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Abstract:

Behavior change is a topic of high relevance and widely studied in the field of psychology. Through the integration of technologies into everyday life, behavior change support systems (BCSS) are gaining attention in the field of information systems. The persuasive systems design (PSD) model of Oinas-Kukkonen and Harjumaa (2009) is a leading framework to provide a generic technical design process including 28 design principles. However, the model is lacking a clear picture regarding which of those design principles should be selected for specific implementations. Consequently, researchers and developers who implement BCSS are missing structured and evidence-based guidance. They need to invest time and cognitive resources in an underlying analysis of different design principles. Because the influence of persuasive systems is strongly linked to the processual state of behavior change, we combine the PSD model with the transtheoretical model (TTM) of Prochaska and DiClemente (1983) and elaborate a model that recommends appropriate design principles for the five transitions along the stages of behavior change. We refined the model using a systematic literature review. The results provide a specification of the PSD model and a guideline to select effective design principles for developing BCSS.

Keywords: Behavior Change Support System, Persuasive Systems Design, Transtheoretical Model, Design Principle.

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1 Introduction

People stay in their established way of behavior even though they know that a different way of life would be beneficial. For example, many want to lead a fit and healthy lifestyle, but remain inactive and make poor eating choices. As a result, serious health problems based on unhealthy behavior are on the rise. Despite this discrepancy between desired and actual behavior, it is hard to change established behaviors sustainably. Behavior and how behavior can be influenced is widely studied in the field of psychology. Established behavioral models are, for example, the transtheoretical model (TTM) of Prochaska and DiClemente (1983), the theory of planned behavior by Ajzen (1991), or the health belief model by Siddiqui, Ghazal, Bibi, Ahmed, and Sajjad (2016).

Along with the integration of technology into the individual´s everyday life, Fogg (2003) envisioned the potential of persuasive technologies to support people in changing their attitudes and behaviors. Based on Fogg's (2003) research, Oinas-Kukkonen and Harjumaa (2009) defined the concept of behavior change support systems (BCSS) and introduced BCSS as "a key construct for research in persuasive technology" (Oinas-Kukkonen, 2010). BCSS include mobile apps, social media, or interactive websites with the aim to change attitudes or behaviors. BCSS are already successfully used in the context of health (e.g., Langrial, Oinas-Kukkonen, & Lappalainen, 2013) and environmental aspects (e.g., Shevchuk & Oinas-Kukkonen, 2016). Additionally, there is further potential to employ BCSS in a working environment supporting behavioral aspects of digital transformation (Merz, 2020; Nkwo, 2019).

The by far most referenced technical framework in research for developing BCSS is the persuasive systems design (PSD) model by Oinas-Kukkonen and Harjumaa (2009) (Otyepka, 2018). The PSD model recommends a generic design process that starts with the analysis of the persuasion context and presents multiple design principles. The PSD model proposes to select context-specific design principles, but a clear picture of how these design principles should be selected is missing (Wiafe, Nakata, & Gulliver, 2014). However, it is essential for persuasive systems design to select effective design principles because it is not practical to include a high number of design principles (e.g., studies apply on average only 15 of 28 design principles of the PSD model (Merz & Ackermann, 2021)). Moreover, studies highlight the importance of choosing the right design principles instead of implementing as many as possible (Prochaska & Norcross, 2001; Wildeboer, Kelders, & van Gemert-Pijnen, 2016). Therefore, researchers and developers of BCSS need to invest time and energy conducting a laborious context-related analysis of users' needs and fitting design principles before implementing their projects instead of focusing their cognitive resources on the specific design of BCSS.

The aim of this work is to fill this gap between technical framework and context-related behavioral model. Because the influence of technology-enhanced behavioral interventions is strongly linked to the state in the process of behavior change (Oinas-Kukkonen & Harjumaa, 2009; Prochaska & Norcross, 2001; Vandelanotte & Bourdeaudhuij, 2003), we combine the widely used and frequently validated stages of change of the TTM (Prochaska & DiClemente, 1983; Prochaska & Norcross, 2001) with the PSD model by Oinas-Kukkonen and Harjumaa (2009). As a result, we take a process perspective on the persuasion context and present a process-based model that recommends appropriate design principles defined by the PSD model. We conduct a systematic literature review to refine our conceptual model in detail and to ensure that the model is in accordance with existing research studies about BCSS.

This work contributes in a descriptive form by presenting researchers and developers of BCSS the role of the design principles of the PSD model along the process of behavior change including examples of implementations. Furthermore, this work contributes in a pragmatic form by concluding implications and guidance for developing BCSS and provides a theoretical specification of the PSD model in order to facilitate the process of designing BCSS.

2 Theoretical Background

Persuasive technology accompanies and supports the process of behavior change. It is defined as “any interactive computing system designed to change people’s attitudes or behaviors.” (Fogg, 2003, p. 1). While persuasive technology is considered as a field of research, BCSS are research objects in this field of research (Oinas-Kukkonen, 2010). According to Oinas-Kukkonen (2013, p. 1225), a BCSS “is a sociotechnical information system with psychological and behavioral outcomes designed to form, alter or reinforce attitudes, behaviors or an act of complying without using coercion or deception”. BCSS are developed based on design principles (Oinas-Kukkonen, 2010).

2.1 Design Principles

Design principles incorporate design knowledge about the design of artifacts and allow to transfer knowledge about how to achieve desired effects to different applications (Möller, Guggenberger, & Otto, 2020). In particular, Fu, Yang, and Wood (2016) derive that “design principles are created to codify and formalize design knowledge so that innovative, archival practices may be communicated and used to advance design science and solve future design problems” (Fu et al., 2016). However, design principles are often used ambiguously and are inconsistently formulated in literature (Gregor, Kruse, & Seidel, 2020) which impairs the ability to present design knowledge in an accessible form. To account for that issue, Gregor et al. (2020) suggest a Design Principles Schema for decomposition and classify design principle formulation in three categories regarding the integration of user activity: 1) design principles “about user activity”, when the principle states what users can do with the artifact, 2) design principles “about the artifact”, when the principle is about a feature of the artifact without directly addressing user activity, or 3) “about both”, user activity and artifact, when the principle is combining design knowledge about user activity and a feature of the artifact (Gregor et al., 2020).

Based on the ability of design principles to provide design knowledge about user activities and system features, design principles are the foundation for developing information systems (Fu et al., 2016; Möller et al., 2020) and thus incorporated in frameworks as, for example, the PSD model by Oinas-Kukkonen and Harjumaa (2009).

2.2 PSD Model

When developing BCSS, most researchers refer to the PSD model by Oinas-Kukkonen and Harjumaa (2009) (Otyepka, 2018). The PSD model acts as a meta-level model and serves as a wide framework including generic steps and design principles for designing BCSS (Räisänen, Lehto, & Oinas-Kukkonen, 2010). In order to draw upon the most referenced and established technical framework in research for BCSS development, we build our study on those 28 design principles of the PSD model. Oinas-Kukkonen and Harjumaa (2009) group the design principles into four different categories with seven design principles each: primary task support, dialogue support, system credibility support, and social support. Table 1 shows a list of the design principles as described by Oinas-Kukkonen and Harjumaa (2009). To further specify the nature of the design principles of the PSD model as a strong foundation for our study, we added a classification according to Gregor et al. (2020) into the three categories about artifact, user activity, or both. We coded the classification independently with an interrater reliability of 0.96 (Cohens Kappa).

