Aiding Users in Green IS Adoption with Persuasive Systems Design [†]

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Abstract: Green information systems (IS) is a research domain that contributes to finding solutions for fostering environmental behavior in individuals, organizations, and communities. So far, researching Green IS for individual users has been less abundant and requires more insight. Users' engagement with technologies start from adoption. Green IS challenges users to modify their lifestyles in order to achieve sustainable behavior patterns. This article is focused on persuasive Green IS, which have in-built features to convince users to modify their lifestyles and to improve technology adoption intention. In the theoretical background, main concepts, especially sustainable behavior, Green IS, IS adoption, persuasive systems, and persuasive systems design (PSD) model are presented. In this article, we analyzed three studies that focused on individual sustainable behavior change with persuasive Green IS. Overviews of these studies are presented and the studies were analyzed as a whole. The reviewed studies suggest that the PSD model has a high potential for becoming a tool for Green IS enhancement. The key themes identified from the studies bring value to both academics and practitioners, as well as suggest directions for researching the individual behavior change with persuasive Green IS in the future.

Keywords: Green IS; persuasive systems design; technology adoption; behavior change; sustainable behavior

1. Introduction

According to multiple sources, human behavior patterns heavily influence environmental quality [1–3]. Therefore, one can conclude that reduction of negative environmental impact can be achieved by changing relevant behaviors. To attain lasting behavior change, we need to understand the psychology of pro-environmental behavior. Additionally, we need to use behavior-altering frameworks to create procedures for achieving a sustainable future. The widespread technologies provide a platform for implementing behavior changes. For over a decade, mobile technologies have become ubiquitous, allowing for persuasive interaction with the users and influencing their behaviors [4]. Nowadays, there is a myriad of omnipresent advanced technological solutions that are powerful enough to alter behaviors and break habits. Yet, the mere presence of these technologies does not contribute to improving environmental conditions. To be effective in behavior change support, design of the information systems should be able to convince the users to accept, adopt, and use these systems.

Social and cognitive psychology provide theories for studying user intentions and behaviors (e.g., the theory of reasoned action (TRA) [5], the theory of planned behavior (TPB) [6]) but exclude a systematic analysis and overview of persuasive software. The Fogg behavior model [7] is often referred to as a main framework for interpreting persuasive solutions. Nevertheless, the Fogg behavior model [7] does not have necessary components for complete evaluations and development of persuasive systems [8]. Thus, in this article, we considered the persuasive system design (PSD) model [8], a different framework that contains thorough guiding principles crafted specifically for evaluating and designing persuasive systems.

Melville [9] stated that IS has several impacts on the environment, shifting, directly or indirectly, sustainable behavior or perceptions. Melville [9] outlined sustainable impact types as follows: belief formation, action formation, and outcome. Belief formation is the first step towards environmentally sound behavior and it describes how individual mental states, such as desires or beliefs, influence people's psychological insights about the ecosystem [9]. Information systems (IS) that are designed specifically for achieving more sustainable living are known as "green", i.e., Green IS. Researching the history of the Green IS field, Shevchuk et al. [10] discovered that the majority of the current theories and frameworks (23 instances were recognized by Shevchuk et al. [10]) assist organizations in executing, applying, and assessing Green IS concepts. Simultaneously, theoretical methods for the individual users (three instances were acknowledged) and social groups (seven instances were acknowledged) are insufficient. Therefore, the historical investigation by Shevchuk et al. [10] recommended that both academics and practitioners allocate more resources to producing Green IS/IT theoretical and practical solutions that are not limited to organizational and work-related subjects.

Brendel et al. [11] analyzed the connection between design science research (DSR) and Green IS to summarize current research knowledge and opportunities presented by these topics. One of the future research suggestions made by the authors was to emphasize the need to examine belief formation as a crucial aspect of sustainability. Diedrich et al. [12] investigated the influence of perceived persuasiveness on sustainability beliefs. It was discovered that there is the positive impact of persuasive and human-like design on individual environmental control and normative beliefs in the context of sustainable behavior. Elliot [13] presented hypotheses that sought to examine relationships among individuals, the environment, technology, and human behavior. Several hypotheses crafted for directing future research addressed mediation of the impact of human behavior on the environment by technology. Prior to using technology for attitude, belief or behavior change needs to be adopted by the users. Therefore, we considered an underaddressed area of researching the influence of persuasive technologies on individual user's intention to adopt Green IS. Therefore, the central research question of the article was stated as follows:

RQ: How does persuasive systems design aid in adoption of Green IS by individual users?

The answer to this question is not only beneficial for the academics but can also be used by practitioners to design and develop persuasive Green IS solutions that appeal to users. In a broader sense, persuasive Green IS applications might be also endorsed by local policymakers, thus promoting behavior change towards sustainable development in communities. To address the research question, the article has the following structure: first, the theoretical background of the related concepts is presented; after that, the existing studies identified as suitable for answering the research question are discussed, and lastly, conclusions are made, and the further venues for the research are suggested. This article summarizes concepts presented in a dissertation that is grounded in the application of the PSD model [8] for fostering Green IS adoption [14].

2. Theoretical Background

2.1. Sustainable Behavior

While planning and executing Green IS projects that target sustainable behavior, it is important to examine thoroughly the essence of sustainable behavior itself. By definition, pro-environmental behavior [15], or sustainable behavior, is a sequence of activities that minimize any potential harmful effects on the environment, or even positively impact it. Encouraging sustainable behavior consists of multiple steps [16]. It starts from investigating aspects that promote environmental quality, followed by applying compulsory interventions, and methodically evaluating the effects of the interventions. The steps necessary for behavior alteration from unsustainable to pro-environmental, are indicated as [15]: (1) recognition of behaviors to be modified, (2) investigation of influencing aspects, (3) creation and implementation of interventions, (4) assessment of outcomes of interventions.

In the framework of sustainable behavior change [15], information systems come in as interventions (stage 3), which should be carefully designed and applied in order to be beneficial. Additionally, it is important to note that frequently pro-environmental behavior is not considered to be pleasant because it is associated with inconveniences like increased discomfort or behavioral restrictions [17]. Overall, behavior change requires changes in daily habits (sometimes involuntary), thus it is not enjoyable [18], leading to confrontation with practicing sustainable behavior [19].

