Behavior Change Support Systems: The Next Frontier for Web Science

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ABSTRACT
The new generation of the web has opened up opportunities for developing new kinds of information systems for influencing users. For instance, one of the most prominent areas for future healthcare improvement is the role of the web in fostering improved health and healthier lifestyles. The success or failure of web information systems seems to rely on their social features. For this reason, a better understanding of the techno-social aspects of web information systems and the way they influence people is needed. This article is conceptual and theory-creating by its nature. It introduces the concept of a behavior change support system and suggests it as a key construct for web science research. The behavior change support systems are characterized by their persuasive purpose.

Keywords
Socio-technical system, behavioral outcomes, psychological outcomes, behavioral change, persuasive technology.

1. INTRODUCTION
The emergence of Web 2.0 concepts and technologies to create, access, and share information in new ways has opened up opportunities for also developing new kinds of web information systems for influencing users. For instance, one of the most prominent areas for future healthcare improvement is the role of the web in fostering improved health and healthier lifestyles [24]. Researchers have reported positive results in areas such as the management of smoking cessation, hazardous drinking, obesity, diabetes, asthma, tinnitus, stress, anxiety and depression, complicated grief, and insomnia [54].

According to Hendler et al. [27], treating the web as the primary object of study involves three aspects: social interactions, application needs, and infrastructure requirements, which ideally should be jointly studied. The strong interplay between these points of view implies the engineering of software properties and understanding interaction between human beings. Even if the systems are interesting mainly for their macro-scale properties, web information systems are currently designed and built at the micro-scale level, 'hoping for the best' at the macro-scale level. Hendler et al. [27] state that the success or failure of web information systems seems to rely mostly on social features. Thus, better understanding of the features and functionalities of the social aspects of web information systems and the way they influence people are needed.

In this article, we define an emerging new area for web science – *behavior change support systems* (BCSS). A key element in behavior change is persuasion. For this reason, behavior change support systems should build upon persuasive systems design and technology [19, 41]. Moreover, we as web scientists but also the general audience should be well aware of the various ways and approaches to how people may be, are being, and will be influenced through the web designs.

This article is conceptual and theory-creating by its nature. It suggests the behavior change support system as a key construct for web science research. The article lays ground for future research in this new frontier of research within web science. The article is structured as follows: Section 2 will discuss the related research. Section 3 will define the concept of a behavior change support system. Section 4 will discuss the design and development of BCSSs with experiences and lessons learned from BCSS research. Section 5 will conclude with the research implications and future research directions.

2. RELATED RESEARCH
The study of users' attitudes and behavior has a long history in information system research. Within the field, lessons have been drawn from social and cognitive psychology, in particular from theories such as the Theory of Reasoned Action [16], the Theory of Planned Behavior [1], Self-Efficacy Theory [4], and Social Cognitive Theory [5]. For instance, according to Social Cognitive Theory, if people are persuaded that they have what it takes to succeed, they exert more effort and avoid focusing on their doubts when problems arise [5]. New models and frameworks based on the abovementioned theories have also been developed, such as the Technology Acceptance Model [13] and the Unified Theory of Use and Acceptance of Technology [58]. These theories are useful for understanding attitudes and behaviors related to information systems and their use, and some of them are well-known among (at least a subset of) web scientists.

Besides these general attitude and behavior-related theories, there are also other useful attitude and/or behavior *change* related theories in social psychology, such as Information Processing Theory [35, 36], Cognitive Consistency Theory [15, 22], and the Elaboration Likelihood Model [46]. For instance, ELM is a processing model for attitude change that has been utilized, *e.g.*, to explain why users sometimes agree with incorrect advice given by an expert system [14] and to study the effects of web

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personalization [55]. These change related theories are not very well-known among web scientists, however.

A key element in behavior and attitude change is *persuasion*. Traditionally, persuasion has been regarded as a communication process in which a persuader sends a persuasive message to someone with the intention of influencing the recipient's attitudes or behavior, though always leaving this audience with the power of decision [53]. Human resource experts have been using this idea for decades, *e.g.*, in their "employee of the month" programs. Besides human communication, human-computer interaction can also be persuasive [18, 51]. The web, mobile and other ambient technologies create opportunities for persuasive interaction, because users can be reached easily and these systems are able to combine interpersonal and mass communication. Fogg [19] names interactive information technology designed for changing users' attitudes or behavior as persuasive technology. There are certain areas where persuasive technology could be especially useful. For example, software systems may be developed to motivate people towards healthy behavior, and thereby possibly delay or even prevent medical problems as well as ease the economic situation in public healthcare.

