Motivation Enhancement in mHealth via Gamification

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***Abstract*—The lack of therapy compliance (adherence) is an already well-studied phenomenon in the health sector. It is known that numerous factors can influence regular medication intake. A promising approach for increasing therapy compliance are patient-related factors. In order to increase motivation, Gamification-based approaches have already been selectively tested here. However, the number of mHealth applications using the potential of Gamification in this context in an effective way is limited so far. Our research therefore focuses on game-design-elements (GDE) that are particularly suitable to increase motivation in the mHealth sector. This includes a well-founded analysis of existing studies and applications with the identification of potential Gamification approaches. A novelty here is the use of comprehensive GDEs to increase motivation in the mHealth area. The result is a classification of GDEs according to their effectiveness and a conceptual design on how to apply them effectively, which is implemented prototypically in a progressive WebApp. Finally, the suitability of our approach for generating motivation was assessed through a user survey. The results show a significant influence on the use of GDEs on the development of Flow, and thus on motivation. Differences in the isolated effect of individual game design elements could not be proven.**

***Index Terms*—Adherence; Gamification; Motivation theory; Medication; mHealth**

I. Introduction

Digitization is a continuously advancing process affecting almost all domains in the everyday life [1]. The number of digital offers also increases in the health sector [2]. Already in 2015, the number of mobile available applications exceeded 103,000 in the *health and fitness* and *medicine* categories [3]. The spectrum ranges from simple, general reminder applications to apps that are highly specialized on certain diseases.

According to the world-health organization (WHO), only 50% of all patients comply with their agreed treatment plan in industrialized nations [4]. In case of a lack of adherence, those patients are often confronted with negative health consequences. In addition to individual effects, such as the worsening of the disease, relapses, drug resistance and a concomitant reduction in quality of life, there are also societal risks, such as an increased risk of spreading contagious diseases and economic costs [4].

According to Neckermann and Schinköthe [5], an improvement of adherence is especially in the domain of the patient- and therapy-related factors indicated. Verbrugghe et al. [6] divide the patient-related factors into conscious and unconscious reasons for non-adherence. The conscious factors are those that may have a negative impact on a patient's motivation to take medication, like the lack of motivation or information [7] and are a promising starting point for increasing adherence [5].

Other studies indicate that the majority of younger citizens already owns a smart-phone [8] and has a medium or high interest in e-health [9]. Therefore, the use of digital health-care applications can be one adequate way to get in touch with patients and help them to build adherent habits.

However, there are hardly any studies on the efficacy of these applications [10]. Although the promising possibilities of using digital applications for adherence enhancement are discussed [5], [11], valid long-term studies are still pending. So, while the effect of individual applications could hardly be validated so far, a few application providers already started to use a method for which studies are available: Gamification. It has already been shown that adherent behavior can be significantly increased with the help of game design elements (GDEs) [12]–[14]. However, GDEs so far seem to be used only isolated in applications for adherence enhancement, or their usage is limited to an application for certain diseases.

This work discusses the potential of Gamification in conjunction with mobile health applications and examines the research question, which principles can be used to design and use GDEs in increase the patient's motivation effectively in order to contribute to a better adherence. We focus on patient-related conscious factors in order to generate intrinsic motivation through the incentive of extrinsic motivation and to promote sustainable habitual education. Therefore, we present the following results:

- a categorization to classify GDE according to their effectiveness,
- a concept for the combined use of GDE in mHealth apps in the field of medication intake,

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- evidence of the significant suitability of GDE to support patient compliance through a proof-of-concept based user study.

The rest of the work is structured as follows: Section II introduces the theoretical foundations of Gamification and the theory of motivation, self-determination and the concept of Flow. Section III presents existing solutions in the same problem area. Section IV defines requirements for GDE use in mHealth and shows our concept for the effective use of Gamification An example implementation and the evaluation are described in Section V. Section VI finally provides a summary and outlook on further research.

