Reviewer’s report

Title: Exploratory Study of The Impact of Perceived Reward on Habit Formation

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Reviewer: Jennifer Labrecque

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Exploratory Study of the Impact of Perceived Reward on Habit Formation

In a longitudinal experiment spanning four months, this paper examined whether reward (i.e., pleasure, intrinsic motivation, perceived utility, and perceived benefits) can accelerate the formation of habits for flossing and taking Vitamin C tablets. Specifically, the authors tested whether such rewards mediated and/or moderated the behavior - automaticity (habit) relationship. Future interventions should benefit from both the improved understanding of the mechanism through which rewards can impact habit formation as well as the exploration into which types of rewards may be most relevant. Because this study is exploratory and without a control condition, replication will be essential. However, I think that the findings as stated in the current manuscript are promising and interesting, and I would recommend that the authors be asked to submit a revision that addresses the following points:

1) Chosen time points need context. I was unclear about why you measured each of the variables at the time points you chose, and during the analyses many of the distinctions seemed arbitrary without sufficient rationalization (e.g., what is the significance of an effect at T2 and T3 but not T4?). For example, you say, "This moderation effect was largely seen eight weeks following the intervention. This timing may reflect a point when original intentions to perform a behaviour start to wane, and behaviour is more maintained by habitual processes." This is an interesting conjecture, and if the time points were originally presented with relevant hypotheses like this (or even described more thoroughly post-hoc based on the results you found, given that this was exploratory), the longitudinal aspect of this work would make a bigger contribution.

2) Specificity of language

A) Please clarify at the start that when the "habit" concept is mentioned in the study, it is operationalized as automaticity measured using the SRBAI.

B) There were several different terms used for the same concepts in this manuscript: habit strength, habit formation, automaticity (e.g., in the 4th paragraph in the Background section: "literature suggests that reward may moderate the impact of repetition on habit formation" followed later in the paragraph by an example from said literature in which "perceived
rewards strengthen the impact of repetition on automaticity", suggesting that automaticity and habit formation are being used interchangeably) (p. 3)

C) In the text, the term automaticity seems to be used both as a synonym for habit and as an antecedent of habit, and it would be helpful to clarify the intended relationship (which seems to be the former).

* Synonym example: "An interaction term was created between reward and behaviour, and included as a predictor of habit, to test whether reward moderates the behaviour-automaticity relationship." (p.12)

* Antecedent example: "identify ways to accelerate gains in automaticity, leading to new behaviours becoming habitual faster" (p. 3)

3) Inclusion criteria: Flossing 3 times a week seems like a lot, especially given that the average number of flossing days reported from your intervention participants is between 4 and 5. Similarly, taking a Vitamin C tablet might be a very new behavior for someone without a daily medication routine, but simply piggybacking onto an existing habit for someone who already has a daily routine. It would be helpful to have more information about whether your participants were actually creating new habits vs restoring old, bolstering weak, or piggybacking onto strong habits. You suggest this issue when you say: "the baseline rates of the target behaviours were in some cases relatively high, such that some participants were increasing the frequency of a behaviour, rather than initiating a novel behaviour" (p. 24).

4) Implementation intentions: Although participants created implementation intentions (when, where) to perform both the flossing and Vitamin C behaviors, the experimenters specified that the flossing should be at night. Was there a reason for this additional temporal component for flossing only, and if so why was night chosen as the temporal cue rather than morning? At T0, previous behavior for flossing was measured as "if they had ever flossed their teeth regularly before" which is much less specific.

5) Flossing pleasure: It surprised me that pleasure was the only reward measured for flossing as it seems that of all that you measured (also intrinsic motivation, perceived utility, and perceived benefits), pleasure would be the least relevant. However, displeasure seems very relevant. So which drives the effect? Is it that people who like flossing floss more, people who don't like flossing floss less, or is it a combination of both effects?

6) Objective measures: All of the measures collected in the current study are self-reported and therefore vulnerable to bias and memory failure. The behavioral measures could be easily
corroborated using objective measures (e.g., participants must return the Vitamin C bottle at the end of the study or at each in-person session, and the remaining pills are counted to verify self-report estimates).

7) Automaticity scores plateau: Given the prior literature on the variable and often extensive time required to form a new habit (e.g., Lally et al., 2010), it seems surprising that participants' automaticity scores plateaued at their second time point after the intervention (4 or 8 weeks out) - and it's possible that they reached this level much sooner and were just unmeasured. This could suggest that despite the increasing strength of associations over time, participants aren't able to discriminate longitudinal changes in habit strength using the SRBAI measure. It is also possible that automaticity was at ceiling for this kind of behavior. Do you have comparable data that could speak to this possibility? What do you think is happening over these additional 2 to 3 weeks (after the plateau) that isn't visible in either behavior or automaticity, and if it is important, do you have any other way to assess these changes?

8) Assumption of the moderation hypothesis: I suspect that your assumption is correct: forming habitual associations more quickly would be advantageous on all counts. However, is it possible that accelerating the habit formation process actually creates less stable habit associations in memory? I'm not aware of any data on the robustness of habit associations that are formed slowly over time vs in a shorter period of time (keeping repetition stable), but maybe this is something you've considered / investigated? One reason in particular for my concern is the heavy reliance on the self-report measure of automaticity, which has been shown to be very sensitive to repetition but unresponsive to other factors that influence the strength of habit associations (Labrecque et al., 2018, under revision).

9) Matching of predictors to outcomes: The results indicated that more experiential (rather than outcome-based, cognitive) rewards predicted the primary habit DV, perceptions of automaticity. Given that the SRBAI is sensitive to other aspects of physical experience (e.g., repetition), do you think that the conceptual match of these measures contributed to this relationship? Do you think perceived utility and benefits might have emerged as a more important predictor of the repetition - habit relationship if a more cognitive / less experiential measure of habit was used?

Recommendation: Revise and resubmit

Are the methods appropriate and well described?
If not, please specify what is required in your comments to the authors.

Yes
Does the work include the necessary controls?
If not, please specify which controls are required in your comments to the authors.

Yes

Are the conclusions drawn adequately supported by the data shown?
If not, please explain in your comments to the authors.

Yes

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