Table 1. Design Principles of the PSD Model by Oinas-Kukkonen and Harjumaa (2009) including Classification according to Gregor et al. (2020) regarding User Activity

Category	Design Principle	Example Requirement by Oinas-Kukkonen and Harjumaa (2009)	Classification regarding User Activity
Primary Task Support	**Reduction**	System should reduce effort that users expend with regard to performing their target behavior.	artifact
	Tunneling	System should guide users in the attitude change process by providing means for action that brings them closer to the target behavior.	artifact
	Tailoring	System should provide tailored information for its user groups.	artifact
	Personalization	System should offer personalized content and services for its users.	both
	Self-monitoring	System should provide means for users to track their performance or status.	both
	Simulation	System should provide means for observing the link between the cause and effect with regard to users' behavior.	both
	Rehearsal	System should provide means for rehearsing a target behavior.	both
Dialogue Support	**Praise**	System should use praise via words, images, symbols, or sounds as a way to provide user feedback information based on his/her behaviors.	artifact
	Rewards	System should provide virtual rewards for users in order to give credit for performing the target behavior.	artifact
	Reminders	System should remind users of their target behavior during the use of the system.	artifact
	Suggestion	System should suggest that users carry out behaviors during the system use process.	artifact
	Similarity	System should imitate its users in some specific way.	artifact
	Liking	System should have a look and feel that appeals to its users.	artifact
	Social role	System should adopt a social role.	artifact
System Credibility Support	**Trustworthiness**	System should provide information that is truthful, fair and unbiased.	artifact
	Expertise	System should provide information showing knowledge, experience, and competence.	artifact
	Surface credibility	System should have competent look and feel.	artifact
	Real-world feel	System should provide information of the organization and/or actual people behind its content and services.	artifact
	Authority	System should refer to people in the role of authority.	artifact
	Third-party endorsements	System should provide endorsements from respected sources.	artifact
	Verifiability	System should provide means to verify the accuracy of site content via outside sources.	artifact
Social Support	**Social learning**	System should provide means to observe other users who are performing their target behaviors and to see the outcomes of their behavior.	user activity
	Social comparison	System should provide means for comparing performance with the performance of other users.	user activity
	Normative influence	System should provide means for gathering together people who have the same goal and make them feel norms.	user activity
	Social facilitation	System should provide means for discerning other users who are performing the behavior.	user activity
	Cooperation	System should provide means for co-operation.	user activity
	Competition	System should provide means for competing with other users.	user activity
	Recognition	System should provide public recognition for users who perform their target behavior.	artifact

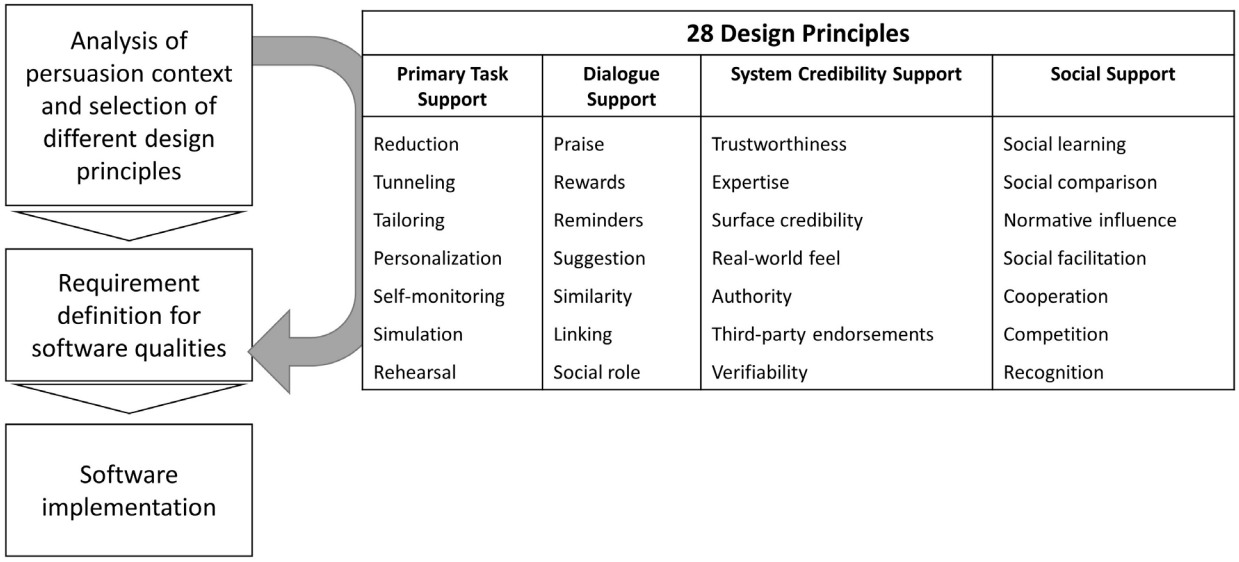
The design principles of the category primary task support “support the carrying out of the user’s primary task” (Oinas-Kukkonen & Harjumaa, 2009, p. 492). Applying the classifications of Gregor et al. (2020), we identified that supporting the primary tasks addresses design principles that describe system functionalities (e.g., *reduction* and *tunneling*) and design principles that also enable users to interact with the system (e.g., *self-monitoring* and *simulation*) (Oinas-Kukkonen & Harjumaa, 2009). The design principle *personalization* covers two aspects: Personalized content can be content that is determined by the system for the individual user, but as well determined by preferences that are defined by the individual users themselves.

The category of dialogue support comprises design principles that provide feedback to its users (e.g., by *praise*, *rewards*, and suggestion) “potentially via verbal information or other kinds of summaries" (Oinas-Kukkonen & Harjumaa, 2009, p. 493). Comprising one-way computer-human-communication, as opposed to human-computer interaction, the design principles describe system features about the artifact according to Gregor et al. (2020).

The category of system credibility support contains design principles that are able to emphasize the credibility and expertise that underlies the system, for example, using *verifiability* and *authority* (Oinas-Kukkonen & Harjumaa, 2009). The design principles on credibility support describe system features without user activities (according to Gregor et al. (2020)).

The design principles of the category social support motivate users through social influence and promote exchange of information between different users, for example, using *social comparison* and *cooperation* (Oinas-Kukkonen & Harjumaa, 2009). In this category, the design principles aim to provide means to enable user activities, with the exception of the design principle recognition which describes support through system features (according to Gregor et al. (2020)).

Those 28 design principles are integrated in the PSD model (Figure 1) as follows: The first step in the development of persuasive technology is the analysis of the persuasion context and, based on the findings, a selection of persuasive design principles. After selecting design principles, the requirement definition for software qualities and the software implementation follow. While the PSD model provides generic steps and various design principles, it remains unclear how these design principles should be selected according to the context of behavior change (Wiafe et al., 2014, p. 1679). However, the model is designed to be extended by integrating suitable theories to specify certain aspects (Räisänen et al., 2010).



