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Accept the Banana: Exploring Incidental Cognitive Bias Modification Techniques on Smartphones

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Abstract

Cognitive Bias Modification (CBM) techniques show promise in psychology as an attitude, affect and/or behaviour change technique, but have yet to be implemented or evaluated extensively on smartphones. We present a pilot study exploring appropriate gestures for accepting and rejecting healthy eating stimuli on smartphones and apply them in an incidental, unobtrusive way within a smartphone screen shown at unlock time. Our main finding is evidence that a short course of incidental smartphone CBM alters some measures of food attitudes. We suggest a programme of future research to explore the area further, informed by our results and a related user survey.

Author Keywords

Cognitive bias modification; smartphones; behaviour change technology; nonconscious behaviour change.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

CBM techniques aim to alter the path of existing cognitive processes that are thought to contribute to

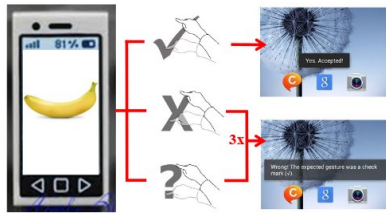


Figure 1 Healthy food unlock procedure

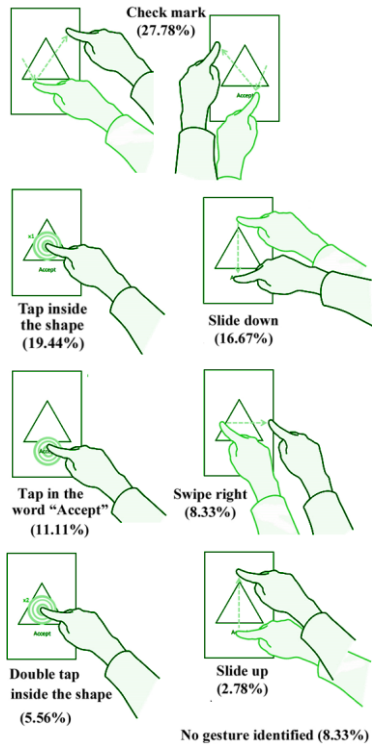


Figure 2 "Accept" gestures

unwanted emotional reactions and/or behaviour by practicing alternative cognitive paths [11,41]. There is increasing interest in the use of nonconscious behaviour change techniques such as CBM [1,28]. This interest is supported on the theoretical side by Dual Process Theories (DPT) [9], which suggest that a significant proportion of behavioural decisions emanate from a fast, associative, automatic set of processes that are not accessible to separate conscious processes. DPT contrasts with rational-action models often cited in technology-based behaviour change interventions such as the Theory of Planned Behaviour [3] and the Transtheoretical Model [30]. Empirical evidence also suggests that rational information-based approaches tend to fail in the long term, yet provision of information and other conscious strategies are common technology-based behaviour change techniques [25,36,39]. Evidence of the abandonment of activity trackers [5,10] supports the DPT prediction of the likely failure of conscious, just-in-time, information based interventions to change habitual behaviour. CBM techniques instead aim to directly alter the automatic processes that drive behaviour.

Related work

There are 4 broad categories of CBM: CBM-Attention (CBM-A), which aims to alter an attention bias towards a particular cue and/or away from a particular cue, e.g. [6,15]; CBM-Approach (CBM-Ap), which aims to reduce an inherent approach bias away from unwanted cues and/or increase an approach bias towards wanted cues, e.g. [35,40,42]; CBM-Interpretation (CBM-I), which aims to reduce negative interpretations of ambiguous information, e.g. [13,22,32,37]; and CBM-Memory (CBM-M), which seeks to alter the memory of negative information, e.g. [14].

A seminal piece of CBM research is Wiers et al.'s finding that 4x15min sessions of a CBM-Ap training task (push away images of alcoholic drinks, pull towards you images of soft drinks using a joystick) had a small but significant effect on relapse rates in alcoholics when measured after 1 year [40]. A more recent anti-smoking CBM-Ap pilot used a single-session training webpage (push away smoking images, pull towards you neutral images using a mouse). A 4-week post-intervention survey showed a reduction in reported cigarette consumption, dependence and compulsion to smoke compared with a control [42].