II. Gamification for therapy compliance

We focus on the definition of Sailer [14] for *Gamification*:

> *"Gamification is a process of playfully designing activities in a non-game context through the use of game design elements."*.

Gamification can be used both to generate motivation and in the mHealth area to achieve a more regular medication intake. In general, the term motivation refers to those psychological processes that serve to initiate, direct, and sustain mental and physical activities [15].

A. Self-determination theory

The basis for this is the self-determination theory according to Deci and Ryan [16]. They postulate three basic psychological needs, which are innate, universal and pursuited by the human psyche. These are:

- competence
- relatedness
- autonomy

According to this, every person strives to interact effectively with their social environment and gain a sense of confidence and effectiveness in their own actions (competence), to feel connected to a social structure and other people (relatedness), as well as acting to their own interests and values (autonomy) [16]. Furthermore, Deci and Ryan [17] distinguish between intrinsic and extrinsic motivation. Intrinsic motivation refers to the performance of an activity on the basis of its own inherent satisfaction, while extrinsic motivation requires behavior directed towards a result that is separable from it.

B. Flow

Regarding the maintenance of motivation, supplements from the Flow theory according to Csikszentmihalyi et al. [18] are considered as an extension. They provide a psychological explanatory model for behavior that is repeatedly demonstrated and maintained despite the lack of extrinsic rewards, and thus corresponds to intrinsically motivated behavior according to Deci and Ryan [17]. Flow describes a subjective state in which an individual is engrossed in an activity and forgets about time, fatigue, and everything else apart from the activity itself [18]. The central elements of Flow are [19]: merging of action and awareness, centering of attention, loss of reflective self-consciousness, sense of control over action and environment, demands for action and clear feedback and autotelic nature of action.

In order to effectively use Gamification to increase motivation, it must meet the requirements of self-determination theory according to Deci and Ryan [16] and allow Flow [20]. Thus, through the proper use of GDEs, which generates Flow, the basic needs for autonomy, competence, and social inclusion can be satisfied and intrinsic motivation generated.

C. Review of game design elements

In the following, we examined various GDEs for their suitability for generating Flow. A rating was done in five different gradations. The criteria used for this are derived from the central elements of Flow in Section II-B. Elements, which contribute without restriction to the generation of Flow are marked as *"conducive"*. Once certain prerequisites have to be fulfilled for an element to be supportive, it is considered *"conditionally conducive"*. Elements that have no influence on the respective Flow aspect, are rated with *"no effect"*. Elements representing an obstacle under certain conditions are considered as *"conditionally obstructive"*, and elements that generally have a negative effect on Flow are marked as *"obstructive"*. Figure 1 shows a summary of the review.

Flow \ Game-design-elements	Avatar	Badges	Leaderboards	Progression	Performance graph	Levels	Missions	Narrative	Points	Team leaderboards
Centering of Attention	(✓)	(✓)	o	o	o	(✓)	(✓)	(✓)	(✓)	o
Loss of self-consciousness	(✓)	(✓)	o	o	o	(✓)	(✓)	(✓)	(✓)	o
Sense of control	(✓)	(✓)	(✗)	(✓)	(✓)	(✓)	(✓)	o	(✓)	o
Demands for action	(✓)	✓	✓	✓	✓	✓	✓	(✓)	✓	✓
Feedback	(✓)	✓	✓	✓	✓	✓	o	(✓)	✓	✓
Autotelic	✓	✓	(✓)	✓	✓	✓	(✓)	(✓)	✓	(✓)

✓ conducive (✓) conditionally conducive o no effect
✗ obstructive (✗) conditionally obstructive

Fig. 1. Assignment of GDEs to central Flow criteria.

D. Categorization and Summary

Figure 1 shows that GDEs are well suited to generate and maintain Flow, but not all equally and easily. The rating in the previous section allows to classify different GDEs into three categories, as shown in Table I.

GDEs, which can be used in principle for all areas of Flow and have no negative effects on motivation, even in an implementation not focusing on flow, are grouped into category I and are thus to be used preferentially.