Persuasive design and technology has received growing interest among researchers for a little more than a decade now (cf. [17]).[1] Fogg's seminal book [19] was the first specialized conceptualization suggested for designers, stating that information technology may play the role of a tool, a medium, or a social actor for its users. Sharp criticism towards persuasive technology and Fogg's book has been offered by Atkinson [3]. Even if about 85% of the research on persuasive technology has been experimental [57], more elaborate conceptual and design frameworks for on and off-the-Web information systems have been suggested on top of Fogg's work, such as the Persuasive Systems Design model [41, 44]. Bogost [6] has suggested an approach to develop persuasive games. One of the major research topics has been the persuasion patterns of social network based information systems and mass interpersonal persuasion, in particular Facebook-related applications [20, 59].

3. DEFINING BEHAVIOR CHANGE SUPPORT SYSTEMS

Even if the web and other information technologies are often considered just as tools to accomplish goals, they are never neutral. Rather, they are 'always on,' influencing people's attitudes and behavior. This means that people are constantly being persuaded in a similar manner to how teachers persuade students in schools, and there is nothing bad in this in itself, of course. To put it simply, information technology always influences people's attitudes and behaviors in one way or another. In some cases, the influence may even be an unintentional side effect of the design. For this reason, we as web scientists but also the general audience should be well aware of the various ways and approaches how people may be, are being, and will be influenced through web design. By discussing these issues, the article lays ground for future research in this new frontier of research within web science known as behavior change support systems.

Based on our earlier works [42], behavior change support systems are defined here as follows:

> *Behavior change support systems (BCSS) are information systems designed to form, alter, or reinforce attitudes or behaviors or both without using coercion or deception.*

In this definition, three potential, successful voluntary outcomes are the *reinforcement, alteration or formation* of attitudes and/or behaviors. A reinforcing outcome means the reinforcement of current attitudes, behaviors or both, making them more resistant to change. An altering outcome means changes in a person's response to an issue, *e.g.*, increasing the level of exercise, decreasing the amount of drinking, or stopping smoking. A forming outcome means the formulation of a pattern for a situation when one does not exist beforehand, *e.g.*, abstaining from substance abuse. In many cases, a forming outcome may have a higher likelihood of success than communication that aims at altering behavior, whereas reinforced beliefs and behavior become the most resistant ones as time goes by [32]. The users' motivational level also plays a big role in forming, altering or reinforcing attitudes and/or behaviors. Persuasion relies on the power of verbal and non-verbal symbols and allows people's voluntary participation in the persuasion process [37]. Naturally, in addition to persuasion other forms of attempted influence do also exist. For instance, a pop-up window or a hyperlink may be purposefully deceitful; inducements are exchanges of money, goods, or services for actions by the person being influenced; coercion implies force and possibly economic sanctions. By definition, these are not persuasive elements.

Behavior change support systems are in essence persuasive, producing either computer-mediated persuasion or computer-human persuasion. Computer-mediated persuasion means that people are persuading others through computers, *e.g.*, discussion forums, e-mail, instant messages, blogs, or social network systems. Even if the web cannot communicate in the same way as humans do, there are studies that suggest that some patterns of interaction similar to social communication may be utilized also in computer-human persuasion [38]. In the case of BCSSs, there must exist other stakeholders who have the intention of influencing someone's attitudes or behavior as computers do not have intentions of their own. These stakeholders are those who create or produce BCSSs, those who give access to or distribute them to others, or the very person adopting or using such a system [19]. BCSSs emphasize the autogenous approaches in which people use information technology to change their own attitudes or behaviors through building upon their own motivation or goal, but they are not limited to only these kinds of systems. They also request a positive user experience and web stickiness, which encourage the user to engage with them regularly over an extended period of time.

When building BCSSs, psychological insight is needed. Several important lessons can be learned from psychological theories, including [41]:

- People like their views about the world to be organized and consistent.
- Persuasion is often incremental.
- Direct and indirect routes are key persuasion strategies.

[1] Affective computing [47] may be recognized as a sister-field of persuasive technology, or perhaps from the persuasive viewpoint as a sub-field of it, which directly focuses on the emotions that information technologies evoke. An example of elaborating on this research stream is the affective loops approach suggested by Höök [28].

