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# INFLUENCE OF PERSUASIVE REMINDERS AND VIRTUAL REHEARSAL ON INFORMATION SYSTEMS FOR SLEEP DEPRIVATION

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## Abstract

Appropriate amount and good quality of sleep are essential for mental and general well-being. Sleep deprivation and other chronic sleep disorders could lead to negative consequences for health, poor quality of life and reduced competence. An individual's quality of life could be unsettled because of several reasons, sleep deprivation is one of them. Information systems (IS) and human-computer interaction (HCI) researchers have paid considerable attention to promote healthy behaviors however sleep deprivation as a problem domain has received relatively little attention. In this paper, we present qualitative findings from a field study that examined potential influence of persuasive reminders and virtual rehearsal on the effectiveness of a Behavior Change Support System (BCSS). Tyyne is a BCSS developed for people suffering from sleep deprivation. The content of virtual rehearsal modules were drawn from Acceptance and Commitment Therapy. Participants were recruited through newspaper advertisements. After screening at the university clinic, eligible participants ( $n = 86$ ) were randomized into an Intervention group and a Control (wait-list) group. For data collection, we employed pre and post study structured questionnaires. Upon completion of the study, 41 participants volunteered to complete post study questionnaires. The findings reveal that a moderate number of participants (60.5%) improved their sleeping habits, a significantly high number of participants (79.1%) approved the BCSS, a staggering high number (93.0%) of the participants agreed that learning new skills through web-based BCSS is a good idea, and a substantial number of participants (72.1%) believed that persuasive reminders help people in task completion and compliance. Even though only about one third of participants (37.2%) reported that after using the BCSS they could better manage their sleep disorders, we suggest that the findings are encouraging. Given that treating sleep deprivation requires much longer periods of time than the intervention's duration (in our case it was 6 weeks), improvement with one third of the participants is nevertheless a promising result. On the whole, persuasive reminders and virtual rehearsal as software features have a significant potential to enhance overall effectiveness of information systems for chronic sleep disorders.

*Keywords: Sleep deprivation, Information Systems, HCI, persuasive reminders, virtual rehearsal, Acceptance and Commitment Therapy, Behavior Change Support Systems, Persuasive Systems Design*

# 1 INTRODUCTION

Appropriate amount and quality of sleep are essential for mental and general well-being. There could be many reasons that might lead to an individual's unhealthy lifestyle and sleep deprivation is one important however understudied causes as outlined by Alhola and Polo-Kantola (2007). They outline that existing literature provides supportive evidence that sleep deprivation is negatively correlated with cognitive functioning of an individual. According to van Straten and Cuijpers (2009), sleep related disorders including insomnia are common among individuals. Sleep deprivation and insomnia have several negative consequences for individuals, for example, fatigue, mood instabilities and psychological stress (van Straten and Cuijpers, 2009). Sleep deprivation results in poor life quality, reduced work productivity, anxiety, depression, and alcohol abuse (Walsh, 2004). It results in neurocognitive consequences as stated above. According to Goel et al. (2009), an estimated 20% of adult population suffers from sleeplessness. They further add that sleep deprivation leads to significant risks for well-being. As outlined by Faubel et al. (2009), the impact of sleep deprivation on general well-being is alarming. For example, those individuals who suffer from sleep deprivation have a higher risk of cardiovascular diseases, hypertension, diabetes and obesity (Faubel et al. 2009).

Sleep disorders have gained increasing attention because of the negative psychological consequences (Moul et al. 2004). Available literature provides strong evidence that in addition to healthy diet and regular exercise, good sleep quality is essential for general well-being as outlined by Choe et al. (2011). Information systems for promoting healthy diet (Purpura et al. 2011) and active lifestyles (Albanina et al. 2009) have been well studied. Unexpectedly, sleep deprivation and insomnia have not received considerable attention apart from medical and psychological researchers. Mental health issues including sleep deprivation pose stern challenges for IS researchers. Designing effective information systems for sleep deprivation and related sleep disorders call for innovative solutions. However, thus far it has proved to be a fairly challenging task. Persuasive information systems and behavioural psychology are well-studied research areas creating opportunities for intermediations based on amalgamation of cognitive behavioural techniques and information systems. Available literature provides evidence that effectiveness of information systems might improve when augmented with Cognitive Behavior Therapy (Andersson and Cuijpers, 2009). A significant number of studies have been conducted in the field of medicine and behavioural psychology that highlight the potential of cognitive behavioural interventions for sleep disorders. For example, Ritterband et al. (2009) evaluated the effectiveness of an Internet-based intervention based on face-to-face CBT for adults suffering from insomnia. The intervention was based on face-to-face cognitive behavioural therapy. It was concluded that participants who received the treatment for insomnia ended up with better sleep patterns.

