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Received: 23 November 2022 | Accepted: 1 June 2023

DOI: 10.1111/aphw.12464

ORIGINAL ARTICLE

APPLIED PSYCHOLOGY: Health and Well-Being IAAP

When nudgees become nudgers: Exploring the use of self-nudging to promote fruit intake

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Funding information
This research was funded by a grant from ZonMW, Netherlands Organisation for Health Research and Development (project number: 91215012). ZonMW did not have any role in the design, collection, analysis and interpretation of data and in the writing of the manuscript.

Abstract

The current study explored (1) the immediate and prolonged effects of self-nudges promoting fruit intake in the home environment, (2) whether the effect of self-nudges on fruit intake persists after self-nudges are no longer used (i.e. a temporal spillover effect) and (3) whether self-nudges can install healthy eating habits that, in turn, explain the temporal spillover effect. Participants ($N = 331$) were randomly assigned to either a control or self-nudge condition in which they had to choose a self-nudge promoting fruit consumption for 8 weeks. Thereafter, participants were asked to remove the self-nudge for 1 week to assess a possible temporal spillover effect. Results showed a positive effect of the self-nudges on fruit consumption right after implementation that continued during the 8 weeks in which the self-nudge was implemented, which was accompanied by an increase in fruit intake habit strength. However, a mixed picture emerged regarding the temporal spillover effect and no support was found for a mediation effect of habit strength. Although this study is only a first exploration of self-nudging to increase healthy food consumption, results indicate that self-nudging may be a promising extension of traditional nudging that can influence behaviour beyond out-of-home settings.

KEYWORDS
choice architecture, food choice, habit formation, self-nudge, temporal spillover

INTRODUCTION

After years of research, there is now ample evidence showing that nudging can be used to effectively promote healthy food choices (e.g. Arno & Thomas, 2016; Cadario & Chandon, 2020). However, traditional nudges are mainly used to affect food choices in out-of-home settings such as supermarkets or restaurants. Still, most of our daily food choices and consumption happen in the private home environment, where nudges are not implemented by someone else (e.g. a policy-maker), but we ourselves are the agent shaping our choice architecture. With self-nudging, people are taught to use the principles underlying nudging and to alter their own surroundings in line with their behavioural goals. In this way, the nudgee becomes the nudger. In the current study, we investigated the immediate and prolonged effects of self-nudges promoting fruit intake. Furthermore, we explored whether these effects persist after the self-nudges are no longer present through the formation of habits.

Self-nudging

With the increasing prevalence of diseases related to unhealthy diets (GBD 2019 Risk Factors Collaborators, 2020), effective interventions that sustainably improve healthy eating are desperately needed. It is therefore no surprise that numerous studies have been, and are being, conducted that investigate the best ways to promote (lasting) healthy eating behaviour. One popular approach that focuses on altering the environment to steer people's behaviour is called 'nudging'. Nudges are described as alterations of the environment (called choice architecture) that affect behaviour in a predictable way without forbidding any options and without changing their economic incentives (Thaler & Sunstein, 2008). To illustrate, in their study on the influence of container size on food intake, Marchiori et al. (2012) found that participants ate more M&M's out of a large container than out of a small container, even though the containers contained a similar number of M&M's. Meta-analyses indicate that, overall, nudges are effective in increasing healthy food choices, with effect sizes ranging from small to medium (Arno & Thomas, 2016; Cadario & Chandon, 2020, but see Maier et al., 2022, for a recent debate on the overall effectiveness of nudging).

Although past research indicated that nudges can be effectively used to affect single food choices, they are often implemented in out-of-home settings where someone else influences the choice architecture. These are generally environments where the food itself will not be consumed (e.g. supermarkets) or in environments where consumers will only sporadically consume food (e.g. football canteens or restaurants). Their impact on overall healthy eating patterns may therefore be limited. Most of our actual food consumption takes place in our homes. For example, in the Netherlands, 80% of our food consumption takes place at home (Van Rossum et al., 2020). It may therefore be worthwhile to investigate the use of nudging as an intervention tool used by individual themselves to stimulate healthier food intake in people's homes. Although it may be difficult to alter the choice architecture in people's homes, Reijula and

Hertwig (2022) propose that the person that is being nudged may also act as the choice architect themselves using self-nudging.

Self-nudging can be described as structuring one's own environment in a way congruent with one's goals (Reijula & Hertwig, 2022) and can therefore be seen as a form of goal striving (Mann et al., 2013). For example, somebody with the goal of changing their sedentary behaviour may adjust the height of a sit–stand desk to standing height at the end of the day to increase the chance of starting work standing the next day. In this sense, self-nudging shows similarities with other concepts that stress the importance of aligning one's surroundings with one's goals such as situational self-control (Duckworth et al., 2016) and stimulus control (one of the Processes of Change from the Transtheoretical Model; Velicer et al., 1998). Self-nudging may also be viewed as a specific form of boosting. The goal of boosting is to equip people with tools to make the right choices, by altering the decision-making environment or through extending decision-making skills (Hertwig & Grüne-Yanoff, 2017). Self-nudging does just this: It lets people in on the manner in which they can use their environment to achieve their goals.