If certain GDEs do not expect a positive effect on individual Flow aspects and, at the same time, have no negative effect,

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TABLE I. CATEGORIES OF GAME DESIGN ELEMENTS

Category	Description	Game design elements
I	for all aspects of Flow (conditionally) conducive	avatar, badges, levels, points
II	for no aspect of Flow (conditionally) obstructive but also not for all aspects (conditionally) conducive	progression, performance graph, missions, team leaderboards
III	for a minimum of one aspect of Flow (conditionally) obstructive	leaderboards

they are assigned to category II. A use of these elements is nothing to oppose.

Category III includes those GDEs that can negatively affect at least one area of Flow. In motivational applications, the use of such elements should be avoided whenever possible.

In addition to the right balance between the skills of the user and the requirements of the application, a sensory overload has to be avoided and a clear set of rules has to be implemented. GDEs should not only be used for their own sake, but always with regard to the intended effect on the user and taking Flow and self-determination theory into account.

III. RELATED WORK

Various papers provide an overview of existing applications for increasing adherence and their effectiveness. A good first overview in this area offers [11]. But there is no focus on Gamification. Other work shows the use of Gamification for increasing motivation [14], [21] without considering the use for increasing adherence.

The most advanced approaches are the use of Gamification with single diseases, such as diabetes [12], [13] with the disadvantage of a very small target group. So, in lack of a broad scientific basis the following analysis refers to existing applications.

Prerequisite for the selection of an application for closer examination are the support with medical adherence and the use of GDEs. Thereby 11 applications where found within the categories reminder applications, applications for building habits, to convey information and for life-logging. Out of these only 4 where to be considered. This is because to the fact that the others where not longer available or at least not available in Europe. The remaining 4 applications are Asthma Action Hero, Habitica, Mango Health and MySugr.

Asthma Action Hero and MySugr are specialized to certain diseases and Habitica is not designed for medical purposes but highly gamified and customizable enough for the intended use. Figure 2 shows the results of the analysis using the requirements introduced in Section IV-A.

The advantage of the introduced concept in this work is the full consideration of all needed aspects to increase medical adherence by using Gamification with a wide target group. So the providing of disease related information, a scientifically founded approach for generating and maintaining motivation and also functional requirements are taken into account.

Requirement / Application	A-1: Information	A-2: Motivation	A-3: Functions	Overall evaluation
Asthma Action Hero	○○○	●○○	○○○	○○○
Habitica	○○○	●●●	●○○	○○○
Mango Health	●●○	●●○	●●○	●●○
MySugr	○○○	●●○	○○○	○○○

Fig. 2. Rating of Existing Applications.

IV. CONCEPT

Patients-related, conscious factors for non-adherence are a promising starting points for improving adherence to therapy. By adequately communicating facts, the lack of information can be reduced as a motivation obstacle. Furthermore, generated and already existing motivation must be sustainably maintained.

The requirements to be met derive from the foundations of self-determination theory according to Deci and Ryan [16], Flow according to Csikzentmihalyi et al. [18] and the study of GDE in Section II.

A. Requirements

Below is a list of requirements for an mHealth application that uses Gamification to generate motivation and Flow to improve adherence.

A-1: Mediation of disease-related information

A-2: Generating motivation

- **A-2.1:** Faciliating Flow
  - **A-2.1.1:** Centering of attention is made possible
  - **A-2.1.2:** Loss of reflective self-consciousness is made possible
  - **A-2.1.3:** Sense of control over action and environment is made possible
  - **A-2.1.4:** Demands for action are generated
  - **A-2.1.5:** Clear and direct feedback is given
  - **A-2.1.6:** Autotelic use is made possible
- **A-2.2:** Principles of self-determination theory are considered
  - **A-2.2.1:** Feeling of competence is made possible
  - **A-2.2.2:** Feeling of autonomy is made possible
  - **A-2.2.3:** Feeling of relatedness is made possible

A-3: Functional requirements

- **A-3.1:** Individual medication input possible
- **A-3.2:** Reminder function available

B. System components

This results in three essential services that must be taken into account when designing an application concept:

- Fulfillment of functional requirements,
- Generation of motivation and
- Education and information transfer.

