Supporting habit formation for long-term weight loss maintenance with a Virtual Coach - A Research Model

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Abstract. Maintaining weight loss is challenging for patients who suffer from obesity as behavior changes need to be kept long-term. Prior research has shown that introducing habitual behavior (i.e., habits) can lead to automaticity in performing a specific behavior so that it becomes second nature. This research-and-progress paper develops a research model to investigate the efficacy of virtual coaches to guide patients in forming habits. In particular, we investigate how virtual coaches can help patients form an implementation intention for a particular habit and positively reinforce this implementation intention using reminders, praise, and self-monitoring. Implications of this work are described for related diseases and long-term evaluations of virtual coaches.

Keywords: Habit, Virtual Coaching, Behavior Change, Obesity.

1 Introduction

Nowadays, overweight amounts to more than 1.9 billion overweight adults, of whom over 650 million are obese [1]. Reasons for obesity are multi-faceted [4], but at a superficial level, obesity results when energy intake exceeds energy expenditure [3]. Consequently, interventions promote physical activity and reduced energy intake. While these interventions are effective over the short term [4, 5], 80% of participants regain weight [6] as actions are not supported in the long run [3]. Habit-based interventions support long-term effects [7–9]. Habits form by repeatedly performing a behavior in the same context so that a mental association between behavior and context is created [10]. For example, seeing a fruit basket may foster healthy fruit intake. When this behavior is trained, a mental association between the fruit basket (as an example for context) and fruit intake (as an example for behavior) strengthens. Cleo et al. investigate the efficacy of habit-based interventions and report significant weight loss [8]. However, forming and strengthening habits is not easy as habits do not settle linearly [14], and persistence is needed. Information Systems (IS) can support persistence to form and strengthen habits. IS may remind to execute habits and reinforce the mental association between context and behavior (e.g., Please remember to get off the bus earlier and walk). IS can also provide information about beneficial habits and help to adapt them. First contributions have been achieved with health behavior change support systems (HBCSS). However, these systems do not support strengthening habits

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[12, 13]. So, the impact is limited to the short-term. Also, further improving system usability and tailoring messages is crucial for maintaining long-term effects [14]. We aim to investigate how HBCSS can best support habit formation and strengthening. As a user interface, we use conversational agents (CAs) to emulate interpersonal communication to ensure high usability and connectedness [15, 16]. In this work-in-progress paper, we report a design science research (DSR) approach to investigate, design, and evaluate a habit-based HBCSS as a virtual coach (VC) for obese patients by extending artifacts we have previously designed [17–20] using adaptations [21]. We contribute a research model of how habit-based HBCSS can be evaluated and an HBCSS that can easily be adapted to other diseases.

2 Background

A habit is an automatic behavior occurring in response to a particular context in which this behavior has been performed consistently and repeatedly [22–24]. To form a habit, a mental association between context (e.g., being on the bus for work) and behavior (e.g., get off one stop earlier and walk) must be created [22]. Contexts include physical settings (kitchen), time (9 a.m.), people (alone), prior behavior (getting up), internal state (being stressed), and combinations thereof [25]. Associations between context and behavior are created with implementation intentions, which link a context (**if** *I am on the bus for work*) to a behavior (**then** *I will get off earlier and walk*) [26]. After its formation, the association must be strengthened by repeating the behavior within the context [27, 28] so that the cognitive effort required to act decreases while alternatives become less accessible [29, 30]. Prior research discusses digital strategies that support habit-forming and strengthening [12, 13], including information provision, setting implementation intentions, and positively reinforcing these intentions. Information provision allows for an overview of behavior, providing a basis to decide which behavior to make habitual. Furthermore, formulating Implementation Intentions (***if*** *I am on the bus for work,* ***then*** *I will get off earlier and walk*) can be digitally supported by providing a context selection that users can choose from and refine. Implementation intentions can be positively reinforced to strengthen the association between behavior and context using self-monitoring, praise, and reminders. Self-monitoring is common for digital behavior change interventions [34], with evidence of small-to-medium changes in attaining health goals [32]. Also, just-in-time reminders [13], delivered when the system anticipates an opportunity to perform habits [12, 33], are used. Yet, while just-in-time reminders support repetition, they hinder the habit from becoming strong [13]. Once the user abandons the system, the behavior will likely be given up. However, (just-in-time) reminders are helpful to foster repetitive behavior for the time it requires to decide whether to keep or abandon the habit. Yet, to strengthen habits, just-in-time reminders should be decreased over time [12, 13].