Although the research field as a whole is moving towards delivering longer interventions within naturalistic settings [18], few CBM interventions have specifically targeted smartphones or other portable devices. Exceptions include a social anxiety training app using CBM-A [8], which found no significant effects but concluded that smartphones are a viable tool to deliver reaction-time based assessments; and a pilot healthy-eating CBM-Ap tablet game [35], replicating the push/pull paradigm with swipe up/down touchscreen gestures. There are also several commercial CBM apps claiming to help with social anxiety, problematic eating and smoking [4,20,21], but the evidence for their efficacy is unclear.

We selected the healthy eating domain because it is a pressing problem: some OECD countries may have 2/3 of their population obese by 2020 [34]. Evidence that CBM can impact this behaviour is provided by Kakoschke et al., who demonstrated that a single-session of CBM-A training (employing a modified Dot-Probe Test [19]) can increase both attentional bias for healthy foods and their subsequent consumption [15].

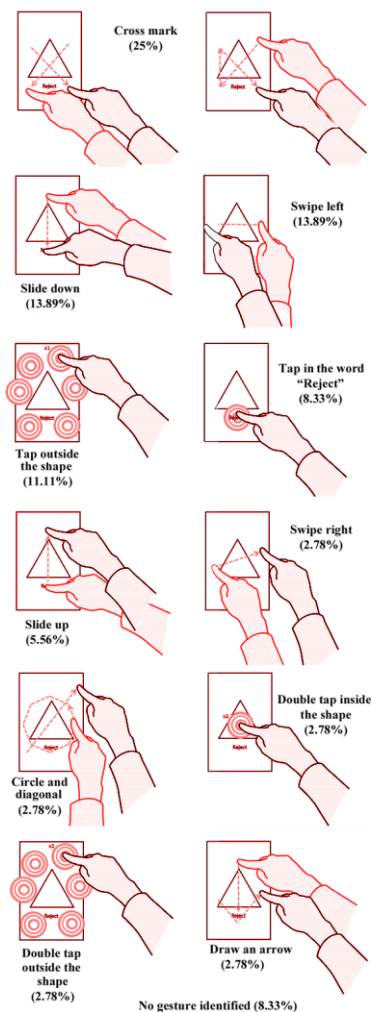


Figure 3 "Reject" gestures

Our approach differs from existing CBM research in several ways. Firstly, rather than using the *implicit* reject/accept gestures of the push/pull paradigm [35], we first undertook an elicitation study to explore how users attempt to accept/reject items on smartphones. Secondly, we incorporated the CBM training as part of existing smartphone actions (unlock activity, performed around 27 times per day [12]) rather than as a separate standalone app to explore *incidental* behaviour change. To our knowledge, this is the first intervention to apply CBM in an incidental way on smartphones. Finally, we prioritised the showing of the healthy foods over unhealthy foods at a ratio of 9:1 to address the possibility of ironic effects where showing unhealthy foods might cue users to consume them [2,7]. Our approach is therefore a combination of CBM-A and CBM-Ap since participants are asked to attend more to healthy than unhealthy foods.

Our hypothesis is that this blend of CBM-A and CBM-Ap will improve user attitudes towards and ratings of healthy foods and the reverse for unhealthy food. The implicit assumption is that this attitude change will impact on behaviour, but we did not test behavioural outcomes at this stage.

Elicitation study

Participants and procedure

We recruited 9 students from the University of Birmingham (3 females, 6 males). Eight participants were right-handed. All participants had previously used an interactive smartphone. Participants were given a smartphone running an app that showed eight different screens in succession: either a triangle or a rectangle in one of two colours with the instruction beneath to either "accept" or "reject" the image. Participants were

asked to perform any gesture to reject or accept the shapes. Participants were asked to perform the gesture 3 times before the image changed to the next one to ensure the experimenter coded their gesture correctly.

