Persuasive User Experiences in Health Behavior Change Support Systems: A 12-month Study for Prevention of Metabolic Syndrome

1 Introduction

1.1 Obesity Epidemic

Obesity is an acute and growing health problem worldwide with which many co-morbidities are associated [1]. The latest statistics indicate that the percentage of obese people (body mass index [BMI[1]] over 30 kg/m^2) has increased in European countries to nearly epidemic portions [2,3]. Globally, mean BMI as well as overweight have increased since 1980 and interventions and policies turning this trend are needed in most countries [4,5].

The most common weight loss strategies employed in the United States include restricted amount of calories, reduced amount of fat, and increased amount of exercise, applying to about 50% of weight losers [6]. Weight loss is in any case difficult to maintain [7] as a change in diet or physical activity is usually not enough to maintain weight loss; a more complete change in lifestyle appears to be necessary [8]. Moreover, relapse is high in lifestyle obesity interventions that involve behavior and weight change. Recent studies suggest that successful lifestyle changes depend not only on inherited factors and factors accumulated during the course of life but also on modifiable factors such as eating behavior, diet, and support provided [9,10]. However, even moderate weight loss can remarkably reduce the risk for health problems. With a 5% reduction of body weight there is less risk of cardiovascular problems and a significant improvement of glycemic control for diabetics [11-13].

Technological interventions known as health Behavior Change Support Systems (hBCSSs) [14] aimed at the general public not only inform people about the risks of low levels of physical activity and dietary habits but also persuade people to adopt healthier behaviors are needed [15].

[1] *Abbreviations in this study:* BCSS, Behavior Change Support System; BMI, body mass index; hBCSS, health Behavior Change Support System; ICT, information and communication technologies; ID, identification; M, mean; MED, meadian; MVC, model-view-controller; n, number; PrevMetSyn, Prevention of Metabolic Syndrome; PSD, Persuasive Systems Design; REST, representational state transfer.

1.2 Health Behavior Change Support Systems

Web-based software systems supporting weight loss and weight management have been one of the most vibrant and active areas within health behavior change [16], and several studies have presented the potential of these in attaining weight loss [17-21]. Website usage has been shown to correlate with the achievement of weight loss [22,23], but some eHealth systems show adherence percentages as low as 1% [24], which practically neutralizes the ability of ICT to reach a large group of participants efficiently. According to many studies, persuasive features play an important role in the acceptance of a health behavior change support system (hBCSS) and in the intention to continue using the system [15,25-30]. The BCSS model emphasizes autogenous approaches, where an individual uses information systems to change his or her own behavior or attitude about his or her own goal [14]. Oinas-Kukkonen's [14 p. 1225] definition of a BCSS is as follows:

> *A behavior change support system (BCSS) is a socio-technical information system with psychological and behavioral outcomes designed to form, alter, or reinforce attitudes, behaviors or an act of complying without using coercion or deception.*

The current study employs a web-based information system called Onnikka as a research medium [31]. Onnikka was designed in the Prevention of Metabolic Syndrome (PrevMetSyn) lifestyle intervention study for participants who are at risk of developing, or have already developed, metabolic syndrome. The Persuasive Systems Design (PSD) model [32] and Behavior Change Support Systems (BCSS) framework [14] provided systematic methods to develop the system.

The PSD model is a state-of-the-art design and evaluation tool for BCSSs [14]. The PSD model includes a set of seven postulates concerning persuasive systems, as well as the analyses of persuasion context. The PSD model also defines 28 potential system features for BCSSs, which are divided into four categories: primary task support, dialogue support, credibility support, and social support [32]. The persuasive features in the primary task support category aim to reflect individuals' behavior goals and track progress toward them. This category also covers essential issues, such as reducing cognitive load and disorientation in system use. The dialogue support category consists of persuasive features that are related to human–computer interaction and user feedback. It outlines principles that motivate, activate, and ideally help users to reach their goals. The credibility support category includes features that

help in designing more credible and thus more persuasive systems. In order to get the full benefit of a BCSS, a user has to trust the given information, accept the system's advice, and believe that it will lead to the desired outcomes. Finally, persuasive techniques in the social support category aim to motivate users by leveraging social influence [32].

The seven postulates defined by Oinas-Kukkonen & Harjumaa [32] in the PSD model must be addressed when designing persuasive systems. These postulates can be thought of as basic principles and not as concrete instructions for designing a persuasive system. The most important postulate in relation to this study is "*persuasive systems should aim at unobtrusiveness*" [32 p. 488]. Persuasive systems should not disturb users while they perform their primary task, but rather systems should seek opportune moments of persuasion [32], e.g., a system designed to help people suffering from sleep deprivation should not send reminders to its users in the middle of the night. In Lehto et al. [27] study, unobtrusiveness reflects also whether the system fits with users' daily lives. Use of a BCSS may depend on whether individuals have the possibility to utilize the system as a seamless part of their daily routines [27].

Analyzing persuasion context means gaining an understanding of the roles of persuader and user as well as understanding the persuasion strategy. The following PSD model persuasion context analysis consists of recognizing three tasks: intent of the persuasion, the persuasion event, and strategies in use [32]. The method of addressing persuasion context in this study is described in more detail in the methods section.

