Using Log-Data as a Starting Point to Make eHealth More Persuasive

Saskia M. Kelders and Julia E.W.C. (Lisette) van Gemert-Pijnen

University of Twente, Department of Health, Psychology and Technology
{s.m.kelders,j.vangemert-pijnen}@uwente.nl

Abstract. Despite the large number of eHealth projects to date and the positive outcomes of evaluation studies, the adherence to eHealth interventions is lower than expected. To understand how persuasive technology can influence the adherence to eHealth interventions process data (log-data) about the usage of technology (system and content) can provide a starting point for employment of persuasive features into the design of technology. The log-data of the usage of an eMental health intervention used as an example in this paper, contained a record of actions taken by each participant with for each action the following information: user-id; action type; action specification; time and day. The log-data showed critical episodes for employment of persuasive components to increase adherence: episodes to determine the willingness to follow a therapy, awareness of their non-coping strategies, adoption of "new" skills for behavior change.

1 Introduction

All over the world eHealth is being increasingly introduced into the healthcare system to support access, safe-care and self-care management [1]. Despite the large number of eHealth projects to date and the positive outcomes of evaluation studies, the actual use of eHealth interventions is lower than expected [1-5]. Many projects fail to survive beyond the pilot phase and studies that investigate the effectiveness of eHealth applications most often do not show any long-term effects. Although many eHealth interventions reach a large group of participants, not all of these participants complete the intervention and might therefore not benefit as much from the intervention as they might. What's the problem?

In the field of health promotion, interventions are rather content-driven. Health-experts often translate a given content into a digital environment, in most cases Internet. Technology is not applied as an adaptive and interactive communication system that can be tailored and personalized to users and context of usage. Another related issue lies in the development process of eHealth interventions. Authors have advocated more user involvement and a more structured development process [2, 6-8]. However, many eHealth interventions are still developed in an ad-hoc manner, which may in part be due to the difficulties of developing in a multidisciplinary environment [2].

S. Berkovsky and J. Freyne (Eds.): PERSUASIVE 2013, LNCS 7822, pp. 99–109, 2013.

Often the development of the technology is expert or engineering driven and the development of technology and content is done separately instead of intertwined, which can lead to stand alone applications where there is no fit with users, content and system [2]. Finally, the capacities of technologies to monitor real-time usage are overlooked due to a merely outcome focus. Technologies have the power to be persuasive, to motivate people in a positive way and as such being a nudge or support for healthier living. In this paper we focus on the capacities of technology to monitor the usage and users of interventions aimed at healthier living. We show how continuous measurement of usage and users via logfiles can be the starting point for employment of persuasive triggers.

1.1 Log Files to Prompt Full Employment of Persuasive Technology

Logfiles can be used to get information about users and usage during real-time use of a technology based intervention. Based on the logfile data critical points can be identified for adherence to the intervention and for personalizing content and system to user's preferences.

Adherence to web-based interventions has been the subject of research for some time. Many studies focus on whether and which respondents' characteristics can explain variations in adherence [9]. Whether intervention or technology characteristics influence adherence has gained less attention, although there have been reviews that have explored this possibility [10,11]. These studies give insight into adherence as an outcome measure, but adherence can also be seen as a process. Adherence as a process measure can be described as the extent to which individuals experience the content of technology based interventions [12] and can be measured by observing the actual usage of the intervention (content & system) and the intended usage. Intended usage refers to the extent users should use the intervention. Given the purpose of lifestyle interventions an intended usage of an intervention is inherent to change behaviors, although in the description of interventions, intended usage is often not explained [12]. Measuring adherence should involve data on usage patterns, preferably on the level of the individual participant, because that will allow us to study how individuals interact with system and content and whether there are differences between adherers and non-adherers.

The adherence profile shows insight in usage and non-usage patterns and as such enables identification of critical points for employment of persuasive triggers. Also it is possible to get insight in differences in adherers and non-adherers with respect to the broad and in-depth usage of the intervention. Descriptive studies of freely accessible interventions have shown that they attract a considerable number of visitors, but that these visitors often interact with a fraction of the possible features of the intervention [13-19]. By observing the individual participants it is possible to determine what characterize users (user profile) and their preferences. This is important to personalize persuasive triggers to the motivations and capacities of a user for self-management.