2.2. Green Information Systems

Pro-environmental concerns should be accounted for in information technologies (IT) [20]. Furthermore, Green IT creates manifold possibilities to impact economics, observing environmental conditions, as well as affecting people's daily routines by introducing technologies that lessen the influence of e-waste, creating sustainable human–computer interaction interfaces, and providing means for reducing energy consumptions by technologies [21]. Green IS is a closely related concept to Green IT. Commonly, Green IS is viewed as a field that focuses on modifying IS-driven organizational procedures in such a way that sustainable goals are incorporated [22]. Green IS intervention in organizations facilitates both economic and sustainable achievements, advances knowledge management, and generates other indirect positive effects [22]. Some examples of the Green IS projects are increased funding of pro-environmental IS, accompanied by its distribution, utilization, and operation aimed at minimizing negative ecological effects of IT, corporate processes, and end-user goods and services [22].

To exemplify a Green IS for individual users, we describe the Joulebug app included in one of the discussed studies in this article. The main purpose of the app is to support the users at acting in a sustainable manner at any time, e.g., while doing household chores, working, vacationing (https://joulebug.com/). The app provides tips on being mindful about using natural resources. The app summarizes pro-environmental suggestions into "actions" for users to discover and take part in. When a user finishes any of these actions, the app provides an option to "buzz" (i.e., share a note that may be accompanied by a photo) to notify the other users of the app about the user's personal achievement. The users receive points for each "buzz", and they are awarded extra recognitions called "badges" when they become experts in a certain field of sustainability. The users also can monitor their own impact on the environment using the stats and the "Trophy Case" sections of the app. The users are being motivated to engage with their acquaintances and neighbors and expand the group of users who contribute to pro-environmental accomplishments and to monitor how the network is improving sustainability in the neighborhood. Additionally, the app recommends participation in contests in which the users compete at being sustainable individually or in teams on a local or a national scale.

2.3. Persuasive Systems and PSD Model

Unlike humans, computers are much more efficient in persuasion because they can be more interactive, meanwhile regulating persuasive techniques based on current circumstances [7]. Needless to say, the characteristic of the computers of being persistent stems from their capacity to present information visualization capabilities, work with immense volumes of data, size up or down depending on the users' demands, provide a higher level of anonymity and confidentiality most of the time, as well as to be accessible from anywhere in the world. Nevertheless, unlike humans, computers themselves do not aim to persuade users. Yet computer applications facilitate users' behavior changes and streamline the course of the behavior change process [23]. Persuasive technologies affect users' attitudes and actions by employing various strategies to achieve the desired behavioral consequences and behavior change approaches [24,25].

Research on persuasion with the help of computers has led to creating a concept of persuasive technologies [7], which are technologies specifically created to introduce modifications to people's attitudes or behaviors. Since the definition of this concept takes into account both perceptions and actions of the users, behavior change technologies research has been enriched with a new perception. Furthermore, persuasive technologies can be influential when no individuals are present, thus they are considered to be social actors [7]. Nowadays, efficient persuasive technologies and information systems interventions are empowered by fast advancement of the Internet and creation of ubiquitous systems [26]. In order to describe connective systems created for influencing people's attitudes and/or behaviors, the "persuasive systems" concept was invented [8]. Persuasive systems are characterized as "computerized software or information systems designed to reinforce, change or shape attitudes or behaviors or both without using coercion or deception" [8], p. 486.

Based on the Fogg behavior model [7], the persuasive systems design (PSD) model was created by Oinas-Kukkonen and Harjumaa [8]. The PSD model is characterized as a methodical framework generated for the evaluation and development of persuasive systems. This framework includes an explanation of the core concepts relevant for behavior change through computerized systems, the procedure of development of persuasive systems, as well as persuasive design techniques. The PSD model can be used both in theory and in practice. As a theoretical tool, the PSD model is suitable for systematic assessment of the persuasion context and persuasive principles. As a practical tool, the PSD model can be used by persuasive systems designers who build applications for targeting specific needs of a certain audience. The PSD model has been employed in numerous application domains, for instance pervasive systems for wellness [27], personal wearable devices for physical training [28], and information systems for promoting healthy behavior [29]. Predominantly, the PSD model is conceptual and it serves as a manual for assessment of the persuasion context, which consists of the intent, the event, and the strategy and offers an assortment of the persuasive principles.

Development of efficient behavior change support systems (BCSS) can be guided by a variety of persuasive principles and system attributes included in the PSD model. There are four groups of persuasive features that can increase the behavior-change potential of information systems. These groups are primary task support, user–system dialogue support, system credibility support, and social support [8]. Although some researchers believe that applying more persuasive principles is more beneficial for behavior change [30], this belief is not universally supported. The research related to the PSD model has stated that the higher number of features used in a system does not necessarily increase persuasiveness. On the contrary, applying as many persuasive principles as possible is not encouraged as a means of incrementing efficiency of a persuasive system. Hence, the PSD model research encourages an optimized choice of persuasive principles instead of applying a larger quantity of features.

The primary task support category includes persuasive features that enable the users to contemplate their own actions, establish individual aims to achieve, and track their own performance directed at attaining the set objectives [8]. The primary task support category also aims to simplify the system–user communication by minimizing mental strain and decreasing confusion. Furthermore, this persuasive

category facilitates the decision-making process [31]. Persuasive principles of this category are based on the tool category in the Fogg behavior model [7,32], for instance, personalization, reduction, simulation, and self-monitoring [8].

The dialogue support category consists of the persuasive principles that enable human–computer communication [8]. This category contains persuasive principles that motivate users to engage with the persuasive system actively with the intention of achieving certain behavioral goals. Sometimes users view persuasive systems as social actors, and interaction with these systems as alike to personal communication [33,34]. Nevertheless, since the system must be unobtrusive according to the PSD model [8], system components that maintain dialogue with the user, such as feedback, triggers, reminders, and suggestions, should never collide with the user's routines. Some examples of persuasive principles in the dialogue support are reminders, praise, rewards, social role, and similarity [8]. These persuasive system features are related to the items in the social actor and media categories in the Fogg behavior model [7,32].