For implementing these digital strategies, HBCSS can be used. HBCSS are often grounded within the Persuasive System Design (PSD) Model [34] that includes 28 design principles that we combine with the guidelines by [12, 13] to ground our design decisions (**Figure** 1). HBCSS should address habits on two levels [35]: IT and content-

related habits. IT habits foster system use adherence for the time required to strengthen content-related habits. Prior research has investigated design strategies for system use adherence like ensuring usability, social connectedness, and login reminders [36–38]. In particular, CAs as user interfaces ensure high usability and connectedness [15, 16]. A subtype of CAs are embodied conversational agents (ECAs) as intelligent software systems with a visual and often humanoid appearance emulating verbal- and non-verbal communication [39]. Embodying the social role of a coach, ECAs can evoke feelings of social presence, trustworthiness, and supporting system use adherence [40].

Recently, prior HBCSS research has investigated habit formation to encourage stair climbing (disembodied CA; [41]) and weight loss [35]. In these systems, first digital strategies are implemented, such as information provision and reminders to positively reinforce repetitive behavior. Yet, implementing the whole range of digital strategies to support habit strengthening (e.g., setting implementation intentions and positively reinforcing habitual behavior) is still missing. Apart from HBCSS, habits have been implemented in lifestyle apps. While reminders and self-monitoring features are already used to foster repetitive behavior, most apps do not guide users in forming implementation intentions by letting them define personalized cues and tasks [13]. CAs can guide users in a dialog-oriented manner but have been less studied regarding habit formation [12]. Hence, to the best of our knowledge, an investigation of HBCSS for habit formation and strengthening by using reminders, self-monitoring, and praise along with an ECA to reinforce and guide implementation intentions in a clinical setting is still missing. Also, in the area of obesity, HBCSS for habit formation have only focused on a BMI range between 27 kg/m^2 and 35 kg/m^2 [35], so that no clinically relevant data is available for morbidly obese patients (BMI > 40 kg/m^2).

3 Design

We aim to design an ECA that fosters habit formation and strengthening using digital strategies to provide information as well as to form and positively reinforce implementation intentions (**Figure** 1a). Therefore, we extend the prototype described in a previous study [17–20] by porting the system to a mobile app. As depicted in **Figure** 1b, the HBCSS gathers data on the patient's side from Bluetooth devices (smartwatch for measuring daily activity, body scale) and manual data inputs (habit check off, goal setting, questionnaires). Due to the error proneness of artificial intelligence (AI)-based speech recognition and possibly resulting biases, we limit the communication to constrained input using action buttons with predefined questions and answers for this study (i.e., rule-based). Habit suggestions, motivational messages, and questionnaires are drawn from a database and specified by a therapist. The procedural knowledge of the VC for guiding the habit formation process is technically modeled following the approach described in the Horizon 2020 project *vCare* [19]. By building on the healthcare data exchange standard HL7 FHIR (http://hl7.org/fhir), integrating and adapting the system to other scenarios is facilitated. In particular, we use the FHIR resources CarePlan, Questionnaire, QuestionnaireResponse, Goal and Observation.