28 Design Principles			
Primary Task Support	**Dialogue Support**	**System Credibility Support**	**Social Support**
Reduction	Praise	Trustworthiness	Social learning
Tunneling	Rewards	Expertise	Social comparison
Tailoring	Reminders	Surface credibility	Normative influence
Personalization	Suggestion	Real-world feel	Social facilitation
Self-monitoring	Similarity	Authority	Cooperation
Simulation	Linking	Third-party endorsements	Competition
Rehearsal	Social role	Verifiability	Recognition

Figure 1. Generic Steps of PSD with Design Principles according to Oinas-Kukkonen and Harjumaa (2009)

2.3 Transtheoretical Model

A model that specifies the context of behavior change in a structured and procedural form is the TTM of Prochaska and DiClemente (1983). The TTM is widely used in the field of psychology and describes the process of changing behavior in consecutive stages (e.g., Boff, Dornelles, Feoli, Gustavo, & Oliveira, 2020; Friman, Huck, & Olsson, 2017; Hashemzadeh, Rahimi, Zare-Farashbandi, Alavi-Naeini, & Daei, 2019). The six stages of change are precontemplation, contemplation, preparation, action, maintenance, and termination (Prochaska & Norcross, 2001). Depending on the stage of behavior change, the addressee of persuasive technology should be supported in the behavior change in a different way (Oinas-Kukkonen & Harjumaa, 2009; Prochaska & Norcross, 2001; Vandelanotte & Bourdeaudhuij, 2003). Therefore, these stages provide guidance and feasible context to select fitting design principles.

2.3.1 Stages of Change

Prochaska and Norcross (2001) describe the stages of change as follows: In the stage of precontemplation, people might wish to change but do not intend or seriously consider changing their behavior patterns. The behavioral problems might be unaware to them but are often known to their families, friends, or employees. In the second stage of behavior change, contemplation, people are aware of their problems and think about working on their behavior. During that second stage, people are "seriously considering changing the problem behavior" (Prochaska & Norcross, 2001, pp. 443–444) but do not intend to change their behavior yet. Next, in the stage of preparation, people prepare to take action and are about to bring their intentions to visible behavior in the near future. When people show their intentions in their actions and start to modify their behavior, they have entered the stage of action. This stage is followed by the stage of maintenance where people are continuing their behavioral change and try to prevent a relapse to their problem behavior. In the stage of maintenance, people strive to reach the last stage of termination where the process of behavior change is completed and there is no risk of relapsing into their former behavior (Prochaska & Norcross, 2001).

2.3.2 Transitions

Focusing on the process of behavior change, we address the transition of one stage to the consecutive stage. This results in five transitions, which are depicted in Figure 2.

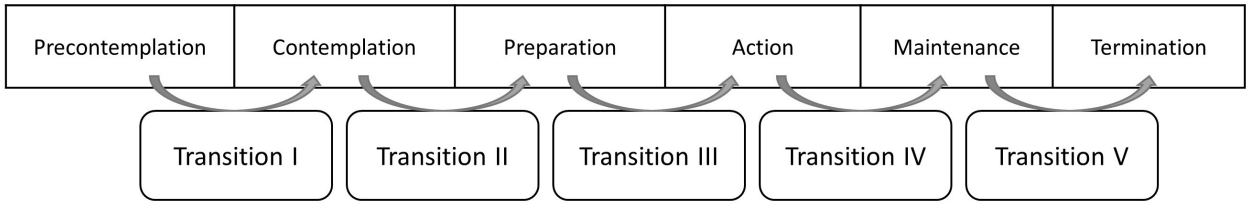


Figure 2. Transitions along the Stages of Change

In order to guide users of BCSS through the process of behavior change, developers should analyze the underlying needs of users to transition from one stage to the next. In accordance with the explanations by Prochaska and Norcross (2001), we identified the following core needs for each transition:

In transition (I) from the stage of precontemplation to contemplation, BCSS need to reveal the problem behavior to users to raise awareness of their problems. In transition (II) from contemplation to preparation, BCSS should further highlight the problem behavior and show the benefits of a changed behavior to form an intent to change. Therefore, BCSS should aim at increasing consciousness and awareness of the problematic behavior. Users in transition (III) from preparation to action need BCSS that get users to start performing the target behavior. BCSS should facilitate the initial approach of its users to adopt their intended behavior. To support users during transition (IV) from action to maintenance, BCSS should reinforce the users' new behavior and strengthen the users' will to maintain their changed behavior. For the last transition (V) to the stage of termination, BCSS should help users to form habits and make the changed behavior their regular behavior to prevent relapses.

2.3.3 Related Work

Also, other researchers see the potential in combining persuasive technology and behavioral models. Wiafe, Alhammad, Nakata, and Gulliver (2012) analyze the persuasion context of the PSD model with the three-dimensional relationship model between attitude and behavior (3D-RAB model), which categorizes users' state of cognitive dissonance. While they discuss how researchers can apply the 3D-RAB model to analyze the persuasion context, they do not include information on specific system design in their considerations and the link between persuasion context and the selection of design principles is still missing.

Klein, Mogles, and van Wissen (2011) use the TTM to build sixteen different constructs that include some design principles, but also external factors that do not directly translate to design features (e.g. emotions, self-efficacy). In contrast to Klein et al. (2011), we concentrate on the 28 design principles of the established PSD model that can directly be implemented into BCSS.

Oinas-Kukkonen (2010) and Oinas-Kukkonen (2013) introduce the "outcome/change design matrix" which presents three behavior outcomes (forming, altering, reinforcing) and three types of behavior change (complying, behavior, attitude). While distinguishing the behavior outcome into forming, altering, or reinforcing extends our approach, both approaches share the understanding that users' awareness of the need for a behavior change is a pre-condition for a sustainable change of behavior. Additionally, both approaches share the same goal of considering targeted forms of behavior change: The matrix shows possible forms of behavior change using the two dimensions of behavior outcomes and types of behavior change, whereas we use a process-based perspective based on the stages of behavior change. Building on the stages of behavior change allows us to examine the specific users' needs and present guidance for referring design principles, while the matrix takes a descriptive point of view. Therefore, the two approaches should not be seen as competing, but as a mutual extension due to their different characters (descriptive vs rather normative).

3 Method

Our method consists of two steps: First, we developed a model linking the 28 design principles to the stages of the TTM. Second, we refined our resulting model using a systematic literature review of research studies implementing BCSS.

3.1 Development of Model Based on Theoretical Background

In the first step, we carefully studied the original literature of the PSD model and the TTM to ensure that our model reflects the underlying models as close as possible. Two researchers independently mapped the 28 design principles to the transitions weighted by the ability of the design principle to address the users' needs (see chapter 2.3.2) of each transition. To ensure an unbiased opinion in this initial mapping, the two researchers coded the 28 design principles independently into three categories "slight recommendation" (1), "recommendation" (2), and "strong recommendation" (3). During the mapping, the researchers both identified the fourth category "no recommendation/ not applicable" (0). Table 2 shows the number of assigned categories and where the researchers agreed and diverged. To measure the interrater agreements of two independent coders with more than one exclusive category, the Cohen's Kappa Coefficient is fitting (Cohen, 1960; Fleiss, Levin, & Paik, 2003). Regarding the mapping of the 28 design principles, the Cohen's Kappa Coefficient κ is 0.445 (with p_0 =0.729, p_e=0.361) indicating a moderate agreement rate (Landis, Richard J., & Koch, 1977).