Several hindrances have been reported that prevent people from using online as well as traditional face-to-face treatments. For example, low motivation to reach experts, unwillingness to discuss personal matters, lack of professional services, distantly located health services, high treatment costs and stigma (Aromaa et al. 2011). HCI researchers have also shown increasing interest in studying behavior change interventions developed with intent to promote desirable behaviors for instance healthy sleep behaviors (Choe et al. 2011). Information systems have been developed to overcome above said barriers by employing explicit or implicit persuasive techniques. Keeping in mind the need for improving sleep behaviors, we carried out this study using a web-based Behavior Change Support System (BCSS) (cf. Oinas-Kukkonen, 2013). The objective of the study was to evaluate potential impact of persuasive reminders and Acceptance and Commitment Therapy (ACT)-based virtual rehearsal on the effectiveness of a BCSS developed for people who suffer from sleep deprivation. Virtual rehearsal has been defined as a key software feature that enables users to complete primary tasks (Oinas-Kukkonen and Harjumaa, 2009). As stated earlier very little research has been conducted on virtual rehearsal (Kelders et al. 2012) especially in the research fields of HCI and persuasive information systems.

Researchers from the field of psychology have called for immediate attention to find effective solutions for sleep deprivation. Lim and Dinges (2008) argue that there is a pressing need to tackle sleep deprivation. Surprisingly very little published literature is available that discusses potential

solutions for sleep deprivation. For example, Manber et al. (2008) conducted a study to examine the impact of Cognitive Behavioral Therapy (CBT) on insomnia and depression. They propose that symptom focused CBT has promising implications for patients of both insomnia and depression. Previously, Langrial et al. (2012) worked on a BCSS for sleep deprivation. They carried out a trial study and evaluated a BCSS that drew its software functionalities from the Persuasive Systems Design model (Oinas-Kukkonen and Harjumaa, 2009). The BCSS was primarily devised with virtual rehearsal with an aim to help users learn new skills in overcoming sleep deprivation. This paper highlights findings from a six-week field study. A BCSS was developed with an aim to support users learn and practice new skills to better manage sleep problems. The paper is structured to report users' pre intervention expectations, post intervention remarks and finally detected differences in pre and post intervention psychological measures.

## 2 BACKGROUND

Existing studies indicate the effectiveness of eHealth interventions that are delivered through Internet and employ CBT-based techniques (Andersson and Cuijpers, 2009). Seligman et al. (2011) support the effectiveness of CBT-based treatments for mental well-being by adding that such treatments have shown significant clinical and statistical outcomes. Likewise, Sivertsen et al. (2006) worked on insomnia in elder adult population. They propose that CBT-based interventions are superior to zopiclone treatment both in short and long-term management of insomnia. Cognitive behavior literature provides sufficient evidence about the use of CBT-based techniques, however a few studies have reported the use of acceptance and value-based interventions incorporated with Acceptance and Commitment Therapy (ACT) (e.g., Gaudiano and Herbert, 2006; Forman et al. 2007), which is the latest wave of CBT. ACT is known to increase psychological flexibility because it is positively correlated with better mental health in general (Hayes et al. 2005). Serious efforts have been made to design, implement and evaluate interventions for mental well-being especially depression and anxiety with a specific focus on task adherence, user satisfaction and overall psychological outcomes. Adequate sleep is positively correlated with a healthy lifestyle yet it is surprising to note that the subject remains under-studied. Rigorous research has been conducted to address the issue in medical informatics and psychology yet there is evident lack of exploration in the fields of IS and HCI when it comes to studying sleep deprivation and related disorders (Langrial et al. 2012). It is interesting to note that individuals have been found to show keen interest and willingness to try different available treatments before reaching out for medical professionals (Morin et al. 2005). Such findings highlight significant premises thereby providing an opportunity for IS and HCI researchers to overcome the identified research gaps. Another encouraging finding indicates that people who suffer from sleep disorders do not necessarily seek medical remedies but are willing to experiment other options, if available (Langrial et al. 2012).

