Exploring Perceived Persuasiveness of a Behavior Change Support System: A Structural Model

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Abstract. There is no healthcare system in the world that has the capacity or resources to provide every person in need of help and support of changing lifestyle behaviors. Consequently, there is a need to design health information systems that enable individuals to manage their health and maintain a healthier lifestyle. However, there is limited knowledge about how individuals perceive these behavior change support systems and how individuals' perceptions affect the use of such systems. In the present study, we tested a persuasive systems design model that had a significant impact on perceived persuasiveness and system usage. Also, there appears to be some local gender differences in the strength of the relationships between factors (perceived persuasiveness and intention, and unobtrusiveness and intention). We discuss future developments of the model and health as a social and personal responsibility.

Keywords: persuasive systems design, behavior change support systems, usage, gender and technology, eating habits, weight loss, partial least squares.

1 Introduction

According to the World Health Organization's [1] projections for 2030, about 51.5 million deaths or 76 percent of the global mortality and burden of disease will be accounted for by non-communicable conditions (i.e. diseases which are largely caused by poor lifestyle and health behaviors). There is no healthcare system in the world that has the capacity or resources to provide every individual in need of help and support of changing lifestyle and health behaviors. New innovations are therefore very much needed and consumer health applications can potentially help to this end. However, many kinds of information system (IS) have been developed and designed primarily for healthcare managers and professionals. Thus, there is a need for health information systems that enable individuals to manage their health and maintain a healthier lifestyle. There is an increasing interest in reaching consumers and patients directly through consumer health IT. According to Payton and colleagues [2] (p. vi),

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there has been "*a shift in the role of the patient from passive recipient to active consumer of health information and active user of healthcare devices, logging, and monitoring systems*". Indeed, by providing consumers with access and tools to personal health information, we can begin to influence how they manage their health and well-being.

Oinas-Kukkonen [3] proposed the generic concept of a behavior change support systems (BCSS) to describe consumer health applications. BCSSs highlight autogenous and voluntary approaches in which people use information technologies to change their attitudes or behaviors through building upon their personal motivation or goal. They harness either technology-mediated persuasion or technology-human persuasion. Technology-human persuasion is fully automatized, whereas technology-mediated persuasion means that people are influencing others through e.g. discussion forums, instant messages, or social network systems. The primary challenge in developing such comprehensive systems for consumers, is that there is modest knowledge of how individuals interact with consumer health informatics and how they process and act on information [4] (i.e. how individuals perceive these systems and how individuals' perceptions affect the use of such systems). In a recent report by Jimison and colleagues [5], the most frequent barrier to use of interactive consumer health IT across studies, was a lack of perceived benefit and lack of convenience. Furthermore, subjects were less likely to use systems if they did not fit seamlessly into their regular daily routines. Other major obstacles were burdensome data entries and lack of trust in the provided information. Clearly, technologies cannot have the capacity to facilitate self-monitoring and self-management or improve consumers' health outcomes if consumers do not accept the technology e.g. [6].

The objective of this study is to investigate consumers' perceptions of a web-based intervention for weight loss. Specifically, we aim to examine factors affecting the perceived persuasiveness of the system and whether perceived persuasiveness predicts intention to use the intervention and actual system usage. First, a theory-driven research model is constructed. Second, a component-based structural equation modeling (SEM) approach, partial least squares (PLS), is used to test the relationships between a latent variable and its indicators (i.e. the measurement model) and the structural relationships among the latent variables in the research model.

2 Theoretical Background and Research Model

The interaction between people and IT is an area of inquiry that accentuates the multi-disciplinary nature of the IS field. Human behavior impacts the whole life cycle of IT; including its design, development, deployment, adoption, and use. In this study, we were interested in a web-based intervention designed to influence its users' eating behaviors and built a theory-driven research model based on the Persuasive Systems Design[1] (PSD) model (see Figure 1) [7], to test the interventions perceived persuasiveness and how perceived persuasiveness of the intervention relates to usage.