1.2 The Show Case; "Living to the Full" Intervention

The show case for this paper is the web-based intervention "Living to the Full". This is an intervention for people with mild to moderate depressive symptoms to prevent the onset of a depression. The content of the intervention is based on ACT (Acceptance and Commitment Therapy) [20] and mindfulness [21,21] and has been published as self-help book [23]. The intervention has been shown to be effective in reducing depressive and anxiety symptoms as a group course and as a self-help course with email support [24-26]. The data used as an example in this paper comes from the web-based intervention that has been developed based on this content. The web-based intervention has been developed employing methods from the CeHRes Roadmap for eHealth development [2]. For in-depth information about the system and its performance see Kelders [12]. The web-based intervention included nine chronological lessons and each lesson consisted of psycho-educational material and exercises. When logging on to the web-based intervention, participants started in their 'cockpit' (Figure 1). From here, they could access all features of the intervention. Participants could access the web-based intervention at any time, from any place, free of charge. Only after finishing a lesson and receiving feedback, participants could proceed to the next lesson. This feedback was provided when a participant worked on the lesson for at least five days, viewed all psycho-educational material and completed all exercises. Participants were instructed to complete one lesson per week, but had twelve weeks in total to complete the nine lessons. Participants were free to choose whether they worked through a lesson in one session or in multiple sessions. It was estimated that participants would spend an average of three hours per week on the intervention (online and offline activities combined).

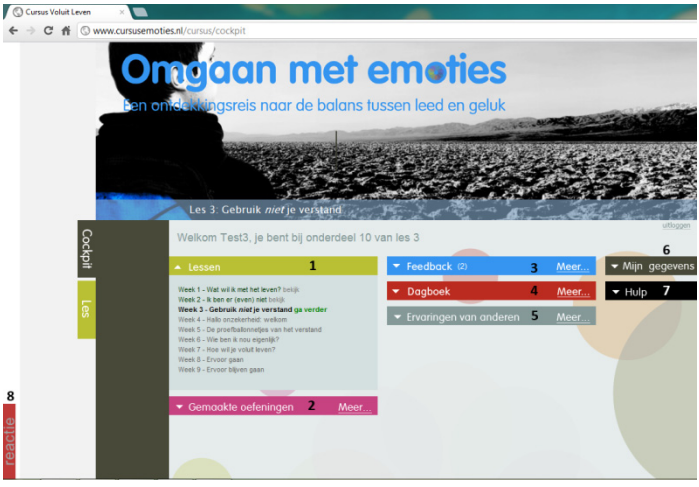

Fig. 1. Personal home screen of the web-based intervention used as an example with the elements: lessons (1), overview of completed exercises (2), feedback (3), diary (4), success stories (5), my account (6), help (7) and a 'react' button where respondents could comment on the application (8)

2 Methods

For this paper, data about usage of the web-based intervention, that has been investigated in a different study, has been taken as an example. In-depth information about the study and the methods can be found in Kelders [12].

This usage data was automatically collected by the intervention itself in the form of log-files. The log-files contained a record of actions taken by each participant with for each action the following information: user-id; action type (for example 'logged in') ; action specification (for example '1-11' [lesson 1, screen 11]); time and day. An excerpt of this usage data can be found in table 1.

Table 1. Excerpt of example log-files, with on each row from left to right: user-id; action type; action specification; time and day.

user-id	action type	specification	time and day
1096	logged in	1-11	30-3-2011 11:35
1096	viewed text-message	2	30-3-2011 11:35
1096	logged out	1-11	30-3-2011 11:35
1081	logged in	0-0	30-3-2011 11:39
1064	logged in	2-1	30-3-2011 11:49
1064	viewed text-message	3	30-3-2011 11:49
1064	logged out	2-1	30-3-2011 11:50
986	logged in	2-1	30-3-2011 11:59
986	logged in	2-1	30-3-2011 12:21
1093	logged in	2-1	30-3-2011 12:25
798	logged in	1-12	30-3-2011 12:27
798	viewed text-message	1	30-3-2011 12:27
798	logged in	1-12	30-3-2011 12:28
1072	logged in	1-1	30-3-2011 12:28
798	logged out	1-12	30-3-2011 12:31
898	logged in	2-1	30-3-2011 12:58
812	logged in	1-1	30-3-2011 12:59
898	logged in	2-1	30-3-2011 13:01
1079	logged in	0-0	30-3-2011 13:09
812	logged out	1-1	30-3-2011 13:10
895	logged in	2-1	30-3-2011 13:12
814	viewed success story	15	24-4-2011 21:49
818	logged in	2-1	30-3-2011 13:13