HCI researchers have emphasized on designing systems that end up bringing intended change in behaviors. Identifying the potential for improving sleep behaviors through computing technologies, Choe et al. (2011) outline that technological innovations could be used to improve poor sleep habits. They add that designing interventions for sleep disorders is a challenging task and a thorough understanding of multiple factors including culture, privacy and individual sleep habits is essential. Their work highlights the importance of improving sleep disorders through interventions and at the same time indicate that there are design opportunities for developing such interventions. Finally, they have proposed a design framework that involves: 1) goal identification (diagnosis, treatment,), 2) features (self-monitoring, tracking sleep patterns, awareness, relaxation), 3) source (clinically-validated therapies), 4) technology platform (web and / or mobile-based), 5) stakeholder (researchers and practitioners), and 6) input mechanism (manual input by the system users). While Choe et al.'s (2011) work provides an attractive preliminary framework for developing interventions for sleep disorders; we cautiously suggest that the framework does not provide specific guidelines to tackle the problem. Nevertheless, it does exhibit a generic overview for future research. In addition, Consolvo et al. (2009) recommend using behavior change theories when designing interventions. Their design strategies are valuable yet to the best of our knowledge evaluating the effect of categorical persuasive software features has somewhat been overlooked. This particular gap is clearly evident when it comes

to features such as virtual rehearsal. Rehearsal or learning through practice (Thorpe et al. 1987) has primarily been used in CBT-related studies. Psychology experts have acknowledged cognitive improvements through performance-based process. Significance of rehearsal as a behavior change technique has further been reported by (Thorpe et al. 1987) who maintain that rehearsal is a helpful technique for improving self-efficacy.

There is some evidence that supports the usefulness of rehearsal for learning new behaviors. Jaafar and Nur (2009) studied virtual rehearsal for educating children with an aim to reduce dental anxiety. However, the actual software implemented was simulation, which is different from virtual rehearsal according to Oinas-Kukkonen and Harjumaa (2009). Likewise, Fogg (2002) promotes virtual rehearsal as a means of providing an environment where people could practice and learn new behaviors. Rehearsal has also been studied in different contexts, for example computer training (Davis and Yi, 2004). They underscore Social Cognitive theory (Bandura, 1986) where Bandura proposes that learning process is primarily “an information processing activity in which information about the structure of behavior and about environmental events is transformed into symbolic representations that serve as cognitive guides for the construction of complex modes of behavior” (Bandura, 1986, p.51). Niemi et al. (2003) have worked on web-based learning environments. They based their research on Self-regulation, Self-determination and Self-efficacy as core psychological techniques that in their opinion lead to empowering users as suggested by Fetterman (2001). Niemi et al. (2003) outline that for learning new skills, rehearsal, critical thinking, connecting previous and new information are key factors for the learning process. In their work, Nakanishi et al. (2005) argue that virtual training (rehearsal) facilitates the learning process. They conclude that it is relatively hard to learn and acquire new skills through reading and simulation thereby giving support to the potential of virtual rehearsal as a desirable technique for learning new skills.

Identifying this gap, we decided to study selected software features and their likely impact on the effectiveness of web-based BCSS for sleep deprivation. As outlined by Oinas-Kukkonen and Harjumaa (2009), interactive information systems are expected to provide feedback and facilitate completion of target behaviors. In other words, we classify web-based information systems as BCSSs that are persuasive in nature, incorporated with augmented software features including but not limited to feedback, persuasive reminders and virtual rehearsal. According to Oinas-Kukkonen (2012), a BCSS is defined as, “an information system designed to form, alter or reinforce attitudes, behaviors or an act of complying without using deception, coercion or inducements”. Building on Fogg’s (2002) pivotal work, Oinas-Kukkonen and Harjumaa (2009) developed the Persuasive Systems Design model. The model provides an opportunity to methodically design and evaluate persuasive information systems. Typically, a persuasive system would prompt users to perform target behaviors when operating the system. Persuasive reminders could augment BCSSs to facilitate task completion (Oinas-Kukkonen and Harjumaa, 2009). Persuasive reminders vary in design and form; for instance, they could be incorporated as guileless messages or feedback (Fry and Neff, 2009) and delivered via different means with varying frequencies. Previously, reminders have frequently been employed in persuasive systems and health informatics. To date, different techniques have been studied to improve the effectiveness of reminders, for example, with tailored content. One of the on-going challenges for eHealth interventions is low adherence (task completion/compliance) and learning new behaviors to tackle mental health (Mohr et al. 2010). For this study, we formulated the following research questions:

**RQ1.** How do participants perceive persuasive reminders to help them complete virtual rehearsal tasks?

**RQ2.** How do participants perceive usefulness of virtual rehearsal in helping them overcome sleep difficulties?

### 3 METHODS

#### 3.1 Recruitment

The study was conducted between October 2013 and November 2013. Participants were recruited through newspaper advertisements. It was explained in the advertisements that we were looking for only those individuals who felt that they were suffering from sleep disorders. The eligibility criteria were: 1) Access to Internet/email, 2) that participants would not take lengthy breaks during the intervention, 3) access to telephone, 4) not being a part of a therapy or study in parallel, 5) Finnish as mother language and 6) age 18 years or older. In response to the advertisements, a total of 122 (76 via email and 46 via phone) individuals contacted the university clinic. Interested participants contacted the university clinic were screened over telephone on the 7<sup>th</sup> and 8<sup>th</sup> of October 2013. In addition, those who contacted the university clinic through email were screened on the 17<sup>th</sup> and 19<sup>th</sup> of October, 2013. Of the 122 individuals who were initially selected for the study, 14 were dropped out because they did not fulfil the eligibility criteria. Further, 22 participants were not included in the study because the number of interested participants was too high when compared with available resources. Therefore, the final number of participants was 86 (N=86). Later, measurement packages explaining the objective of the study and informed consent forms were sent to eligible participants. Because the study included actual patients of sleep deprivation, approval was formally obtained from the Ethical Committee at the University of Jyväskylä, Finland.

#### 3.2 Participants' Randomization

Randomization was performed using the randomizing tool (<https://www.random.org/lists/>) on the 9th of October 2013. Participants were randomized into two groups: (1) Intervention group (n = 43) that received the measurements, had access to the BCSS, received two weekly reminders (via email) and had access to weekly rehearsal modules, and (2) Wait-list control group (n = 43). For ethical reasons, the wait-list control group received the same program (but no reminders were sent) and URL as access point to the BCSS was sent out when the intervention group had completed the program. The study commenced on the 21<sup>st</sup> of October and concluded on the 25<sup>th</sup> of November 2013. This paper presents results from the intervention group only. A total of 12 (27.9%) males and 31 (72.1%) females aged between 24 to 73 years comprised the sample (Mean = 55.74, Std. Deviation = 10.99) A majority of participants (58.5%) had obtained higher education either and college or university level.

#### 3.3 BCSS: Tyyne

A research group from the Department of Information Processing Science, University of Oulu, Finland designed and implemented the BCSS. It was a challenging task and took several iterations and testing phases before being finalised. A research team from the Department of Psychology, University of Jyväskylä, Finland prepared the content for the BCSS especially ACT-based virtual rehearsal modules. ACT-based rehearsal exercises provided novel techniques for managing sleep problems. Virtual rehearsal as a software feature was used to enhance mindfulness, acceptance skills, psychological flexibility and commitment towards value-based actions among participants by utilizing a variety of metaphors, experiential exercises (both audio and video) for mindfulness and behavioural activation (Hayes et al. 2005). Table 1 presents a brief overview of the ACT themes used for the rehearsal content.

Week	Theme	Content
1	Values and value-based actions	Knowing what matters the most for an individual in his/her life and acting in accordance
2	The present moment	Living in the present moment (mindfulness)
3	Cognitive defusion	Understanding that an individual's thoughts could be different
4	The observer stance	Learning to view one's thoughts and feelings from an observer's stance
5	Acceptance	Accepting one's feelings, and thoughts and admitting that one cannot change things
6	Summary	Rehearsing ACT exercises from the previous weeks.

*Table 1. Acceptance & Commitment Therapy themes and content.*

### 3.4 The Persuasive Systems Design Model

The PSD model enables thorough evaluation of the persuasion context (the intent, the event and the persuasion strategy). The model provides a wide range of persuasive design features and software functionalities for BCSSs. The four distinct categories outlined in the PSD model are primary task, user-system dialogue, credibility and social support features. Several researchers have used to the PSD model in varying contexts, for example, Lehto and Oinas-Kukkonen (2011), Räisänen et al. (2010), Stibe et al. (2013), Drozd et al. (2012), Wiafe et al. (2012) and Yetim (2011). The PSD model has been successfully applied in the area of ubiquitous applications for well-being (Langrial et al. 2012), personal wearable devices for physical training (Harjumaa et al. 2009), and design for persuasive information systems that promote healthy behavior (Purpura et al. 2011). Further, Kelders et al. (2012) support the use of persuasive system design for web-based interventions. The PSD model does not promote assimilation of all the software features to develop an effective BCSS meaning thereby the persuasiveness of a given BCSS is by no means guaranteed in terms of the quantity of incorporated persuasive software features. On the contrary, it is the characteristics of selected software features that could lead to an effective BCSS.