[1] The "social support" category from the PSD model [9] has been omitted from the proffered research model, since the web-based program under investigation does not facilitate social support in its current form.

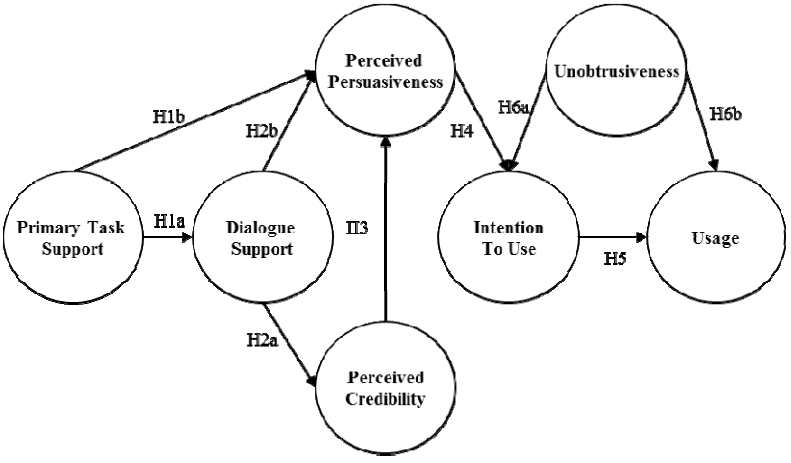

Fig. 1. The PSD model with hypothesized relationships between constructs in the present study

Primary Task Support. Primary task support encompasses the means to aid the individual in performing his or her primary task [7]. The aim of primary task support is to enhance the self-efficacy of the user and to reduce the cognitive burden and disorientation towards system use [10], [9]. According to Johnston and Warkentin [10] (p. 3), self-efficacy is "*the degree to which an individual believes in his or her ability to enact the recommended response*." In addition, primary task support increases positive affect [11] which augments the persuasiveness of the source [12]. Therefore, we put forward the following hypotheses:

H1a: Primary task support is positively related to dialogue support.
H1b: Primary task support positively affects perceived persuasiveness.

Dialogue Support. People tend to react to IT applications as if they were interacting in social situations [13], [14], [15]. Thus, supporting the dialogue between the IT application and the individual user is essential. Dialogue support defines the key principles in keeping the user active and motivated in using the system, and involved in his or her behavior change process. System-to-user prompts, praise and reminders play an important role in dialogue support [7]. The dialogue support may be further enhanced, for instance, by providing users with appropriate counseling and feedback. Such instances of dialogue support promote users' engagement, motivation, and positive affect, which will likely influence users' confidence in the source (credibility). Consequently, the following hypotheses are formulated:

H2a: Dialogue support positively influences perceived credibility.
H2b: Dialogue support positively affects perceived persuasiveness.

Perceived Credibility. Perceived credibility contains both a subjective and objective component. The subjective component is based upon people's initial evaluations of the system credibility based on their first impression. An encounter with a (novel) system is largely a visual one, and during system interaction, constant visual

information immediately elicits aesthetic judgments. This principle is called surface credibility [7]. Perceived credibility also has an objective component which might be bolstered by providing endorsements from respected and renowned sources (e.g. a recommendation by an authoritative organization, an award for excellence in usability, or a privacy seal to ensure confidentiality). Both the subjective and objective component of perceived credibility should affect the believability of the IT application. Consequently, we state the following hypothesis:

H3: Perceived credibility positively affects perceived persuasiveness.

Perceived Persuasiveness. In classical models of attitude change, messages are presented, received, processed, and if successful, recipients' attitudes shift toward the advocated position [16]. The altered attitude may have an impact on subsequent behavior under appropriate conditions [16] but, according to Crano and Prislin [16], a central aspect that must be taken into account when reflecting on persuasion involves the fundamental construct of attitude. They state the following (p. 347): "*Today, most accept the view that an attitude represents an evaluative integration of cognitions and affects experienced in relation to an object.*" In the present study, perceived persuasiveness is operationally defined as individual's favorable impressions toward the system. The following hypothesis is rendered:

H4: Perceived persuasiveness has a positive impact on intention to use the system.