Results & discussion

Figure 2 and Figure 3 show aggregated results from the Accept and Reject conditions respectively. Double tap gestures should be disregarded because this gesture was used to start the experiment and may therefore have had a priming effect. The results show that there is no clear 'natural' accept or reject gesture, but the top gestures in each condition (check mark and cross mark) form a logical pair, so we selected these for our pilot app. Note also that both "slide up" and "slide down" – the most directly mapped gesture from the CBM-Ap push-pull paradigm – appear on both lists, making these gestures unsuitable for accept/reject training.

Pilot intervention study

Method

PARTICIPANTS AND DESIGN

22 participants (who had not participated in study 1) were recruited from the University of Birmingham (10 females, 12 males; mean age 29.3 years, *SD* 9.8 years). All participants with Android mobile phones were invited to take part in the intervention experiment; 12 agreed to do so; other participants acted as the control group ($n=10$).

Intervention participants ($n=12$) received an app that on unlock showed an image of either a healthy or unhealthy food as a full-screen overlay, in addition to any other unlock screen because of security concerns. Participants were instructed to use a check mark to

Healthy food	% times shown
Broccoli	12.47
Apple	10.24
Banana	10.16
Cabbage	10.12
Water	10.08
Peach	9.80
Orange	9.57
Avocado	9.37
Tomato	9.14
Strawberry	9.06

Unhealthy food	% times shown
Burger	1.38
Soft drinks	1.14
Potato crisps	0.99
Ice cream	0.92
Beer	0.89
Donut	0.89
Fries	0.89
Pizza	0.89
Cake	0.75
Muffin	0.71

Table 1 Healthy and unhealthy foods with percentage of times shown

accept healthy foods and a cross mark to reject unhealthy foods. If the correct gesture was performed, the overlay was removed and the participant was shown a brief notification for “accepted” or “rejected”. If the participant performed the wrong gesture, the application first asked them to try again, then reminded them of the correct gesture, then removed the overlay and showed another reminder of the correct gesture—see Figure 1 for the “healthy” unlock procedure. The picture shown was randomly selected from a group of 10 healthy food images and 10 unhealthy food images in a ratio of 9:1. Table 1 shows the relevant foods and the percentage of times each one was shown.

EVALUATION

Evaluating the impact of behaviour change interventions using technology is difficult, particularly in the short term [16]. Measuring the efficacy of interventions via self-report measures may not be accurate because of the persistence of the intention-behaviour gap [38]. CBM interventions should measure their impact on the relevant cognitive bias using non-self-report techniques and check for generalisability [18]. Yet the appropriateness of alternative measures of attentional bias, e.g. the emotional Stroop test [27], for studies relating to food consumption is not clear [24]. We therefore selected a pleasantness rating task from “extremely unpleasant” to “extremely pleasant” for the experiment set of healthy (HPR) and unhealthy (UHPR) food images as an implicit measure of attitudes towards them. Alongside this measure, we also implemented two explicit measures of food and food-related attitudes: The Health and Taste Attitude Scale (HTAS) [33], including only the General Health Interest (GHI) on the Health scale, but including all Taste scale components; and a 7-point Likert explicit attitude

rating for “healthy food” (HFA) and “unhealthy food” (UHFA) in general incorporating the following semantic differential scales: important-unimportant, healthy-unhealthy, enjoyable-unenjoyable, harmful-beneficial; satisfying-unsatisfying; pleasurable-unpleasurable.

PROCEDURE

All participants completed demographics, a consent form and a pre-test questionnaire. Intervention participants installed the app on their phones for 2 weeks or 256 trials (replicated from [15]), whichever happened first. Control participants received no intervention. After 2 weeks, all participants completed a post-test questionnaire identical to the first. The questionnaires, as outlined above, comprised the HTAS; ratings of experiment images to generate HPR and UHPR measures; and HFA and UHFA measures. All intervention participants were invited to participate in a post-intervention email interview; 6 accepted.

Results

QUANTITATIVE-USAGE

All participants completed 256 trials. On average, participants completed 232 healthy food-check trials ($SD=6.27$) and 24 unhealthy food-cross trials ($SD=6.27$). Figure 6 and Figure 7 show the number of tries required to complete the required gesture, showing participants found it more difficult to perform the cross gesture correctly first time than the check gesture. The mean error rate (participant failed to perform the correct gesture 3 times in a row) was 1.31% ($SD 1.04$). 2 participants (18%) had no trials marked “Incorrect”. On average, participants completed the 256 trials in 5 days (max=11, min=2). The average number of trials per day was 51.