1.3 Current Study

Despite the promising results of health information and communications technology interventions, there are also studies showing either poor results or no positive effects at all [15,33-36]. Black et al. [33] state that there is insufficient understanding of why some eHealth interventions do not work and why some succeed. Moreover, even though the web-based and mobile applications have become part of our everyday lives [37], Oinas-Kukkonen [14,38] explains that technology is often treated as a black box, a mere tool for content delivery that has no value of its own. He maintains that this kind of black-box thinking is a symptom of a misunderstanding as regards conducting research into technological interventions and recommends more research on the level of system features [38]. As an important research area, Kelders et al. [39] propose in-depth qualitative analyses of adherence to increase knowledge of the characteristics of web-based interventions.

The aim of this study is to go inside the black box of an eHealth intervention and describe how users perceive the persuasive features implemented in the system. A total of 43 system users were interviewed for this study. Login data and clinical BMI information were also used to select interviewees and to build interpretations of the data. The research questions in this study are “How do the users of a web-based lifestyle intervention system perceive different persuasive software features; what are the main reasons for using or not using the system; and to what extent do the perceptions differ between individuals who managed to lose 5% or more of their body weight and those who could not?”

This article is organized as follows. Section 2 introduces the study setting, including system implementation, research methods, and data collection principles. Section 3 consists of the results of the study. The discussion of the results, implications for research and practice, and the limitations of the study are elaborated in Section 4. Finally, Section 5pakarpp contains the conclusions.

2 Methods

2.1 Research Context

This study is part of a large ongoing research project called PrevMetSyn. The study subjects are working-age females and males who are overweight or obese (BMI 27–35), with or without metabolic syndrome. Participants are Finnish citizens from the Northern Ostrobothnia hospital district area. PrevMetSyn is a randomized lifestyle intervention study with two different counseling interventions: group A, with eight group counseling visits, and group B, with two group counseling visits. Group C is a control group and uses Onnikka without any face-to-face counseling. The Ethics Committee of the Oulu University Hospital granted permission for the study on March 26, 2012. Two amendments were approved on November 23, 2012 and February 18, 2013.

The participation of healthcare professionals with extensive experience in guiding people in lifestyle changes played a vital role in the design of the system. These professionals provided all the content, such as weekly articles and exercise recommendations, used in the system. The theoretical basis for the information content in Onnikka was the cognitive-behavioral approach [40]. The goal of this approach is to educate users to identify and cope with dysfunctional thoughts which interfere with their behavioral goals and self-efficacy beliefs regarding eating, exercise,

weight monitoring and weight loss. The Onnikka system was designed to be a stand-alone web system that is not linked to face-to-face counseling and that can be accessed with personal credentials. A total of 259 Onnikka users were divided into five different starting groups who started the experiment at different times between March 2013 and March 2014. The persuasion context addressed in this study is summarized in Table 1.

Table 1. Persuasion context addressed in this study following the guidelines of Oinas-Kukkonen and Harjumaa [32] and Oinas-Kukkonen [14].

The Intent	
Persuader	The hospital district and university researchers are key stakeholders behind the intervention platform. The system itself is designed to be autogenous to the extent that users could influence their own attitudes and/or behaviors without the need for active continuous consultation with health professionals.
Intended Outcome/Change	The primary aim of the system is to alter users' health behavior regarding the prevention of metabolic syndrome (A-Outcome, B-Change). The secondary aim is to reinforce the users' newly adopted behaviors (R-Outcome) thanks to the long intervention period (12 months).
Designer Bias	The intervention is a modern web application, which enables reaching a very wide population with minimal technical restrictions. Those less technically inclined may not be familiar with the look and feel the designer takes for granted.
The Event	
Use Context	The problem domain is the prevention of metabolic syndrome. User groups received health exercise and information relating to lifestyle habits. Each week a weekly article, exercise, and a brief health tip are provided.
User Context	A user's phase of intervention is taken into account by providing suitable information for that phase. The content of the BCSS is delivered based on the progress of 52 weeks of intervention. The users are also encouraged to set their own target weight and new lifestyle goals.
Technology Context	The system was developed as a generic web application that users can access both on their desktop and on their mobile devices without requirements for any specific operating system or device. On par with the web-based application, interface email is used to interact with users. The system was

	developed by applying modern web technologies, such as an MVC web application framework [41], REST-based software architecture [42], and a mobile-aware responsive layout. For a more detailed description of the technological implementation, please see [31].
The Strategy	
Message	The aim was to increase users' self-efficacy in their lifestyle change. The content system offered was based on the principles of the cognitive behavioral model.
Route	A direct route is used to persuade users to change their health behavior. The system provides users with strong arguments in the form of weekly informational content provided by health professionals.

The Onnikka home page provides a starting point for users to access the different functionalities of the system, such as submitting self-monitoring entries or reading the weekly content. The outlook of Onnikka was designed to be very neutral, and a *liking* feature was implemented by using photographs of local people and environments in the content. *Reminders* were another important feature adapted from the dialogue support category. Onnikka sent weekly e-mail messages to participants on Mondays, and if they had not logged into the system, another message was sent on Thursday during the same week. Table 2 summarizes the key persuasive features addressed in this study, the categories they belong to, and how they were implemented in the system design.

Table 2. Persuasive software features addressed in this study following the guidelines of Oinas-Kukkonen and Harjumaa [32] and Oinas-Kukkonen [14].