Intention to Use and Usage. Behavioral intentions are proposed by several psychological theories, as an immediate and important predictor of behavior. In IS research, behavioral intentions are often used as a proxy for system usage or net benefits of an IT system. The problem of using only behavioral intentions as an outcome is that intention is not always a good predictor of behavior. Meta-analyses show that intentions do have a significant impact on behaviors but typically explain just under 30 percent of the variation across different types of behaviors [17], [18]. Therefore, it was important to include the link from intention to actual system usage in this study:

H5: Intention to use the system at two weeks predicts actual usage after six weeks.

Unobtrusiveness. To understand and close the intention-behavior gap, much of the attention of research has been drawn to various perspectives such as self-regulation [19] or intervention characteristics [20]. According to the PSD model, unobtrusiveness may be one such important factor that bridges some of the intention-behavior gap. Technology provides the information and means to aid the individual in his or her tasks but the key to successful implementation and use, depends on whether users have the opportunity to use the system or whether they find it disturbing. According to Oinas-Kukkonen and Harjumaa's PSD model [7], systems should aim at unobtrusiveness. Unobtrusiveness is a contextual construct that reflects whether the system fits with the user's environment in which he or she uses the system. On the one hand, research shows how important it is to have a fit between technology and its

users on individual performance [21]. On the other hand, intrusive technology characteristics are found to have negative consequences such as stress [22]. Consequently, we hypothesized that:

H6a: Unobtrusiveness has a positive relationship to intention to use the system.
H6b: Unobtrusiveness has a positive relationship to actual usage of the system.

3 Research Method

3.1 Data Collection and Subject Characteristics

Subjects were recruited through online ads and banners over a period of 14 days during October 2011. By clicking on a banner, potential subjects were redirected to an external website containing study information and an informed consent. Subjects had to confirm to have read the study information before they could proceed to fill in the online survey. Subjects with a verified e-mail address, ≥ 18 years, and < 5 missing values, were included in the dataset. Data were collected online at baseline, two weeks, and six weeks post-intervention. The surveys consisted of questions related to 1) demographics, 2) primary task support, 3) dialogue support, 4) perceived credibility, 5) perceived persuasiveness, 6) unobtrusiveness, and 7) intention to use. A seven-point Likert scale was applied for all continuous items (ranging from strongly disagree to strongly agree). Usage was collected by means of log-file data six weeks post-intervention, about the time as users would have finished the program with optimal program compliance. Overall, 128 complete responses were obtained. See Table 1 for detailed information regarding the respondents.

Table 1. Baseline sample characteristics

Characteristic	Females (n=64)	Males (n=64)	Total (n=128)
Age (yrs)	37.6 ± 12.3	41.8 ± 10.5	39.7 ± 11.6
Education			
Elementary	1 (1.6)	2 (3.1)	3 (2.3)
High-school	16 (25.0)	17 (26.6)	33 (25.8)
1-3 yrs college or university	16 (25.0)	20 (31.3)	36 (28.1)
4-5 yrs college or university	15 (23.4)	12 (18.8)	27 (21.1)
> 5 yrs college or university	16 (25.0)	13 (20.3)	29 (22.7)
Occupational status			
Employed	36 (56.3)	56 (87.5)	92 (71.9)
Unemployed	1 (1.6)	0 (0.0)	1 (0.8)
Student	16 (25.0)	4 (6.3)	20 (15.6)

Note. Numbers represent mean and ± SD for age and number of observations with percentage of observations in parenthesis for education and occupational status.

3.2 Description of the Behavior Change Support System

Ned i Vekt is a fully automated web-based behavior change support system developed by Changetech AS. The aim of the program is threefold: 1) assist users changing their

eating habits, 2) up-regulate positive emotions and mood, and 3) losing weight. It is a tunneled program consisting of two program days for six weeks. Every Monday and Thursday, the user receives an e-mail with a link to the day's website. As shown in table 2, every day in the program is unique and consists of psycho-educative information, online exercises, and home assignments. Much of the program content is based on consumer psychology [23], positive psychology [24], and the basic premises of the non-dieting paradigm [25], i.e., 1) stable mild and moderate overweight is not unhealthy, 2) dieting is ineffective, and 3) dieting is harmful.