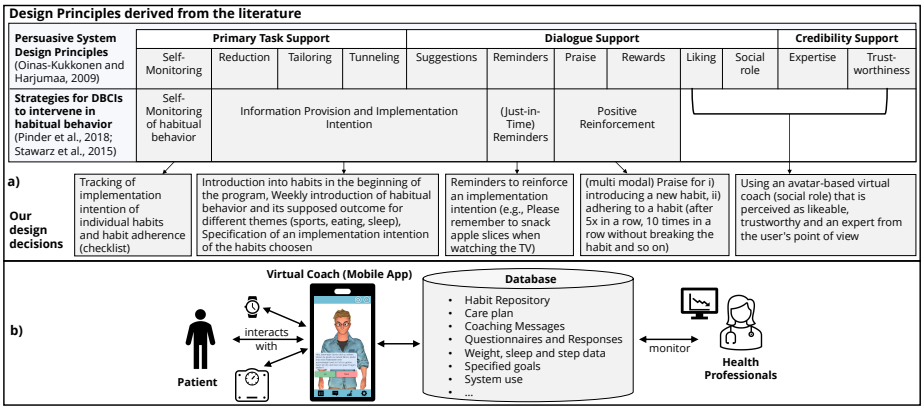

Figure 1**.** a) Design decisions for this study and b) High-level system architecture

4 Evaluation Approach

VC-guided interventions allow to flexibly implement habits, while traditional interventions require a therapist to guide patients. So, we suppose that VC-guided interventions lead to more introduced habits (H1; **Figure** 2). After implementation, habits need to be adhered to and strengthened. We operationalize habit adherence as the percentage of days that habits are executed and habit-strength using the Self-Report Habit Index [42], which has been the most prominent instrument to measure habit strength in psychology. This leads to H2&3, suggesting that VC-guided interventions lead to a higher percentage of days of habit execution (H2) and to stronger habits (H3).

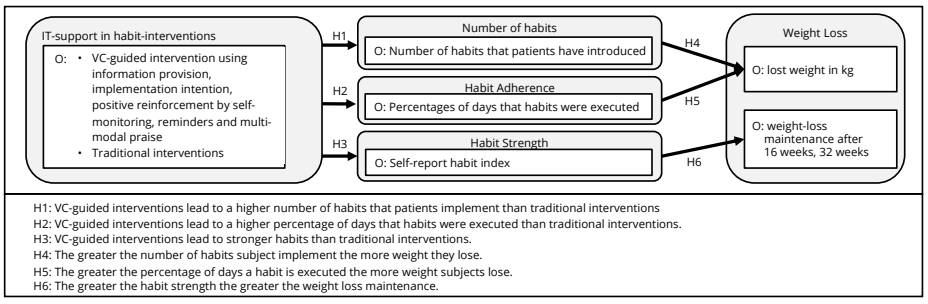

Figure 2**.** Research Model and hypotheses

Usually, more habits result in increased actions. So, we suppose that the more habits subjects implement (H4) and the more often a habit is executed (H5), the more weight subjects lose. Executing many habits regularly does not imply that habits become strong [12, 13]. H6 helps investigating whether our strategies help to strengthen habits. We investigate H1-6 with the research design of **Figure** 3. After a therapist introduces the subjects to the program, subjects implement habits by processing habit information

(e.g., positive influence of fruit intake), selecting habits and forming implementation intentions. Habit implementation for the intervention group is VC-guided and can be done whenever there is time. In contrast, the control group follows a weekly therapist-guided habit implementation and does not have IT support for positive reinforcement.