Traditional nudging versus self-nudging

One of the key differences with traditional nudging is that the person who uses self-nudging is aware that nudges are used to steer their behaviour, because he or she is the choice architect themselves. Being unable to recognise the influence of the nudge used to be thought of as a key ingredient for nudges' effectiveness (Bovens, 2009). However, more recent studies examining the effect of explaining the aim of the nudge show that such nudge transparency does not compromise, and can even enhance, its effectiveness (Bang et al., 2020; Bruns et al., 2018; Loewenstein et al., 2015; Michaelsen et al., 2020, 2021; Paunov et al., 2019; Steffel et al., 2016). Awareness of the nudge when self-nudging may thus not compromise its effectiveness. In fact, so-called 'transparent nudges' have even been found to be more effective than nontransparent nudges. Better yet, such nudge transparency has been regarded as a solution to (partly) mitigate concerns surrounding the manipulative character of nudges and their potential negative effect on autonomy (Hansen & Jespersen, 2013; Wachner et al., 2020). Moreover, self-nudging per definition circumvents the critique that is often voiced against traditional nudging, namely, that behavioural goals are defined by others and are exactly similar for all that encounter the nudge, even though individual needs may differ (Hausman & Welch, 2010; Qizilbash, 2011). With self-nudging, behavioural goals are set by the nudgee themselves. In other words, the nudgee becomes the nudger.

Self-nudging may thus seem as a promising addition to traditional nudging because it promotes food choices in a stable environment in which much of our actual food consumption takes place and in a way that aligns with the individual's own goals in a transparent manner, making the nudge potentially even more effective and alleviating ethical concerns related to autonomy and manipulation. In view of these potential benefits, the first aim of the present study is to assess whether self-nudging is effective and whether effects remain over time.

Temporal spillover effects

In addition to assessing the immediate and prolonged effects of self-nudges when they are in place, this study also aims to examine whether these effects continue once the self-nudge is no longer present. Because of their subtlety, features crucial to nudges' effectiveness may easily get

changed or removed. For example, a study by Van Rookhuijzen and De Vet (2021) found that implemented nudges in two football canteens were often removed by others not involved in the study. Although this study examined nudges in out-of-home settings, home environments are not impervious to such effects, for example, through family members that are not aware of the self-nudge. The question therefore arises how lasting the effects of self-nudges are once they are no longer in place, effects also known as temporal spillover effects.

Although an earlier study (Van Rookhuijzen et al., 2021) did find temporal spillover effects of a nudge promoting prosocial behaviour, no temporal spillover effects were found for a nudge promoting healthier food choices. However, the choices in that study involved only hypothetical food choices that were only nudged once. In the current study, a nudge is implemented and real food consumption is reported for an extended period of time (8 weeks). Such an extended period of time in which nudges repeatedly affect behaviour allows for forming habits that may be needed for any temporal spillover effects to occur.

While traditional nudging mostly encourages the sporadic consumption of healthier foods, self-nudging can be implemented in the home environment, which likely is a more stable environment in which many food choices take place. An advantage of such stability is that this increases the potential for habit formation. Habits are automatic behavioural tendencies in response to a cue (Wood & Neal, 2009). An advantage of habits is that they are hard to break and that they thus can have lasting effects on health in general. The third aim of this study is therefore to assess whether self-nudges can install healthy eating habits and whether these habits can induce behaviour when the self-nudge is no longer present, that is, mediate the temporal spillover effect. In testing whether nudges are able to install habits, we address one of the most central unanswered questions surrounding the use of nudges in the long run (Congiu & Moscati, 2022).

Current study

In the current study, we conducted an experiment to explore (1) the immediate and prolonged effects of self-nudges promoting fruit intake and, if effective, (2) whether the effect of self-nudges on fruit intake persists after self-nudges are no longer used (i.e. temporal spillover effect) and (3) whether self-nudges can install healthy eating habits that, in turn, mediate the temporal spillover effect. Hereto, a study was conducted in which participants were randomly assigned to either a self-nudge or control condition. Participants in the self-nudge condition were asked to choose a self-nudge and to implement this nudge for 8 weeks. After these 8 weeks, participants in the self-nudge condition were asked to remove the nudge for 1 week. Fruit intake and fruit intake habit strength were measured six times: at baseline, four times during the self-nudge intervention and one time at the end of the study when the self-nudge had been removed for 1 week to assess potential temporal spillover effects.

METHODS

Transparency and openness

In this article, we report how we determined our sample size, all data exclusions, all manipulations and all measures that were included in the study. The study was approved by the Social

Sciences Ethics Committee of Wageningen University and Research. All data and analysis code are available online (https://osf.io/zu5bw/). Data were analysed using R version 4.2.1 and IBM SPSS Statistics (Version 28.0.1.1) (R Core Team, 2022). This study was preregistered at https://aspredicted.org/G1J_Z4T (#63981).

Participants

Three hundred and forty-four participants[1] were recruited via the online crowdsourcing website *Prolific Academic*. To be eligible for participation, participants had to (1) express an intention to increase their fruit consumption,[2] (2) indicate to be working from home during the COVID-19 pandemic, (3) be aged 18 or older, (4) be of UK nationality and speaker of the English language and (5) have two or more previous submissions and a 95% approval rate on Prolific Academic.

The intention to increase one's fruit intake was deemed a necessary precondition for the fruit intake promoting self-nudges to work in this study, because a defining feature of self-nudging is structuring one's surrounding congruent with one's goals. The inclusion criterion that participants should work from home was chosen because the COVID-19 pandemic resulted in the mandate of the government to work from home if possible. This was seen as an opportunity to study the use of self-nudging in a relative stable environment. Such stability is necessary for habits to form.

Participants in the main study were rewarded for each finished questionnaire according to the minimum standard set by Prolific Academic: £0.59 for the 7-min baseline questionnaire and £0.42 for the five 5-min follow-up questionnaires. Moreover, they were given a bonus of £2.00 once they completed all six questionnaires.