One of the core issues to be realized is that people like their views about the world to be organized and consistent to such an extent that inconsistency may motivate attitude change [53]. Psychological inconsistency disturbs people, and they easily want to reorganize their thinking and restore consistency, and they may perhaps even feel obliged to do so. Inconsistency may exist between attitudes and behavior, attitudes toward other people, attitudes toward objects, and other people's attitudes toward the same objects [53]. The inconsistency must be represented and brought to the attention of the receiver. If a person finds the inconsistency unpleasant, (s)he will accept personal responsibility for it, and cognitive dissonance will then occur. However, the dissonance has to be powerful enough to motivate the person to engage in an attitude or behavior change to restore cognitive consistency [22]. This holds true even if people are not 100% consistent in their actions and minor inconsistencies have to be dealt with every day. Nevertheless, one has to feel commitment before inconsistency creates dissonance. Thus, if systems support the making of commitments, users will more likely be persuaded [10]. For example, a user may express greater confidence in his or her decision to exercise regularly after having bought a gym membership card. The idea of commitment also implies that BCSSs could provide means to make private or public commitments to performing the target behavior. This can be implemented, for example, by offering an easy way to send a text message or email to one's relatives, friends, or colleagues.

Persuasion is often incremental [32], which means that it is easier to initiate people into doing a series of actions through incremental suggestions rather than a one-time consolidated suggestion. This implies that a BCSS should enable making incremental steps toward target behavior. For example, an application for healthier eating habits could first encourage users to eat at least some vegetables at their meals, whereas the system could later suggest filling half the plate with vegetables. Yet, from the ethical point of view it is necessary that the overall goal is made clear at all steps of incremental persuasion. Persuading a user is indeed a multi-phased and complex task, and different factors, such as the user's goal, may change during the process. For instance, in the beginning of using a pedometer, a user might simply be interested in the number of steps taken, but after using the device for a while (s)he may become more interested in burning calories. BCSSs should be able to adapt to these kinds of challenges.

Direct and indirect routes are key persuasion strategies in behavior change [42]. Models that build upon the distinction between direct and indirect persuasion are ELM [46], and the Heuristic Systematic Model (HSM) [8, 56].[2] An individual who carefully evaluates the content of the persuasive message may be approached by the direct route, whereas an individual who is less thoughtful and uses simple cues or stereotypes for evaluating the information may be persuaded through the indirect route. When an individual sees relevant cues, cognitive shortcuts, which are normally derived from experience, are triggered [56]. They are often socially shared, but in practice such a heuristic is available only if there is a stored representation of it in one's memory.

[2] In ELM, the direct route is called a central route and the indirect route a peripheral route, whereas in HSM, the direct route is called a systematic route and the indirect route a heuristic route. The direct process in ELM excludes the indirect process [46], whereas in HSM both processes can act simultaneously [8,56].

4. DESIGNING BEHAVIOR CHANGE SUPPORT SYSTEMS

When people are persuaded that they have what it takes to succeed, they exert more effort and avoid focusing on their doubts when problems arise [5]. For this and other reasons, behavior change support systems should be built upon the persuasive systems design principles [19]. Three important requirements to be always kept in mind when developing BCSSs are [41]:

1. Behavior change support systems should be both useful and easy to use.
2. Behavior change support systems should be unobtrusive.
3. Persuasion through behavior change support systems should always be transparent.

Behavior change support systems should aim at being both useful and easy to use, *i.e.*, serving the needs of the user in a true sense. This includes a multitude of components, such as responsiveness, ease of access, lack of errors, simplicity, convenience, high information quality, positive user experience, attractiveness, and user loyalty. Quite understandably, if a system is useless or difficult to use, it is unlikely that it could be very persuasive. It should be noted, however, that these aspects are general software qualities and not specific to BCSSs only.

Behavior change support systems should aim at unobtrusiveness, *i.e.*, avoid disturbing users while they are performing their primary tasks with the aid of the system. In this manner, the system is capable of fulfilling users' positive expectations. The principle of unobtrusiveness also means that the opportune and inopportune moments for a given situation should be carefully considered [49]. The use of persuasive features at improper moments, *e.g.*, a heart rate monitor suggesting one to exercise while sick or getting a reminder to take medication for high blood pressure while giving a presentation at a meeting, may result in undesirable outcomes.

