Behavior Change Support Systems Research in the Era of Emerging Technologies

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Abstract

Behavior Change Support Systems (BCSS) have proven effective in encouraging and assisting individuals to change their behaviors and attitudes. As a research discipline, BCSS has been applied in various domains, from health and well-being to marketing, leveraging various technologies. This paper highlights how BCSS has been applied in research and discusses the technologies used for behavior change, presenting opportunities and raising concerns about the challenges they may pose. The paper also discusses this edition's latest contributions to the BCSS discourse.

Keywords

Behavior change support systems, emerging technology, persuasive technology

1. Introduction

Systems targeting behavior change – often called, *behavior change support systems* – have become increasingly popular for their transformative nature in modifying user behaviors. While changing attitudes and behaviors have long been studied in information systems, behavior science, and social psychology, the concept of "behavior change support systems (BCSS)" was introduced in 2010 as an essential element in studying persuasive technology [1]. Typically, a BCSS is a "*socio-technical information system with psychological and behavioral outcomes designed to form, alter or reinforce attitudes, behaviors or an act of complying without coercion or deception*" [2]. Therefore, behavioral change can be divided into three progressive levels: *C-change,* which involves adhering to requests imposed by the system; *B-change*, which includes more enduring modifications in behavior; and finally, *A-change*, which requires a change in an individual's attitude.

Over the years, BCSS research has grown, covering a wide range of application domains [3]. While several areas, such as marketing, environmental sustainability, cybersecurity, and education, have emerged, the health and well-being domain continues to gain the most sustained interest [4]. Within this space, BCSS interventions (often referred to as health BCSS) target alleviating known health challenges like being overweight and obesity, cardiovascular care, cancer, and mental health (i.e., depression, anxiety, and stress).

Health BCSS applications have shown promise in supporting sustainable and long-term lifestyle changes. For instance, a two-year randomized controlled trial evaluating a weight loss health BCSS found that while combining digital and face-to-face interventions produced the

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most noticeable weight loss, also the health BCSS alone was effective as a scalable, low-resource solution [5].

Besides health, BCSS studies have explored a variety of lifestyle-related behaviors, including waste disposal habits [6], digital addiction [7], and smartphone security [8], to name a few. They frequently employ interactive or visually engaging methods to change behavior. Relatedly, the sustainability aspect (specifically concerning the environment) has suggestively contributed to promoting eco-friendly behaviors, such as sustainable transportation and energy conservation, through personalized support and unobtrusive feedback mechanisms [9, 10].

Although some of these interventions remain web-based, mobile technology is currently the most utilized, often in combination with other technologies. Still, with the ongoing advancement of the digital landscape, BCSS research is starting to integrate emerging technologies to provide other innovative solutions. Therefore, we reflect on technology applications in BCSS research while presenting new opportunities for exploration.

2. BCSS Technology Applications

2.1. Mobile Phones as Catalyst for BCSS

The term BCSS was initially introduced during the Web 2.0 period, which presented avenues for web-based interventions. Yet, technological advancements have paved the way for smart, virtual, and persuasive systems that offer a range of sensory cues and feedback, encouraging personal development through improved emotional, social, and physical interactions. For example, the increased penetration of mobile phones opened new opportunities for cost-effective mobile-based interventions, particularly in the health domain [11]. Moreover, the proliferation of smartphones has served as a catalyst for innovation in BCSS, placing mobile apps at the center of BCSS research [3].

Studies have established that mobile apps can drive health behavior change, particularly by incorporating features like reminders and offering real-time feedback, self-monitoring, and goal setting [12]. In addition, the apps provide user-focused interfaces through simple motivations, not requiring a very high level of user attention. Because of their widespread availability, mobile phones offer a robust platform for health BCSS, effectively facilitating the distribution of educational content, continuous monitoring, and encouraging positive behavior changes. For instance, Hartin et al. [13] demonstrated that sustained engagement with a mobile app, which provided educational materials and personalized feedback, significantly improved health outcomes (i.e., increased HDL cholesterol levels and reduced BMI). Similarly, Markkanen et al. [14] showed that the mobile health BCSS, when used as a stand-alone intervention for obesity, resulted in meaningful weight loss and sustained outcomes over 12 months without the need for additional counseling. These studies point out the growing effectiveness and real potential of BCSS interventions delivered via mobile technologies in managing health-related challenges.

2.2. Emerging Technology Paradigms into BCSS

While mobile phones have played a significant role, strides have been made in research to leverage emerging (perhaps newer) technologies in designing and implementing BCSS.

2.2.1. Monitoring technologies

The introduction of smartphone applications accelerated the growth of wearable sensors, such as activity trackers, to collect real-time data. While some interventions still rely on users to manually self-monitor, monitoring technologies, such as wearable trackers, blood pressure monitors, and digital weight scales, are now being used to track users' step counts, sleep patterns, and blood pressure [15]. Additionally, Internet of Things (IoT) devices, such as sensors and other sensing technologies, have been utilized to monitor key signals and encourage positive behavior change. For example, Vandelanotte et al. [16] used a 'just-in-time' adaptive approach, activity trackers, to collect real-time physical activity data to provide personalized content (conversations) on motivations to be more active through a digital assistant.