Of the 344 participants that completed the baseline questionnaire, 331 (96.2%) participants also completed at least one follow-up questionnaire and were therefore included in the analyses. Of these 331 participants, 170 (51.4%) had been randomly assigned to the control condition and 161 (48.6%) had been randomly assigned to the self-nudge condition. Seventeen participants (5.1%) completed two questionnaires, 25 participants (7.6%) completed three questionnaires, 28 participants (8.5%) completed four questionnaires, 52 participants (15.7%) completed five questionnaires and 209 participants (63.1%) completed all six questionnaires.

The mean age of the 331 participants that were included in the analyses was 38.81 years ($SD = 11.63$, age range 19–74), with 41.7% males and 58.3% females. A high school degree was the highest obtained diploma by 26.6% and a BSc diploma by 49.5% of the participants. Of all participants, 85.5% indicated to work from home at least 5 days a week. Regarding household size, 11.8% of participants indicated to live alone, 38.1% with two people, 23.6% with three people, 21.5% with four people and 5.1% with more than four people.

Design

The study used a 2 (between-subjects factor = Condition: control vs. self-nudge) × 6 (within-subjects factor = Time (moment of measurement): Tbaseline vs. T1 vs. T2 vs. T3 vs. T4 vs. Tspillover) mixed design with fruit intake and fruit intake habit strength as main dependent variables. A week before the end of the study, participants were asked to remove the self-nudge in the self-nudge condition. A schematic presentation of the study design can be found in Figure 1.

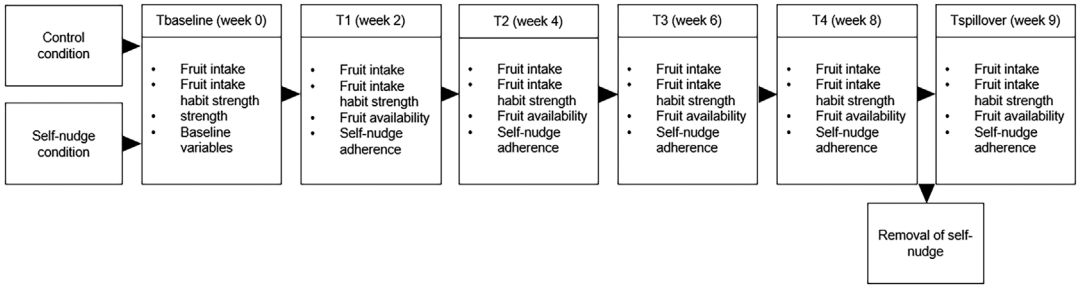

FIGURE 1 Experimental design.

Procedure

Data collection took place during February–April 2021. The entire study lasted 9 weeks and consisted of two periods: an intervention period (8 weeks) and a spillover period (1 week). This duration was chosen to allow for habit formation to occur (Keller et al., 2021; Lally et al., 2010). During these 9 weeks, participants received six similar questionnaires: one baseline questionnaire, four questionnaires during the intervention period and one questionnaire at the end of the spillover period.

At the start of the study (Tbaseline), participants were randomly assigned to either a control or self-nudge condition. After having given informed consent, participants completed a baseline question, measuring demographics, baseline fruit intake and fruit intake habit strength. Participants in the experimental condition were urged to choose one out of six self-nudges that they had to implement during the following 8 weeks: the intervention period. During this period, participants received four questionnaires, again measuring their fruit intake and fruit intake habit strength. Moreover, in the self-nudge condition, adherence to the chosen self-nudge was measured. These four questionnaires were administered with 2 weeks in between every questionnaire (T1–T4). To account for different intake levels of fruit during the week, the days at which these four questionnaires were distributed alternated between Wednesdays and Fridays. At the end of the intervention period (T4), participants in the self-nudge condition were urged to remove the self-nudge that they implemented during the intervention period for 1 week: the spillover period. In this way, we could assess possible temporal spillover effects of the intervention period. After this week, participants received their last questionnaire measuring fruit intake, fruit intake habit strength, fruit availability and self-nudge adherence (not using the self-nudge in this case).

Measures and materials[3]

Baseline questionnaire

At Tbaseline, participants were asked their age (in years), gender (male, female, or other), the highest degree of completed educational level (less than a high school diploma/high school degree or equivalent/bachelor's degree/master's degree/doctorate/other [please specify]) and household size. At Tbaseline and Tspillover, participants were also asked the number of days they worked and the number of days they worked from home. The intention to increase fruit

intake was measured during all measurements (Tbaseline–Tspillover) by taking the mean of the following items: 'I intend to increase my fruit consumption', 'I plan to increase my fruit consumption' and 'I want to increase my fruit consumption' to which participants had to indicate the extent to which they agreed with each statement on a 7-point Likert scale ranging from *strongly disagree* to *strongly agree*. For Tbaseline–Tspillover, Cronbach's alphas for the intention to increase fruit intake were >.935.

Manipulation

At the end of the baseline questionnaire (Tbaseline), participants in the self-nudge condition were explained what nudges are and asked to choose one nudge that they had to implement for 2 months to help them put their intention to eat fruit into practice. They were asked to choose a nudge that they did not yet use and that was feasible to implement. Participants could choose one nudge from two accessibility, two salience and two reminder nudges. Chosen nudges were based on the typology of self-nudges by Reijula and Hertwig (2022) and were formulated during brainstorm sessions. The self-nudges can be categorised in the Behaviour Change Technique Taxonomy of Michie et al. (2013) as restructuring of the physical environment and prompts/cues. After 2 months, participants were asked to remove the nudge. Participants could choose one of the following nudges:

1. Prepare and cut fruit I want to eat in advance (accessibility), which was chosen by 17 participants (10.6% of the self-nudge condition).
2. Place a portion of fruit within reach of where I spend much of my time (accessibility), which was chosen by 27 participants (16.8% of the self-nudge condition).
3. Put a fruit basket within sight of where I spend much of my time (salience), which was chosen by 43 participants (26.7% of the self-nudge condition).
4. Place fruit in the refrigerator in a clearly visible place (salience), which was chosen by 28 participants (17.4% of the self-nudge condition).
5. Set an alarm that reminds me to eat a piece of fruit (reminder), which was chosen by 28 participants (17.4% of the self-nudge condition).
6. Place a reminder that I have to eat fruit in a clearly visible place (e.g. a note on the refrigerator) (reminder), which was chosen by 18 participants (11.2% of the self-nudge condition).