Persuasion through BCSSs should always be transparent. It is very important to reveal the designer bias behind the BCSS. For instance, if the designer bias behind a simulation remains unclear for its users, the simulation may lose some of its persuasiveness. More importantly, content that is based on untruthful or false information does not fit with the overall goal of users voluntarily changing attitudes or behaviors.

The Persuasive Systems Design model proposed by Oinas-Kukkonen and Harjumaa [41, 43] is the state of the art conceptualization for designing and developing BCSSs. Multiple applications and discussions of PSD exist [12, 25, 30, 31, 33, 48, 52, 57]. Based on the PSD model, we will next describe and discuss the analysis and design of BCSSs.

4.1 Analysis of persuasion context: the intent, the event and the strategy

Persuasive communication produces in a user's mind a complicated psychological event in which the user is a human information processor. This emphasizes the role of attention and comprehension [35]. In order for a person to be persuaded, information must be presented, and the persuadee must pay attention to the argument(s) presented and comprehend it. After this, (s)he often yields to the position presented, at least for some time, and takes action to comply with the new position.

Cognitive consistency theory [22] explains that sometimes behavior change may be possible without systematically going through all the information processing phases. This theory also suggests that one can sometimes proceed more efficiently from behavior to attitudes. If the behavior changes first, for example by legal constraints, it may be expected that an attitude change will follow. In any case, we do believe that full behavior change occurs only when attitude change takes place. Altering a previous attitude may be much harder than forming or reinforcing an attitude. According to Lerbinger [32], if a user's existing attitudes are based on one's personal experience and perhaps a long socialization process, they are even harder to change, whereas if a user's existing attitudes have been recently learned from other people, they are easier to change.

There are also other theories which suggest that certain rules or conditions can be defined under which attitudes predict behavior. For instance, the Theory of Reasoned Action, which aims at explaining volitional behavior, defines intentions as a function of attitudes toward modes of behavior and subjective norms [16]. This theory suggests that a person's attitudes toward behavior and subjective norms indicate how that person will behave in a situation. The attitude toward the behavior and subjective norms are the key elements in attitude change, because in order to change the behavior, the intention to perform that behavior should be influenced.

For promoting either attitude or behavior change, it is important to carefully analyze the persuasion context. Without doing this, it will be hard or even impossible to recognize inconsistencies in a user's thinking and discern opportune and/or inopportune moments for delivering the message. This context analysis includes recognizing the intent of the persuasion, understanding the persuasion event, and defining the strategy to be used [41].

THE INTENT. A central feature of analyzing the intent is to consider the *change type*, in particular whether the persuasion aims at attitude and/or behavior change. One-time behavior change may be achieved more easily, whereas permanent behavior change is much more difficult. An attitude change that directs behavior may be the most difficult to achieve. Petty and Wegener [1998] describe that attitudes can vary in many ways; they may be based on emotions, beliefs, or past experiences and behaviors, and they may be internally consistent or ambivalent.

THE EVENT. A central facet in analyzing the persuasion event is to consider the *use context*, in particular, the features arising from the problem domain. For instance, for BCSSs developed for promoting health and well-being, it is often characteristic that users in fact have the necessary information to act and, in many cases, they even have the proper attitudes, but they have problems with behaving in line with them. In these cases, BCSSs should reinforce proper attitudes but also make them easier to stick with even in challenging, spontaneous situations.

In parallel with understanding the use context, the *user context* also needs to be analyzed. People have individual differences which influence their information processing. For example, individual tendencies to engage in and enjoy effortful cognitive endeavors may differ remarkably between different people [7]. A user's need for cognition has an influence on the persuasion strategy that will be successful. People who have a high need for cognition tend to follow the direct route to persuasion [45]. However, in some situations, users may have to be approached through the larger contexts in their lives, such as a middle-age crisis or the loss of a loved one. One of the most essential facets of analyzing the user context relates to understanding the user's goals, including current progress toward achieving them, and potentially also past performances. The Goal Setting Theory [34] explains that goals affect performance through directing attention and effort; high goals lead to greater effort than low goals; hard goals lengthen effort; tight deadlines lead to a more rapid work pace than loose deadlines; and goals lead to the arousal and/or use of task-relevant knowledge and strategies. Thus, when users have the opportunity to set a goal, they will use their pre-existing knowledge and earlier experience more effectively to achieve their goals. According to this theory, the highest and most difficult goals produce the highest levels of effort and performance; specific, difficult goals consistently lead to higher performance than urging people 'to do their best'; when goals are self-set, people with high self-efficacy set higher goals than people with lower self-efficacy; and people with high self-efficacy are more committed to the assigned goals and to finding and using better task strategies to achieve the goals as well as to responding more positively to negative feedback. Even if goal specificity in itself does not necessarily lead to high performance, BCSSs should encourage users to set goals and discover ways of achieving them in a systematic and effective way.