Category	Feature	Implementation
Primary task support	Self-monitoring	Weight graph, Food diary, Exercise diary, Mood diary
	Reduction	Weekly content on separate themes
	Tunneling	Unchangeable rhythm of weekly content, exercises, and tips
	Tailoring	Additional e-mail messages, information content, and tailored exercises for those in need of advice on eating behavior
Dialogue support	Reminders	Weekly e-mails to log into the system, followed by another reminder to log in if the user had not logged in by Thursday
	Praise	Encouraging textual feedback after successful weight-loss performance

	Suggestions	Tips for good eating behaviors sent to the tailored group
	Liking	Visual appearance of a modern web application, using photographs of local environments and people in the content
Social support	Social learning	Discussion forum
	Social facilitation	Number of logged users for the current intervention week and the number of comments given shown on the front page
Credibility support	Verifiability	Links to external sources

Regarding the weekly content, a user is presented with health information and exercises according to the phase of intervention and tailored preferences. Each week a weekly article, exercise, and a brief health tip are provided. The system also provides a weekly task relating to the topic at hand. Participants can record their answers in the system and make additions or alterations to their responses later. The content of the site followed the principle of *reduction* by simplifying complex behavior—weight management—into separate themes (nutrition, exercise, etc.), thus helping users to better evaluate their behavior and target their change to the areas that most need it. A feature closely related to reduction is *tunneling*, which was implemented as the unchangeable weekly rhythm of providing new content. A user can browse back over past weeks to re-read earlier content and personal entries; however, it is not possible to access the weekly content in advance. Because not all people with metabolic syndrome have the need for counseling specifically for eating behavior, the informational content and the software features relating to improving eating behavior were designed to only be visible to a certain group of users based on their behavioral profiles. This group received additional health information and exercises to improve their eating behavior habits, following the principles of *tailoring*.

The *self-monitoring* section is one of the core functionalities of the Onnikka system. To track their behavior change progress, users can submit entries about their weight, mood, exercise, and eating habits. The weight entries can be browsed in table form or as a visualized graph, and persuasive messages are conveyed in the submission process that follow the recommendations of the *praise* feature in the dialogue support category. To follow mood and

motivation, users can write short diary entries with emojis to indicate their feelings during the current intervention period. To monitor weekly exercise, users may submit entries in which they describe the type of exercise, the level of strain, and the amount of exercise done. Finally, as a self-monitoring feature, participants can keep a food diary, a tool often used in weight counseling. The submitted food entries contain information about the meal type, eating time, description, and where the meal was eaten. After adding a meal, users can tag an individual meal as “good” or “unnecessary,” resulting in a reflection on their eating habits.

Social learning was implemented via a discussion forum attached to each weekly health information section. Users are able to share their thoughts anonymously using pseudonyms. It was decided that the discussion forum would be a place for peer support only, and nutrition therapists or system developers would not interfere in the discussions. The *social facilitation* feature was implemented as an information element on the home page and indicated the total number of logged participants for any particular intervention week. Health care professionals considered *competition* and *recognition* features as too harsh, as the weight loss process is emotionally very stressful for many participants.

The familiarity of the institutions (university and hospital district) was leveraged to provide credibility support. Onnikka also had links to external sources from where subjects could *verify* the information offered in the system and from where they could obtain extra knowledge.

2.2 Data Collection and Analysis

This study utilizes hermeneutics as a qualitative method to explore individual experiences of BCSS usage. Ontologically interpretive research leans toward the social construction of reality; in other words, the interpretation is gained through language, consciousness, and shared meaning (e.g., [43]). Klein and Myers [43] perceive the hermeneutic circle as the fundamental principle for any interpretive field research in which collected data and gained new understanding aid the researcher in determining where to look next. During this research case, interviews were carried out in three different circles. Semi-structured interview questions were altered according to the interpretation of each circle.

The strategy for choosing the interviewed subjects was to obtain as many different voices as possible, but at the same time to keep a balance between males (n=21) and females (n=22); subgroups A (n=15), B (n=14), and C (n=14);

and whether a subject received tailored additional information (*n*=22) or not (*n*=21). Unfortunately, one subject ended his participation during the research project, and therefore this interview material includes the responses of 43 Onnikka users instead of 44. Interviewed subjects' age ranged from 22 to 61 (*M*=47.1), their baseline BMI ranged from 27.2 to 34.8 (*M*=30.5), and total number of logins ranged from 2 to 500 (*MED*=61). Onnikka users were recommended to log into the system at least once a week to read the provided content. The demographics of the subjects, their use adherence over the whole intervention period, and BMI information are presented in Table 3. Subjects who have 100 % adherence in Table 3 logged into the system at least once a week throughout the whole 52-week intervention period.

Table 3. The demographics of the subjects, their BMI information, and the system's use adherence percentages.

ID	Intervention week	Gender	Age	Baseline BMI	Counseling group	Tailored	Total number of logins	System use adherence
1	12	Male	44	28.9	A	Yes	154	90 %
2	12	Female	49	32.9	A	Yes	99	98 %
3	12	Male	40	28.3	A	No	31	33 %
4	12	Female	47	32.8	A	No	11	6 %
5	12	Female	58	30.6	B	Yes	81	88 %
6	12	Male	46	31.0	B	Yes	74	94 %
7	12	Male	55	32.0	B	No	70	96 %
8	12	Female	56	30.3	B	No	74	94 %
9	12	Male	46	28.3	C	Yes	15	8 %
10	12	Male	34	32.1	C	Yes	36	67 %
11	12	Male	53	30.0	C	No	60	83 %
12	12	Female	57	30.0	C	No	99	96 %
13	25	Female	58	27.8	A	Yes	57	65 %
14	25	Female	53	27.4	A	No	14	19 %
15	25	Female	22	33.4	B	Yes	61	17 %
16	25	Female	42	33.9	B	No	166	92 %
17	25	Female	48	30.4	C	Yes	134	92 %
18	26	Male	42	27.6	A	No	39	38 %
19	26	Male	58	34.8	B	Yes	56	56 %