From this 'raw' usage data, the number of times each participant performed an action in the web-based application was extracted. Using the 'action specification' data, these actions were further classified. Following are examples of the actions 'login' and 'viewing success stories'. For logins this meant that not only the total number of logins per participant during the intervention period was extracted, but furthermore, the number of logins per participant per lesson of the intervention. Moreover, from this data it was extracted which lesson each participant had reached. For the viewing success stories, not only the number of times a success story was clicked was extracted, but also how many and what percentage of possible unique stories were clicked.

For a more in-depth pattern analysis, we arbitrarily selected 20 participants (5 participants that reached lesson 3 or 4; 5 participants that reached lesson 6 or 7; and 10 participants that completed the full intervention). Effort was made to ensure that selected participants had the same distribution of demographic characteristics and randomized group as the full sample. Of these participants, we examined all actions in lesson 2 (all selected participants), lesson 5 and lesson 8 (for those that reached these lessons) to identify emerging use patterns. We chose to examine these lessons because they reflect the three main segments of the content of the intervention and because we wanted to avoid the first and the last lesson for the expected non regular use pattern in these lessons. We expect the participants to explore and get to know the application more in the first lesson and the last lesson is shorter (i.e. less text and exercises) than the other lessons. For each participant and for each of the selected lessons, we recorded all actions in between the time they started the lesson under investigation and the time they started the following lesson.

We chose to do this analysis only for a small subsample of the data, because the focus of this analysis was on pattern recognition related to use of features of the interventions. Furthermore, the choice was pragmatic, because due to the lack of software to analyze logfiles at that time, all analyses were done by hand.

3 Results

The full results of the example study are presented elsewhere [12]. However, some of the data will be presented here as an example of the results that can be attained using log-data.

First, from the log-data on the lesson reached per participant, an adherence or attrition diagram can be attained. Figure 2 presents the attrition diagram for the 206 participants that started lesson 1 in the aforementioned study of the web-based intervention "Living to the Full" [12].

The average number of lessons started was 6.9 out of a possible 9 and 57% of the participants in this study completed all lessons. From this diagram we can see that the largest group of non-adherers started to non-adhere during lesson 2, followed by lessons 3 and 6. This is important to know at *what* moment persuasive features can be of value to motivate persistence.

Second, the extraction of the number of times each participant performed an action in the web-based application yields, for example, the results shown in Table 2.

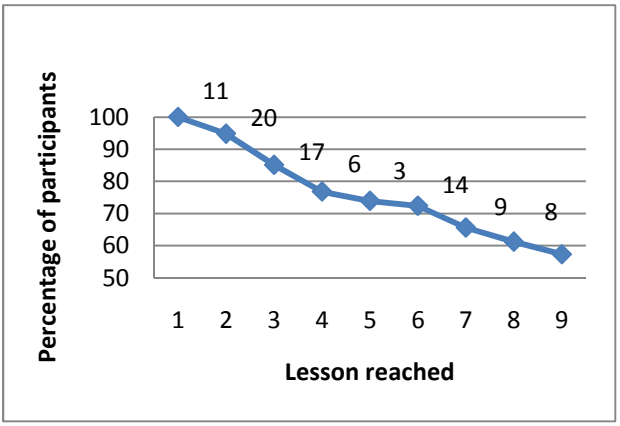

Fig. 2. Example attrition diagram. Highest lesson reached by percentage of participants, with above each line the number of participants that started to non-adhered during that lesson [12].