Table 2. Results of the independent coding

		Researcher 1				∑
		0	**1**	**2**	**3**	
Researcher 2	**0**	**24**	6	0	2	32
	1	4	**1**	0	1	6
	2	8	3	**63**	6	80
	3	2	2	4	**14**	22
∑		38	12	67	23	140

weight	category
0	not applicable/ no recommendation
1	slight recommendation
2	recommendation
3	strong recommendation

We discussed the mapping with a third, independent researcher and resolved identified inconsistencies. In sum, we concluded four levels of recommendation as follows: A strong recommendation suggests that the design principles serve the core needs of users (see chapter 2.3.2) who transition from their current stage in the process of behavior change to the next. Design principles identified as strong recommendation should therefore be considered with high priority for the design of BCSS that support this transition. If a design principle is indicated as recommended, the corresponding design principle does not directly address users' core needs of a specific transition but supports the transition to a high extent. Slight recommendation indicates that the design principle might have positive effects on users' transition, but does not include an effect directly needed for the transition. Besides these classifications, it is possible that some design principles are not applicable or not recommended in specific transitions because there are no indications for the assumption of positive effects.

For example: The design principle *suggestion* is defined as "system should suggest that users carry out behaviors during the system use process" and that "fitting suggestions will have greater persuasive powers" (Oinas-Kukkonen & Harjumaa, 2009, p. 493). Regarding the five transitions, suggestions are not able to reveal problem behavior to users, which is needed for transition (I). Therefore, *suggestion* is not applicable/ not recommended for designing a BCSS targeting transition (I). On contrary, users in the second and third stages of behavior change need to see the benefits of a changed behavior and an approach to take the first steps of their changed behavior. Specific suggestions for behavior and actions address those core needs to transition into the stages of preparation and action (Prochaska & Norcross, 2001) and are consequently strongly recommended for transitions (II) and (III). For transition (IV), when users are in the stage of action and strive to reach maintenance, users need to strengthen their will to maintain their changed behavior that they already started performing (Prochaska & Norcross, 2001). Here, the design principle *suggestion* does not address the users' core needs of that transition, in contrast to design principles such as *reminders, self-monitoring,* and *competition* (Oinas-Kukkonen & Harjumaa, 2009). Therefore, *suggestion* is slightly recommended for the design of transition (IV). Regarding transition (V) where users form a habit and make the changed behavior a regular behavior, the relevance of *suggestion* rises compared to transition (IV) to prevent a relapse. Consecutively, the design principle *suggestion* is recommended for transition (V) into the stage of termination.

In addition, we identified that some design principles, for example, *personalization, trustworthiness,* and *expertise*, are recommended for all transitions of the BCSS and address basic needs of users. We incorporate this finding by assigning these design principles to "basic requirements". Our understanding of basic requirement is comparable to the concept of hygiene factors of Herzberg, Mausner, and Synderman (1959).

3.2 Refinement of Model Based on Systematic Literature Review

In the second step, we studied the role of the design principles regarding the transition phases in a systematic literature review to ensure that the model is in accordance with existing research studies about BCSS and to refine the conceptual mapping (Figure 3). A systematic literature review mitigates the risk that we disregard studies that could contradict our model, as well as the risk that we use studies that cause a

biased model (Boell & Cecez-Kecmanovic, 2015). Outlining the approach transparently, we defined a search protocol as suggested by Boell and Cecez-Kecmanovic (2015) and Vom Brocke et al. (2015).

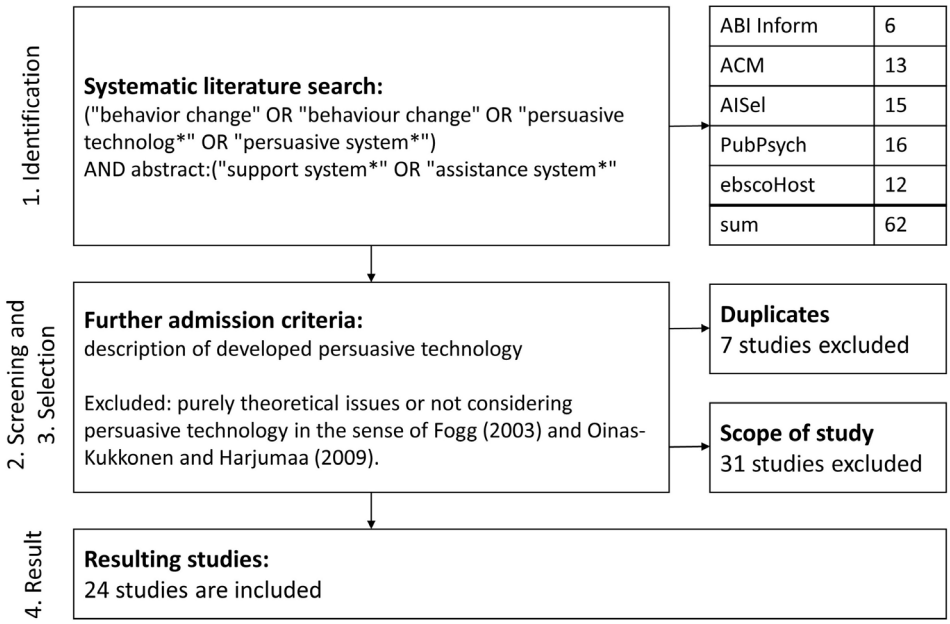


Figure 3. Flow Chart of Literature Review

To systematically identify relevant studies that introduce persuasive technologies targeting behavior change in different domains, we conducted a systematic keyword search in the databases ABI/Inform Collection, ACM, AISel, PubPsych, and ebscoHost, using the search string: *("behavior change" OR "behaviour change" OR "persuasive technolog*" OR "persuasive system*") AND abstract:("support system*" OR "assistance system*")* leading to 62 studies. Further admission criteria for the literature review is the description of developed persuasive technology in order to be able to clearly analyze the design elements. We excluded seven duplicates and 31 papers that deal with purely theoretical issues or do not consider persuasive technology in the sense of Fogg (2003) and Oinas-Kukkonen and Harjumaa (2009). Because we include all studies that were not excluded, we did not define specific inclusion criteria. Therefore, in total 24 studies are included in our literature review to refine the model.

We compared the findings of the literature review with our conceptual model looking for inconsistencies. Based on this comparison, we refined our model to ensure consistency in practical use, conceptual definitions, and understanding. Where necessary and fitting, examples of implementations were added from additional studies to elaborate the specific design principles along the transitions.

Supplementing our example from step one, based on the theoretical analysis, with insights from the literature review in step two: The design principle *suggestion* is not applicable/ not recommended for designing BCSS targeting transition (I). In fact, our literature review shows that users tend to be averse to advice when they do not experience any problems yet (Phillips & Landon, 2016). Regarding transition (II) and (III), Nguyen, Ruiz, Wilson, Strong, and Djamasbi (2018) and Song, Kim, and Kim (2017) implement suggestions to reveal the benefits of a changed behavior and an approach to take the first steps of their changed behavior. This confirms the strong recommendation of the design principle *suggestion* for transitions (II) and (III). In transition (IV), our literature review shows that *suggestion* can act as a form of feedback and positively affect the alteration of behavior change (Wilson & Djamasbi, 2017), which is in accordance with a slight recommendation. Because suggestions can help to recall target goals and present new perspectives (Nguyen et al., 2018), *suggestion* has a high impact to prevent a relapse, which indicates a recommendation for transition (V).

4 Analysis

Table 3 presents the resulting mapping of the different design principles to the five transitions of behavior change and presents the studies that we used for the refinement and our discussion. The table links the 28 design principles of the PSD model (see Figure 1) to the transitions along the stages of change of the TTM (see Figure 2). The design principles are weighted using a scale of four color grades, from white indicating not applicable/ no recommendation to black indicating strong recommendation. A black dot indicates a basic requirement indicating underlying relevance along the whole process of behavior change. The listed studies indicate and substantiate the weighting of the referring design principle.