In computer-human and computer-mediated persuasion, the *technology context* also plays an important role. Web technologies are being developed with great speed and new technologies become available rapidly. The strengths and weaknesses, as well as the risks and opportunities, of specific technological platforms, applications and features need to be thoroughly understood in developing BCSSs.

THE STRATEGY. A central feature of defining the persuasion strategy is analyzing the *message* to be delivered to the user. A persuasion situation may be defined as an event in which the one persuaded makes optimal compromises among conflicting forces [35]. This view may be criticized for its heavy emphasis on the rational processing of arguments [10]. Nevertheless, this is a relatively large part of the whole picture of persuasion. Persuasion relies primarily on symbolic strategies that trigger the emotions, whereas conviction relies on strategies rooted in logical proof [37]. Yet, drawing the line between convincing and persuasion is difficult.

Another central question in defining the persuasion strategy is the proper *route* to be used, in particular whether to choose a direct or indirect route for persuasion. The route selection depends particularly on the user's potential to carefully evaluate the content of the persuasive message. If (s)he is able to do that, a direct route could be used. In many cases, this is advisable since direct persuasion has turned out to be the more enduring of the two [35, 46]. In these cases, persuasion basically aims at convincing the user by appealing to reason and intelligence. However, in the era of information overflow, people are forced to use indirect cues more often than before because of the abundance of information to be handled. An individual who is less thoughtful and uses simple cues or stereotypes for evaluating the information may be persuaded through the indirect route [46]. A user's personal background and the use situation also have an influence on his or her information processing. When the user has high motivation and high ability, (s)he is more likely to be interested in the content of the persuasive message than when (s)he has low motivation and low ability. In challenging situations such as being in a hurry, it is highly likely that one will use shortcuts for processing the information.

4.2 Design of system features: Categories and principles

The ideas mentioned above in the previous chapters already cover a multitude of aspects that need to be recognized when designing BCSSs. However, more precise software requirements are needed to communicate the ideas from the management and/or conceptual design to software designers and programmers. For this reason, the PSD model suggests a set of design principles under four categories, namely primary task, dialogue, system credibility, and social support [41]. The design principles of the primary task category focus on supporting the carrying out of the user's primary task. Design principles related to computer-human dialogue help move towards achieving the goal set for using the BCSS. The system credibility design principles relate to how to design a system so that it is more believable and thereby more persuasive. The design principles in the social support category describe how to design the system so that it motivates users by leveraging social influence. For the categories and design principles belonging to them, see Figure 1. Tørning and Oinas-Kukkonen [57] have studied the scientific research of system features in these categories. According to their study, the most utilized features are tailoring, tunneling, reduction, and self-monitoring (representing the primary task category), suggestion (for supporting dialogue), surface credibility (in support of system credibility), and as social comparison, normative influence, and social learning (relating to social support).

A wide variety of BCSSs have been developed using these kinds of design principles. For instance, Forget et al. [21] developed an easy-to-use password creation mechanism to get users to create stronger passwords (many people choose weak passwords that are vulnerable for attackers who guess the passwords within the most probable password spaces). Obermair et al. [40] unobtrusively integrated into a physical working environment an interactive picture frame which contains a moving portrait of a person the user likes, and provides affective feedback for the user to adopt better sitting habits while working at the computer. Chi et al. [9] developed a smart kitchen application for improving home cooking by providing calorie awareness regarding the food ingredients used in the meals prepared during the cooking process. This was based on ubiquitous sensors for tracking the number of calories in different ingredients, and then providing real-time feedback on these through a display. Parmar et al. [44] presented a personal health information system, which was designed to influence the health behaviors of rural women in India through offering them information for increasing their awareness about menses and maternal health. Their design was based on the Theory of Planned Behavior and employed social cues to increase the perceived behavior control.