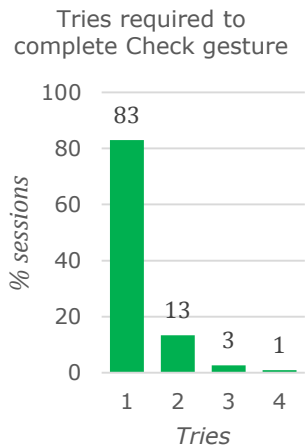


Figure 6 Check gesture tries

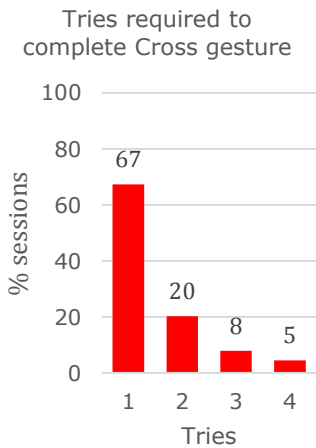


Figure 7 Cross gesture tries

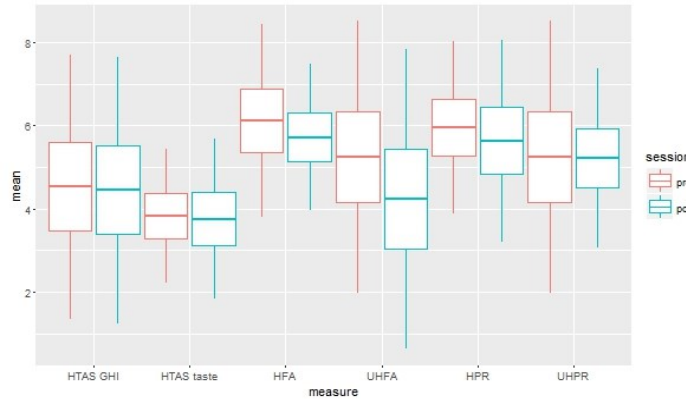


Figure 4 Control group - pre and post mean scores

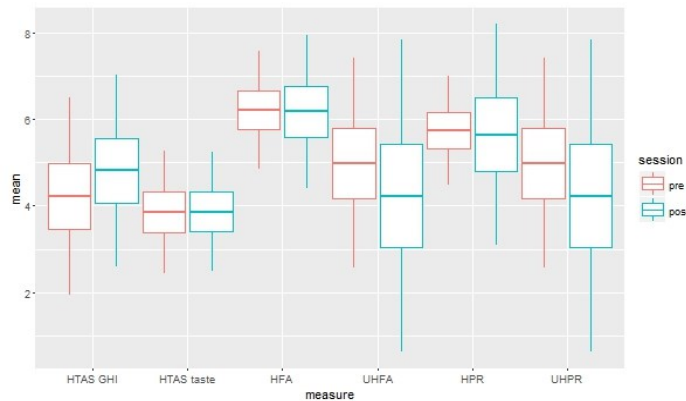


Figure 5 Intervention group - pre and post mean scores

QUANTITATIVE-ATTITUDES

Figure 4 and Figure 5 show mean values for each measure (HTAS GHI, HTAS taste, HFA, UHFA, HPR and UHPR) for the control and intervention group respectively for each session (pre- and post-). We constructed multilevel linear models in R version 3.2.3

[31] using the nlme package [29] to determine the effect of the interaction between intervention group and session on each measure, taking into account individual participant variation. We found a significant effect of the interaction on the HTAS GHI measure $\chi^2(1) = 5.39$, $p = 0.02$, with post-hoc analysis showing a significant increase in post-test GHI score for the intervention group, $b = 0.62$, $t(17) = 2.35$, $p = 0.03$. This confirms our hypothesis that the intervention group's GHI measure would improve post-intervention. No significant effects were found for any other attitude scores.