Table 2. Example actions per participant during the whole intervention period

Action	Average number of times per participant
Login[a]	
total, n	29.1
per started lesson, n	3.9
Feedback messages viewed	
total, n	15.7
unique messages, n	8.5
unique messages per lesson, n	1.1
Mindfulness exercises	
total started, n	6.0
unique started, n (%)[b]	2.9 (73.0)
unique downloaded, n (%)[b]	1.9 (45.6)
unique used, n (%)[b]	3.5 (85.0)
Success stories viewed	
total, n	6.5
unique, n (%)[b]	4.0 (59.1)

[a] Only logins more than 30 minutes after the previous login were counted
[b] % = unique actions / possible actions

Third, the pattern analysis yielded, for example, the use patterns of 5 respondents for lesson 2 (Table 3). From these patterns, critical episodes for persuasive features to support usage of content can be identified. Examples of these critical episodes are:

- Sessions that involve only a login and a logout action, with less than a minute in between
- Feedback messages are not read the first session after they are available

Table 3. Example use patterns of 5 respondents for lesson 2

Session	User 1	User 2	User 3	User 4	User 5
1	login; start lesson	login; start lesson	login; start lesson, mf player 2; multimedia, logout	start lesson; download mf 2	start lesson; login; mf player 2; logout
2	login; continue lesson; multimedia; mf player 2; download mf 2; feedback 1877	login (3x); success story 2, login	login; feedback 3371	login; continue lesson; mf player 2 (2x); logout	
3		login; continue lesson		login; feedback 1; success story 2	
4		login; feedback 2106		login	
5				login; feedback 2	

4 Discussion

4.1 Implications for Persuasive Design

The results show several critical episodes for the employment of persuasive components to increase adherence during an intervention period. In depth analyses of the results showed when and for whom persuasive components can matter.

The logdata revealed that not all content features (like feedback, success stories) were used. The overall study showed that users (adherers and non-adherers) differ in the usage of the content (program, lessons to be completed) [12]. To increase the adaptability of the intervention to users and usage, continuous process measurement should be built in the system and scheduled during treatment process instead of a fixed measurement approach (before and after the usage of an intervention).

The results indicate that there are critical moments for persuasion. Critical episodes for employment of persuasive features in this mental health therapy setting are the focus on the willingness to follow a therapy, the awareness of their non-coping strategies, and the adoption of "new" skills for behavior change. From prior research [27] we know that in other interventions (lifestyle program) 3 weeks after start might be a critical point for drop-out. Saturation (attrition curve [28]) can be a reason, as well as characteristics of the therapeutic program. In any case, it shows that technology can

be supportive to design persuasive content. Persuasive features are needed at those critical episodes to support motivation, to explain the risks of drop out, and to stimulate users in a positive way to achieve their goals. The differences in user patterns can be used to motivate low adherers to login and to remind them to use the content that is crucial for progress in treatment. The effectiveness of reminders can be evaluated to log the moments of prompting and the actions taken based upon those reminders.

Remarkable is that, in this show-case, feedback was not checked when this is available. One reason could be that participants are not triggered to use feedback or that feedback is not perceived or experienced as important for progress and persistence. The role of feedback, human or automated, should be further investigated. We know from the other experiments with the same intervention that although human support is more effective during the intervention, automated feedback is as effective as human support three months after the intervention has been completed [12]. The effects of mode and frequencies of interactions (feedback, human, automated) with a system should be studied more in depth to know how dialogue support can be optimized. Especially automated feedback can be of value for reasons of efficiency.

A different possibility to adapt the design of web-based interventions to enhance adherence can be found in use patterns. It has been observed that adherers and non-adherers seem to have different use patterns. With this insight, it is possible to act: either on the level of the intervention or on the level of the participant. On the level of the intervention it may sometimes be advantageous to adapt to the observed patterns (i.e. 'pave the cowpaths': "look where the paths are already being formed by behavior and then formalize them, rather than creating some kind of idealized path structure that ignores history and tradition and human nature and geometry and ergonomics and common sense" [29]), while on the other hand, it may sometimes be more prudent to adapt the design of the intervention to increase the likelihood of preferred patterns. On the level of the participant, the intervention can be designed to provide guidance to the participant to increase the likelihood of employing a preferred pattern (e.g. by providing feedback on the usage pattern or providing links to features that should be accessed on the home page) or intervene when the chance of the participant becoming a non-adherer is high, either through the intervention itself or through, for example, a phone call from a care professional. Adaptive interfaces seem to provide a method of achieving this flexibility. When redesigning an intervention in this manner, attention should be paid not only to the system, but also to the content as it is likely that changing one aspect influences the other aspects. Losing the 'holistic' overview may lead to a deterioration of usage and adherence instead of the desired improvement [2].