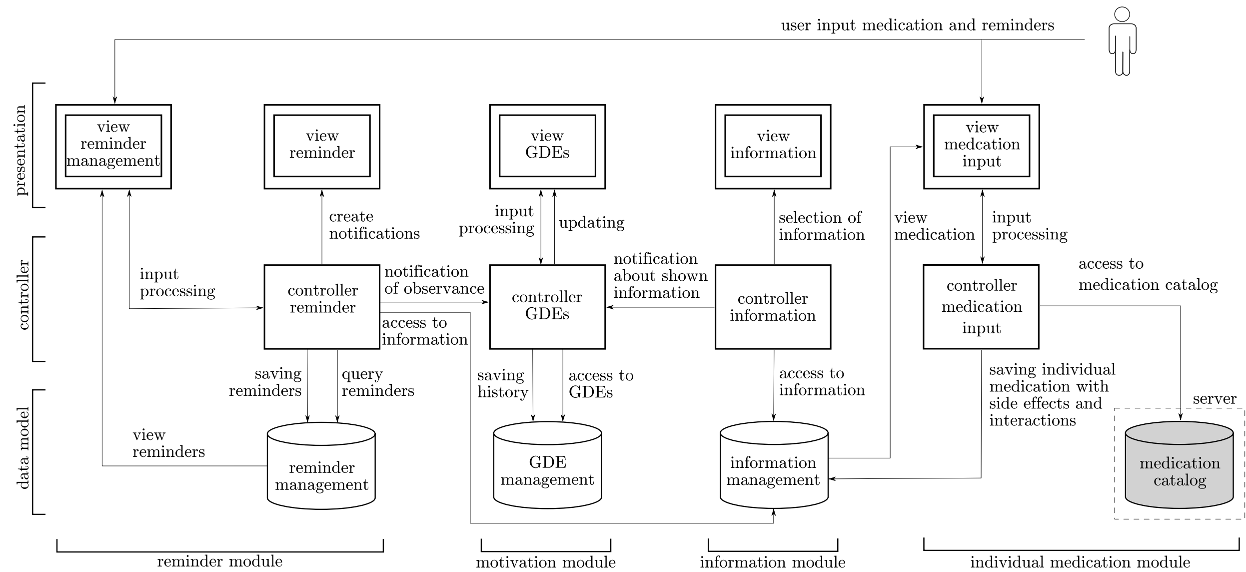

Fig. 3. Application Modules as a Complete System with Layers of the MVC Pattern.

This allows a modularization and thus separation of responsibilities based on the Model-View-Cotroller pattern (MVC). The range of functional requirements may still be further divided into the subcategories of the individual medication input and the reminder function. Figure 3 provides an overview of the application modules as a complete system. The following describes the functionality of each component.

1) Reminder module: The reminder module at the presentation layer level consists of the reminder administration view for entering the reminders and a reminder component for notifying the user of the due date of a scheduled medication and a demurring stock of medicine. The user inputs and reminders are processed by the control layer of the module. It also contains interfaces for storing and querying medication times in the data model layer, as well as for communicating with the controller of the GDEs.

2) Motivation module: The motivational module includes the presentation of the GDEs, their processing in the control layer, and the management of the GDEs in the data model layer. The controller of the GDEs has interfaces for communication with the controller parts of the reminder and information module in order to be able to process information about (non-) compliance with the deadlines and the information already presented. Application usage history data, such as obtained *points* or *levels*, is stored in the management part and retrieved from the control layer as needed.

3) Information module: The information module is responsible for the storage, selection and presentation of disease-related information. The drug-specific information on the interactions and side effects of the drugs entered are read from the control section of the module for individual drug input via the network from a corresponding database. Subsequently, this data is stored locally in the data memory of the information module. Furthermore, the module has an interface to the control layer of the motivation module at the level of the control layer. The content of the information module is divided into a learning part and a *quiz* part. In the learning part, the information is presented, while in the *quiz* section, this information is consolidated with the support of GDEs.

