and Pearson-spearman correlations will be reported as our effect sizes of interest alongside any deltas accompanied by their 95% confidence intervals.~~

~~For H1, we will test the homoscedasticity assumption using the car R package[33]. If the assumption is violated (Levene test with $p<0.05$), we will apply the Greenhouse–Geisser correction using the rstatix R package[34].~~

~~Bayes Factors against the null hypothesis will be computed using the BayesFactor R package[35] for any non-significant result.~~

~~Data exclusion~~

~~We will exclude all participants who completed less than 7 sessions of training.~~

~~Participants outside a 2.5*MAD (median average deviation; conservative criterion) range around the median of the assessed outcomes and predictors (i.e., days of successful restrictive dieting, pre-post reduction in sugary drinks explicit liking, and days of training) will be excluded from their respective analyses. This exclusion rule will be done after the positive control rules application (see corresponding section).~~

~~*Analogue scales of explicit liking*~~

~~To ensure a thorough filling of the analogue scales, we will exclude items with a reaction time shorter than 300 ms. The mean explicit liking of each participant will be trimmed of their 20% highest and 20% lowest rated items at pre-intervention, to only target the items with room to change, thus preventing ceiling and floor effects.~~

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a mis en forme : Couleur de police : Arrière-plan 2, Anglais (États-Unis)

~~Statistical contrasts~~

~~For all hypotheses, if the effect size is below a Cohen's d or correlation of 0.4, the corresponding result will be interpreted as non-relevant even with a p-value below the alpha.~~

~~For H1, we expect more successful days of diet in the experimental than control training condition, as assessed by a one-sided dependent t-test. This result will be interpreted as relevant only if the difference between both conditions is at least of 7 more days of successful dieting.~~

~~For H2, we expect a positive linear link between the number of successful diet days and the pre-post reduction in the trained sugary drinks' explicit liking, as assessed by a one-sided correlation test.~~

~~For H3, the test will depend on the density distribution of the number of training days. If visual inspection shows a normal or uniform distribution, a one-sided correlation between the number of successful diet days and the number of training days will be computed. If the distribution appears bimodal, a one-sided t-test will be computed between the participants training for 10 days or less and those training for 11 days or more. If the distribution appears unimodal without spanning across the whole range of training days possible, H3 will not be inspected at all. We expect a correlation based on past data showing a uniform distribution of the number of training days across participants[11].~~

Positive controls

Baseline reported consumption

For all hypotheses, the baseline reported consumption frequency of the trained items should be equivalent between the experimental and control training conditions. In case of a Cohen's d above 0.4, participants further away from their group's average will be excluded until this criterion is met.

Tolerance for dieting compensatory strategy

For all hypotheses, the presence of dieting compensatory strategies (see Questionnaire section) in the experimental training condition can be tolerated, as long as the majority of participants do not report one. If the majority of the experimental training participants compensate for their restrictive diet by drinking other types of sugary drinks, then the interpretation of this study's results will be adapted accordingly.

Expectation~~Frequency of dieting compensatory strategy~~

~~For H1, the frequency of reported dieting compensatory strategy (see Questionnaire section) should be equivalent between the experimental and control training conditions. In case of a difference of~~

a mis en forme : Police :Italique, Couleur de police : Bleu

a mis en forme : Police :Italique, Couleur de police : Bleu

~~*proportions above 15% (arbitrary conservative threshold), participants in the outlier cells will be excluded until this criterion is met.*~~

~~*Pre-post explicit liking reduction*~~

~~*For H2, a pre-post reduction of sugary drinks' explicit liking should be observed. In the case of a Cohen's d below 0.4 between the explicit liking before and after training, participants showing the smallest reduction will be excluded until this criterion is met.*~~

~~*Planned exploratory analyses*~~

~~*Frequency of dieting compensatory strategy*~~

~~*For H1, t*~~*The frequency of reported dieting compensatory strategy (see Questionnaire section) should* ~~*be equivalent between*~~*might be different from the experimental and control training conditions,* ~~*showing a different side on how the training may affect real-life dieting behavior. In case of a difference of proportions above 15% (arbitrary conservative threshold), participants in the outlier cells will be excluded until this criterion is met.*~~

~~*Non-uniform distribution for H3*~~

~~*In case of a non-uniform distribution of the number of training days across participants (i.e., bi-modal, or unimodal without spanning across the whole range of modalities) as assessed through visual inspection, then H3 will be explored under a different more appropriate test, such as a one-sided t-test with a dichotomized dependent variable.*~~

on the study's outcome

For H1, the expectation on the impact of training on the maintenance of the diet should be balanced between groups to interpret the results without this bias. In case of a Cohen's d above 0.4 on the average score between the two Likert scales (see Questionnaire section) between the experimental and control groups, participants further away from their group's average will be excluded until this criterion is met.