Of the 28 design principles of the PSD model, 11 design principles are identified as basic requirements and 17 design principles are categorized into the four levels of recommendation. Linking the 17 design principles and the five transitions results in 85 combinations: 31 (36%) show not applicable or not recommended in the referring transition, 17 (20%) show a slight recommendation, 11 (13%) recommendation, and 26 (31%) show a strong recommendation of the design principle in the referring transition. The mapping reveals that the seven design principles of the category system credibility support act as basic requirements (Lehto & Oinas-Kukkonen, 2013; Oinas-Kukkonen, 2013). Most design principles are linked to the transitions (IV) and (V), from action to maintenance and from maintenance to termination.

Table 3. Resulting Mapping of the Design Principles to Transitions of Behavior Change and Referring Studies

Category	Principle	I	II	III	IV	V	Studies (cf. chapter 3.2)
Primary Task Support	Reduction						Lehto & Oinas-Kukkonen, 2013
	Tunneling						Sunio, Schmöcker, & Kim, 2018
	Tailoring						Liang, Xue, & Berger, 2006; Schäfer & Willemsen, 2019; Sunio et al., 2018
	Personalization			•			Kelders, 2015; Klein, Mogles, & van Wissen, 2014; Lehto & Oinas-Kukkonen, 2013, 2015; Nguyen et al., 2018; Oinas-Kukkonen & Harjumaa, 2009; Schäfer & Willemsen, 2019; Wilson & Djamasbi, 2017
	Self-monitoring						Harjumaa & Muuraiskangas, 2013; Klaassen, op den Akker, Hendrikus J.A., & Nijholt, 2015; Klein et al., 2014; Kulyk, op den Akker, Klaassen, & van Gemert-Pijnen, 2014; Lehto & Oinas-Kukkonen, 2013; Sunio et al., 2018
	Simulation						Lehto & Oinas-Kukkonen, 2015; Sunio et al., 2018
	Rehearsal						Harjumaa & Muuraiskangas, 2014; Langrial, Oinas-Kukkonen, & Lappalainen, Päivi, Lappalainen, Raimo, 2014; Lehto & Oinas-Kukkonen, 2015
Dialogue Support	Praise						Harjumaa & Muuraiskangas, 2014; Lehto & Oinas-Kukkonen, 2015; Toscos, Faber, An, & Gandhi, 2006
	Rewards						Nguyen et al., 2018; Wilson & Djamasbi, 2017
	Reminders						Harjumaa & Muuraiskangas, 2014; Klaassen et al., 2015; Kulyk et al., 2014; Langrial et al., 2013; Langrial et al., 2014; Lehto & Oinas-Kukkonen, 2013, 2015
	Suggestion						Lehto & Oinas-Kukkonen, 2015; Nguyen et al., 2018; Phillips & Landon, 2016; Song et al., 2017
	Similarity			•			Kulyk et al., 2014
	Liking			•			
	Social role			•			
System Credibility Support	Trustworthiness			•			Lehto & Oinas-Kukkonen, 2014, 2015
	Expertise			•			
	Surface credibility			•			
	Real-world feel			•			
	Authority			•			
	Third-party endorsements			•			
	Verifiability			•			

Table 3. Resulting Mapping of the Design Principles to Transitions of Behavior Change and Referring Studies

Category	Principle	I	II	III	IV	V	Studies (cf. chapter 3.2)
Social Support	Social learning						Davis, 2012; Nkwo, 2019
	Social comparison						Davis, 2012; Lehto & Oinas-Kukkonen, 2015; Nkwo, 2019; Sunio et al., 2018
	Normative influence						Kamphorst, Klein, & van Wissen, 2014; Sunio et al., 2018
	Social facilitation						Nkwo, 2019
	Cooperation						Divjak & Rupel, 2018; Minichiello, Marx, McNeill, & Hailey, 2019
	Competition						Davis, 2012; Nkwo, 2019
	Recognition						Davis, 2012; Nkwo, 2019

white: not applicable/ no recommendation
light grey: slight recommendation
dark grey: recommendation
black: strong recommendation
black dot: basic requirement

We discuss the role of the design principles of the PSD model along the process of behavior change including examples of implementations. We start with the basic requirements that are relevant to the whole transition process following with a discussion of the five transitions.

4.1 Basic Requirements

According to the analysis, 11 design principles act as basic requirements along the five transitions and should be considered regardless of the specific stage of behavior change. These design principles are *personalization*, *similarity*, *liking*, *social role* as well as the whole category system credibility support with its design principles *trustworthiness*, *expertise*, *surface credibility*, *real-world feel*, *authority*, *third-party endorsements,* and *verifiability*.

Researchers address *personalization* as a design principle that is relevant along the whole process of behavior change as personalized elements have a high impact to motivate users (Harjumaa & Muuraiskangas, 2014) and lead to users feeling more engaged and invested (Wilson & Djamasbi, 2017). Therefore, *personalization* has the potential to support people in starting their behavior change as well as preventing relapses into old and undesired behavior patterns (Harjumaa & Muuraiskangas, 2014; Schäfer & Willemsen, 2019). Developers of BCSS integrate *personalization* by allowing users to create their own profile with name and picture (Kelders, 2015; Oinas-Kukkonen & Harjumaa, 2009) or to select design features (Lehto & Oinas-Kukkonen, 2015). Personalized feedback or advice (Klein et al., 2014; Lehto & Oinas-Kukkonen, 2013; Nguyen et al., 2018) as well as *personalization* based on *tailoring,* by leading users to individually set their goals (Schäfer & Willemsen, 2019), are additional examples.

Kulyk et al. (2014) emphasize that users of BCSS appreciate *similarity*, *liking,* and *social role*. Oinas-Kukkonen and Harjumaa (2009) address the relevance of the design principle *similarity* as they state that users of BCSS are more likely to be persuaded through systems that remind them of themselves. The design principle *liking* adds an attractive and appealing look and feel (Oinas-Kukkonen & Harjumaa, 2009). Oinas-Kukkonen and Harjumaa (2009) further specify that BCSS that include the design principle *social role* act more persuasive.

Next to these design principles, the category system credibility support also serves as a basic requirement for BCSS. The category system credibility support comprises the design principles *trustworthiness*, *expertise*, *surface credibility*, *real-world feel*, *authority, third-party endorsements,* and *verifiability*. The consideration of these design principles during the design of BCSS does not enable user activities, however, their absence would result in dissatisfaction. *Trustworthiness*, *expertise,* and *authority* affect the persuasiveness of the BCSS, as they let the system seem truthful, fair, and unbiased as well as demonstrate knowledge, experience, and competence (Oinas-Kukkonen & Harjumaa, 2009). *Surface credibility*, *real-world feel*, *third-party endorsements* affect perceptions on system credibility because these design principles provide a competent look and feel, information about the people behind the BCSS, endorsements from respected sources, and links to outside sources (Oinas-Kukkonen & Harjumaa, 2009). Lehto and Oinas-Kukkonen (2014, 2015) highlight the importance of this category as perceived credibility strengthens the intention to continue.

4.2 Transition I, Precontemplation to Contemplation

Users in the stage of precontemplation are unaware that the addressed problem exists (Prochaska & Norcross, 2001). Due to the unawareness, it is difficult to reach potential users, because they are not actively looking for a behavior change and a transition to the next stage of contemplation. Therefore, only a few design principles are applicable in BCSS for transition (I). To reach users in the stage of precontemplation, other efforts outside BCSS are beneficial, for example, interventions by families, friends, or coworkers, or supplementing measures such as marketing. The most fitting design principles for transition (I) are *simulation* and *social learning* (recommendation), as well as *tunneling* and *normative influence* (slight recommendation). These design principles are able to reveal the problem behavior to users.