20	26	Male	44	34.8	C	Yes	39	40 %
21	26	Female	42	28.5	C	No	43	38 %
22	27	Male	30	27.9	A	No	72	96 %
23	27	Male	52	30.2	B	No	62	88 %
24	30	Female	46	32.0	C	No	24	35 %
25	31	Male	30	29.7	A	Yes	76	83 %
26	31	Female	46	33.1	A	No	272	92 %
27	32	Male	30	32.8	B	Yes	24	38 %
28	43	Male	46	28.5	A	Yes	63	94 %
29	43	Female	58	31.5	C	Yes	86	40 %
30	44	Male	36	31.4	B	No	162	98 %
31	44	Female	49	31.5	C	No	44	35 %
32	52	Female	46	27.2	A	No	49	83 %
33	+2	Male	54	27.2	C	Yes	66	71 %
34	+3	Male	50	27.8	B	No	13	12 %
35	+4	Female	50	29.5	C	No	17	23 %
36	+18	Male	33	31.6	A	Yes	2	4 %
37	+18	Female	58	29.7	C	No	74	96 %
38	+19	Female	46	30.8	A	Yes	17	19 %
39	+19	Male	54	30.6	B	No	187	100 %
40	+27	Male	55	32.2	A	Yes	33	19 %
41	+27	Male	45	30.4	B	Yes	23	27 %
42	+27	Female	61	29.9	B	No	500	100 %
43	+27	Female	56	28.5	C	Yes	401	100 %

The subject

s for the first interview set comprised the first 37 individuals who started using Onnikka in March 2013. Twelve individuals took part in the interviews between June 5 and 7, 2013 (Subjects 1–12 in Table 3), in their twelfth intervention week. The second set of interviews was conducted between November 6 and 21, 2013. The interviewees were selected from a group consisting of 60 study subjects who started using Onnikka in May 2013. At

the time of the interviews, the subjects were in intervention weeks 25–27. The third set of interviews was conducted between September 22 and October 21, 2014; this group contained 20 participants, four individuals from each of the five different starting groups.

All the interviews were conducted via phone, recorded, and transcribed. Simple and broad questions such as “How has it been to use Onnikka?” were asked during the first part of the interview to relax the interviewee and to obtain their initial thoughts regarding the system. During the course of an interview, more detailed questions were asked. Moreover, questions from research themes other than persuasive features were asked during the interviews; findings related to flow experience have been published previously [44].

3 Results

In the following paragraphs, the subjects’ responses are divided into themes in accordance with the PSD model’s categories. Some of the subjects’ quotations include comments in parentheses that represent the interviewer’s interpretations.

3.1 Primary Task Support

During the first set of interviews, weight monitoring and food diaries were mentioned often. Self-monitoring was considered one key reason for using the system; however, the user experiences with the different tools varied greatly. A total of 9 out of 12 who gave feedback on weight management had positive experiences. Many praised the weight graph for making even the slightest weight loss visible and stated that it gave them greater motivation for behavior change. Nearly all the users interviewed in the first hermeneutic circle complained about the use of Onnikka’s food diary, which was often said to require too much effort. The general dichotomy between the weight tool being the most praised and the food diary the most criticized remained the same throughout all three hermeneutic circles. Typically, if users were dissatisfied with a certain tool, they just stopped using it. Only clear exception is Subject 19, whose negative user experience of the food diary directly impacted the use of the whole system. Subject 42 was one of the few respondents, who had positive experiences of the food diary, and she used it every day for the whole year and had more food diary entries than all the others combined. The exercise tool divided opinions, since many had experiences with other commercial exercise systems or mobile applications that made the Onnikka tool feel less appealing. Surprisingly, the mood diary was mentioned only once during the first hermeneutic

circle. The other primary task support features other than self-monitoring were hardly mentioned by the interviewees if not specifically asked about. Subject 7's answer is a somewhat typical representation of self-monitoring enthusiasm, and it also shows the difference between the perceptions of tools experienced by many participants.

> ***Subject 7****: Well, here* [in the Onnikka web system] *you can record the exercise and weight, so these are motivating. There isn't anything else that motivates you more than when you see you're losing weight all the time you know. One needs these kinds of facts. It doesn't help if you go on the scale once a month, and if you don't remember how heavy you were previously. But when you come here and you look, when you see that graph... that's the most important thing; it motivates you the most. The food diary doesn't motivate at all. I've told those girls* [healthcare professionals in the counseling group] *that I last used it on the 4th of April, and it sure has stayed that way. Because for me it's not important to start typing in my breakfast, lunches, dinners, snacks. It doesn't give me anything. It's too difficult, there are too many things. Like if you select a meal type, there are six different options.*

During the second and third hermeneutic circles, when users were on their intervention week 25 or beyond, subjects were generally not as enthusiastic about self-monitoring as in the beginning. During the long span of the intervention, many participants were faced with the situation in which their weight loss had stalled. There were even a few users who seemed to be discouraged by the use of weight monitoring after a setback (e.g., Subject 15 stopped using the system altogether because of a temporary relapse).