### 3.5 Use of virtual rehearsal and persuasive reminders.

The study was designed in a way that the participants were instructed to complete and rehearse one ACT-based virtual rehearsal module before moving on to the next step in the following week. This was intentionally planned for two reasons: 1) to provide sufficient time for participants to rehearse and 2) to bring in the element of incremental behavior change process, which is promoted by the PSD model (Oinas-Kukkonen and Harjumaa, 2009). The prime goal of sending email-based persuasive reminders was to encourage the participants to interact with the BCSS without being obtrusive and rehearse newly learned skills. Each week three email-based automated reminders were sent out to the participants with an aim to trigger interaction between participants and the BCSS. The first reminder was to praise the participants for successful completion of the allocated task (for example, completing rehearsals for week 1, the second reminder was sent to motivate users to keep on practicing skills that they had learned and the third reminder was sent to advise that participants could access the next rehearsal module and start practicing new skills.

### 3.6 Data Collection about participants' experiences.

System usefulness and users' overall experience with the BCSS were evaluated using Likert-scale (Likert, 1932) questionnaires at the beginning and the end of the intervention. For data collection, we developed pre and post study questionnaires. The questionnaires consisted of two parts. The first part included demographic questions devised to collect information about the participants, their computing skills and familiarity with Internet. The second part in the pre study questionnaire involved questions about participants' expectations and perceived usefulness of the BCSS. The post study questionnaire was developed to gather information about the actual experiences of the participants after having used the BCSS. Special emphasis was laid on system usefulness, easy of use; impact of persuasive reminders on task completion, impact of virtual rehearsal on sleep management skills, and participants' views about the effectiveness of virtual rehearsal as a learning technique. We used seven-point rating scales for all items (1 = Strongly disagree; 7 = Strongly agree) (Likert 1932). Finally, participants were interviewed in a post study satisfaction survey where experiences with the intervention were recorded, coded, and analyzed.

### 3.7 Measures for well-being.

For measuring psychological outcomes, we employed Beck Depressive Inventory – II (Beck et al. 1961) and Epworth Sleepiness Scale (ESS) (Johns, 1991). Beck Depressive Inventory – II comprises of 21 questions about depressive symptoms and their severity. The scale ranges from 0 – 63 (where 0 – 13 no or few depressive symptoms, 14 -19 indicate mild depression, 20 – 28 indicate moderate depression and 29 – 63 indicate severe depression). BDI-II has been recognised to have reliability and validity in both nonclinical and clinical populations. Epworth Sleepiness Scale (ESS) is a self-administrated eight-item questionnaire (Johns, 1992). It determines level of sleepiness during daytime (Johns, 1991). ESS scores that is greater than 16 indicate a high level of daytime sleepiness. The ESS has proven to be reliable and internally consistent according to Johns (1992).

## 4 DATA EVALUATION

The PSD model (Oinas-Kukkonen and Harjumaa, 2009) was applied for evaluation of the BCSS because it is equally applicable for designing and evaluating persuasive information systems. The model outlines 28 distinct persuasive software features however for the purpose of this study, persuasive reminders and virtual rehearsal were selected as the key software features. The goal of the study was to examine the effectiveness of persuasive reminders in terms of triggering first step towards expected task completion/compliance. The major task for the participants was to learn new behaviors through practice for better managing sleep disorders through ACT-based virtual rehearsal modules. Particular emphasis was placed upon the said software features to understand how a combination of the two could be further improved to develop effective BCSSs for sleep disorders. In addition to the aforesaid, we also aimed to explore participants' expectations from the BCSS in terms of system usefulness, ease of use, expected enjoyment, whether participants perceived virtual rehearsal as a good idea, their willingness to use the system, and whether participants considered persuasive reminders as an effective technique. The research methodology used was qualitative data gathering using structured questionnaires. Participants completed pre and post study questionnaires representing their responses both in terms of expectations and actual experiences respectively. Finally, participants were given an option to give comments about the BCSS in general. For the purpose of the analyses and answer abovementioned research questions, we followed a qualitative research methodology. We used elements of the grounded theory method (Strauss and Corbin, 1998). It allows using previously defined themes and, at the same time provides an opportunity to collect emerging theses as sated by Fereday and Muir-Cochrane (2008). Further we evaluated frequency distribution between pre and post measurements using Chi-square test.