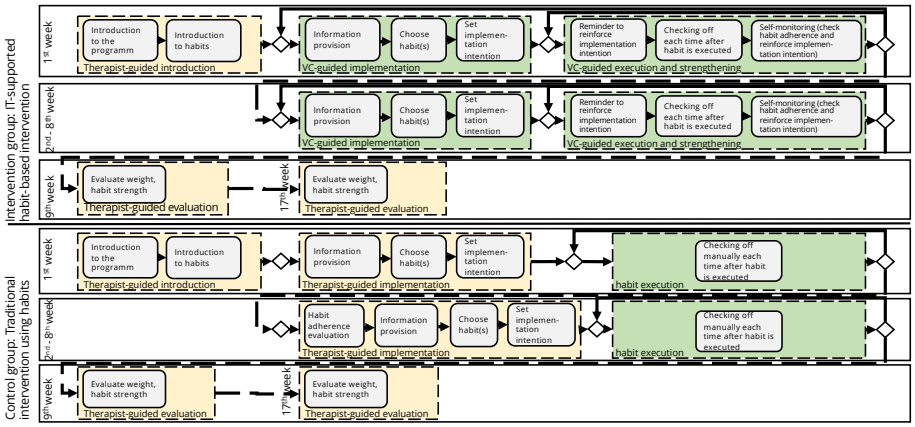

Figure 3**.** Research Design

5 Conclusion

We investigated VCs for habit formation and strengthening. The results are reflected in a research model to investigate the efficacy of VC-guidance to form and strengthening habits. In case this investigation reveals a positive impact, large-scale implementation can be facilitated for the area of obesity. Considering obesity as a representative example of behavior-modifiable diseases, the results may prompt future research to other chronic diseases such as diabetes, heart failure, or multiple sclerosis. Taking a more agile approach by collaborating with users [43] of various fields [44–46] may lead to an broader habit repository for multiple diseases and even wellbeing and stress reduction [47]. Future research could also equip the system with more advanced capabilities incorporating AI-based speech recognition along with algorithms to automatically learn about habits preferred by the patient or states for forming good and breaking bad habits. By conducting a study over several months, this research may also contribute evidence on the advantageousness of ECAs as interface modality in the long term. So far, most studies remain on short-period interactions in a controlled lab setting leading to a lack of studies investigating ECA-use in the long term [48].

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References

1. World Health Organisation: Obesity and overweight, https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight, last accessed 2021/06/23.
2. Butland, B., Jebb, S., Kopelman, P., McPherson, K., Thomas, S., Mardell, J., Parry, V.: Tackling obesities: future choices-project report. Citeseer (2007).
3. Gardner, B., Richards, R., Lally, P., Rebar, A., Thwaite, T., Beeken, R.: Breaking habits or breaking habitual behaviours? Old habits as a neglected factor in weight loss maintenance. Appetite. 105183 (2021).
4. Parretti, H.M., Jebb, S.A., Johns, D.J., Lewis, A.L., Christian-Brown, A.M., Aveyard, P.: Clinical effectiveness of very-low-energy diets in the management of weight loss: a systematic review and meta-analysis of randomized controlled trials. Obesity Reviews. 17, 225–234 (2016).
5. Hartmann-Boyce, J., Johns, D.J., Jebb, S.A., Summerbell, C., Aveyard, P., Group, B.W.M.R.: Behavioural weight management programmes for adults assessed by trials conducted in everyday contexts: systematic review and meta-analysis. obesity reviews. 15, 920–932 (2014).
6. Wing, R.R., Phelan, S.: Long-term weight loss maintenance. The American journal of clinical nutrition. 82, 222S-225S (2005).
7. Gardner, B., de Bruijn, G.-J., Lally, P.: A systematic review and meta-analysis of applications of the self-report habit index to nutrition and physical activity behaviours. Annals of Behavioral Medicine. 42, 174–187 (2011).
8. Cleo, G., Beller, E., Glasziou, P., Isenring, E., Thomas, R.: Efficacy of habit-based weight loss interventions: a systematic review and meta-analysis. Journal of behavioral medicine. 1–14 (2019).
9. Rothman, A.J., Sheeran, P., Wood, W.: Reflective and automatic processes in the initiation and maintenance of dietary change. Annals of Behavioral Medicine. 38, 4–17 (2009).
10. Neal, D.T., Wood, W., Quinn, J.M.: Habits—A repeat performance. Current directions in psychological science. 15, 198–202 (2006).
11. Gardner, B., Rebar, A., Lally, P.: How does habit form? Guidelines for tracking real-world habit formation. Psyarxiv. (2021).
12. Pinder, C., Vermeulen, J., Cowan, B.R., Beale, R.: Digital behaviour change interventions to break and form habits. ACM Transactions on Computer-Human Interaction (TOCHI). 25, 1–66 (2018).
13. Stawarz, K., Cox, A.L., Blandford, A.: Beyond self-tracking and reminders: designing smartphone apps that support habit formation. In: Proceedings of the 33rd annual ACM conference on human factors in computing systems. pp. 2653–2662 (2015).
14. Wang, Y., Min, J., Khuri, J., Xue, H., Xie, B., A Kaminsky, L., J Cheskin, L.: Effectiveness of Mobile Health Interventions on Diabetes and Obesity Treatment and Management: Systematic Review of Systematic Reviews. JMIR Mhealth Uhealth. 8, e15400 (2020). https://doi.org/10.2196/15400.
15. Tropea, P., Schlieter, H., Sterpi, I., Judica, E., Gand, K., Caprino, M., Gabilondo, I., Gomez-Esteban, J.C., Busnatu, S., Sinescu, C., Kyriazakos, S., Anwar, S., Corbo, M.: Rehabilitation, the Great Absentee of Virtual Coaching in Medical Care: Scoping Review. J Med Internet Res. 21, e12805 (2019). https://doi.org/10.2196/12805.
16. Kramer, L.L., ter Stal, S., Mulder, B.C., de Vet, E., van Velsen, L.: Developing Embodied Conversational Agents for Coaching People in a Healthy Lifestyle: Scoping Review. J Med Internet Res. 22, e14058 (2020). https://doi.org/10.2196/14058.