3.2 Dialogue Support

Regarding the dialogue support category, it was assumed that some of the participants would be annoyed by the weekly e-mails, but on the contrary, it was one of the most praised features in Onnikka. Even most of the users who had not been active users perceived reminders as a positive feature. Reminders combined with new weekly content that was delivered at a set pace created a sense of continuity for many subjects. The first reminder had a short introduction to that week's theme and a link to the system's web address, which was an effective way to make it easy for individuals to log into the system. Tunneling feature, despite of being part of primary task category in the PSD model, was often linked to reminders in subjects' answers. After the first hermeneutic circle, participants were

deliberately and provocatively asked about the tunneling feature: How did you feel about the forced weekly schedule of Onnikka? Despite the use of the word "force", almost none of the respondents perceived it as a negative feature; on the contrary, some subjects started to defend the system's modular setting. Subject 27 was the only respondent among all those interviewed who argued that the unchangeable weekly rhythm was the main reason for him to stop using Onnikka. Subject 22's answer is a quite typical representation of perceived continuity created by content, tunneling, and reminders.

> ***Researcher:*** *What features are most supportive in your lifestyle change?*
>
> ***Subject 22****: It's this stable continuity, when there is something to do all the time, and if I'm too busy to do weekly tasks in that particular moment* [on Mondays]*, I'll get another reminder after a couple of days, and that's the time when I'll go and check it.*

Other features from the dialogue support category did not stimulate much discussion. Neither suggestions nor praise of the weight tool were mentioned if not specifically requested. Regarding Onnikka, the liking feature did not seem to have any meaning whatsoever. In the second hermeneutic circle, the question related to visual appearance was straightforward: "Did Onnikka's visual appearance affect its use?" The most typical answer was "no," and despite the efforts of the interviewer, no further comments were forthcoming. The visual appearance did not offend anyone, but it did not appear to bring any added value either.

3.3 System Credibility Support

Onnikka was perceived by almost all participants as credible. Some participants had certain doubts relating to official health recommendations, but mostly these doubts were not perceived as issues critical enough to affect system use. Subject 40 was the only subject to strongly disagree with the provided content among all the 43 interviewed participants. He questioned the health advice given in the project and wanted to continue his weight-loss progress using his personal methods. Despite the perception of the system as credible by most of the individuals, it was difficult for the users to define the features that made Onnikka so credible. Most subjects mentioned the themes of trustworthiness and expertise of the information providers, the system having been developed by recognized authorities and not promoting any 'wonder diet' or commercial products.

> ***Subject 2****: I consider this a more trustworthy source than, for instance, yellow tabloids. It's like when you have a doctor who is putting his reputation on the line, and you know there is no commercial interest behind it. I feel this is trustworthy. When you know who has designed it, and where it was designed. So for me, those things are meaningful.*

3.4 Social Support

According to the findings from the third hermeneutic circle, the need for social support seemed to increase during the intervention's use, although subjects who had not used Onnikka for several months did not claim to need social support when interviewed (intervention weeks +18 and higher in Table 3). Despite the increased need for social support, the comment tool was used very rarely among the participants. The subjects' explanations for low usage varied notably. Many responses related to individual characteristics such as shyness, laziness, or not feeling comfortable using social media types of tools. Some subjects believed that an outside moderator or an active individual is needed as a catalyst for lively discussion. Longing for better social support was the only apparent difference between intervention groups, and the need was more often mentioned among the participants in group C, who received no face to face counseling. For example, when subjects were asked about the social facilitation feature on the system's home page, users in starting groups A and B did not pay much attention to it; however, several subjects in control group C were following how many people had visited the site to gain a sense of belonging to a group. Many users perceived the lack of social support as one of the key reasons for not using the system throughout the whole intervention period.

> ***Subject 29****: In the beginning, it was great* [using Onnikka]*, but eventually it started to feel so lonely doing it all alone that I got bored. I wish we would've met even once as a group, or there could've been at least a chat possibility. I followed the instructions for lifestyle change, and I don't need Onnikka anymore for that. I got what I could get.*

Regarding the feature of tailoring, everyone was asked whether they perceived the system to be personal enough. After all the interviews were combined, most of the subjects (*n*=32) thought that the system was more or less personalized for their needs. Surprisingly, of the 11 subjects who perceived the information in the Onnikka system as too general, five belonged to the tailored group.

3.5 Weight results

For the last phase of this study, the weight results for the twelfth month were collected (Subjects 4 and 16 did not participate in the twelfth month measurement), and Onnikka's use data for the whole intervention time were gathered. The possibility of using weight information gave a new dimension, permitting subjects to be divided into different use groups and use information to serve as a new lens of interpretation. Subjects who were able to lose 5% or more of their weight were divided out as a separate group from users who were not able to lose 5% over the course of 12 months. In addition, the system's use adherence (using the system at least once a week) was categorized into three activity levels: high (75% adherence or more); medium (adherence between 25% and 75%); and low (25% adherence or less).

3.5.1 Participants who achieved 5% weight loss

Of 41 subjects interviewed, 14 were able to achieve 5% weight loss in 12 month's intervention period. Most of these subjects (10 individuals) named one or more self-monitoring tools as the best feature(s) in Onnikka. Three users in this group were primarily interested in the content that the system offered. As seen from Table 4, the use amounts of different tools varied greatly even among the highly active users.

Table 4. Participants who were able to lose weight, and their data entries using system tools.