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Table 1: Design

Question	Hypothesis	Sampling plan	Analysis plan	Interpretation given different outcomes	Theory that could be shown wrong by the outcomes
Can food ECT modify real-world consumption ~~behaviour~~behavior?	H1: Participants in the experimental training will report more successful days of high sugary drinks restrictive dieting than the control training.	For 90% power and alpha = .05, n = 72 (36 per group) for a one-sided t-test with a smallest effect size of interest of 7 days and an estimated SD of 10.	One-sided t-test between participants in the experimental vs. control training group. If homoscedasticity assumption violated, GG correction. If $p > .05$, then BF_{01} will test the null hypothesis.	If the test is significant and the difference between both trainings is of at least 7 days, then we interpret food-ECT as improving restrictive dieting capacities.	If the hypothesis is not validated, then it would give support to an independence between the already observed food-ECT effects on reduction on items' valuation and in-lab consumption, and real-world consumption ~~behaviour~~behavior.
Does the food-ECT induced reduction in perceived value influence consumption ~~behaviour~~behavior?	H2: The reduction in the explicit liking of trained items in the experimental group will correlate positively with the number of days of successful dieting.	For 90% power and alpha = .05, n = 50 for a one-sided correlation with a smallest effect size of interest of r = .4.	If H1 is significant, then one-sided correlation between the pre-post reduction in explicit liking and the successful days of diet. If $p > .05$, then BF_{01} will test the null hypothesis.	If the test is significant and shows an effect size above the minimal effect size of interest ($r > .4$), then the robust devaluation effect of food-ECT influence restrictive dieting capacities.	
Does the amount of training modify the intervention's effect size?	H3: The amount of days of training in the experimental condition will correlate positively with the number of days of successful dieting.		If H1 is significant, then one-sided correlation between the amount of days of training and the successful days of diet. If the distribution of the amount of days of training is bimodal instead of unimodal or uniform, then the correlation will be replaced by a one-sided t-test. If the distribution is unimodal, not ranging from all possible modalities, then no analyses will be performed. If $p > .05$, then BF_{01} will test the null hypothesis.	If the test is significant and shows an effect size above the minimal effect size of interest ($r > .4$), then participants should be encouraged to train for longer than one-week to reach a larger effect of food-ECT on restrictive dieting capacities.	If the hypothesis is not validated, then it would indicate either a ceiling effect appearing before a week of training, or an absence of influence of training sessions ~~longer than one week~~ on the effect of~~n~~ restrictive dieting ~~behaviour~~behavior.

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References

1. World Health Organization. Non communicable diseases. https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases.
2. Jones, A. *et al.* Inhibitory control training for appetitive behaviour change: A meta-analytic investigation of mechanisms of action and moderators of effectiveness. *Appetite* **97**, 16–28 (2016).
3. Allom, V., Mullan, B. & Hagger, M. Does inhibitory control training improve health behaviour? A meta-analysis. *Health Psychol. Rev.* **10**, 168–186 (2016).
4. Veling, H., Lawrence, N. S., Chen, Z., van Koningsbruggen, G. M. & Holland, R. W. What Is Trained During Food Go/No-Go Training? A Review Focusing on Mechanisms and a Research Agenda. *Curr. Addict. Rep.* **4**, 35–41 (2017).
5. Stice, E., Lawrence, N. S., Kemps, E. & Veling, H. Training motor responses to food: A novel treatment for obesity targeting implicit processes. *Clin. Psychol. Rev.* **49**, 16–27 (2016).
6. Verbruggen, F., McLaren, I. P. L. & Chambers, C. D. Banishing the Control Homunculi in Studies of Action Control and Behavior Change. *Perspect. Psychol. Sci.* **9**, 497–524 (2014).
7. Jones, A. & Field, M. The effects of cue-specific inhibition training on alcohol consumption in heavy social drinkers. *Exp. Clin. Psychopharmacol.* **21**, 8–16 (2013).
8. Schonberg, T. *et al.* Changing value through cued approach: an automatic mechanism of behavior change. *Nat. Neurosci.* **17**, 625–630 (2014).
9. Bakkour, A., Lewis-Peacock, J. A., Poldrack, R. A. & Schonberg, T. Neural mechanisms of cue-approach training. *NeuroImage* **151**, 92–104 (2017).
10. Eberl, C. *et al.* Approach bias modification in alcohol dependence: Do clinical effects replicate and for whom does it work best? *Dev. Cogn. Neurosci.* **4**, 38–51 (2013).
11. Najberg, H., Rigamonti, M., Mouthon, M. & Spierer, L. Modifying food items valuation and weight with gamified executive control training. *R. Soc. Open Sci.* **8**, (2021).
12. Najberg, H., Mouthon, M., Coppin, G. & Spierer, L. Reduction in sugar drink valuation and consumption with gamified executive control training. *Sci. Rep.* **13**, 10659 (2023).

a mis en forme : Français (Suisse)

13. Marteau, T. M., Hollands, G. J. & Fletcher, P. C. Changing human behavior to prevent disease: The importance of targeting automatic processes. *Science* **337**, 1492–1495 (2012).