17. Weimann, T., Schlieter, H., Fischer, M.: Designing an Avatar-Based Virtual Coach for Obesity Patients. In: International Conference on Design Science Research in Information Systems and Technology. pp. 52–57. Springer (2021).
18. Weimann, T., Fischer, M., Schlieter, H.: Peer Buddy or Expert? – On the Avatar Design of a Virtual Coach for Obesity Patients. In: Proceedings of the 55th Hawaii International Conference on System Sciences (2022).
19. Gand, K., Böcking, L., Kreiner, K., Schlieter, H., Burwitz, M., Gißke, C., Philipp, P., Kropf, J.: Technically representing clinical knowledge for rehabilitation care. In: Proceedings of MIE 2021 (2021).
20. Gand, K., Stark, J., Schlieter, H., Gißke, C., Burwitz, M.: Using Clinical Pathways to Virtual Coach Patients For Home Rehabilitaton. In: Proceedings of the ICIS Conference (2021).
21. Schlieter, H., Stark, J., Burwitz, M., Braun, R.: Terminology for Evolving Design Artifacts. In: Proceedings of the WI 2019 (2019).
22. Lally, P., Gardner, B.: Promoting habit formation. Health psychology review. 7, S137–S158 (2013).
23. Wood, W., Neal, D.T.: The habitual consumer. Journal of Consumer Psychology. 19, 579–592 (2009).
24. Verplanken, B., Aarts, H.: Habit, attitude, and planned behaviour: is habit an empty construct or an interesting case of goal-directed automaticity? European review of social psychology. 10, 101–134 (1999).
25. Ji, M.F., Wood, W.: Purchase and consumption habits: Not necessarily what you intend. Journal of Consumer Psychology. 17, 261–276 (2007).
26. Gollwitzer, P.M., Sheeran, P.: Implementation intentions and goal achievement: A meta-analysis of effects and processes. Advances in experimental social psychology. 38, 69–119 (2006).
27. Lally, P., Van Jaarsveld, C.H., Potts, H.W., Wardle, J.: How are habits formed: Modelling habit formation in the real world. European journal of social psychology. 40, 998–1009 (2010).
28. Lally, P., Wardle, J., Gardner, B.: Experiences of habit formation: a qualitative study. Psychology, health & medicine. 16, 484–489 (2011).
29. Danner, U.N., Aarts, H., de Vries, N.K.: Habit formation and multiple means to goal attainment: Repeated retrieval of target means causes inhibited access to competitors. Personality and Social Psychology Bulletin. 33, 1367–1379 (2007).
30. Danner, U.N., Aarts, H., de Vries, N.K.: Habit vs. intention in the prediction of future behaviour: The role of frequency, context stability and mental accessibility of past behaviour. British Journal of Social Psychology. 47, 245–265 (2008).
31. Orji, R., Moffatt, K.: Persuasive technology for health and wellness: State-of-the-art and emerging trends. Health informatics journal. 24, 66–91 (2018).
32. Harkin, B., Webb, T.L., Chang, B.P., Prestwich, A., Conner, M., Kellar, I., Benn, Y., Sheeran, P.: Does monitoring goal progress promote goal attainment? A meta-analysis of the experimental evidence. Psychological bulletin. 142, 198 (2016).
33. Nahum-Shani, I., Smith, S.N., Spring, B.J., Collins, L.M., Witkiewitz, K., Tewari, A., Murphy, S.A.: Just-in-time adaptive interventions (JITAIs) in mobile health: key components and design principles for ongoing health behavior support. Annals of Behavioral Medicine. 52, 446–462 (2018).
34. Oinas-Kukkonen, H., Harjumaa, M.: Persuasive Systems Design: Key Issues, Process Model, and System Features. CAIS. 24, (2009). https://doi.org/10.17705/1CAIS.02428.
35. Karppinen, P., Oinas-Kukkonen, H., Alahäivälä, T., Jokelainen, T., Teeriniemi, A.-M., Salonurmi, T., Savolainen, M.J.: Opportunities and challenges of behavior change support