				Self-monitoring tools							
Activity	ID	Twelfth month BMI	Weight drop %	Weight graph	Mood diary	Exercise diary	Food diary	Weekly tasks	Commenting tool	Perceived as the best feature	Main reasons for using or not using the system (marked with +/-)
High	6	26.3	15.4	17	1	0	4	15	0	Information and links to external sources	+ System supports and reminds
	32	23.3	14.3	24	3	16	4	50	0	Self-monitoring tools	+ Being part of research project; support; reminders
	39	26.6	13.0	22	3	4	20	1	0	Weight graph	+ Monitoring weight regularly
	12	26.5	11.5	41	40	67	45	44	2	Weight graph	+ Helps to cope; commitment
	42	27.3	8.8	48	24	254	1677	38	1	Food diary	+ Commitment
	7	29.7	7.3	11	1	39	17	7	0	Exercise diary and	+ Ability to monitor the outcome

									weight graph	of behavior
	1	26.9	7.0	25	2	45	84	3	0	Weight graph	+ Reading weekly content; self-monitoring
	26	31.1	6.0	55	33	16	178	1	4	Weight graph	+ Support; free to use; commitment
	2	31.2	5.1	55	26	67	29	54	0	Self-monitoring tools	+ Ability to follow the progress
Medium	31	26.6	15.5	15	9	48	2	6	1	Exercise diary and weight graph	- Successful weight loss
	21	26.6	6.4	1	1	1	0	1	0	Weekly information	- E-mails were sufficient
Low	36	26.6	16	0	1	3	3	0	0	Content	- Own weight-monitoring tool
	15	28.2	15.6	6	8	17	73	0	0	Self-monitoring tools	- Relapse in weight management
	40	29.6	7.8	6	0	1	0	0	0	[Did not specify]	- No need for the system

Nearly all subjects who were not highly active perceived at the time of the interview that they either had already succeeded in their weight loss or that they had sufficient self-regulation skills to manage without the help of the system. Generally, Onnikka was perceived more or less as persuasive in this group. Most subjects did not pinpoint any specific feature to clarify their reasoning as to why the system felt persuasive.

3.5.2 Participants who did not achieve 5% weight loss

Of the 41 interviewed participants who attended the twelfth month measurement, 27 were not able to achieve 5% weight loss. In general, it appears as if self-monitoring was perceived as less meaningful in this group of interviewees than among the subjects who were able to lose weight, as seen in Table 5.

Table 5. Participants who were not able to lose weight, and their data entries using system tools.

				Self-monitoring tools							
Activity	ID	Twelfth month BMI	Weight drop %	Weight graph	Mood diary	Exercise diary	Food diary	Weekly tasks	Commenting tool	Perceived as the best feature	Main reasons for using or not using the system
High	22	26.8	4,0	0	0	2	0	36	1	Continuity; weekly content	+ Reminder; system reinforces the change
	30	30.4	3,1	64	13	257	27	44	3	Exercise diary and weight	+ Weekly content; self-

									graph	monitoring
	23	30.0	0.7	0	0	39	0	0	0	System use combined with clinical health checks	+ Weekly content and tasks
	11	30.0	0.1	2	1	0	0	0	0	Reminders and weekly information	- Lack of time to utilize fully
	5	30.6	0.0	4	1	2	4	0	4	Weekly information	- Lack of time to utilize; demands too much effort
	8	30.4	-0,2	5	4	6	11	20	0	Reminders	- Lack of persuasiveness
	37	29.8	-0,3	20	7	65	6	0	0	Information; exercise diary	+ Commitment
	25	29.8	-0.3	3	3	7	13	6	2	Weekly information	- Challenging life situation
	17	30.7	-0.9	22	2	11	9	0	0	Weight graph	+ Commitment; curiosity - Lack of social support
	43	29.3	-2,7	53	90	91	13	50	24	Weekly information; self-monitoring tools	+ Possibility of achieving results with minor changes
	28	29.4	-3,0	1	0	0	3	0	0	Weekly information	+ Reading weekly information is important
Me	27	31.5	4.0	8	3	8	9	7	1	Weight graph; weekly information	- Relapse in system use
diu											
m	19	33.9	2.7	0	1	2	4	0	0	Weekly content	- Bad user experience
	29	30.9	1.9	15	18	57	99	8	5	Food diary; weight graph	- Lack of social support
	24	31.6	1.3	15	14	14	16	22	8	Weekly content; self-monitoring tools	- Lack of time to utilize
	10	31.7	1.1	10	7	124	0	0	1	Exercise diary	- Lack of personal guidance and social support
	13	27.5	1.1	6	0	0	0	0	0	System use combined with counseling visit	+ Continuance; reinforcement
	20	34.4	1.1	0	0	0	0	2	0	regularity; E-mails	- Lack of time to utilize; lack of social support
	3	28.3	-0,1.	16	1	1	8	7	0	None	- Lack of persuasiveness
	33	27.2	-0.2	1	0	0	0	4	0	Weekly information	- Not severe weight problem
	18	28.4	-3.2	8	1	26	50	2	5	Knowledge of healthy	- Not severe weight

										living	problem; lack of persuasiveness
	41	31.4	-3.4	2	0	1	0	1	0	Weekly information	- Lack of time to utilize; lack of persuasiveness; do not use computers
Low	9	28.3	0.2	2	0	2	1	1	0	[Did not specify]	- Lack of social support; lack of time to utilize; lack of perceived persuasiveness
	34	28.3	-2.0	8	0	4	0	0	0	Information	- No need to lose weight
	38	31.5	-2.0	0	1	0	3	17	1	Reading comments	+ Commitment
	14	28.3	-3.4	6	1	1	3	12	2	Weight graph; food diary	- Lack of time to utilize
	35	30.6	-3.7	7	6	3	7	11	4	Weekly information	- Challenging life situation; lack of persuasiveness