The credibility support category comprises the persuasive principles that ensure accuracy, trustworthiness, and authenticity of the system [8]. With a higher level of trust in the system, its persuasiveness increases [35] in such a way that the user feels more confident in believing the material presented by the system and in taking the advice of the system [36]. Instances of the persuasive principles included in the system credibility support category include authority, trustworthiness, expertise, and verifiability [8]. The features in this persuasive category originate from the Fogg behavior model [7,32].

Technology-mediated interaction is being used increasingly for establishing and maintaining people's social relationships in modern life [25]. Online social support is established with the system-mediated communication [31]. Social support can be represented by social networks (e.g., professional, hobby-focused etc.), behavioral assistance (sentimental or instructive), or even mere accessibility of assistant assets [37]. Hence, social support persuasive features intend to engage users by applying social influence. Some of the persuasive principles present in the social support category are cooperation, social learning, competition, and normative influence [8]. Predominantly, social support category's principle features originate from the mobility and connectivity items in the Fogg behavior model [7,32].

In contrast to the Fogg behavior model, the PSD model emphasizes systems development as a process, with the definition of persuasion as software features rather than generic psychological concepts, as well as providing categories of software features more than implementing a particular software feature.

2.4. Information Systems Adoption

In order to develop information systems for meeting a wider range of the end users' needs [38], constant review and research of the user–system interactions are required. In the IS studies, understanding technology adoption has long been a relevant widely researched question. Technology adoption can be described as the acceptance or an initial use of a recently released technological system [39]. Increasing knowledge on how individuals interact with technology and how they process and act on information is helpful for development of a comprehensive IS for the end users [38]. Research questions related to technology adoption/acceptance have unveiled a broad discussion about the reasons, stimuli, and defining aspects of accepting various technological solutions in areas of implementation of the IS [40]. Research on technology adoption has focused on understanding, explaining, and predicting variables that impact adoption behaviors in both personal and organizational contexts. These studies have resulted in the development of theories, conceptual models, and frameworks that explain the relationship of these variables with the adoption behavior of the users [39]. Among the most frequently applied IS adoption theories are the theory of reasoned action (TRA) [5], the theory of planned behavior (TPB) [6], the technology acceptance model

(TAM) [41] (as well as the consequent versions TAM2 [42] and TAM3 [43]), and the unified theory of acceptance and use of technology (UTAUT) [40] (with its consequent version UTAUT2 [44]).

3. Summary of the PSD and Green IS Adoption Literature

A systematic literature review of the IS publications [45] discovered only a few studies that focused exclusively on Green IS and persuasion. To address the research question using the most relevant findings, we focused on the studies that described individual users in nonorganizational contexts and specifically considered the relation of the persuasive systems design constructs and the intention to adopt Green IS (namely, [46] (Study I), [47] (Study II), [48] (Study III)). To find these studies in information systems literature, we performed a systematic review of literature in the AIS Electronic Library. The search query was "abstract:sustainable AND abstract:(intention to adopt)" with the date range from 2008 to 2020. The search returned 15 papers, which represented three publication types: conference (10), series (4), journal (1). We examined abstracts of all 15 papers. After modifying the query to "abstract:sustainable AND abstract:adoption AND abstract:persuasive", without modifying the date range, the search returned six results, with publication types conference (5) and series (1). Among the six papers, one was not focused on pro-environmental behavior [49], one did not focus on persuasive design of information systems [50], and one was a literature review [45]. Only the remaining three papers, which were our own studies, met the other criteria, i.e., analyzing individual users in nonorganizational contexts and considering the relation of the persuasive systems design constructs and the intention to adopt Green IS, these papers, referred to as Study I [46], Study II [47], and Study III [48], were analyzed. The research questions of these studies, as well as the common constructs are summarized in Figure 1.
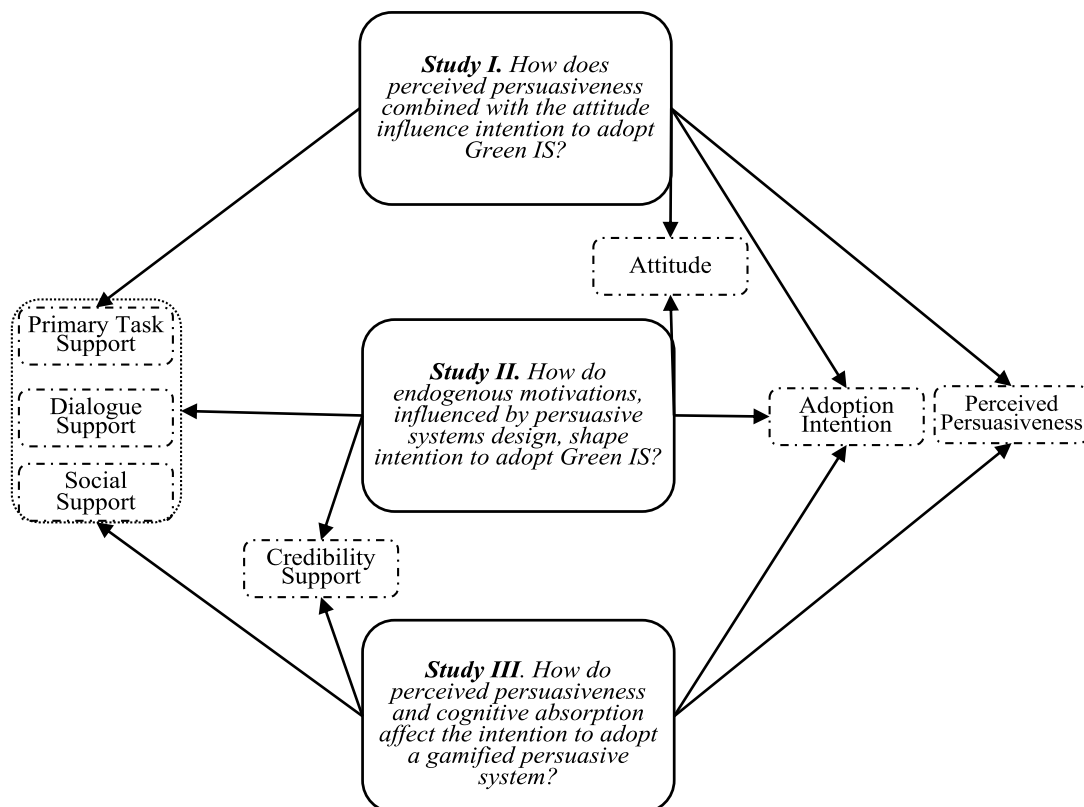

Figure 1. Studies I–III: research questions and common research constructs.