To assess users' mobility patterns, i.e., travel trajectories, time spent outside the home, and activity levels, Thorpe et al. [17] developed and evaluated a behavioral monitoring system to support dementia patients using smartphones, smartwatches, and home locations based on global positioning system (GPS). Findings highlight the potential of unobtrusively providing personalized care to patients outside the clinical setting. Similarly, Ohira et al. [18], designed and developed a BCSS that encourages people to take the stairs instead of the elevator using Bluetooth low-energy signals transmitted from elevator terminals. These devices are coupled with mobile or web solutions to create a seamless user experience, allowing users to monitor things like weight, dietary choices, and physical activity. Ultimately, monitoring technologies provide new opportunities to tailor interventions, give feedback based on individual needs, and promote positive behavior.

2.2.2. Immersive technologies

Given virtual reality (VR) technology's potential to simulate reality, it presents a means to enhance engagement through immersive, interactive, and personalized experiences. Klaassen et al. [19], suggest persuasion by doing as an approach to behavior change by exploring a VR environment integrated with therapy sessions on substance abuse for people with mild to borderline intellectual disabilities. They propose a way to treat substance abuse (through self-control techniques) in a safe and personalized space by introducing participants to virtual risk situations (i.e., bar and coffee-shop simulations). On the other hand, Wiafe et al. [20] examine how persuasive system features influence students' learning satisfaction in immersive VR learning environments, highlighting the value of incorporating persuasive design to effectively engage students in immersive educational experiences. Overall, research highlights that VR can effectively influence an individual's behavior, such as paper conservation, by providing perceptually rich and interactive experiences, and that these embodied, lived experiences have an impact on both short and long-term behaviors [21].

2.2.3. Social and collaborative technology

The prevalent use of social (digital) media has presented opportunities to incorporate it into behavior change applications that target various concerns, such as weight management, mental health, diabetes management, and tobacco control [22,23,24]. Some of the platforms used include Twitter and social messaging apps (e.g., WhatsApp) to deliver information or feedback, encourage interactivity, and foster collaboration and social engagement. It is already established that social support as a design principle is key to influencing and modifying behaviors. For example, Tikka et al. [25] leveraged Twitter messaging to explore the social influence (peer support) of individuals who are receiving (non-tweeting) versus sharing (tweeting) messages that encourage healthier eating behaviors and their influence on perceived health behaviors. Highlighting that peer support through social media supports health behavior.

2.2.4. Artificial intelligence technology

Different techniques of artificial intelligence (AI), like natural language processing [16], machine learning [26], and large language models (LLM) [39] have powered its application, acting as a driving force for innovative solutions in various fields. A common methodological approach leveraging techniques like machine learning is the "just-in-time" approach to delivering adaptive and context-aware interventions that are personalized to the users and delivered at the time when needed [16,26,27].

The use of conversational AI agents (AI chatbots) to provide real-time feedback and promote behavior change is on the rise (see review by [28,29]. Studies demonstrate the high effectiveness of AI chatbots in promoting healthy lifestyles, such as increased medication adherence and decreased substance abuse [28]. We are also starting to see the use of generative AI in implementing behavior change support systems to provide meaningful information as a response to user queries. For example, in their study on increasing physical activity, for their Queston & Answer feature, generative AI, such as ChatGPT, Bard was used to generate content related to users' questions on physical activity [16]. AI chatbots are emerging as new solutions to ongoing health challenges. Research on experiences of using generative AI for mental health reported high engagement and positive impacts such as better relationships and healing from trauma and loss [30].

With the rise of generative AI and the continued advancement of intelligent systems, so do the potential opportunities and challenges associated with BCSS. We now see a transition of BCSS research from conceptual to real-world applications greatly informed by user data, providing opportunities for tailored and highly personalized systems. However, even with the increased prospects of new technology, it is not without challenges. It is, therefore, important to consider ethical and human-centered design for BCSS, which is at the heart of these systems (as per definition), encouraging behavior change without deceit or coercion.

3. Latest Contribution to the BCSS Discourse

The 2025 workshop edition highlighted research papers focused on the design and implementation of BCSS, from health and well-being to renewable energy communities to its ethical applications.

3.1. From Theories to Design Practice for BCSS

To connect theoretical frameworks with practical applications of BCSS, Tikka et al. [31] explore how features of a persuasive system can be explicitly mapped to the psychological needs defined by Self-Determination Theory (SDT) [32] to foster motivation in a mobile BCSS. Using a mobile app for microentrepreneurs' occupational health as a case study, the authors align Persuasive Systems Design (PSD) [33] features with SDT needs of autonomy, competence, and relatedness. The study highlights the practical importance of designing software features intentionally to support theory-based motivational goals, enabling a clearer evaluation of how digital systems influence behavior change

In the study by Koranteng et al. [34] the concept of personalization is addressed by investigating how different approaches influence users' credibility perceptions of academic social networking sites. Through a survey of ASNS users and analysis using Partial Least Squares Structural Equation Modeling, the study found that implicit personalization (i.e., where systems automatically adapt to user behavior) enhances perceived credibility. In contrast, explicit personalization (where users manually adjust system settings) has a negative effect. Implicit personalization was also identified as important and effective in fostering credibility perceptions. These findings provide practical guidance for designers of such systems and highlight the need to prioritize seamless, adaptive system behavior to build trust.