Regarding reasons for not using the system, five subjects were disappointed to be assigned to group C and wanted more social support. Another common argument for not using Onnikka was lack of time to utilize the system to the full (*n*=6). Even Subjects 5, 11, and 25, who were highly active in terms of system use adherence, perceived that they did not have enough time to use the system properly. They felt that their work and life situation as a whole was too demanding, and they did not want to do much extra in their limited spare time, as the following quote from Subject 5 reveals:

> ***Researcher****: What do you think, what would it require to make the Onnikka more engaging?*
>
> ***Subject 5****: I don't think I… maybe in my case, the thing is that after a hard workday when I get home, there's so much else you need to do… so no… I don't know what would make it more engaging.*

Challenges in personal life like an overwhelming work load, divorce, or the death of a loved one naturally had a great impact on use adherence. One of the reported challenges for not using the system actively or not achieving weight loss was personal health. For some, mere commitment kept them signing into the system regularly.

On the contrary, of the users who felt that they could not utilize the system as much as they would have wanted to, four subjects argued that they did not have a severe weight problem to begin with (Subjects 18, 22, 33, and 34 in Table 5) and therefore did not have full motivation to pursue a lifestyle change. Subject 22's answer is a typical representation of a less serious attitude among some of the Onnikka users concerning lifestyle change:

> ***Subject 22****: I've tried to keep this as nice and cozy so it wouldn't kind of stress or occupy too much of my time, so that I wouldn't have to fill these systems every day as a routine. I'd rather take this a bit less seriously, this weight watching and this whole lifestyle change project.*

Quite similarly, three other users (Subjects 13, 23, and 28 in Table 5) saw the system in more of a supportive role, where the use of the system was inseparable from counseling visits or clinical health checks.

For four subjects in this group, the lack of persuasiveness was clearly one of the main reasons for not using the system, as can be seen from the following quote:

> ***Researcher****: Has Onnikka helped you to change your lifestyle to be healthier?*
>
> ***Subject 3****: Well… no.*
>
> ***Researcher****: You said before that it wasn't motivating enough.*
>
> ***Subject 3****: Yes that's true. When I logged there for the first times, it felt great. I used the food diary, exercise diary and weight. Later on when I logged there it was like I could type stuff there every day but it doesn't even draw a graph anywhere of what's happened. Or give me any points like from exercising or eating healthier foods.*

4 Discussion

According to our findings, *self-monitoring* is perceived as a beneficial persuasive feature among the users who achieved 5% weight loss. However, the preference for the self-monitoring tool and use amounts varied greatly. Among all interviewed subjects *reminders* and *tunneling* were also highly valued persuasive system features. The need for social support appeared to grow in importance through the duration of the intervention, and it was named as one of the reasons for not using the system particularly by subjects in group C. Other main reasons stated for not using the system were lack of time, challenging life situation, or health concerns. There were also several individuals

who perceived they did not have a need for the system, or it had only a minor supportive role in their lifestyle change process. Perceived persuasiveness did not appear to be vital for active users; however, a lack of perceived persuasiveness seemed to play a role in attrition.

4.1 Implications for Research

According to Kelders [25], it seems that there are no universal characteristics of participants that predict adherence, but rather the match between the characteristics of participants and the intervention may predict adherence. Studying non-adherers is difficult as well, as they are not a homogenous group. Our results imply that the people who *do not need* the system and the ones who *cannot use* the system are counterpoints that should be addressed differently (see also [45]). One of the common arguments in the eHealth field is that user attrition and reduced engagement among those participants who continue using the system are significant problems of web-based behavior change interventions [34,46,47]. According to our interpretation, not using the system can also be a sign of success. If a health BCSS does what it is actually designed to do, it should make its use eventually obsolete.

Kelders et al. [39] argue that persuasiveness has an impact on adherence, but it should be noted that in their study persuasiveness was measured by system features used, and not by subjects' perceived persuasiveness of the system. In this study, the lack of perceived persuasiveness seems to have an impact on attrition, but this does not mean that the relationship would be unambiguous. First, users were surprisingly active despite the lack of perceived persuasiveness. Even Subject 3, who of all the interviewed subjects was the most critical of Onnikka, still had three logins during the last quarter of the intervention period (weeks 40–52). Second, perceived persuasiveness did not rise explicitly from the high adherers' answers, which suggests that when an individual is fully engaged with using the system, he/she might not be fully aware of being persuaded and thus merely experiences the system as useful to him/her. Both these interpretations can explain why in Lehto et al.'s [26] study the effect of perceived persuasiveness explained nearly one third (31%) of the variance in the *intention to adopt*, but in another article by Lehto et al. [27], the effect of perceived persuasiveness on *actual use* (at 2 weeks) was not statistically significant.

In Lehto et al.'s [27] study, unobtrusiveness plays a key role in their research model, where unobtrusiveness has a statistically significant connection to perceptions of primary task features, perceived persuasiveness, actual usage of the system, and intention to continue system use. In their research setting, it was the only construct that

significantly decreased over time [27]; in other words, obtrusiveness increased over time. This could explain why in the current study some individuals who had used the system for a long time and had high adherence still struggled to find sufficient time to use the system.