Fruit intake

Fruit intake of participants in both the self-nudge and control conditions was assessed at baseline (Tbaseline), during the intervention (T1–T4) and after participants were asked to remove the self-nudge (Tspillover). Participants were asked what types and the number of units of fruit they had consumed the day before they received the questionnaire and the day before that to calculate the portions of fruit consumed during the 2 days before measurement.[4] For both days, participants were presented with a so-called fruit diary: a list of common fresh fruits, dried fruits, canned fruits and fruit juices of which they had to indicate *what* and *how much* they had consumed, which could be a whole number or fraction. For all categories, multiple 'other' options were also presented. Standard units were given as default for each fruit (e.g. 'hands' for

grapes), but participants could choose between 'pieces', 'hands', 'slices' and 'glasses'. To calculate the number of consumed portions, guidelines of the National Health Services in the United Kingdom to what consists of one portion were followed (National Health Service, n.d.). This means that for some fruits, one piece was considered one portion (e.g. apple); for other fruits, more than one piece was considered a portion (e.g. tangerine); and for others, one piece was considered as more than one portion (e.g. mango). Moreover, on each day, fruit juice could count as a maximum of one portion per day. These portions were added together to calculate the number of consumed fruit portions.

Fruit intake habit strength

Fruit intake habit strength was measured by administering the self-reported habit index (Verplanken & Orbell, 2003). Participants had to indicate on a 7-point Likert scale ranging from *totally disagree* to *totally agree* to which extent they agreed with the following statement: Eating fruit at home is something ... followed by 12 items (e.g. ... is something I do automatically). For Tbaseline–Tspillover, Cronbach's alphas were >.963. The mean of these items was calculated and taken as a measure for fruit intake habit strength.

Fruit availability

Because the effect of the self-nudges to increase fruit consumption in the home environment is reliant on the availability of fruit, we measured fruit availability in both the control and self-nudge conditions on the five timepoints after baseline (T1–Tspillover). Participants were asked whether they had any fruit in their home on both 2 days prior to receiving the questionnaire ('yes'/'no').

Self-nudge adherence

Adherence to the chosen self-nudge was reported at T1–T4 in the self-nudge condition. Participants were asked whether their chosen self-nudge was in place on both 2 days prior to receiving the questionnaire ('yes'/'no'). Moreover, participants were given room to comment. At Tspillover, a week after participants were asked to remove the self-nudge, participants in the self-nudge condition were asked whether they indeed *not* implement the nudge on these days. If they indicated that they did use the self-nudge on one of these days, they were asked why this was the case (I did it without thinking/I forgot the instructions/I did not want to change back to the old situation/I did not read the instructions/I did it automatically/other) and to explain their answer.[5]

End questions

At Tspillover, participants in both the control and self-nudge conditions were asked to indicate how often they used each of the self-nudge strategies during the first 8 weeks of the study to help them increase their fruit intake for every strategy with a 5-point Likert scale ranging from

never to *always*. Participants in the self-nudge condition were also asked to indicate on a 5-point Likert scale from *strongly disagree* to *strongly agree* the extent to which they found it easy to consistently use the chosen self-nudge during these 8 weeks, the extent to which they found the chosen self-nudge helpful in increasing their fruit intake and whether the chosen self-nudge helped others in their household to consume more fruit (with the addition of a 'not applicable' option).[6]

RESULTS[7]

Descriptive information

Participants on average had a relatively high baseline intention to eat more fruit (M = 5.96, *SD* = 0.88). Results showed very high numbers of fruit availability, with percentages ranging from 89.4% to 95.8% in the control condition and percentages ranging from 95.0% to 98.7% in the self-nudge condition.

Randomisation check

We first examined whether the control and self-nudge conditions were comparable on a number of variables at Tbaseline using analyses of variance and chi-square tests. No differences were found regarding age ($F(1, 329) = 0.144$, $p = .705$), gender ($\chi^2(1) = 0.063$, $p = .802$), education ($\chi^2(5) = 4.999$, $p = .416$), number of work days ($F(1, 329) = 0.076$, $p = .783$), number of days working from home ($F(1, 329) = 0.003$, $p = .956$) and household size ($F(1, 329) = 2.007$, $p = .158$). However, the intention to consume more fruit was significantly higher in the self-nudge (M = 6.22, *SD* = 0.60) than in the control condition (M = 5.72, *SD* = 0.98) ($F(1,329) = 30.44$, $p < .001$, $\eta_p^2 = .085$). Moreover, intention to consume more fruit at Tbaseline significantly correlated with fruit intake at T1 ($r = .114$, $p = .043$). Conform preregistration, intention to consume more fruit was therefore added to our statistical models.

Manipulation check: Self-nudge adherence

Throughout the study, self-nudge adherence was measured in the self-nudge condition. During the time participants were asked to implement the chosen self-nudge (T1–T4), the percentage of participants reporting that they made use of the self-nudge ranged from 81.6% to 84.8%. During the last week, participants were asked to remove the self-nudge. Most of the participants adhered to this request, with 91.1% of the participants reporting to have adhered to this request.