Simulation enables users to observe the link between cause and effect (Oinas-Kukkonen & Harjumaa, 2009). Sunio et al. (2018), for example, use *simulation* in a slideshow to present before and after pictures. The effects of certain behavior can also be revealed by *social learning* when users observe others performing the behavior (Oinas-Kukkonen & Harjumaa, 2009). *Social learning* is addressed, for example, by including experience reports (Davis, 2012) or by enabling the exchange of best practices (Nkwo, 2019).

Tunneling guides users along the attitude change process by providing relevant information (Oinas-Kukkonen & Harjumaa, 2009). Additionally, *normative influence*, *tailoring,* and *expertise* could be added as design principles in transition (I) to increase the likelihood that a person will adopt a target behavior (Lehto & Oinas-Kukkonen, 2015; Oinas-Kukkonen & Harjumaa, 2009; Sunio et al., 2018).

In transition (I), *reduction, self-monitoring, rehearsal, praise, rewards, reminders, suggestion, social comparison, social facilitation, cooperation, competition,* and *recognition* are design principles that are not able to address users' needs. The design principle *suggestion* is not recommended for transition (I) because it can lead to users' rejection in the stage of precontemplation when they do not have problem awareness yet (Phillips & Landon, 2016). Design principles such as *rehearsal, praise,* and *reminders* require a certain awareness of the problem that is not present in this stage, yet. Other design principles such as *rewards, recognition,* and *cooperation* are not applicable because they require the execution of the target behavior (Oinas-Kukkonen & Harjumaa, 2009).

4.3 Transition II, Contemplation to Preparation

In the stage of contemplation, users are aware of an existing problem but do not actively intend to change (Prochaska & Norcross, 2001). Transition (II) to the stage of preparation mostly relies on the categories primary task support and social support. In detail, the design principles *tunneling*, *tailoring*, *simulation*, *social learning*, and *normative influence* are strongly recommended for transition (II). These design principles are able to raise awareness for the problem behavior, show benefits of a changed behavior, and therefore to form an intent to change. In this transition (II), *tunneling* guides users and provides means for action (Liang et al., 2006). *Tailoring* refers to ensuring that information is aligned to the context and needs of the targeted user group (Oinas-Kukkonen & Harjumaa, 2009). As an example for *tunneling* and *tailoring*, Oinas-Kukkonen and Harjumaa (2009) suggest providing relevant information about the problem behavior and possible treatments and stories of peers, which are referring to different user groups. Sunio et al. (2018) apply this by reporting personalized diagnostics including a goal and directing to relevant new elements. *Simulation* is maintaining its purpose as described in transition (I) to highlight the problem behavior and to show results of behavior change (Lehto & Oinas-Kukkonen, 2015). *Social learning* and *normative influence* provide means to behavior change and motivate users by observing the results of other people performing the target behavior and gathering people with the same goal (Oinas-Kukkonen & Harjumaa, 2009). *Social learning* can connect people, for example by using a shared fitness journal (Consolvo, Everitt, Smith, & Landay, 2006). *Normative influence* impacts behavior, for example by adding peer pressure (Oinas-Kukkonen & Harjumaa, 2009) or by bringing the culture and environment of users into account (Kamphorst et al., 2014).

Besides these strong recommendations, the model indicates *rehearsal* as recommended. *Rehearsal* is able to raise awareness by emphasizing the benefits of changed behavior (Harjumaa & Muuraiskangas, 2014) and supports the preparation of real situations (Langrial et al., 2014; Oinas-Kukkonen & Harjumaa, 2009). *Rehearsal* can be implemented, for example, in the form of a role-play (Harjumaa & Muuraiskangas, 2014) or a video-based exercise builder (Lehto & Oinas-Kukkonen, 2015). Additionally, the model indicates a slight recommendation for *praise*, *social comparison*, and *social facilitation* to raise motivation and strengthen the intent to change (Lehto & Oinas-Kukkonen, 2015; Sunio et al., 2018).

Design principles that are not applicable for BCSS that address transition (II) are *reduction, self-monitoring, rewards, reminders, cooperation, competition,* and *recognition*. As stated regarding transition (I), these design principles cannot be implemented per definition, as they require the execution of the target behavior (Oinas-Kukkonen & Harjumaa, 2009) that is not yet performed during transition (II) (Prochaska & Norcross, 2001).

4.4 Transition III, Preparation to Action

Users in transition (III), from preparation to action, need BCSS that help them with an initial approach ("game plan", Prochaska & Norcross, 2001, p. 445) to take first steps and form their intended behavior. Mostly the categories of primary task support and social support are recommended in this transition, providing guidance and means for the change as well as social components emphasizing motivation to change.

The design principles *reduction*, *suggestion,* and *rehearsal* are strongly recommended for transition (III). *Reduction* breaks down complex behavior into simple tasks or sub-tasks (Lehto & Oinas-Kukkonen, 2013; Oinas-Kukkonen & Harjumaa, 2009) and therefore also lowers the barriers to do the first step of the target behavior and increases the willingness that users engage with the BCSS. *Suggestion* offers specific applications of the target behavior, for example, an exercise plan based on preferences and goals (Lehto & Oinas-Kukkonen, 2015). Advice is especially effective when users are experiencing some form of loss or the situation is comprising a low risk (Phillips & Landon, 2016). *Rehearsal* explicitly supports the preparation for real situations (Oinas-Kukkonen & Harjumaa, 2009) as a training technique (Langrial et al., 2014).

Besides these strong recommendations, the model presents the following design principles as recommendations: *tailoring*, *praise*, *social learning*, *normative influence*. *Tailoring* supports users to make better choices (Schäfer & Willemsen, 2019). *Praise* has the ability to strengthen motivation for reaching individual goals (Harjumaa & Muuraiskangas, 2014; Toscos et al., 2006). *Social learning* can supplement *tailoring* by observing the behavior of peers and helps to build an individual goal for intended behavior (Consolvo et al., 2006). *Normative influence* is able to induce active behavior by defaults. Such defaults can appear, for example, as default goals and contribute to *tailoring* by facilitating the decision process of users (Loock, Staake, & Thiesse, 2013). Goal-setting is not explicitly introduced as a design principle by the PSD model. However, goal-setting is a widely studied subject that influences behavior (Locke & Latham, 1991, 2002) and should be considered in the process of behavior change. Regarding the design principles of the PSD model, goal-setting may serve as a combination of *suggestion*, *reduction*, *tailoring*, and *normative influence*. Therefore, setting an individual goal has strong potential to support the transition (III) from preparation to action.

In transition (III), the design principles *self-monitoring, rewards, reminders, cooperation,* and *recognition* are not applicable, because they are not aiming at supporting an initial approach to the target behavior. As described in transition (I) and (II), the design principles are per definition only applicable when users already perform the target behavior (Oinas-Kukkonen & Harjumaa, 2009). This is not the case during transition (III) but in the following stage (Prochaska & Norcross, 2001).

4.5 Transition IV, Action to Maintenance

During transition (IV), from action to maintenance, BCSS should reinforce users' new behavior and strengthen users' will to maintain their changed behavior. Therefore, design principles that analyze the behavior of the users are in focus. Categories that especially address these needs are dialogue support and social support.