Table 2. Overview of program days in Ned i Vekt

Day	Psychoeducative information	Exercise(s)
1	Food and emotions	Test of eating behaviors; personal reasons for changing eating behaviors
2	Willpower (focus on one thing at the time)	Implementation intentions and optimism exercise
3	Eating environment and "forbidden" foods	Suppression-countersuppression experiment (ironic mental processing)
4	Willpower, blood sugar levels, and performance	Savoring positive moments
5	Eating environment	How environmental factors such as lighting, temperature, music, distractors, etc., affect our eating behaviors
6	Temptations and impulses	Attentional control ("cold spots" exercise) and stereotype lift
7	Food and expectations	Demonstration of the size-contrast and vertical-horizontal illusions
8	Associations with food (e.g. affect heuristics)	Relaxation training
9	Self-efficacy and change	Positive self-talk and mindful eating (the raisin exercise)
10	Stress, willpower, and choice of foods	Exemplar priming (i.e. a story with word primes for increased performance)
11	Summary and repetition	Test of eating behaviors

4 Data Analysis and Results

We analyzed our research model using partial least squares (PLS) by utilizing WarpPLS 2.0 (Scriptwarp Systems; www.scriptwarp.com/warppls/) software for data analysis. WarpPLS is a component-based path modeling software application which is appropriate to use when the purpose of the model is to predict, rather than to test established theory [26]. Moreover, PLS is reasonably robust to deviations from a multivariate distribution [27]. The statistical objective of PLS is similar as that of linear regression, i.e., to demonstrate explained variance in the latent variable as indicated by R^2 values, to indicate the strength of the relationship between latent variables in terms of β-values, and test the significance of the relationship between latent variables by estimating t-values and reporting their corresponding p-value [27]. It is often suggested that the minimal sample size in PLS analysis should be at least 10 times the number of indicators in the most complex construct. Our total sample

size exceeded this requirement. However, we applied the jackknifing procedure to generate more stable re-sample path coefficients. Overall, testing the PLS model is carried out in two steps: 1) the assessment of the reliability and validity of the measurement model, and 2) the assessment of the structural model. The measurement model includes the relationships between the constructs and the indicators used to measure them. The convergent and discriminant validity of the research instrument is examined in order to verify that the constructs' measures are valid and reliable before attempting to draw conclusions regarding relationships among constructs (structural model). The structural model includes testing the full research model in a single step.

The Measurement Model. Descriptive statistics for the research constructs are presented in Tables 3 and 4. The properties of the scales are assessed in terms of item loadings, discriminant validity, and internal consistency. Item loadings and internal consistencies greater than .70 are considered acceptable [28]. The values presented in Table 3 have been obtained through IBM SPSS Statistics 19 software. All constructs in the model display good internal consistency as evidenced by their composite reliability scores (from .90 to .97) and Cronbach's alpha scores (from .84 to .96).

Table 3. Construct means and reliability scores for total sample (n=128)

Construct	No. of items	Mean ± SD	Composite reliability	Cronbach's alpha
Primary task support (PRIM)	3	14.7 ± 4.0	.94	.91
Dialogue support (DIAL)	4	19.3 ± 5.4	.95	.93
Perceived credibility (PCRED)	5	26.7 ± 5.5	.95	.94
Perceived persuasiveness (PERS)	4	20.3 ± 5.3	.93	.84
Unobtrusiveness (UNO)	4	21.2 ± 5.0	.90	.91
Intention to use (INTE)	4	23.8 ± 5.7	.97	.96
Usage (USE)	1	10 (2–11)	.94	

Note. Usage was measured with an ordinal single indicator based on how many program days a user had completed. Thus, usage is reported as median with range in parenthesis.