Main analyses[8]

Descriptive statistics and intercorrelations for fruit intake and fruit intake habit strength can be found in Table 1. To structure our analyses, we first examined the effect of the self-nudges on fruit intake during the intervention period (T1–T4) and spillover period (Tspillover). Thereafter, we examined whether any habit formation occurred and whether this mediated fruit intake at

TABLE 1 Descriptive statistics and intercorrelations for fruit intake and fruit intake habit strength (both nontransformed).

				Control condition			Self-nudge condition												
	n	M	*SD*	*n*	M	*SD*	*n*	M	*SD*	1	2	3	4	5	6	7	8	9	10	11
Fruit intake																				
1. Tbaseline	331	4.0	3.0	170	4.2	2.9	161	3.8	3.2	—										
2. T2	316	5.0	3.4	165	4.8	3.6	151	5.3	3.2	.49*	—									
3. T3	294	5.3	4.3	151	4.7	3.7	143	5.9	4.8	.43*	.58*	—								
4. T4	283	5.3	3.8	142	5.3	4.1	141	5.3	3.4	.43*	.53*	.62*	—							
5. T5	257	5.1	4.0	132	4.6	4.1	125	5.6	3.9	.37*	.56*	.53*	.57*	—						
6. Tspillover	254	5.6	4.3	133	5.6	4.6	121	5.5	4.0	.31*	.58*	.56*	.66*	.55*	—					
Fruit intake habit strength																				
7. Tbaseline	331	3.4	1.3	170	3.5	1.8	161	3.3	1.3	.49*	.28*	.21*	.26*	.25*	.21*	—				
8. T2	316	3.7	1.4	165	3.8	1.4	151	3.7	1.3	.43*	.34*	.25*	.30*	.29*	.25*	.84*	—			
9. T3	294	3.9	1.4	151	3.9	1.4	143	3.8	1.3	.43*	.34*	.31*	.32*	.24*	.27*	.83*	.89*	—		
10. T4	283	4.1	1.4	142	4.1	1.5	141	4.1	1.4	.41*	.35*	.30*	.39*	.25*	.31*	.77*	.85*	.89*	—	
11. T5	257	4.1	1.5	132	4.0	1.5	125	4.2	1.4	.43*	.36*	.34*	.39*	.34*	.39*	.75*	.82*	.87*	.89*	—
12. Tspillover	254	4.2	1.4	133	4.2	1.4	121	4.2	1.4	.40*	.35*	.28*	.37*	.31*	.40*	.72*	.78*	.83*	.86*	.93*

*$p < .001$.

Tspillover. Finally, we discuss questions about the subjective evaluation of the self-nudging intervention.

Fruit intake during the intervention period (Tbaseline–T4) and spillover period

Linear mixed models comprising of both fixed and random effects were formulated to assess the effect of self-nudging fruit intake for Tbaseline–Tspillover. After visual inspection of the normality of residuals, a log-transformation was performed for fruit intake, and 0.5 was added to account for the number of participants that did not consume any fruits.

The overall model including both the self-nudge and control conditions and intention to increase fruit intake showed a significant condition * time interaction effect ($F(5, 1420) = 5.840$, $p < .001$, $\eta_p^2 = .020$). Estimated marginal means of fruit intake on the different timepoints for the control and self-nudge conditions can be seen in Figure 2.

Simple effects within time: Intervention period (T1–T4)

Although participants were randomly assigned to either the control or self-nudge condition, surprisingly, baseline fruit intake was significantly higher in the self-nudge condition than in the control condition ($p = .025$, $\eta_p^2 = .250$). Post hoc tests for the intervention period (T1–T4) were therefore conducted comparing fruit intake in the control and the self-nudge conditions at every timepoint while controlling fruit intake at Tbaseline. When controlling for fruit intake at Tbaseline, significant differences between the groups were observed at T1 ($p < .001$, $\eta_p^2 = .429$), T2 ($p < .001$, $\eta_p^2 = .466$) and T4 ($p < .001$, $\eta_p^2 = .533$) and a marginally significant difference was found for T3 ($p = .059$, $\eta_p^2 = .288$), all indicating a higher fruit consumption in the self-nudge condition.

In addition, post hoc tests were conducted comparing the control and the self-nudge conditions at every timepoint while controlling for the previous timepoint. These tests were conducted to test out expectation that fruit intake would increase after Tbaseline, but that thereafter, fruit intake would remain stable. As expected, differences between the self-nudge and control conditions were observed at T1 (when controlling for baseline) ($p < .001$,

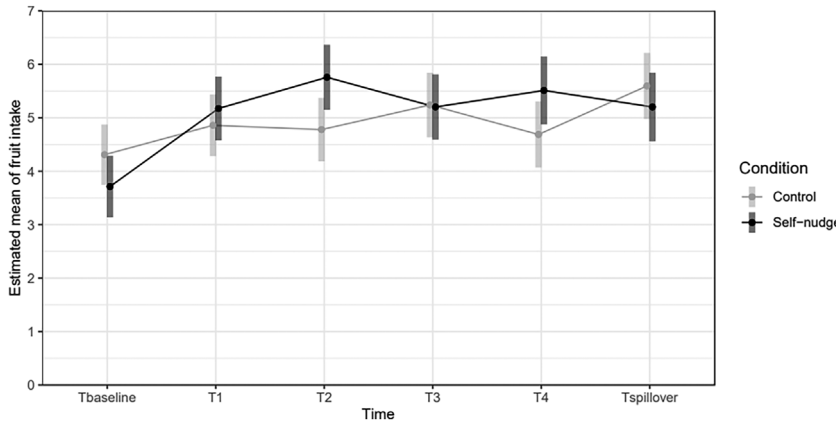

FIGURE 2 Estimated means of fruit intake (portion) at Tbaseline–Tspillover for the control and self-nudge conditions. Error bars represent 95% confidence intervals.