14. Stroebe, W., Mensink, W., Aarts, H., Schut, H. & Kruglanski, A. W. Why dieters fail: Testing the goal conflict model of eating. *J. Exp. Soc. Psychol.* **44**, 26–36 (2008).

15. Camp, B. & Lawrence, N. S. Giving pork the chop: Response inhibition training to reduce meat intake. *Appetite* **141**, 104315 (2019).

16. Lawrence, N. S. *et al.* Training response inhibition to food is associated with weight loss and reduced energy intake. *Appetite* **95**, 17–28 (2015).

17. Aulbach, M. B., Knittle, K., van Beurden, S. B., Haukkala, A. & Lawrence, N. S. App-based food Go/No-Go training: User engagement and dietary intake in an opportunistic observational study. *Appetite* **165**, 105315 (2021).

18. Adams, R. C., Lawrence, N. S., Verbruggen, F. & Chambers, C. D. Training response inhibition to reduce food consumption: Mechanisms, stimulus specificity and appropriate training protocols. *Appetite* **109**, 11–23 (2017).

19. Houben, K. Overcoming the urge to splurge: Influencing eating behavior by manipulating inhibitory control. *J. Behav. Ther. Exp. Psychiatry* **42**, 384–388 (2011).

20. Houben, K. & Jansen, A. Chocolate equals stop: Chocolate-specific inhibition training reduces chocolate intake and go associations with chocolate. *Appetite* **87**, 318–323 (2015).

21. Lawrence, N. S., Verbruggen, F., Morrison, S., Adams, R. C. & Chambers, C. D. Stopping to food can reduce intake. Effects of stimulus-specificity and individual differences in dietary restraint. *Appetite* **85**, 91–103 (2015).

22. Oomen, D., Grol, M., Spronk, D., Booth, C. & Fox, E. Beating uncontrolled eating: Training inhibitory control to reduce food intake and food cue sensitivity. *Appetite* **131**, 73–83 (2018).

23. Weinbach, N., Keha, E., Leib, H. & Kalanthroff, E. The Influence of Response Inhibition Training on Food Consumption and Implicit Attitudes toward Food among Female Restrained Eaters. *Nutrients* **12**, 3609 (2020).

24. Veling, H., van Koningsbruggen, G. M., Aarts, H. & Stroebe, W. Targeting impulsive processes of eating behavior via the internet. Effects on body weight. *Appetite* **78**, 102–109 (2014).

25. Verbeken, S., Braet, C., Naets, T., Houben, K. & Boendermaker, W. Computer training of attention and inhibition for youngsters with obesity: A pilot study. *Appetite* **123**, 439–447 (2018).

26. Carbine, K. A. *et al.* Does inhibitory control training reduce weight and caloric intake in adults with overweight and obesity? A pre-registered, randomized controlled event-related potential (ERP) study. *Behav. Res. Ther.* **136**, 103784 (2021).

27. Stice, E. *et al.* Efficacy of a food response and attention training treatment for obesity: A randomized placebo controlled trial. *Behav. Res. Ther.* **158**, 104183 (2022).

28. Adams, R. C. *et al.* Food-related inhibitory control training reduces food liking but not snacking frequency or weight in a large healthy adult sample. *Appetite* **167**, 105601 (2021).

29. Schoeller, D. A. How Accurate Is Self-Reported Dietary Energy Intake? *Nutr. Rev.* **48**, 373–379 (1990).

30. Keeler, J. L. *et al.* App-based food-specific inhibitory control training as an adjunct to treatment as usual in binge-type eating disorders: A feasibility trial. *Appetite* **168**, 105788 (2022).

31. McClure, S. M. *et al.* Neural Correlates of Behavioral Preference for Culturally Familiar Drinks. *Neuron* **44**, 379–387 (2004).

32. Faul, F., Erdfelder, E., Lang, A. G. & Buchner, A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. in *Behavior Research Methods* vol. 39 175–191 (Psychonomic Society Inc., 2007).

33. Champely, S. pwr: Basic Functions for Power Analysis. (2020).

34. Fox, J. & Weisberg, S. *An {R} Companion to Applied Regression*. (Sage, 2011).

35. Kassambara, A. rstatix: Pipe-Friendly Framework for Basic Statistical Tests. (2023).

36. Morey, R. D. & Rouder, J. N. BayesFactor: Computation of Bayes Factors for Common Designs. (2018).