5 Conclusion

The capacities of technology to persuade should be articulated in the development of web-based interventions to change behaviors. Built in log data and user data (demographics; eHealth literacy, involvement etc.) can provide information to know when and for whom persuasive features are important. Further research is needed on what features, dose and timing of persuasive features matter most for adherence and for the effects to be achieved. An important step might be to identify use patterns that are

related to adherence and to (re)design interventions in such a way to promote these use patterns. A different area of future research lies in the investigation of a more pragmatic way to identify participant characteristics that may influence or predict adherence, following the 'persuasion profiling' approach [30]. Furthermore, our results indicate that the content of lessons may need a different amount or mode of interaction. Here lies an interesting line of research; how can technology be supportive to present the content of eHealth interventions in a persuasive format? In ongoing research projects we are investigating how different persuasive formats can increase adherence and effects of web-based systems aimed at behavior change, using the persuasive system design model [31].

Analyzing logfiles is time consuming; to use the results of real-time usage during an intervention period to prompt persuasive triggers in time and in the right format, we need more advanced analytics. More advanced analytics are also needed to identify patterns that emerge and that can further clarify the in depth interplay between content an system.

References

1. Nijland, N., van Gemert-Pijnen, J.E.W.C., Kelders, S.M., Brandenburg, B.J., Seydel, E.R.: Factors Influencing the Use of a Web-Based Application for Supporting the Self-Care of Patients with Type 2 Diabetes: A Longitudinal Study. Journal of Medical Internet Research 13(3) (July-September 2011)
2. Van Gemert-Pijnen, J.E., Nijland, N., Van Limburg, M.A.H., Ossebaard, H.C., Kelders, S.M., Eysenbach, G., Seydel, E.R.: A holistic framework to improve the uptake and impact of eHealth technologies. Journal of Medical Internet Research 13(4) (2011)
3. Black, A.D., Car, J., Pagliari, C., Anandan, C., Cresswell, K., Bokun, T., McKinstry, B., Procter, R., Majeed, A., Sheikh, A.: The impact of eHealth on the quality and safety of health care: a systematic overview. PLoS Med. 8(1), e1000387 (2011)
4. Christensen, H., Reynolds, J., Griffiths, K.M.: The use of e-health applications for anxiety and depression in young people: challenges and solutions. Early Intervention in Psychiatry 5(suppl. 1), 58–62 (2011)
5. Riper, H., Smit, F., Van der Zanden, R., Conijn, B., Kramer, J., Mutsaers, K.: E-mental health. High tech, high touch, high trust. Programmeringsstudie e-mental health in opdracht van het ministerie van VWS. Trimbos-Instituut, Utrecht, The Netherlands (2007)
6. Glasgow, R.E.: eHealth evaluation and dissemination research. Am. J. Prev. Med. 32(5), S119–S126 (2007)
7. Hesse, B.W., Shneiderman, B.: eHealth research from the user's perspective. Am. J. Prev. Med. 32(5), S97–S103 (2007)
8. Pagliari, C.: Design and evaluation in eHealth: challenges and implications for an interdisciplinary field. J. Med. Internet Res. 9(2), e15 (2007)
9. Christensen, H., Griffiths, K.M., Farrer, L.: Adherence in internet interventions for anxiety and depression. Journal of medical Internet Research 11(2), e13 (2009)
10. Brouwer, W., Kroeze, W., Crutzen, R., de Nooijer, J., de Vries, N.K., Brug, J., Oenema, A.: Which intervention characteristics are related to more exposure to internet-delivered healthy lifestyle promotion interventions? A systematic review. Journal of Medical Internet Research 13(1), e2 (2011)