Table 1 provides definitions of all constructs used in these studies, while Table 2 gives descriptive statistics of the samples involved in the studies. The data collected in the studies were analyzed using the PLS-SEM approach. More detailed overviews of the studies follow after that.

Table 1. Constructs used in Studies I–III.

Construct	Definition	Study
Primary task support [8]	The capacity of a system (1) to break down complicated user behaviors into simpler actions; (2) to observe the user's habits, set individual aims, and monitor the process of achieving them.	I, II, III
Dialogue support [8]	The capacity of a system to give timely evaluation to the users with messages, audio, graphics, etc.	I, II, III
Credibility support [8]	The capacity of a system to guarantee trustworthiness, authenticity, dependability, and consistency.	II, III
Social support [8]	The capacity of a system to operate as a social agent and inspire the users by using social influence.	I, II, III
Perceived persuasiveness [25,51]	An individual's positive view of the system.	I, III
Cognitive absorption [52,53]	A state of deep engagement with the system defined by perceived enjoyment, temporal dissociation, focused immersion, control, and curiosity	III
Intention to adopt [41,44,54]	An individual's inclination to begin engagement with the system in the future.	I, II, III
External PLOC [55,56]	An individual's perception of the need to engage in behavior to comply with authority or to meet someone else's requirements.	II
Internal PLOC [55,56]	An individual's perception of self-determination with the emphasis on the self as an initiator of behavior.	II
Introjected PLOC [55,56]	An individual's perception of a disagreement triggered by unbalanced external behavioral stimuli and the individual's standards and morals.	II
Attitude [41,54]	An individual's critical combination of perceptions and impressions (e.g., positive or negative emotions) regarding the system.	I, II
Perceived effectiveness [40,44]	An individual's perception of how useful the system will be for carrying out certain actions.	I
Perceived effort [40,54]	An individual's perception of the anticipated level of effortlessness related to using the system.	I
Social affirmation [6,44,56]	A combination of social influence and subjective norms; an individual's perception of how the others assess the system, which motivates the individual's to match their own opinions with those stated by the others in order to receive the confirmation from the others.	I

Table 2. Descriptive statistics of the samples in Studies I–III.

Demographics	Value	I		II		III	
		#	(%)	#	(%)	#	(%)
Age	18–24	26	43%	35	45%	17	18%
	25–34	25	41%	37	47%	49	53%
	35–44	3	5%	3	4%	18	19%
	45–54	4	7%	3	4%	5	5%
	55–64	3	5%	-	-	3	3%
	65–74	-	-	-	-	1	1%
Gender	Female	50	82%	50	64%	42	46%
	Male	11	18%	28	36%	48	52%
	No answer	-	-	-	-	3	2%
Education	High school	9	15%	25	32%	16	17%
	Bachelor's Degree	27	44%	41	53%	50	54%
	Master's Degree	19	31%	11	14%	22	24%
	Doctorate Degree	6	10%	1	1%	5	5%
Total #		61		78		93	

Note: # stands for "number of participants".

3.1. Study I Overview

The purpose of Study I [46] was to examine factors that influence perceived persuasiveness and user attitudes towards a Green IS mobile application. In order to administer a survey, a JouleBug mobile application was selected to be an instance of a Green IS. Findings showed that the construct of primary task support together with dialogue support and social support constructs explained 52% of the variance in the perceived persuasiveness construct. The dialogue support construct alone explained almost 41% of the variance in primary task support construct and 20% of the variance in social support construct. The constructs of social affirmation, perceived effort, and perceived effectiveness explained 67% of the variance in attitude construct. The construct of perceived effort was a particularly important one in the study about sustainable behavior because primary task support persuasive principles can help eliminate mental obstacles and decrease the perceived effort of engaging in pro-environmental behavior that some people consider to be laborious. The constructs of attitude and perceived persuasiveness explained 76% of the variance in the construct of intention to adopt. Additionally, the study considered the influence of gender on intention to adopt. A statistically significant negative impact was encountered when the impact of gender on the construct of intention to adopt was controlled for, ($\beta = -0.181$, $p = 0.005$), thus raising the amount of the total variance explained in the construct of intention to adopt to 79%. Finally, examination of the impact of the other variables related to the respondents' demographics, (i.e., age, employment, and education) on the construct of intention to adopt revealed that none of these variables showed a statistically significant relationship with the construct of intention to adopt the system.

3.2. Study II Overview

Study II [47] investigated motivations and hypothesized that the PSD variables would have an impact on different kinds of perceived loci of causality (PLOCs), which are defined as the degrees to which persons trigger and recognize their own deeds [55]. This hypothesis stems from a premise that the categories from the PSD model [8] are able to activate various kinds of motivations, resulting in a match or a mismatch with the individual's moral principles. Moreover, existing studies [56–58] have suggested that the individual's attitudes are affected by all kinds of PLOCs. Furthermore, in accordance with the theory of reasoned action (TRA) [5] and the theory of planned behavior (TPB) [6], the constructs of attitude and intention to adopt are expected to demonstrate a substantial relation. With the intention of reducing bias stemming from a specific instance, Study II did not analyze a concrete Green IS system

or app. On the contrary, the study aimed to explore the respondents' expectations of an ideal Green IS mobile application.