Sharma and Ludden [35] explore older adults' challenges, motivations, and needs to inform the design of a user-centered, self-managed, multidomain digital toolkit to support cognitive health in the Dutch aging population. Drawing insights from domain experts, the study highlights the importance of incorporating features personalization, autonomy, adaptive goal setting, education, and skill development into the support systems. They suggest that effective adoption hinges on flexibility, trustworthiness, and relevance to individual users' circumstances. The study contributes to the design of digital health interventions that promote sustained cognitive well-being in older adults.

3.2. BCSS Practical Applications

Manzke's [36] research-in-progress aims to promote healthier food choices through an randomized controlled trial in a simulated online grocery store. Grounded in Fogg's Behavior Model [37], the study seeks to investigate how real-time feedback, personalized reflection prompts, or their combination can enhance fruit and vegetable purchases. Participants will complete two shopping tasks spaced a week apart, with interventions introduced during the second task. These interventions consist of a live counter displaying the portions of fruit and vegetables in the basket (real-time feedback) and a personalized message referring to previous shopping behavior (reflection prompt). The findings are anticipated to deepen understanding of food choice behavior and guide the design of persuasive systems that promote healthier shopping habits in online environments.

Haque et al. [38] investigate how Moodle, as a BCSS, supports metacognitive strategies to enhance self-regulated learning among software engineering students. Through a master's course case study, they find that while students effectively engage in monitoring, evaluation, and self-regulation, goal setting and planning remain challenging. Feedback and interviews indicate overall satisfaction with the self-study module. The study suggests improving BCSS design by emphasizing structured goal setting and integrating gamified features to sustain learner engagement and autonomy.

In their study, Deconcini et al. [39] propose a recommender system that combines rule-based user modeling with large language models to promote participation in renewable energy communities. Unlike traditional recommender systems, their system personalizes its recommendations based on users' values, expertise, and available resources, generating tailored benefit descriptions through a dialogue-like interaction. The system uses LLMs to describe user-profiles and craft persuasive, context-aware messages that adapt to feedback. By fine-tuning models like Llama-3-8B-Instruct and integrating prompt engineering, the authors demonstrate the system's potential to engage users meaningfully and support sustainable behavior change.

Federspiel et al. [40] investigate how social bonding and situational motivation influence user acceptance of interactive systems, in continuous improvement environments. By proposing an extension to the Unified Theory of Acceptance and Use of Technology (UTAUT) [41], the paper introduces two key constructs: techno-social bonding and situational motivation, which better explain long-term engagement beyond utility and usability. Their conceptual model, informed by emotional attachment theory [42] and motivation science, focuses on the roles of personalized avatars and conversational chatbots in enhancing system engagement. The study proposes a four-week micro-randomized trial in a second labor market setting to evaluate how avatar customization and chatbot interactions affect feedback quality, user situational motivation, and techno-social bonding. Ultimately, this research aims to demonstrate that integrating social and motivational design elements into what the authors call 'continuous improvement systems' can foster deeper user engagement, improve system feedback quality, and promote sustainable behavior.

3.3. Upholding Ethical Designs

Trust plays a vital role in the acceptance and success of persuasive technologies; however, many current systems lack clear design elements that foster trust. In their study, Rahman and Adaji [43] explore how ethical design elements – such as transparency, autonomy, consent, data privacy, and security – impact users' trust in persuasive systems. A user study revealed that interfaces featuring ethical elements consistently scored higher in trust, with transparency being the most significant factor. These findings emphasize the importance of user-centered, ethical design in building trust.

Algorithm-driven user interfaces have revolutionized digital experiences by enabling personalized interactions. However, they raise ethical concerns when the underlying algorithms introduce biases. Abhadiomhen and Oyibo [44] explore how such interfaces can facilitate discrimination through biased personalization, manipulative design (i.e., dark patterns), and exclusionary algorithms. They assert that algorithmic bias is not inevitable but stems from design choices that prioritize engagement and profit over fairness. They advocate for industry-wide efforts toward ethical, inclusive, and transparent design. The authors recommend fairness-oriented design strategies, including algorithmic transparency, regular bias audits, inclusive training data, and user-centric control features.

4. Conclusion

The incorporation of various emerging technologies raises significant design and ethical considerations. For instance, how can one achieve a balance between customization and privacy? What ethical concerns arise from immersive persuasive environments that must be addressed? Although mobile applications lay the groundwork for BCSS, technological advancements offer new methods and tools to shape behaviors. The latest contributions provide distinct perspectives on how BCSS research can transition from theoretical frameworks to practical applications, utilizing recent technologies like LLM to implement and ensure the ethical design of these systems.

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