$\eta_p^2 = .429$), while no differences between the two conditions were observed at T2 (when controlling for T1) ($p = .998$), at T3 (when controlling for T2) ($p = .476$) and at T4 (when controlling for T3) ($p = .201$). Overall then, these results indicate that the difference between the self-nudge and control conditions remains similar throughout the study.

We also analysed the effect of time within the self-nudge condition only to investigate how fruit intake is affected throughout the intervention period for those using self-nudging. Comparing Tbaseline to all of the following timepoints separately revealed significant differences for all contrasts (all $p < .001$, all η_p^2 between .445 and .516) indicating that fruit intake was higher during all timepoints of the intervention period than during baseline. In addition, we compared fruit intake in the self-nudge condition at every timepoint during the intervention period with the previous timepoint, indicating that only the difference between Tbaseline and T1 was significant ($p < .001$, $\eta_p^2 = .516$, all other $p > .985$).

Simple effects within time: Spillover period (Tspillover)

To assess whether the effects of the self-nudges continued once they were removed, a post hoc test was conducted comparing the control and the self-nudge conditions at Tspillover while controlling for fruit intake at Tbaseline. This comparison did not show a significant difference ($p = .423$), which means that we could not find support for a difference in fruit intake between the two conditions after the self-nudge was removed. In addition, a post hoc test was conducted comparing the control and self-nudge conditions at Tspillover while controlling for the previous timepoint (T4). This test did show a significant difference between the two conditions ($p = .03$, $\eta_p^2 = -.349$), meaning that the difference between the two conditions at T4 did not continue to Tspillover, with fruit intake in control condition increasing and fruit intake in the self-nudge condition decreasing from T4 to Tspillover.

The lack of a significant difference between the two conditions at T5 does not seem to stem from a decreasing fruit intake in the self-nudge condition but a surprising increase in fruit intake in the control condition. A post hoc test comparing Tspillover with T4 in the control condition namely showed a significant effect ($p = .011$, $\eta_p^2 = .273$), with higher fruit intake at Tspillover than T4. In addition, post hoc tests in the self-nudge condition showed a significant difference between Tbaseline and Tspillover ($p < .001$, $\eta_p^2 = .402$), with higher fruit intake at Tspillover than at Tbaseline, while no difference was found when comparing T4 with Tspillover ($p = .893$).[9]

Fruit intake habit strength

To assess whether the self-nudge promoted habit formation, linear mixed models comprising of both fixed and random effects were formulated to assess the effect of the self-nudge on fruit intake habit strength for Tbaseline–Tspillover. In the overall model including both the control and self-nudge conditions and intention to increase fruit intake, a significant condition * time effect was observed ($F(5, 1401) = 3.740$, $p = .002$, $\eta_p^2 = .013$). Figure 3 shows the estimated marginal means of fruit intake habit strength on different timepoints for the control and self-nudge conditions.

Because the difference between the control and self-nudge conditions on fruit intake habit strength at Tbaseline was marginally significant ($p = .060$, $\eta_p^2 = .211$), post hoc tests were conducted comparing the control and self-nudge conditions at every timepoint while controlling for habit strength at Tbaseline. A significant difference was observed at T4 ($p < .001$,

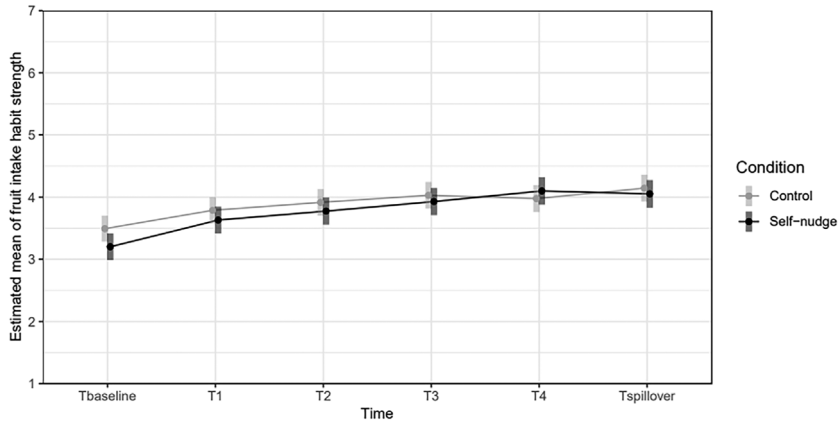

FIGURE 3 Estimated means of fruit intake habit strength at Tbaseline–Tspillover for the control and self-nudge conditions. Error bars represent 95% confidence intervals.

$\eta_p^2 = .300$), but not for T1 ($p = .448$), T2 ($p = .359$), T3 ($p = .166$) and Tspillover ($p = .163$). This means that the increase in habit strength initially was similar in the control and self-nudge conditions, but that fruit intake habit strength increased significantly stronger in the self-nudge condition compared with the control condition at T4.

To test whether fruit intake habit strength at Tspillover mediated the effect of condition on fruit intake at Tspillover, a mediation analysis was conducted with the PROCESS macro for SPSS (model 4) using a 95 percentile bootstrap approach with 5000 samples. The mediation analysis revealed no mediating effect of fruit intake habit strength (B = 0.0009, SE = 0.2278, 95% CI [−0.4461, 0.4687]).