To explore which mobile app persuasive principles were considered to be the most significant for fostering sustainable habits, mean values were determined for every persuasive feature construct and for every category were calculated. Based on the calculations of the mean values, the importance of the persuasive categories from highest to lowest is the following: credibility support, primary task support, dialogue support, and social support. The PLS-SEM analysis revealed that the dialogue support construct explained 16% of the variance in primary task support construct, 8% of the variance in credibility support construct, and 10% of the variance in social support construct. Collectively, the constructs of primary task support, dialogue support, and social support explained 19% of the variance in external PLOC construct, nearly 25% in introjected PLOC construct, and 2% in internal PLOC construct. The constructs of internal, external, and introjected PLOCs explained 40% of the variance in attitude construct, which alone explained 50.5% of the variance in the construct of intention to adopt a Green IS mobile application.

3.3. Study III Overview

Since the PSD model and gamification have been known for changing people's behaviors and decision-making processes, Study III [48] investigated how gamification and persuasive features influence intention to adopt a Green IS mobile application, namely, GreenApes. Environmental awareness of the participant was high, since it had a mean of 5.65 (SD = 1.04) on a 7-point Likert scale. PLS-SEM analysis conducted in Study III demonstrated statistically significant relationships between the dialogue support construct and the constructs of primary task support, credibility support, and social support, explaining 55%, 35%, and 18% of the variances accordingly. The constructs of dialogue support and cognitive absorption explained nearly 71% of the variance in perceived persuasiveness construct. Meanwhile, the constructs of primary task support, credibility support, and social support did not have a statistically significant connection to the perceived persuasiveness construct.

The construct of cognitive absorption was considered as a construct with two levels of abstraction and was a higher-order construct (HOC) in the hierarchical component model (HCM). The lower-order constructs (LOCs) in this HCM (i.e., perceived enjoyment, temporal dissociation, focused immersion, control, and curiosity) were statistically significantly related to HOC. The dialogue support and credibility support constructs showed a statistically significant relationship to cognitive absorption, explaining 72% of its variance. On the contrary, the primary task support and social support constructs did not relate to the cognitive absorption construct in a statistically significant manner. Together, the constructs of perceived persuasiveness and cognitive absorption explained neatly 74% of the variance in the construct of intention to use a gamified Green IS mobile application.

4. Discussion

Studies I–III focused on examining persuasive mobile applications due to the fact that mobile applications are the most well-known, readily available, and easily accessible examples of Green IS for the individual use in nonorganizational context. Table 3 summarizes the hypotheses presented in the studies and Figure 2 summarizes the constructs with their relationships. Although adoption of Green IS was the overall theme in all of the studies, the specific topics of persuasiveness, user motivations, and gamification were discussed in the studies. Therefore, next, a summary of the focal points of the studies is presented, namely Green IS adoption, perceived persuasiveness, motivation, and gamification.

Table 3. Summary of the hypotheses in Studies I–III [1].

Hypothesis	I	II	III
Attitude -> Intention to Adopt	S	S	N/A
Cognitive Absorption -> Intention to Use	N/A	N/A	S
Cognitive Absorption -> Perceived Persuasiveness	N/A	N/A	S
Credibility Support -> External PLOC	N/A	S	N/A
Credibility Support -> Internal PLOC	N/A	NS	N/A
Credibility Support -> Introjected PLOC	N/A	NS	N/A
Credibility Support -> Cognitive Absorption	N/A	N/A	S
Credibility Support -> Perceived Persuasiveness	N/A	N/A	NS
Dialogue Support -> Cognitive Absorption	N/A	N/A	S
Dialogue Support -> Credibility Support	N/A	S	S
Dialogue Support -> External PLOC	N/A	NS	N/A
Dialogue Support -> Internal PLOC	N/A	NS	N/A
Dialogue Support -> Introjected PLOC	N/A	S	N/A
Dialogue Support -> Perceived Persuasiveness	NS	N/A	S
Dialogue Support -> Primary Task Support	S	S	S
Dialogue Support -> Social Support	S	S	S
External PLOC -> Attitude	N/A	S	N/A
Internal PLOC -> Attitude	N/A	S	N/A
Introjected PLOC -> Attitude	N/A	S	N/A
Perceived Effectiveness -> Attitude	S	N/A	N/A
Perceived Effort -> Attitude	NS	N/A	N/A
Perceived Persuasiveness -> Intention to Adopt	S	N/A	S
Primary Task Support -> Cognitive Absorption	N/A	N/A	NS
Primary Task Support -> External PLOC	N/A	NS	N/A
Primary Task Support -> Internal PLOC	N/A	NS	N/A
Primary Task Support -> Introjected PLOC	N/A	NS	N/A
Primary Task Support -> Perceived Persuasiveness	S	N/A	NS
Social Affirmation -> Attitude	S	N/A	N/A
Social Support -> Cognitive Absorption	N/A	N/A	NS
Social Support -> External PLOC	N/A	NS	N/A
Social Support -> Internal PLOC	N/A	NS	N/A
Social Support -> Introjected PLOC	N/A	S	N/A
Social Support -> Perceived Persuasiveness	NS	N/A	NS

[1] Note. S = "Supported", NS = "Not Supported", N/A = hypothesis not tested.
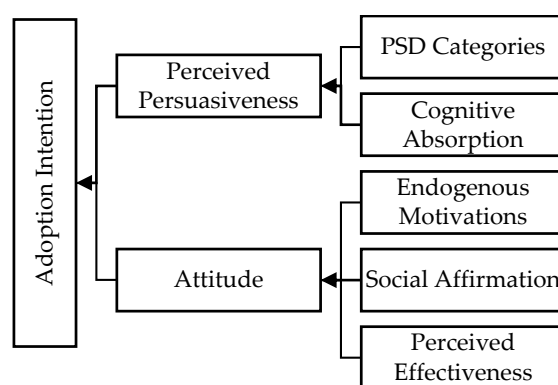

Figure 2. Dependence of constructs in Studies I–III.

4.1. Green IS Adoption

In all of the investigated studies, adoption intention of Green IS was the core focus. This focus helped to explain what influences individuals' willingness to initiate engagement with mobile applications designed for fostering sustainable lifestyle. Besides, considering perceived persuasiveness as a causal variable of Green IS adoption intention in Studies I and III, the attitude (Studies I and II)

and cognitive absorption (Study III) constructs were hypothesized to influence adoption intention. In accordance with the theory of reasoned action (TRA) [5], the theory of planned behavior (TPB) [6], and the technology acceptance model (TAM) [41], behavioral intention is a crucial element of engaging in behavior, while attitude is a factor that impacts behavioral intention. Furthermore, since a notion of flow is known as a predictor of behavioral intention [59], Study III considered cognitive absorption construct related to flow.