QUANTITATIVE-RATINGS

Average pleasantness ratings for healthy foods (HPR) and unhealthy foods (UHPR) were calculated for each participant, and we again constructed a multilevel linear model in R using nlme. No significant differences were found for this score the interaction between intervention and session, contrary to our expectation that repeatedly viewing the healthy food items would have an effect on HPR both from the CBM intervention and the mere exposure effect.

QUALITATIVE-INTERVIEWS

6 of the 12 intervention participants completed a brief semi-structured post-intervention interview via email where responses to questions on the app's usability and the general approach were elicited. Interestingly, 5 of the 6 respondents felt that the app supported them to make conscious healthy food choices. Requests for feature improvements included personalisation of the healthy/unhealthy food (3 participants), with one participant not recognising an avocado. One participant reported frustration with gesture recognition, particularly when they were in a hurry.

Category	Mentions
Food	34
Drink	22
Technology*	22
Exercise	20
Sedentary behaviour	19
Sleep	5
Study/work	5
Stress	4
Posture	2
Confidence	1
Tidiness	1
Camping	1

*1 mention was pro technology; the rest classed it as a negative item.

Table 2 Category mentions for CBM behavior change

Item	Mentions
Chocolate	18*
TV	18*
Fruit	18+
Water	17+
Book	15+
Sofa	12*
Phone	10*
Alcohol	10*

* reject items

+ accept items

Table 3 Top 8 specific item mentions for CBM behaviour change

Discussion

Our pilot results are naturally limited by the small sample size and non-randomised nature of the intervention. Our hypotheses were that the intervention group's HTAS scores and healthy food ratings would increase following intervention relative to the control group. The results show that this only held for HTAS GHI scores. No other evidence for changes was found, despite the larger proportion of healthy 'accept' trials completed, which we expected to have some impact via the mere exposure effect [43]. Nevertheless, the HTAS GHI score questions are general rather than specific, indicating that the intervention may have generalised effects.

Future research

We will repeat the elicitation study with larger numbers to determine the most appropriate simple accept/reject gestures. Next, we will repeat the intervention with a more rigorous experimental design, including a larger group, a longer period of intervention, and random allocation of conditions. A longer intervention period would also support the automaticity of response to a healthy or unhealthy cue as distinct from the participants' perception of a conscious choice: automaticity in behaviour may take 66 days to plateau [17]. A further condition should be introduced to determine whether the effect we found on HTAS GHI scores was a product of either CBM-Ap (i.e. the reject/accept gesture) or CBM-A (i.e. the mere exposure to healthy foods).

Future experiments should explore personalisation i.e. allowing users to provide their own images. A stronger effect may thus be obtained because healthy and unhealthy targets will reflect user preferences and

address the avocado recognition problem. Further, using photos of foods in naturalistic contexts may also result in a stronger effect since the context may also form part of the food-cueing process [26]. To inform future developments, we undertook a survey (n=58, mean age 30.5, SD 11.43, 43 females) asking users to list pairs of items for this sort of accept/reject training. Table 2 shows the categorised results, showing that users wish to alter food and drink intake, usage of technology and levels of activity. Table 3 shows aggregated specific items mentioned: chocolate and TV are the highest-mentioned reject items, with fruits and water the highest-mentioned accept items.

Future experiments in the domain should measure efficacy directly via a behavioural measure (e.g. food consumption) because of the difficulties of ascertaining an uncontroversial implicit measure of food attitude [24], the intention-behaviour gap [38], and the habitual nature of food consumption. Further, it may be that the *physical* push/pull effort in the CBM-Ap paradigm is important: future work could explore the use of motion gestures (e.g. [23]) to accept/reject wanted/unwanted stimuli on smartphones. CBM techniques could be further embedded into existing interaction gestures, e.g. integrating cues into the swipe gestures in an image gallery interaction.

In summary, we have demonstrated the feasibility and potential impact of an incidental CBM intervention on smartphones that integrates unobtrusively into users' existing behaviour. We continue to undertake a programme of research in the area because we feel it has the potential to provide an important contribution to the emerging field of nonconscious behaviour change techniques.

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