## 5 RESULTS

Table 2 represent participants' responses for both pre and post study questionnaires. The table exhibits pre and post intervention responses in percentage (Agreed; Unsure or Disagreed), pre and post intervention mean scores and standard deviation, and t-test revealing statistical differences between pre and post mean values.

Question/Theme	Pre: % (n)	Post: % (n)	$\chi^2$	Pre: Mean (sd)	Post: Mean (sd)
BCSS will improve my sleep habits/helped me improve my sleep habits				2.91 (.29)	2.54 (.67)
Agreed	90.7% (39)	60.5% (26)	$\chi^2 = 9.83$ ; df = 2 (p < 0.01)		
Unsure or Disagreed	9.3% (4)	34.9% (15)			
BCSS will be/was easy to interact with				2.77 (.48)	2.95 (.26)
Agreed	79.1% (36)	90.7% (39)	$\chi^2 = 2.85$ ; df = 2 (p = 0.09)		
Unsure or Disagreed	20.9% (7)	4.7% (2)			
Web-based BCSS for sleep disorders is a good idea				2.88 (.50)	2.83 (.38)
Agreed	93.0% (40)	79.1% (34)	$\chi^2 = 4.22$ ; df = 2 (p = 0.12)		
Unsure or Disagreed	7.0% (3)	16.3% (7)			
Learning new skills through web-based BCSS is a good idea				2.93 (.258)	2.98 (.156)
Agreed	93.0% (40)	93.0% (40)	$\chi^2 = 0.93$ ; df = 1 (p = 0.33)		
Unsure or Disagreed	7.0% (3)	2.3% (1)			
Reminders will help people complete web-based interventions				2.95 (.213)	2.68 (.610)
Agreed	95.3% (41)	72.1% (31)	$\chi^2 = 7.12$ ; df = 2 (p = 0.03)		
Unsure or Disagreed	4.7% (2)	23.3% (10)			
After using the BCSS, I will be/am able to manage my sleep problems better				2.88 (.324)	2.32 (.610)
Agreed	88.4% (38)	37.2% (16)	$\chi^2 = 22.63$ ; df = 2 (p < 0.01)		
Unsure or Disagreed	11.6% (5)	58.2% (25)			

Table 1. Pre and post study responses depicting statistical outcomes.

## 5.1 Psychological Measures

Symptoms of sleeplessness were assessed at the beginning and the end of the study. For the purpose of measuring psychological symptoms, Beck Depression Inventory –II (Beck et al. 1961) and Epworth Sleepiness Scale (Johns, 1991) were used as primary measures. BDI-II (Beck et al. 1961) was used as a primary measure because depression is a common reason for sleeplessness and insomnia (Hall et al. 2000). Epworth Sleepiness Scale (Johns, 1991) also known as ESS is a simple, self-administrated questionnaire that has shown to provide a measurement of a given individual's general level of daytime sleepiness. ESS (Johns, 1991) provides valid measurements of sleep propensity in adults. Outcomes from the analysis for pre and post BDI-II measurements revealed statistically significant decrease in the intervention group where mean values dropped from 12.20 to 8.15 ( $t = 5.54$ ,  $df = 38$ ,  $p < 0.01$ ). Similarly, promising results were observed when ESS was analysed. Outcomes from the pre and post study for ESS showed noteworthy decrease in mean values from 6.98 to 5.63 ( $t = 2.59$ ,  $df = 37$ ,  $p < 0.05$ ). Mean values for the psychological measurements provide evidence that support overall effectiveness of the BCSS. Figure 1 exhibits scores for Mean and Standard Deviation for Intervention group.