Statistical analysis in Study I determined that the attitude construct influenced the adoption intention construct. The construct of attitude was hypothesized to be impacted by the constructs of social affirmation, perceived effectiveness, and perceived effort. While the impact of the former, too, was supported, the latter hypothesis was rejected. The social affirmation construct can be characterized as a combination of social influence and subjective norms. This construct describes a person's impression of the significance the other people attribute to the intended behavior combined with their anticipation that the person would also engage in the same behavior [5,6]. The person receives approval from family members, friends and/or neighbors, making social influence a significant factor that impacts the person's own impressions as well as intention to adopt Green IS.

Taking into consideration that construct of performance expectancy is a predictor of the construct of attitude in the UTAUT model [40], Study I researched how a comparable construct, perceived effectiveness [52], influenced the construct of attitude. In the researched context, perceived effectiveness indicates the users' impression about the capacity of the Green IS to encourage adoption of sustainable behavior. Understandably, if the users do not recognize the effectiveness of the app, their attitude towards adopting the Green IS will be negative. In the above mentioned theoretical models of adoption, perceived ease of use (TAM [41]) and effort expectancy (UTAUT [40]) are similar and essential in predicting intention to use a system. While the perceived ease of use concept defines how effortless using the system seems to be [41], effort expectancy is the amount of struggle related to engagement with a system [40]. Data analysis of Study II confirmed that the attitude construct was statistically significantly influenced by different external, internal, and introjected perceived loci of control and had an impact on the adoption intention construct. Study III data analysis showed that cognitive absorption predicted intention to adopt the Green IS app. Moreover, in Study III, only two constructs from the PSD model [8], namely, dialogue support and credibility support constructs, influenced the construct of cognitive absorption. Finally, it was observed that the primary task support and social support constructs were influenced by dialogue support construct in all studies, while credibility support was influenced by dialogue support in Studies II and III.

4.2. Perceived Persuasiveness and Green IS

Studies I and III focused on researching perceived persuasiveness of Green IS. Intended persuasiveness, i.e., a degree to which persuasive capacity is incorporated in the design of the system, describes attempts of the system to convince a user to pursue behavior change. Consequently, perceived persuasiveness is the extent to which this capacity is utilized, i.e., the degree to which the system is able to convince the user. After persuasive information is sent to the recipient, recognized, and handled, it can change the receiver's attitude to the desired viewpoint [60]. If appropriate conditions exist, the modified attitude can result in changing behavior. Hence, when attitude or behavior is altered in a desired manner, persuasion is effective. Attitude is also viewed as a representation of an evaluative integration of reasoning, which affects interactions with the environment [60]. Referring to the previous research [51,61], Studies I and III defined perceived persuasiveness as a person's positive evaluation of the system. It was hypothesized in Study I that the constructs of primary task support, dialogue support, and social support influence the construct of perceived persuasiveness. The reason why credibility support was not hypothesized as one of the causal variables is because the persuasive Green IS application used in the study did not have distinct credibility support persuasive features. The hypothesis about the impact of the primary task support construct on the perceived persuasiveness construct stemmed from a notion that the users perceive a system as more persuasive if the system assists the users

to carry out the desired habits. Additionally, the hypothesis about the influence of the dialogue support construct on perceived persuasiveness construct was grounded in findings of the previous studies [51,61]. The hypothesis about the relationship of the social support construct and the perceived persuasiveness construct was formed because oftentimes views of family, friends, and acquaintances influence opinions of an individual on persuasive Green IS adoption and engagement in sustainable behavior [62]. Moreover, some individuals are more prone than others to modify their behavior in order to match the behavior of the people in their community [63]. The hypothesis about the influence of the perceived persuasiveness construct on the adoption intention construct was formulated in Study I based on finding of the previous studies [51,61].

Study III postulated that constructs related to all persuasive categories, together with the construct of cognitive absorption, influence the construct of perceived persuasiveness. Since users of mobile applications are inclined to displaying immersive habits during the engagement with their smartphones, a relationship between the construct of cognitive absorption and the construct of perceived persuasiveness was assumed, suggesting that cognitive absorption is an essential part of using a persuasive Green IS application. Furthermore, a concept of flow, which linked to the construct of cognitive absorption, was shown to impact formation of attitudes and customer experiences [64]. Similarly to Study I, Study III suggested that perceived persuasiveness influences intention to adopt a persuasive Green IS application.

Unlike it was hypothesized in Study I, only the construct of primary task support (and no other persuasive system constructs) significantly influenced the construct of perceived persuasiveness. This result, divergent from the prior research as well as from Study III, might be a consequence of the set-up of the study, including the persuasive Green IS application that was used. It is likely that the primary task support principles present in the application were sufficient for the survey participants to find the application convincing. Furthermore, because of the pervasive availability of interactive mobile applications, the study participants might not consider that the application is convincing (perceived persuasiveness) based on interaction with both the application and its other user. This finding also proves that persuasiveness of the system does not depend on the number of implemented persuasive principles in a system, and that the presence of too many of the principles can even cause decline in perceived persuasiveness [25].

In Study III, the construct of perceived persuasiveness was influenced by only one persuasive category construct, namely, dialogue support, demonstrating that interaction between the application and the user does make the system seem more convincing. Similarly to Study I, the constructs of primary task support and social support (similarly to Study I) did not show a statistically significant impact on perceived persuasiveness. This outcome can be attributed to the persuasive Green IS application used in the Study III. Additionally, because the respondents were highly environmentally aware, they probably were familiar with which actions to engage in, thus they relied less on primary task support offered by the application, and in turn did not find primary task support features to contribute to the persuasiveness of the application. Statistical insignificance of the impact of the construct of credibility support on the construct of perceived persuasiveness may be attributed to the application users' unwillingness to examine how credible the application is, i.e., the credibility of the application may be established in the users' minds as long as it is visually similar to other credible applications the users are already familiar with. Consequently, the credibility support category did not strengthen or weaken the users' perception of persuasiveness of the system. Similarly to Study I, an overwhelming amount of interaction with technologies in everyday life could have adversely influenced the respondents' perception of the application causing the social support category to have no impact on perceived persuasiveness of the application.