Subjects' indifferent perceptions of the *liking* feature were quite unexpected, as in a previous study by Lehto et al. [27] design aesthetics was found to substantially contribute to user perceptions of primary task support, dialogue support, perceived credibility, and perceived persuasiveness. Similarly, in previous studies, *tailoring* has been shown to be positively related to the effectiveness of interventions in printed health behavior change interventions [48], and it has been suggested that tailoring may be able to promote a healthy diet via computer-tailored interventions as well [49]. A potential explanation for the lack of any perceived effect of tailoring by users could be that the system was designed with one clear purpose in mind and the subjects were handpicked to such an extent that the system was perceived as tailored in any case. The obtained confusing results regarding liking and tailoring merit further investigation.

Social support is acknowledged as a beneficial strategy in behavior change [50-52]. Kelders et al. [39] did not find evidence that social support would affect adherence, and according to them, reporting a social support feature as part of the intervention does not say anything about whether it is actually being used, meaning that if an intervention contains a discussion board, social support is employed in system design even if there is not a single post on the discussion board [39]. It is possible that, as in our Onnikka case, social support was rarely used in the studied interventions. The results of this study seem to agree with those of Krukowski et al. [22] and Lehto et al. [30], who indicate that in online communities, peer support gains importance in the maintenance phase. As an explanation, Lehto et al. [30] suggest that new users have not yet developed affective commitment to the community of users. In this study, the need for social support appears to decline again after the connection to the virtual community is lost.

4.2 Implications for Practice

According to Webb et al.'s [17] findings, interventions that employ more behavior change techniques show larger effects than interventions with fewer techniques. Kelders et al. [39] claim the effect of these interventions is decreased if the exposure to the intervention is not optimal. The PSD model does not claim that there is a

relationship between how many features are implemented in the system and the effectiveness of a BCSS [32]. Our results show that self-monitoring is not a clear-cut case, as all the tools offered by Onnikka were not used and perceived homogenously, even among high adherers. Persuading an individual to use all the tools that the system is offering sounds intuitively like an appealing strategy, but based on our interpretation it would in fact more likely increase the dropout rate drastically. As the critical reviews of the food diary imply, design flaws in one self-monitoring tool can ruin the use experience of the whole system. Our results indicate that offering more self-monitoring tools is an effective design strategy because it helps individuals to better adjust the system to their personal needs.

According to our results, tunneling is also one of the most influential software features and should not be overlooked when designing BCSSs. Yet, for instance, in Lehto and Oinas-Kukkonen's [53] study of six widely used weight-loss websites, tunneling was not implemented in any of those sites. The value of reminders in increasing adherence and the effectiveness of web-based health interventions is illustrated in several articles (e.g. [17,30,39,54,55]). For example, text messages have been found to relate to increased physical activity when compared to control groups who did not receive reminders [17]. The relationship between different persuasive feature categories has been discussed in many articles [26-29,29,30] that hold important findings regarding the role of dialogue support. According to Lehto and Oinas-Kukkonen [30], dialogue support is crucial to a system's effectiveness; however, it does not impact use continuance directly but rather indirectly via multiple proxy constructs. In their study, dialogue support did not have a direct significant effect on continuance intention, although it had a large impact, for example, on primary task support. Our interpretation is that system dialogue alone might not be enough to support individuals' behavior change; a reminder has to lead an individual to pursue his or her intended goals.

4.3 Limitations

There are multiple limitations in this study. BCSSs are not used in isolation from all other technological applications. There are many other persuasive software features that could have been implemented but were not in our case. For example, the persuasive feature *simulation* could have a great impact on managing one's health when an individual can more concretely see how their lifestyle choices influence their health and wellbeing in the future. Furthermore, based on this study, it is impossible to say whether the studied features would work in other health behavior change

contexts or with other user groups. The use of self-reported behaviors may also bias results due to the effect of social desirability.

5 Conclusions

In this study, a health behavior change support system designed and developed following the BCSS framework [14] and the PSD model [32] was used as a research medium. Forty-three users were interviewed to gain insight about the influential features of its design. In addition, the system's login data and the subjects' BMI measurements were used to interpret the results.

Our study elaborates the differences between the subjects able to achieve 5% weight loss and those who could not, and their system use activity. According to our findings, self-monitoring, reminders, and tunneling were perceived as the most beneficial persuasive features among the subjects. Dialogue support is a highly influential persuasive software feature, yet reminders alone, even if important, are not enough to support a user's change in behavior. Interestingly, the need for social support seemed to gain increasing importance at later stages of the intervention. Unobtrusiveness is very important in all stages and not merely at the beginning of the intervention. For BCSS designers, the current study sheds light on the design process and the actual use of these types of systems in real-life settings.

A much deeper understanding of the actual mechanisms of how BCSSs help individuals break unwanted habits and maintain healthier lifestyles is still required, and studies on the use of BCSSs in their actual contexts are needed to discover how different persuasive features can help in achieving healthier lifestyles in practice. Even though a BCSS's core aim is to impact individuals' lives and to help them manage lifestyle changes, behavioral gains are often lost when an active intervention period ends [56]. The web is one of the most prominent areas for future healthcare improvement through fostering healthy lifestyles [37 p. 148]. Ideally, a giant step forward in health BCSS research will be achieved when system users' inactivity can be considered a sign of successful behavior change rather than attrition.

Acknowledgements

We would like to show our gratitude to the PrevMetSyn research consortium, Maija-Leena Huotari, Heidi Enwald and Kreetta Askola. We also thank Dr. Piiastiina Tikka for comments that greatly improved the manuscript.

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