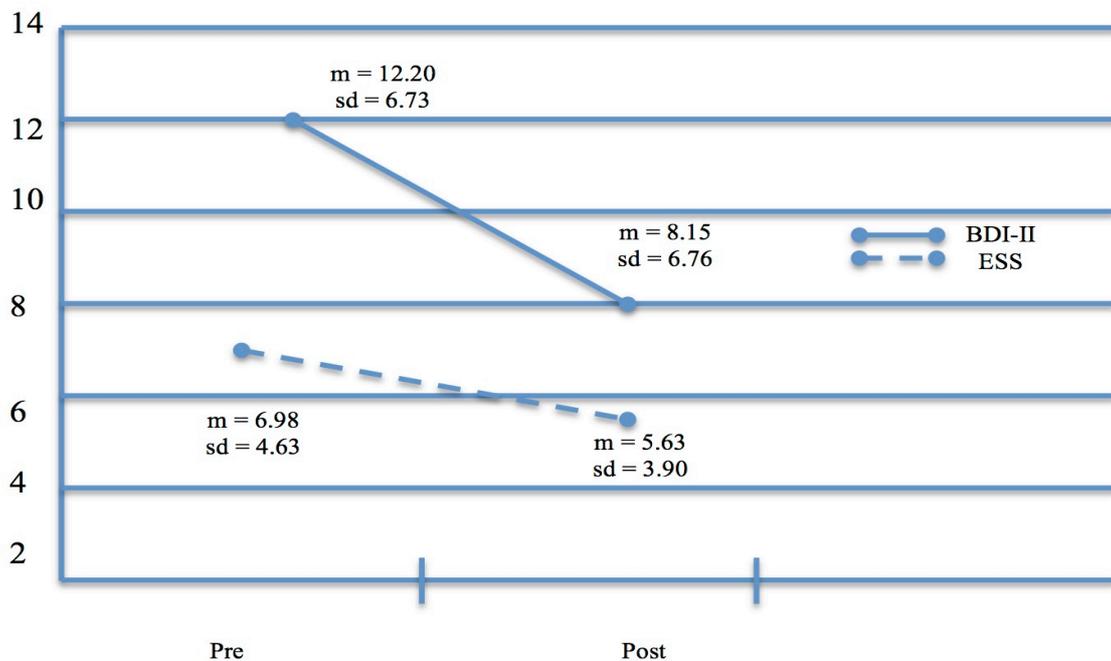


Figure 1. Mean scores and standard deviations for psychological measures.

## 5.2 Participants' open comments

Of the 43 participants, 41 volunteered to complete post study questionnaires. Several critical remarks were noted and themes were identified. Keeping in mind the identified themes, below are some of the exemplary comments:

### 5.2.1 Need for extended interaction

*"A little more interaction (prolonged period of study) would have been better (desirable) otherwise it was a god experience". (Female; 45 years)*

*"I had high expectations but I did not have enough time for the system (to interact with the system)". (Female; 45 years)*

*"The program (intervention) did not help me. The study period should have been longer". (Male; 53 years)*

*“The period of the study (intervention) was too short”. (Male; 58 years)*

#### 5.2.2 Persuasive reminders are beneficial

*“The system met my expectations. Reminders worked fine. Adding SMS-based reminders would have been better”. (Male; 53 years)*

*“The system was good! I found reminders and rehearsal to be beneficial”. (Female; 62 years)*

*“I expected a little more from the system. The rehearsals were good and so were the reminders (they were much needed)”. (Female; 62 years)*

#### 5.2.3 Virtual rehearsal is a useful technique

*“I got to know myself (better) and now I have new (better) viewpoints (about my life)”. (Female; 65 years)*

*“I am highly grateful! I am (feel calm) about my waking up during night time and (now) I (manage) to sleep gain”. (Female; 65 years)*

*“I had no problems using the system (BCSS). It was (indeed) a positive experience. The program (intervention) was well built (designed) both technically and content wise. There was enough information given the short study (intervention) period. My sleep did not improve. The process of improvement was just starting (to happen). I learned new views (techniques) to think about my life”. (Female; 67 years)*

*“There was a lot of new information. The program provided broad (comprehensive) approaches towards sleep problems, it was engaging. Although, my sleep problems are the same but I will continue to rehearse”. (Male; 67 years)*

*The system (BCSS) was easy to use. Rehearsals were reasonable (logical). It was an interesting experience. I (would) highly recommend using the (same) system. Now, I can sleep easily and (also) breathe better”. (Female; 50 years)*

*“I cannot compare this (experience) to anything else. The memories are pleasant. I would like to take part in something similar (intervention) in future”. (Female; 63 years)*

*“The system met my expectations. It was a positive experience. Working out the exercises (rehearsing) has improved my situation”. (Female; 57 years)*

*“The system was good. It did not resolve my insomnia but I still feel it (the BCSS) was useful”. (Female; 47 years)*

*“Very surprising and exciting experience. I committed (myself) to the program (intervention) and learnt new skills. The best results are thoughtfulness that I have achieved in six weeks”. (Female; 56 years)*

*“The system taught me to listen, breathe and meditate well. It helped me accept that there are bad times. Thank you”. (Female; 56 years)*

*“My expectations were met and exceeded. Quality of sleep has increased remarkably. Length of sleep is bit better. Not so much of awakening during night. Best of all, I have almost quit using sleeping pills.” (Female; 50 years)*