Table 4. Latent variable (LV) correlations for total sample (n=128).

LV	AVE	PRIM	DIAL	PERS	PCRED	UNO	INTE	USE
PRIM	.84	.92						
DIAL	.83	.84	.91					
PERS	.78	.78	.83	.88				
PCRED	.80	.69	.69	.77	.90			
UNO	.69	.48	.57	.61	.51	.83		
INTE	.90	.56	.60	.67	.51	.60	.95	
USE	1.0	.24	.32	.32	.22	.31	.31	1.0

Notes. The principal diagonal (shaded cells) is the square root of the AVE (Average Variance Extracted) between the constructs and their measures. Off-diagonal figures are the inter-construct correlations. For discriminant validity, the principal diagonal should be greater than off-diagonal elements.

The Structural Model. The total sample size was 128; however, in order to examine the female and male sub-groups individually, we employed jackknifing. Kock [29] suggests that for small samples (i.e. < 100 subjects), jackknifing is the recommended re-sampling approach. For consistency, we also tested the total sample with jackknifing procedure. Figure 2 provides the results of the PLS analysis for the final model in the total sample. For the most part, there is substantial support for the model, although the relationships between primary task support and perceived persuasiveness (β = .13, p = .10), and unobtrusiveness and usage (β = .18, p = .18) were not supported. All of the significant hypotheses were supported at p < .001. Primary task support accounts for 72 percent of the variance in dialogue support (β = .85), while dialogue support accounts for 48 percent of the variance in perceived credibility (β = .69). Dialogue support (β = .55) and perceived credibility (β = .39) together explain a substantial amount, 76 percent, of the variance in perceived persuasiveness. Fifty-five percent of the variance in intention to use program is explained by perceived persuasiveness (β = .52) and unobtrusiveness (β = .31). Finally, intention to use program (β = .32) explains actual program usage but accounts for only 10 percent of the variance.

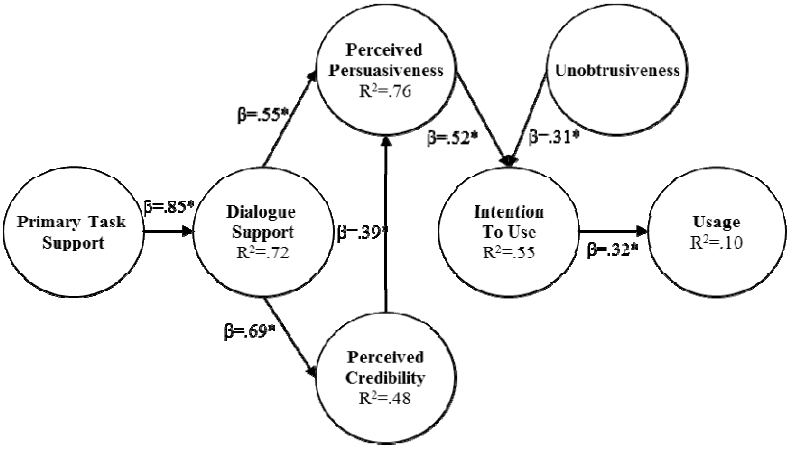

Fig. 1. A path diagram for the total sample (n=128) displaying the final results of the PLS analysis for the PSD model (*p<.001)

Further analyses between female and male sub-groups identified the same relationships between constructs as for the total sample. There were slightly different R^2 values among females and males (see table 5). The largest R^2 difference between the sub-groups occurred in the relationship between primary task support and dialogue support (PRIM→DIAL). For the female subgroup the R^2 is 68 percent, whereas for the male sub-group it is 76 percent, indicating that primary task support explains more variance in dialogue support for males. However, most interesting, are the findings that the relationship between perceived persuasiveness and intention (PERS→INTE) was stronger for males (β = .55) than for females (β = .37), and that the relationship between unobtrusiveness and intention (UNO→INTE) was stronger for females (β = .45) than males (β = .32).