Subjective evaluation of self-nudging intervention

Most participants (85.1%) (strongly) agreed with the statement that it was easy to consistently use the self-nudge. Of those that did use the self-nudge, 75.2% (strongly) agreed with the statement that the self-nudge helped them consume more fruit. Of those participants that shared their household with other people, 50.9% believed that the self-nudge helped others in the household consume more fruit.

DISCUSSION

Where traditional forms of nudging can be used to promote healthy eating in out-of-home settings, self-nudging (Reijula & Hertwig, 2022) may be a viable tool to use in the promotion of healthy eating inside people's homes. In this study, we (1) investigated the immediate and prolonged effects of a self-chosen self-nudge promoting fruit intake, (2) whether these effects persist after the self-nudge is removed (i.e. temporal spillover effect) and (3) whether self-nudges can install healthy eating habits that, in turn, mediate the temporal spillover effect. Results showed tentative evidence for an increase in fruit intake during the 8 weeks that the self-nudge was implemented. Mixed results were found for the presence of a temporal spillover effect, that

is, fruit intake in the self-nudge condition remained high relative to baseline fruit intake after the self-nudge was removed. However, it is difficult to interpret this effect as an indication for a temporal spillover effect or as result of other influences, because fruit intake in the control condition suddenly increased to a similar level as the self-nudge group during the spillover phase. The stronger increase in fruit intake in the self-nudge condition was accompanied by an increase in fruit intake habit strength relative to the control group. However, although we did find an increase in fruit intake habit strength, no mediation effect of fruit intake habit strength was found for the temporal spillover effect. In sum, these results imply that self-nudging should be considered as a promising intervention tool in addition to traditional nudging, but no convincing evidence was found indicating a temporal spillover effect.

One of the key differences between traditional nudging and self-nudging is that the nudger 'knows' about the use and purpose of the self-nudges. Although nudges' effectiveness was originally thought to depend upon the nudgee being oblivious to their use (Bovens, 2009), our findings imply that nudges can still affect behaviour even when implemented by the nudgee themselves. These results are in line with recent findings that show that openness about the goal and mechanisms of nudging does not negate its effectiveness (Bang et al., 2020; Bruns et al., 2018; Loewenstein et al., 2015; Michaelsen et al., 2020, 2021; Paunov et al., 2019; Steffel et al., 2016).

After we explained the concept of self-nudging, we let participants choose one out of six predefined self-nudges to help them increase their fruit intake. The question remains whether such specific directions are needed for self-nudging to effectively alter behaviour or whether people can effectively be taught the theory behind self-nudging and how to alter their environments in line with their goals, without specifying which specific alterations should be made. An advantage of such general skill training is that the self-nudging technique is not limited to one single behaviour in one context but can be used to promote all kinds of behaviours in multiple contexts. It can be argued that this flexibility could enhance prolonged effects (Hertwig & Grüne-Yanoff, 2017). Future research is needed to uncover the effect and bandwidth of self-nudging as a form of general skills training.

Although the importance of studies into the prolonged effect on nudges is often underlined, it has not been topic of many studies. In this study, we found that fruit intake remained stable after an initial increase during the 8 weeks that the self-nudge was implemented. Although future research is needed on this topic, we hypothesise that self-nudging may be particularly suited to affect behaviour for an extended period for two reasons. First, unlike with traditional nudging, the behaviour that is targeted by a self-nudge always aligns with the goals of the nudgee. Observing a change in one's own behaviour through the use of self-nudges may act as positive reinforcement, making it more likely to continue the behaviour. Second, it may be easier to keep nudges in place in home settings than in out-of-home settings, where nudges are easily removed when people confronted with them do not know their purpose, because they often consist of very small changes in the choice architecture (Van Rookhuijzen & De Vet, 2021). This is illustrated by the large number of participants that was able to keep the nudge implemented throughout the study.

Despite that the data pattern seemed to indicate that the self-nudges had immediate and prolonged effects on fruit intake, the data did not allow for any definitive conclusions regarding the prolonged effect of self-nudges after their removal and the role of habit strength in the temporal spillover effect. Although fruit intake remained stable during the spillover period relative to the intervention period in the self-nudge condition, we also observed a sudden increase in fruit intake during the last week of the study in the control group. It is unclear what may have

caused this sudden increase. Moreover, we did find a stronger increase in fruit intake habit strength in the self-nudge condition than the control condition but could not find any indication of a mediation effect of fruit intake habit strength to explain the temporal spillover effect. A possible explanation for these results may be that the self-nudge consistently acted as cue for fruit intake. The habit of taking fruit would then depend on the self-nudge being present. We hypothesised that other features of the environment could become associated with fruit intake over time, leading them to elicit the behaviour instead of the self-nudge. Clearly, more research in this area is needed.

Limitations and suggestions for future research

Some limitations that warrant future research should be mentioned. First, the data in this study provide strong support for the positive effect of self-nudging on fruit intake and habit formation during the 8 weeks of implementation. However, even though participants were randomly assigned to either the control or self-nudge condition, there were baseline differences in fruit intake and fruit intake habit strength between the two conditions, with participants in the self-nudge condition having a lower fruit intake and fruit habit strength than participants in the control condition. It can be argued that the steeper increase in fruit intake in the self-nudge condition is the result of this baseline difference, because there was more room for improvement. Future research should replicate this study's findings to further uncover the effect of self-nudging on fruit intake.