Strongly recommended are *self-monitoring*, *praise*, *rewards*, *reminders*, *social comparison*, *social facilitation*, *cooperation*, *competition*, and *recognition*. *Self-monitoring* enables users to keep track of their performance or status and therefore supports users in achieving their goals (Oinas-Kukkonen & Harjumaa, 2009). Regarding the intended continual interaction with BCSS, *self-monitoring* has the potential to raise awareness for behavior patterns. Because deviations become recognizable, the appearing links to negative consequences encourage users to make progress (Sunio et al., 2018) and serve as guidance (Kulyk et al., 2014). Furthermore, *self-monitoring* functions as a reminder, warning, advice, or assessment (Klaassen et al., 2015). Examples for implementation are calculators for own eating habits or medication (Klein et al., 2014; Lehto & Oinas-Kukkonen, 2013). Displaying users' behavioral values besides the values of peers serves as a combination of *self-monitoring* and *social comparison*. *Praise* provides information-based feedback, for example, via words, images, or sounds (Oinas-Kukkonen & Harjumaa, 2009), which has positive effects on individuals' motivation (Harjumaa & Muuraiskangas, 2014; Toscos et al., 2006). The

design principle *rewards* gives credit for performing the target behavior and is able to provide great persuasive powers (Oinas-Kukkonen & Harjumaa, 2009). Therefore, *rewards* should be integrated into BCSS as soon as users get into the action phase and perform the desired behavior. *Rewards* can function as a form of positive feedback (Harjumaa & Muuraiskangas, 2014), which leads users to recall their target goals (Nguyen et al., 2018) and thus affects alteration and reinforcement of behavior (Wilson & Djamasbi, 2017). The design principle *reminders* is able to call the target behavior to the users' mind (Oinas-Kukkonen & Harjumaa, 2009), make people remember to use the system during the intervention (Langrial et al., 2013; Langrial et al., 2014; Lehto & Oinas-Kukkonen, 2013), and keep users motivated (Lehto & Oinas-Kukkonen, 2015). *Reminders* can be implemented as regular text messages (Klaassen et al., 2015; Lehto & Oinas-Kukkonen, 2013) or provide impulses at opportune moments (Harjumaa & Muuraiskangas, 2014), for example, as soon as the performance of the users is less than a target score (Kulyk et al., 2014).

Additionally, the integration of *competition* can be beneficial and raise social motivation (Davis, 2012), however, a healthy level of competitiveness is important (Nkwo, 2019). Davis (2012) and Nkwo (2019), for example, implement *competition* through *social comparison*. *Social comparison* and *social facilitation* are able to raise users' motivation and strengthen the intent to change (Sunio et al. 2018; Lehto and Oinas-Kukkonen 2015) and are highly relevant to keep users in action. Both go hand in hand, as *social facilitation* can be achieved by *social comparison* (Nkwo, 2019). Additionally, *cooperation* can motivate users to adopt a target attitude or behavior as humans have a natural drive to cooperate (Oinas-Kukkonen & Harjumaa, 2009). *Cooperation* is typically addressed through tasks that require teamwork (Divjak & Rupel, 2018; Minichiello et al., 2019). By offering *recognition* to an individual or a group, BCSS can increase the likelihood of users adopting a target behavior (Oinas-Kukkonen & Harjumaa, 2009). *Recognition* is addressed, for example, when users receive appreciative and grateful messages to reward good performance (Davis, 2012; Nkwo, 2019).

Besides the design principles with strong recommendation, *reduction* is recommended in transition (IV) as it is important to keep the users performing the new behavior. Slight recommendations in transition (IV) are *tailoring*, *suggestion*, and *normative influence*. *Tailoring* supports users to make better choices (Schäfer and Willemsen 2019) and *suggestion* provides specific applications of the target behavior (Lehto and Oinas-Kukkonen 2015). Both design principles are slightly recommended in transition (IV) as users already know how to adopt their new behavior. For the same reason, *normative influence* also is slightly recommended.

Design principles that are not able to address users' needs in transition (IV) are *tunneling, simulation, rehearsal,* and *social-learning*. *Simulation*, *rehearsal,* and *social-learning* are necessary during preparatory transitions but do not explicitly support users during performing the target behavior. This also includes *tunneling,* which guides "users in the attitude change process" (Oinas-Kukkonen & Harjumaa, 2009, p. 492), thus the need for this effect ends after the stage of preparation.

4.6 Transition V, Maintenance to Termination

For the last transition (V), BCSS should help users to form habits and make the changed behavior their regular behavior. Therefore, it is important to continue the integration of design elements of the transition (IV), but also integrate elements of precontemplation to address the importance of keeping up the new behavior. Comparison to users' past status can help to extend and reawake motivation. Looking at the different categories dialogue support and social support are the ones that stand out.

As well as for transition (IV), *self-monitoring*, *praise*, *rewards*, *reminders*, *social comparison*, *cooperation*, *competition*, and *recognition* are strongly recommended for transition (V). *Self-monitoring* tracks users' behavior and makes progress or new behavioral patterns visual. This can keep up motivation (Harjumaa & Muuraiskangas, 2013) and visible deviations from the desired behavior remind people of negative consequences to stay on track (Sunio et al., 2018). Because the design principles *praise*, *rewards*, *social comparison*, *cooperation*, *competition,* and *recognition* are able to raise or strengthen motivation, they can be implemented in the same way as in transition (IV), but with a different focus. While the focus in transition (IV) is on motivating users to change their behavior, the focus in transition (V) lies on maintaining their motivation for long-term behavior change. Additionally, *reminders* can be used to bind users to the BCSS in the long term.

In transition (V), the design principles *tailoring*, *suggestion*, *social facilitation* are recommended. *Tailoring* and *suggestion* rise in relevance compared to transition (IV). Both design principles support users in giving advice regarding fitting exercises or impulses to simplify complex tasks of changing behavior (Song et al., 2017). Users in the stage of maintenance are already prepared and rehearsed in their actions, it is a new

task to keep up with the changed behavior. Therefore, users need more support through *tailoring* and *suggestion* to facilitate the stage of maintenance. Additionally, *social facilitation* can raise motivation, strengthen the intent to maintenance, and consequently prevent relapses. Additionally, there is a slight recommendation for *normative influence*, *simulation,* and *social learning*.

Design principles that are not able to address users' needs in transition (V) are *reduction, tunneling,* and *rehearsal.* While they facilitate initial steps in earlier transitions, they do not affect the sustainability of behavior change that is needed to achieve the stage of termination. In particular, the definition of *tunneling* highlights the supporting effect for preparatory stages by describing its effect as bringing users "closer to the target behavior" (Oinas-Kukkonen & Harjumaa, 2009, p. 492). As soon, as users perform the target behavior, this effect is no longer supporting users' needs (Prochaska & Norcross, 2001).

5 Conclusion

Our model (Figure 4) presents process-based guidance for developing BCSS based on the PSD model by Oinas-Kukkonen and Harjumaa (2009) and the stages of change of the TTM of Prochaska and DiClemente (1983) and Prochaska and Norcross (2001). We introduce a tangible model for implementing fitting and effective design principles according to the targeted stages of behavior change to researchers and developers of BCSS. Figure 4 summarizes the recommendation model in a condensed form filling the gap between the analysis of persuasion context and selection of different design principles for the software implementation of BCSS. The model provides guidance on which design principles should be implemented in BCSS depending on the users' current stage in the process of behavior change, while not restricting individual decisions. The levels of recommendation indicate the priority for implementation differentiating between strong recommendation, recommendation, and slight recommendation; the design principles at the bottom present the basic requirements along all transitions.