As hypothesized in both Studies I and III, the construct of adoption intention was influenced by the construct of perceived persuasiveness. Moreover, in both studies, the construct of perceived persuasiveness was the strongest causal variable of adoption intention construct among all other predictor variables, specifically, attitude in Study I, and cognitive absorption in Study III.

4.3. Impact of Motivations on Green IS Adoption

Up-to-date, external stimuli has been viewed in the IS literature as one of the main causes of motivations [56]. Nevertheless, not only the stimuli themselves, but also the emotional subjective meanings of the stimuli, as well as autonomous or controlled kind of motivation, have also been found to be significant [65]. Study II presumed that PSD could be used as a tool for influencing people's motivations and resulting in encouragement of Green IS adoption. The organismic integration theory (OIT) [65] was included in the theoretical background of Study II, since this theory has been commonly used to describe the perceivable level of self-determination in behavioral intention. OIT aims to clarify how the users' experiences and/or feelings affect the users' intentions and behaviors. OIT supports the view that individuals' behaviors are initiated by the individuals themselves meaning that the individuals' behaviors are volitional [65]. Hence, OIT interprets stimuli not as direct causes of the individuals' behaviors but rather as opportunities and affordances used by individuals to meet their own needs. To clarify if the users of a system feel independence and/or external coercion, OIT investigates mental conditions of the users using perceived locus of causality (PLOC). PLOC describes the relative autonomy of behavior because it stands for the extent to which the individuals commence behaviors and stand by them [55]. Individuals' feelings affect behavior, with or without outward pressure, meaning that individuals can experience obligation even without environmental influences (e.g., acting because of feeling accountable or guilty, instead of behaving by their personal volition). Consequently, OIT states that the individuals' senses of own will and coercion depend on PLOC instead of external stimuli. OIT characterizes the range of feelings from independent choice to pressure as internal and external PLOCs, as well as highlights introjected PLOC. Introjected PLOC describes a joined simultaneous impact of independent decisions and outside influences on an individual's actions while the individual prefers to behave alternatively to what an external source requires.

Analysis of the impact of constructs related to PSD on constructs representing various kinds of motivations showed that the internal PLOC construct was not influenced by any of the persuasive categories constructs. The implication to be drawn from this finding is that internal PLOC is difficult to be changed since it is a representation of the individual's personal disposition. The constructs of dialogue support and social support influenced the construct of introjected PLOC. This finding suggests that communication with a persuasive Green IS application, as well as with the other users of the same application, affects the user's motives even if they are misaligned (i.e., introjected) with the individual opinions. The construct of external PLOC was influenced only by the construct of credibility support, indicating that the impact of the external control on the individual's behavior varies based on the perceived authenticity and dependability of the persuasive Green IS application.

Hence, none of the PLOC constructs influenced the construct of primary task support. In the meantime, the construct of dialogue support influenced the construct of introjected PLOC, as well as constructs representing the rest of the persuasive categories. This finding underlines the significance of establishing efficient communication between the application and its users in order to reach the established behavioral goals with the application. The analysis of the interaction of the PLOC constructs and the construct of attitude towards the persuasive Green IS application suggests that all PLOC constructs are related to the construct of attitude in a statistically significant manner. The internal PLOC construct has the strongest impact on the construct attitude compared to the other two PLOC constructs; comparatively, the construct of the introjected PLOC shows the weakest influence on the construct of attitude. Consequently, the construct of attitude displayed a strong statistically significant connection with the adoption intention construct.

4.4. Gamification and Cognitive Absorption in Persuasive Green IS

Study III focused on researching these concepts in relation to Green IS adoption intention, since the PSD model and gamification are known for assisting people to form and to change behaviors. In Study III, constructs of perceived persuasiveness and cognitive absorption were viewed as important aspects for reaching the intended behavioral results. Previous research has suggested gamification strategies are

powerful at capturing people's attention and enhancing motivation. These strategies are characterized as "simpler, easier, sustainable, and fun ways to develop healthier habits based on behavior-change psychology, alternative reality games, and quantified self-methods and techniques" [18] (p. 199). Combined with gamification, social web and mobile applications have augmented possibilities of using game-like social experience for multiple users that can happen live [18]. Unlike persuasive systems that are focused on the overall attitude or behavior change, gamification is concentrated on invoking users' intrinsic motivations [66]. Since gamification techniques are considered to be efficient at triggering alterations in habits, pro-environmental behaviors (e.g., waste separation [67] or reduction of energy use [68]) have already been facilitated by these techniques. For instance, ranking lists have been used so that the users could compare their own performance with the others, and thus competing in reducing the energy use or increasing sustainable transportation use [69]; graphic aids (e.g., a growing or fading tree) have been employed to visualize the extent to which peoples' mobility patterns affect the environment [70]. Even though gamification plays an important role in persuasive systems, it does not cover all available persuasive principles [71].

Since gamification is often merged with functional systems without changing the practicality of the systems [72], gamification can be defined as: "the incorporation of game elements into a target system while retaining the target system's instrumental functions" (p. 1013). Additionally, two types of outcomes of gamified systems have been identified, namely experiential and instrumental [72]. The instrumental outcomes stem from the enhancement of the achieved results with gamification techniques, while experiential outcomes are achieved by providing enjoyable user experiences, such as flow, cognitive absorption, enjoyment, joy [52], attention, arousal, etc. Study III considered the following experiential outcomes:

1. Cognitive absorption, viewed as a criterion for evaluation of engagement with the persuasive Green IS application;
2. Perceived persuasiveness, viewed as a criterion for evaluation how convincing the user's find the persuasive Green IS application.