#### 5.2.4 General remarks about expectations

*“I did not have any expectations (that my sleep problems will be solved).” (Female; 60 years)*

*“I expected a more from the system (intervention). However, my own laziness (has) influenced my (learning) progress”. (Male; 51 years)*

*“The system met my expectations. I had problems but because of my Internet connection. (Female; 64 years)*

*“I am still practising (rehearsing). Let us see what happens”. (Female; 56 years)*

*“The program (intervention) was positive (good). I just did not have much time. It was worth a try”. (Male; 59 years)*

## **6 DISCUSSION**

The main objective of the study was to evaluate (i) how do participants perceive persuasive reminders in helping them to complete weekly virtual rehearsals and, (ii) how do participants perceive usefulness of virtual rehearsal in overcoming sleep difficulties. According to Oinas-Kukkonen and Harjumaa (2009) effective dialogue support features should be incorporated to keep the users motivated in continuing to interact with the system and assisting them to achieve their goals. It has been stated that features supporting users' primary task are desirable for persuasion (Oinas-Kukkonen and Harjumaa 2009). Further, primary task support features aim to improve users' self-efficacy while decreasing cognitive efforts and disorientation (cf. Webster and Ahuja 2006). This study demonstrates how the PSD model could be applied in implementing and evaluating a BCSS. It is evident that the participants had high expectations from the BCSS in the pre study survey however upon completion of the study, the post study survey responses exhibit a relatively different picture. We had two research questions for this study. RQ1 was aimed to examine how and to what extent persuasive reminders helped users in task completion/compliance. Post study results indicate that persuasive reminders were perceived as beneficial. This is especially evident in participants' open comments where majority of the participants (72.1%) reported persuasive reminders as a suitable method for task completion/compliance in both pre and post study questionnaire. RQ2 was developed to assess the extent to which virtual rehearsal would help users learn new behaviours through practice. An overwhelming majority of participants (93.1%) approved virtual rehearsal as a helpful feature to learn new behaviours. In addition, participants' open comments provide significant evidence supporting the usefulness of virtual rehearsal as a desirable technique. Several participants expressed their desire for an extended period of the intervention.

A notable limitation of this is that the duration period of the intervention was relatively short. Chronic disorder such as sleep deprivation requires an extended period of interaction between users and the BCSS. Our work opens opportunities for IS, HCI and e-Health researcher to further investigate selected software features that could enhance efficacy of BCSSs designed for sleep deprivation and related disorders. It is imperative to note that the mere presence of persuasive software features might not be enough to make a BCSS effective. Whether a BCSS is persuasive or perceived to be persuasive in a certain context, longitudinal studies with adequate number of participants is highly advisable. Further research is also crucial to improve practices that could help researchers understand how and under what circumstances explicit software features (either in isolation or collectively) could lead to desired outcomes in BCSSs (Oinas-Kukkonen 2009) in diverse contexts and across larger populations.

## **7 CONCLUSION**

This paper presents findings from evaluation of a web-based BCSS for sleep deprivation. The software features were drawn from the PSD model, however; in this case the prime focus was only on studying persuasive reminders and virtual rehearsal. Majority of the participants agreed that the BCSS was beneficial and the study was a good idea. Almost all the participants agreed that learning new skills through web-based systems was a good idea. Although almost all of the participants agreed at the beginning of the intervention that persuasive reminders would help them in task completion, the number decreased significantly upon completion of the intervention. A high majority of the participants anticipated that upon completion of the intervention, they would be able to manage their sleep problems better. However, it was observed that several participants' expectations were not met. Nevertheless, 16 participants agreed that they could better manage their sleep problems, 22 participants were unsure and 3 participants disagreed upon completion of the intervention. The findings indicate that participants had high expectations from the intervention majority reported that their expectations were not met at the end of the intervention. One major reason for this outcome is

relatively short time period for the intervention. Despite the fact that the study lasted for a period of six weeks only, the findings are evidently encouraging especially for the fact that the entire intervention was carried without face-to-face therapy and a significant number of participants evaluated the intervention positively i.e. the BCSS was easy to use and using web-based BCSSs was a good initiative.

We believe that our work is a decent starting point to further develop and investigate information systems that would support people in overcoming sleep deprivation. Our work has several implications for HCI and IS researchers especially those who wish to analyse the influence of persuasive reminders on task completion and virtual rehearsal on behavior change. In future, we plan to carry out a longitudinal study with an aim examine whether there are any differences in behavioural outcomes when participants are provided an opportunity to use the BCSS for an extended period of time.

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