Table 5. Paths, coefficients, and R^2 values for the final models

	β-values (weights)			R^2		
Path(s)	Females	Males	Total	Females	Males	Total
PRIM→DIAL	.83**	.87**	0.85**	.68	.76	.72
DIAL→PCRED	.68**	.72**	0.69**	.46	.52	.48
DIAL→PERS	.53**	.59**	0.55**			
PCRED→PERS	.42**	.35**	0.39**	.76	.78	.76
PERS→INTE	.37*	.55**	0.52**			
UNO→INTE	.45**	.32**	0.31**	*.57*	*.58*	*.55*
INTE→USE	.35*	.43*	0.32**	.12	.19	.10

Notes. Jackknifing was used for re-sampling. *p < .05, **p < .01.

It would seem that the R^2 difference on intention was attenuated because of these inverted relationships between perceived persuasiveness and intention, and unobtrusiveness and intention, among males and females. Overall, the differences between R^2 values appear to be rather modest between males and females, however, the path coefficients suggests moderating effects of gender on the relationships between perceived persuasiveness and intention, and unobtrusiveness and intention. Thus, the data indicate slightly different patterns of how the information system is perceived among males and females. This may explain why intention accounts for more variance in usage among males (19%) than females (12%).

5 Discussion

The persuasive systems design categories in the PSD model [7] appear to have a significant impact on perceived persuasiveness and actual system usage. The results supported most of the hypothesized relationships between factors that affect the perceived persuasiveness and system usage, except the direct relationship between primary task support and perceived persuasiveness. The results also demonstrate that contextual factors such as unobtrusiveness, directly affect intention but not actual usage. Furthermore, the final PSD model was replicated across female and male sub-groups at the global level. Admittedly, there appears to be local gender differences in perceptions of the system, most notably, in the strength of relationships between perceived persuasiveness and intention, and unobtrusiveness and intention. Significant gender differences have previously been documented in perceptions of website design and website satisfaction [30] and online trust [31]. More such differences between genders in perceptions and usage of IT can be expected, especially since some of these differences appear to be biologically founded, see [32].

We argue that dialogue support (system-to-user and user-to-system) is a crucial factor for the persuasiveness of IT systems and acts as a connecting node to other related factors. Dialogue support has three major connections: primary task support, perceived credibility and perceived persuasiveness. Through dialogue support, users receive appropriate feedback and counseling, which keeps them motivated, engaged, and involved in their change process. Low dialogue support would not only appear to

result in low motivation to behavior change, but to have a negative impact on the perceived persuasiveness of the entire system. As Lyytinen [33] noted, computers are no longer merely reactive devices that are optimized to respond to user requests but more proactive. Current technological advances allow novel solutions for dialogue support, such as embodied conversational agents [11] or even persuasive robotic assistants [34].

This study has a number of limitations. First, this study represents an exploratory test of a theoretical model and should be subject to further testing with various participants, technologies, and contexts. Second, the relationship between primary task support and other factors in the PSD model are not yet fully clear and they need to be validated more thoroughly. Third, research subjects were from one country, so the results may not generalize to other settings and contexts.

6 Conclusions

This paper tested a theory-based model predicting factors contributing to perceived persuasiveness and actual usage of a consumer health application. Researchers and designers in e-health may benefit from this type of approach to promote IT adoption and usage. Clearly, the enormous costs in healthcare demand for innovative solutions for various stakeholders in healthcare [see 2]. By providing consumers with access to personal health information, we can begin to influence and support self-management of health. From a societal point of view, people's health is not only a social responsibility; it is also a personal responsibility which affects other people and the available capacity and resources in the healthcare system. From an academic perspective, results of this research will contribute to the IS and e-health literatures by developing an IT adoption model for persuasive behavior change support systems. It is hoped that this research will attract the attention of researchers to further develop and test constructs and models applicable to consumers' use of health information systems as preventive health measures. From a more practical viewpoint, we argue that studying the adoption, use and impact of novel consumer health IT is feasible as it will guide future implementations.

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Conflicts of Interest. The first author is working for Changetech AS which has developed the web-based program under investigation.

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