Cognitive absorption is a complex construct that grounds on several concepts, namely, absorption [73], flow [74], and cognitive engagement [75]. Absorption is a disposition or trait of an individual, i.e., an essential measurement of character that results in complete focus, during which all cognitive resources of a person are preoccupied with the object of attention [73]. Flow was characterized as "the holistic experience that people feel when they act with total involvement" [74] (p. 36), which includes merging action awareness, centering of attention, loss of self-consciousness, feeling of control, coherent and noncontradictory demands, and autotelic nature. Cognitive engagement relates to the condition playfulness and comprises intrinsic interest, curiosity, and attention focus [75]. The elements of the cognitive absorption construct came from the definition by [52], who defined cognitive absorption as "a state of deep involvement with software" (p. 673) composed of temporal dissociation, focused immersion, control, curiosity [74,76], and enjoyment [77,78].

The cognitive absorption construct was hypothesized to be a predictor of the perceived persuasiveness construct. This hypothesis was built on a premise that a person views the application as more convincing if the person is absorbed in engagement with the application. The constructs of dialogue support and credibility support related in a statistically significant manner to the construct of cognitive absorption. This indicates that the condition of intense engagement with the persuasive Green IS application is influenced by both authority and trustworthiness of the application and communication of the individual and the application. The constructs of primary task support and social support did not show an influence on the construct of cognitive absorption. This implies that deep engagement with the application does not depend on the application's support with fulfilling the primary task, nor on the communication with the other users of the application. Furthermore, comparing the impact of the perceived persuasiveness construct with the impact of the cognitive absorption construct, the former one showed a stronger influence on the construct of adoption intention.

Nevertheless, the implications of Study III suggest that gamification design can benefit from using the PSD model as an implementation tool.

4.5. Limitations of the Studies

Although the reviewed studies contribute to the new knowledge, future studies should be conducted in order to address limitations present in the discussed studies. One of the improvements could be a modification of the research methods in such a way that a long-term behavior of the Green IS users is being addressed. The survey respondents in Study I were familiarized with the researched Green IS by watching a video overview of the app. Whereas this approach does describe the functionality of the app, a personal use of the app can provide other insights. Study II did not use any particular application in order not to bias the survey responders, allowing to exercise the individual judgement on what a Green IS should look like. In Study III, the participants were briefly introduced to the Green IS so their responses, as well as data analysis, reflected only a short-term encounter with the system. Thus, the actual behavior change was not captured in the discussed studies. Furthermore, future research of Green IS adoption can benefit from alternatives to survey data collection methods. For instance, interviews, focus groups, or experiments are likely to offer different insights. We also recommend conducting mixed-method longitudinal studies in order to research how the influence of the persuasive techniques changes in the long term. Although the studies analyzed in this article did not employ actual confirmatory theory-testing techniques, the methods used in these studies build a foundation for the future implementation of theory-testing research. Furthermore, the analyzed studies used exclusively only PLS-SEM data analysis techniques; therefore, other quantitative method approaches could be employed in data analysis to provide important new insights. Future studies can also explore different correlations among constructs, as well as construct development to enhance the existing measures. Moreover, improving the obtained findings could be achieved by connecting concrete persuasive features to quantitatively measured behavioral changes.

4.6. Future Research Ideas

Apart from employing research approaches to address current limitations in these studies, the research of Green IS for fostering sustainable behavior should be developed beyond the focal theme discussed in the reviewed papers. For example, the following related prospective research questions can be investigated: (1) Is a longer period of using a persuasive Green IS application associated with an increase in sustainable behavior? (2) Which categories from the PSD model are the most helpful in encouraging sustainable behavior? (3) Are there multiple ways of integrating persuasive features in persuasive Green IS applications? (4) Does the influence of the persuasive categories alter over the course of the persuasive Green IS application adoption process? (5) Can a long-lasting sustainable behavior change be achieved with the help of persuasive Green IS applications? (6) How to keep people engaged with a persuasive Green IS over the extended period of time while maintaining unobtrusiveness? (7) How to achieve cognitive absorption in persuasive Green IS without causing technostress?

5. Conclusions

Researching environmentally friendly behavior change is a relevant subject since it has a straightforward link to the much-needed societal sustainable development. Besides behavior change being a challenge in itself, an additional difficulty at achieving sustainable habits emerges because of the type of this specific behavior change. That is, an adverse influence of individuals' unhealthy behaviors on the individuals' overall well-being is easier to observe than a negative impact of individuals' unsustainable behavior. Since Green IS is one of the means of stimulating environmentally sound behavior, a greater awareness of tactics that facilitate Green IS adoption is necessary. This article reviewed a set of three studies that focused exclusively on the PSD model and individual users' intention to adopt Green IS in a nonorganizational context. These studies presented and discussed

suggestions for researchers and practitioners on implementation of the PSD principles in Green IS to facilitate pro-environmental behavior change through increasing adoption of Green IS. Furthermore, persuasive Green IS solutions could be used for sustainable development in communities if endorsed by local authorities.

This article provides several contributions. First, it continues previous scientific exploration of the mediating influence of technology, specifically persuasive, on the relationship between human behavior and environment. Additionally, it presented a theoretical overview of persuasive systems design, Green IS, and IS adoption. The article identified and discussed multiple empirical papers on Green IS mobile applications. Finally, major themes and implications for the future research of persuasive Green IS applications were extracted from the selected studies. Summarizing the implications supplements prior research and contributes to academics studying facilitation of pro-environmental behavior with the help of persuasive Green IS applications. Designers and developers of persuasive Green IS applications can also benefit from learning about users' adoption intention and factors that influence it. Information systems provide tools for guiding the users in achieving certain goals; however, system adoption, continued use, and regular interaction with the system also depend on the seamless integration of the system in the users' daily routines. Furthermore, persuasive Green IS applications should be able to keep the users motivated as this encourages adoption of the application, together with reaching behavior change targets. Incorporating gamified persuasive techniques was also found to influence cognitive absorption and perceived persuasiveness, allowing the users to form adoption intentions regarding behavior changing applications. All in all, the theoretical concepts, the created research models, and the proposed extended framework extracted from the existing studies could be applied and examined in other conditions, for example, increasing the sample size, inviting participants with more diverse backgrounds, using other persuasive Green IS applications, or exploring long-term use of persuasive Green IS applications systems. Moreover, experimental studies that explore connections between persuasive categories or features and behavioral changes could be carried out.

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