systems for enhancing habit formation: A qualitative study. Journal of biomedical informatics. 84, 82–92 (2018).
36. Doherty, K., Doherty, G.: Engagement in HCI: Conception, Theory and Measurement. ACM Comput. Surv. 51, 1–39 (2019). https://doi.org/10.1145/3234149.
37. Wei, Y., Zheng, P., Deng, H., Wang, X., Li, X., Fu, H.: Design Features for Improving Mobile Health Intervention User Engagement: Systematic Review and Thematic Analysis. J Med Internet Res. 22, e21687 (2020). https://doi.org/10.2196/21687.
38. O'Brien, H.L., Toms, E.G.: What is user engagement? A conceptual framework for defining user engagement with technology. J. Am. Soc. Inf. Sci. 59, 938–955 (2008). https://doi.org/10.1002/asi.20801.
39. Seeger, A.-M., Pfeiffer, J., Heinzl, A.: Texting with human-like conversational agents: Designing for anthropomorphism. Journal of the Association for Information Systems: JAIS. (2020).
40. Loveys, K., Sebaratnam, G., Sagar, M., Broadbent, E.: The effect of design features on relationship quality with embodied conversational agents: a systematic review. International Journal of Social Robotics. 1–20 (2020).
41. Piao, M., Ryu, H., Lee, H., Kim, J.: Use of the Healthy Lifestyle Coaching Chatbot App to Promote Stair-Climbing Habits Among Office Workers: Exploratory Randomized Controlled Trial. JMIR Mhealth Uhealth. 8, e15085 (2020). https://doi.org/10.2196/15085.
42. Verplanken, B., Orbell, S.: Reflections on past behavior: a self-report index of habit strength 1. Journal of applied social psychology. 33, 1313–1330 (2003).
43. Zumpe, S., Heijden, H. van der: On the use of variable user goals to measure perceived usefulness. In: Proceedings of the European Conference on Information Systems (2007).
44. Matook, S., Soltani, S., Maruping, L.: Self-organization in agile ISD teams and the influence on exploration and exploitation. In: Proceedings of the International Conference on Information Systems (2016).
45. Maruping, L.M., Matook, S.: The Multiplex Nature of the Customer Representative Role in Agile Information Systems Development. MIS Quarterly. 44, (2020).
46. Andrias, M.S., Matook, S., Vidgen, R.: Towards a typology of agile isd leadership. In. Proceedings of the European Conference on Information Systems (2018).
47. Stark, J., Dörfel, D.: Fast and Effective Stress Relief in Women through Brainwave-Entrainment Technology in Pandemics. In: Proceedings of the European Conference on Information Systems (2021).
48. ter Stal, S., Kramer, L.L., Tabak, M., op den Akker, H., Hermens, H.: Design Features of Embodied Conversational Agents in eHealth: a Literature Review. International Journal of Human-Computer Studies. 138, 102409 (2020). https://doi.org/10.1016/j.ijhcs.2020.102409.