11. Schubart, J.R., Stuckey, H.L., Ganeshamoorthy, A., Sciamanna, C.N.: Chronic health conditions and internet behavioral interventions: a review of factors to enhance user engagement. Comput. Inform. Nurs. 29(suppl. 2), TC9–TC20 (2011)
12. Kelders, S.M.: Understanding adherence to web-based interventions. Dissertation University of Twente (2012)
13. Balmford, J., Borland, R., Benda, P.: Patterns of use of an automated interactive personalized coaching program for smoking cessation. J. Med. Internet Res. 10(5), e54 (2008)
14. Binks, M., van Mierlo, T.: Utilization patterns and user characteristics of an ad libitum Internet weight loss program. Journal of Medical Internet Research 12(1), e9 (2010)
15. Couper, M.P., Alexander, G.L., Zhang, N.H., Little, R.J.A., Maddy, N., Nowak, M.A., McClure, J.B., Calvi, J.J., Rolnick, S.J., Stopponi, M.A., Johnson, C.C.: Engagement and Retention: Measuring Breadth and Depth of Participant Use of an Online Intervention. Journal of Medical Internet Research 12(4), 41–55 (2010)
16. Davies, C., Corry, K., Van Itallie, A., Vandelanotte, C., Caperchione, C., Mummery, W.K.: Prospective associations between intervention components and website engagement in a publicly available physical activity website: the case of 10,000 Steps Australia. Journal of Medical Internet Research 14(1), e4 (2012)
17. Linke, S., Murray, E., Butler, C., Wallace, P.: Internet-based interactive health intervention for the promotion of sensible drinking: patterns of use and potential impact on members of the general public. Journal of Medical Internet Research 9(2), e10 (2007)
18. Zbikowski, S.M., Hapgood, J., Smucker Barnwell, S., McAfee, T.: Phone and web-based tobacco cessation treatment: real-world utilization patterns and outcomes for 11,000 tobacco users. Journal of Medical Internet Research 10(5), e41 (2008)
19. Krukowski, R.A., Harvey-Berino, J., Ashikaga, T., Thomas, C.S., Micco, N.: Internet-Based Weight Control: The Relationship Between Web Features and Weight Loss. Telemed. J. E-Health 14(8), 775–782 (2008)
20. Hayes, S.C., Strosahl, K., Wilson, K.G.: Acceptance and Commitment Therapy: An experiential approach to behavior change. Guilford Press, New York (1999)
21. Kabat-Zinn, J.: Full catastrophe living: using the wisdom of your body and mind to face stress, pain, and illness. Delacorte Press, New York (1990)
22. Kabat-Zinn, J.: Wherever you go, there you are: Mindfulness meditation in everyday life. Hyperion, New York (1994)
23. Bohlmeijer, E.T., Hulsbergen, M.: Voluit Leven. Mindfulness of de kunst van het ervaren, nu als praktisch hulpboek [Living to the full. Mindfulness or the art of acceptance, now as a practical help book]. Boom, Amsterdam (2008)
24. Bohlmeijer, E.T., Fledderus, M., Rokx, T.A., Pieterse, M.E.: Efficacy of an early intervention based on acceptance and commitment therapy for adults with depressive symptomatology: Evaluation in a randomized controlled trial. Behav. Res. Ther. 49(1), 62–67 (2011)
25. Fledderus, M., Bohlmeijer, E.T., Pieterse, M.E., Schreurs, K.M.: Acceptance and commitment therapy as guided self-help for psychological distress and positive mental health: a randomized controlled trial. Psychol. Med., 1–11 (2011)
26. Fledderus, M., Bohlmeijer, E.T., Smit, F., Westerhof, G.J.: Mental health promotion as a new goal in public mental health care: a randomized controlled trial of an intervention enhancing psychological flexibility. Am. J. Public Health 100(12), 2372 (2010)
27. Postel, M.G., de Haan, H.A., ter Huurne, E.D., van der Palen, J., Becker, E.S., de Jong, C.A.J.: Attrition in Web-Based Treatment for Problem Drinkers. J. Med. Internet Res. 13(4), e117 (2011)
28. Eysenbach, G.: The Law of Attrition. J. Med. Internet Res. 7(1), e11 (2005)

29. Crumlish, C., Malone, E.: Designing social interfaces, 1st edn. O'Reilly Media, Beijing (2009)
30. Kaptein, M., Eckles, D.: Selecting Effective Means to Any End: Futures and Ethics of Persuasion Profiling. In: Ploug, T., Hasle, P., Oinas-Kukkonen, H. (eds.) PERSUASIVE 2010. LNCS, vol. 6137, pp. 82–93. Springer, Heidelberg (2010)
31. Oinas-Kukkonen, H., Harjumaa, M.: Persuasive Systems Design: Key Issues, Process Model, and System Features. Communications of the Association for Information Systems 24, 485 (2009)