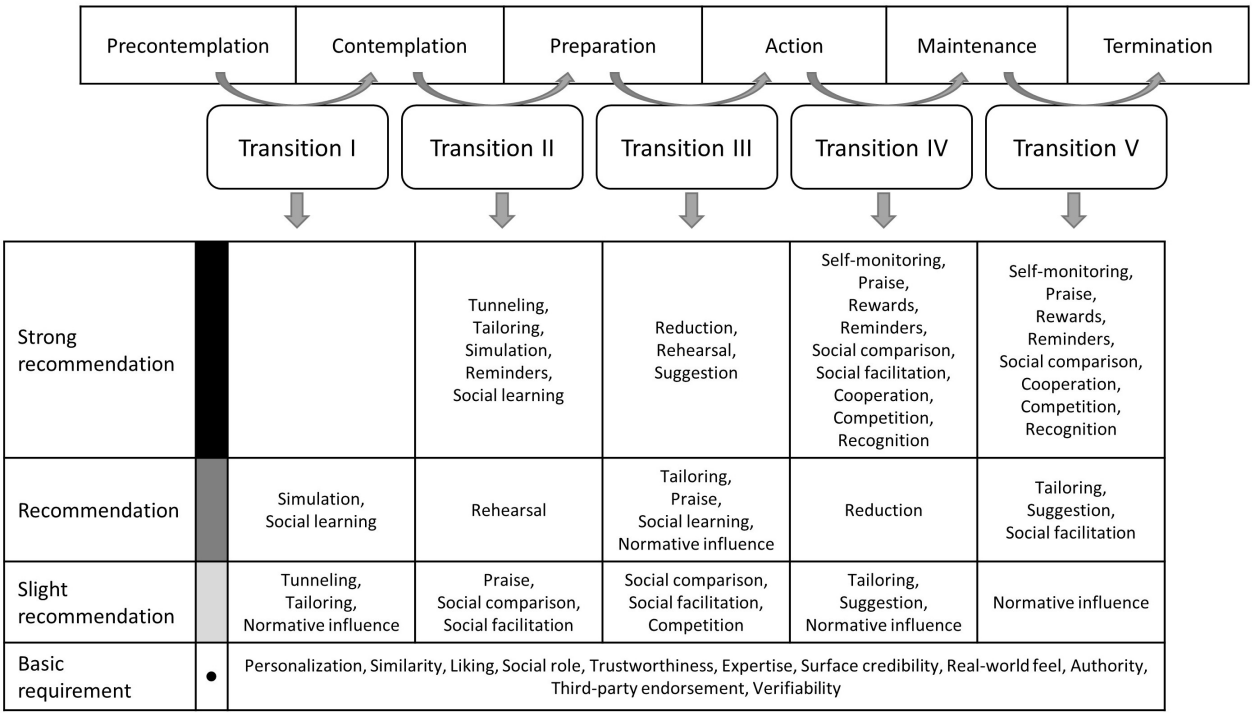


Figure 4. Model in a Condensed Form Integrated in the Process of the PSD Model

The model presents the appropriate design principles regarding each transition along the stages of behavior change. It highlights and depicts in a tangible and applicable form that it is important to choose the fitting design principles according to users' stage of behavior change and the targeted transition.

Most existing BCSS focus on users that are in the stages of action and maintenance (i.e. transitions (IV) and (V)) and target users that already have problem awareness and are preparing to change. This is in accordance with the finding that most design principles of the PSD model are categorized in the transitions

(IV) and (V) (cf. Figure 4) and that it is a major challenge for BCSS to reach users in the first stage for transition (I) without intent to change behavior. Our model further indicates that BCSS by themselves may not be sufficient enough to persuade users in the first stage of behavior change of precontemplation. Other research areas as marketing have the potential to reach users and therefore to supplement BCSS for transition (I).

Addressing all transitions allows to involve a broader target audience, independent of the current stage of behavior change, and to address problem awareness to prevent relapses. When a BCSS supports multiple transitions, we propose to design the BCSS with different sections and corresponding features for each transition. An implementation example is proposed by Merz (2020) where the user passes different levels each addressing a transition in the process of behavior change. Dividing the BCSS into specific sections related to the transitions allows for a focus on selected design principles whose effects and impacts are tailored to the targeted stage of behavior change. In addition to providing guidance on choosing relevant design principles depending on the users' current stage of change, the model emphasizes integrative approaches to design persuasive systems.

Our paper is subject to several potential limitations. First, our resulting model is still quite general, despite our motivation to develop the model because the PSD model is a generic technical framework for developing BCSS. However, we decided consciously not to narrow the focus to maintain the applicability of the model in different fields of research (health, environment, work, etc.), and we still were able to develop a tangible model by specifying and facilitating the recommendation analysis and selection of design principles of the PSD model for developing BCSS. Therefore, this approach provides a starting point for future research in developing more context-specific models. Second, we decided to draw upon the stages of change of the TTM by Prochaska and DiClemente (1983) and Prochaska and Norcross (2001) to fill the gap between technical and behavioral model. The TTM was originally developed for the treatment of people with addictive behavior but has since been applied to various other situations (e.g., stress management (Velicer, Prochaska, Fava, & Redding, 1998), academic procrastination (Grant & Franklin, 2007), and consumer debt behavior (Xiao et al., 2004)). There are also other behavioral models that address stages of behavior change, such as the 3D-RAB by Wiafe, Nakata, Moran, and Gulliver (2011). The 3D-RAB states 12 transitions (Wiafe et al., 2012). In favor of the applicability of the model, we decided on the less complex TTM with five transitions. It could be subject to further research to specify the model using a narrower focus and a different behavioral model. Third, we may have missed potentially relevant studies in our literature search and the model is partly based on subjective coding. However, following our methodological procedure of the literature search using four interdisciplinary databases with a wide search string, we are confident that we incorporated adequate studies into our analysis for confirmation and were able to minimize potential bias as possible.

While we tried to minimize the subjective bias of our qualitative analysis using our described methodology, it should be subject to further research to validate our model and test the applicability when developing BCSS. Additionally, while we build on the PSD model as the most referenced and established technical framework for developing BCSS, there is a need for further research regarding the consistent understanding of design principles for BCSS (Gregor et al., 2020; Möller et al., 2020). Our theoretical base for the model was particularly sparse regarding our identified basic requirements, especially the category of system credibility support that is mostly neglected in existing research (Matthews, Win, Oinas-Kukkonen, & Freeman, 2016). Therefore, future research should investigate the potentials and possible implementations of these design principles. Also, other design principles should be subject to further research and development: First, a recognizable number of studies and developments of BCSS are adding forms of feedback. For example, Wilson and Djamasbi (2017) define the design principles of *praise*, *rewards*, *reminder,* and *suggestion* as feedback. In the PSD model, the whole category of dialogue support is stated to provide system feedback. To ensure a consistent use and understanding, the concept of feedback should be elaborated further in the context of BCSS. Second, it is notable that in recent studies since the development of the PSD model the concept of gamification has become increasingly popular. So far, gamification is indirectly incorporated in the PSD model in *competition* or *cooperation*. It should be subject to further research to integrate gamification more explicitly and more elaborated. Third, we propose to integrate goal-setting into the model as an additional design principle that can strongly contribute to the process of behavior change.

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