Many interesting BCSS research contributions can be found directly on system features. Harper et al. [26] have studied the roles that social influence and social comparison may play in online communities for motivating members rather than editors to contribute and moderate content in them. Web information systems may display social comparisons to show members how they compare to others in the system in a manner similar to how Amazon shows a list of its top reviewers. The findings suggest that these techniques are a powerful way to redirect the users' attention and increase their input into the system. Andrew et al. [2] have studied the challenges in implementing suggestion and how it differs from and overlaps with other techniques, in particular tunneling, reduction, and self-monitoring. Räisänen et al. [49] have studied the right-time suggestions of messages through smoking cessation as an example, and their findings seem to confirm that delivering messages does affect people more at certain moments than it does at other moments. Cugelman et al. [11] have demonstrated that system credibility, in particular the system's trustworthiness, affects a user's behavioral intent. Gamberini et al. [23] have shown that in some situations a strategy based on reciprocity is more effective than one based on reward. Quite interestingly, the presence of social proof features seems counterproductive when using a reciprocity strategy, whereas it seems to improve compliance with a request when using a reward strategy.

At a more general level, Zhu [60] conducted a meta-study of persuasive techniques in BCSSs motivating for regular physical activity. The results of this study suggest that very few previous studies resulted in achieving the intended goal. Only a few studies took advantage of any persuasive techniques, and none of these interventions were conceptually designed through persuasive design frameworks. The conclusion of this study was that designing a new generation of BCSSs should be based on such frameworks.

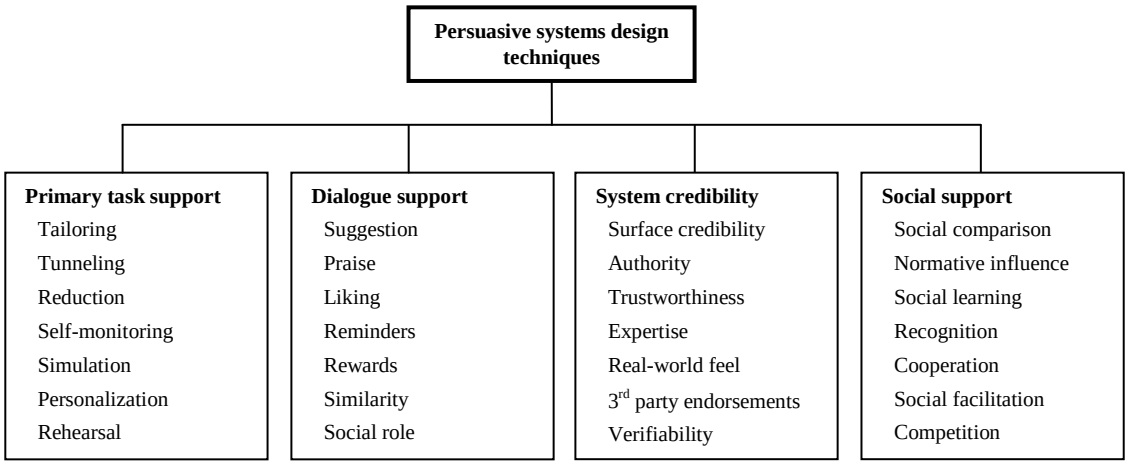

Figure 1. Persuasive systems design techniques.

Kraft et al. [29] suggested a set of propositions to be addressed when developing BCSSs for sustained behavior change in health and well-being. The study by Nguyen and Masthoff [39] suggested that in addition to persuasive techniques, perceived persuasiveness also affects the intention to revisit a BCSS. They also note that systems based on approaches like motivational interviewing are more effective than, *e.g.*, argumentation-based approaches. In line with this, Ramachandran and Canny [50] studied two speech-based information systems, one using a recorded message-based lecture presentation and another one using an interactive dialogic presentation. They found that the dialogic system was significantly more persuasive than the lecture system.

5. CONCLUSIONS

This paper presented a new terrain of interaction for web science known as behavior change support systems. Human-web interaction and social interaction through the web can be used to influence people's behavior. Yet, even the relatively well-known persuasion techniques need to be adapted to match web-based and social computing specificities. Moreover, the development of BCSSs is much more than just a user interface issue. It relates to technological services, applications, platforms, and functionality as well as the quality and content of information. In many cases, the BCSSs must be available 24/7, they have to address global and cultural issues with a multitude of standards, habits, and beliefs, and they have to be adaptable into a variety of business models.

The contemporary and future web will keep opening up a myriad of opportunities for building various kinds of behavior change support systems and benefiting from them. Web designers must also realize that they exercise enormous power over web users because their designs always influence users in one way or another whether they are intended to do so or not. Moreover, web science as a field has the responsibility of educating the general audience about the pros and cons of people's behaviors being influenced by the web.

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