Second, during the entire study, only self-report measures were used. For example, fruit intake was measured with fruit diaries and habit strength was measured using the self-reported habit index (Verplanken & Orbell, 2003). This may have resulted in bias for two reasons. First, memory recollections are not infallible. Bias in memories is a common occurrence and may result in bias in self-reports (Stone et al., 1999). Second, self-reports may partially act as interventions themselves. Knowing that you have to write down what you ate during the day may already affect your intake, which may have caused the increase in fruit intake and fruit intake habit strength in the control condition. Moreover, anticipating and filling in the questionnaires may also have acted as reminders for participants in the self-nudge condition to keep the self-nudge implemented. It is unclear whether instructing participants only once would cause the same effects. Moreover, although we asked participants whether they adhered to the self-nudge, we did not objectively check whether the nudge was implemented as described. Future research into self-nudging is advised to include more objective measurements (e.g. observations) and to use more intricate designs, such as the Solomon four-group design, to control for these limitations and to confirm the results found in this study.

Third, the found effect sizes were only small. This is not surprising, because studies into nudge effectiveness generally find small to medium effect sizes (Arno & Thomas, 2016; Cadario & Chandon, 2020). Still, bringing about a change in behaviour through such a small self-nudge intervention as used in the current study can be regarded as promising because it is strategy that may potentially be implemented in large groups of people and thereby create impact. It is not unlikely that a combination of more self-nudges aimed at the same goal could enhance the small effect found in this study. We recommend future research to study the effects of using more than one self-nudge.

CONCLUSION

Compared with more traditional forms of nudging, self-nudging may be especially suited for the promotion of healthy eating patterns, because most of our food consumption takes place in the home environment. By being an inherently transparent form of nudging which focusses on goals set by the nudgee themselves, many of the ethical concerns surrounding traditional nudging do not hold for self-nudging. This study is a first step in investigating the (prolonged) effects of self-nudging in the promotion of healthy eating. We conclude that self-nudging shows promise as an interventional tool in addition to traditional nudging to promote healthy eating.

CONFLICT OF INTEREST STATEMENT

We have no conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

All data and analysis code are available at https://osf.io/zu5bw/.

ETHICS STATEMENT

This study was preregistered at https://aspredicted.org/G1J_Z4T Identifier: #63981. The study was approved by the Social Sciences Ethics Committee of Wageningen University and Research.

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ENDNOTES

[1] As preregistered, sample size was calculated with the software G*Power 3.1.9.2. to detect a medium sized effect ($F = 0.25$) of the effect of group on fruit intake (one-way analysis of variance) with a power of 0.90. This resulted in a recommended sample size of 172. To account for a drop-out rate of 50%, 344 participants were recruited at baseline. However, after data were collected, advancing insights resulted in the addition of a statistician to our team. Therefore, the use of linear mixed models was not planned. Therefore, this is not reported in the preregistration and was not used to base the sample size used in this study on.

[2] To ensure that participants would have the intention to increase their fruit intake, a pilot study ($N = 150$) was conducted to gauge the percentage of people with the intention to increase their fruit intake, operationalised as a mean of 4.00 or higher on the items 'I intend/plan/want to increase my fruit consumption' measured on a 7-point Likert scale ranging from *totally disagree* to *totally agree*. Because 76.6% of participants fulfilled this criterium, a prestudy ($N = 1000$) was conducted measuring willingness to participate in the current 9-week study and intention to increase fruit consumption. Two hundred and ninety-eight participants were excluded because they indicated not to work from home. Of the remaining participants, 702 participants indicated to be willing to participate and had a mean of 5.00 or higher on their intention to increase their fruit consumption (Cronbach's $\alpha = .911$). These 702 participants were then invited to participate in the main study with 344 participant slots.

[3] Full instructions and materials can be found in Data S1.

[4] Analyses were conducted both for fruit intake during the day before the participants received the questionnaires and for fruit intake during the 2 days before participants received the questionnaire, because recalling consumed fruits of 2 days ago may be subject to more bias than for 1 day ago. Because results of both the

analyses showed a similar pattern, results are only reported for the fruit intake recall during the 2 days before participants received the questionnaire.

[5] All described analyses were also conducted with only those participants that adhered to the self-nudge at all timepoints. Because results showed a similar pattern to those reported, results are only reported for analyses including all participants.

[6] For exploratory purposes, we also measured unhealthy snack intake and unhealthy snack intake habit strength at Tbaseline–Tspillover. In the last questionnaire (Tspillover), participants were also again asked about their 'work from home' behaviour and how often they used each of the self-nudges that were included in the study during the eight experimental weeks. Discussing these variables is beyond the scope of this paper, but a discussion of unhealthy snack intake can be found in Data S2.

[7] As mentioned in the discussion on sample size calculation, advancing insights resulted in the addition of a statistician to our team. Therefore, the preregistered analyses differ slightly from the performed analyses (e.g. the use of linear mixed models to account for both fixed and random effects and data transformations to account for assumption violations). As such, one could argue that we deviate from the preregistered analyses. Therefore, in this article, our transformed analyses could be regarded as 'exploratory'.

[8] Although not mentioned when discussing each specific test, when conducting post hoc tests, *p*-values were adjusted for multiple testing using the multivariate approach.

[9] As preregistered, we also conducted the analyses without controlling for the differing baseline variables (intention to increase fruit intake and baseline fruit intake). These results showed a similar pattern, with differences found between the conditions on T1 ($p = .040$, $\eta_p^2 = .228$) and T4 ($p = .05$, $\eta_p^2 = .332$), but not at Tspillover ($p = .896$).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: van Rookhuijzen, M., de Vet, E., Gort, G., & Adriaanse, M. A. (2023). When nudgees become nudgers: Exploring the use of self-nudging to promote fruit intake. *Applied Psychology: Health and Well-Being*, *15*(4), 1714–1732. https://doi.org/10.1111/aphw.12464