4) Individual medication module: In the presentation layer, a user interface is provided for individual drug input, alternatively, a barcode scan allows direct reading of the medication. The control layer of the module realizes the remote access to the drug catalog and the storage of the data at the level of the data model layer in the information module.

5) Cross-module content: To facilitate the use of the application, an optional tutorial is helpful. As an introduction to the functionalities and operation of the app, this must cover all modules in terms of content. The usage of tooltips is encouraged, which appear next to the corresponding buttons when first used. Overall, the design of the application should also take into account the guidelines of ISO 9142-10 *"Principles of Dialog Design"*.

C. Selection of Game Design Elements

Not all GDEs are equally suitable for all purposes. Furthermore, the combination of certain GDEs may result in a more immersive user experience as they complement and support each other. The use of *points* makes it easy to see a *level* progress, *badges* can easily be used hand in hand with a *progress bar* and for visualizing *missions*. There are multiple possibilities in the design and the combination of the individual GDEs.

Due to their particular suitability, all GDEs from *category I* are selected for use in the proof-of-concept (*points*, *badges*, *levels*, *avatars*). In addition, to improve and expand the interaction of the GDEs, from *category II progress bar* and *performance graph* are used.

The overall concept is based on the targeted use of the GDEs to generate Flow, taking account of the self-determination

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theory. A novelty here is the use of comprehensive GDEs to increase motivation in the mHealth area.

V. Evaluation

To evaluate the fulfillment of the requirements from Section IV, an empirical analysis was carried out as a user survey with non-experts and an online questionnaire with explicit research questions, including a demonstrator.

The main component of the demonstrator is the implementation of the motivational module to test the interaction of the various GDEs to generate Flow. The implementation of the special functional requirements of reminders and medication input has been put into the background. Likewise, the module of information transfer is implemented only to the extent necessary to clarify the interaction with the motivation module.

The implementation is based upon React + Bootstrap and was done as a progressive web app and single-page application. A working version of the demonstrator can be found here (July 2019): https://www.purl.org/net/vsr/gamification.

A. Hypotheses

The following falsifiable hypotheses served as basis for the operationalization:

- Hypothesis I: *All GDEs used in the demonstrator are equally suitable for generating Flow*.
- Hypothesis II: *The development of Flow is not possible with the GDEs used in the demonstrator*.

Variables and indicators were defined and questions were formulated for the survey to prove these hypotheses. The most relevant questions from the survey are listed in Table II.

TABLE II. Selection of survey questions

No.	Question
5	How concentrated did you feel during application usage?
6	Did you think of anything else than the application during application usage?
7	How understandable did you find the context of the application?
8	How strong was your feeling in controlling the application?
9	How well did the application respond to your input?
10	How intuitive did you find the application control?
11	How motivating did you find the following items when using the application?
12	How necessary do you consider the following application elements to motivate you to take your medication?
13	How much did you feel motivated by the following elements to try the application further?

B. Results

In total, 91 people participated in the online survey over a 14-day period. Of these, 53 completed the questionnaire. The age range of the participants was between 18 and 75 years, focusing on the age group 26 to 35 years. The proportion of female participants was 69.81% (37 people), the male gender was 28.30% (15 people), and one person did not specify their sex. Of the 53 participants, 43 (81.13%) stated that they had already taken medication or did so regularly.

When testing for Flow, the mean of all answers to each question is above the expected mean ($p < 0.01$) as shown in Table III. This shows that the GDEs used in the demonstrator are able to produce Flow. Thus, Hypothesis II is refuted and the premise for Hypothesis I is met.

TABLE III. Pearson Chi-Square-Test of the Flow Related Questions

Question number	μ	σ	χ^2	α
5	3,68	1,09	47,14	0,001
6	1,89	0,32	31,72	0,001
7	3,47	1,01	17,24	0,01
8	3,53	1,01	23,49	0,001
9	3,85	1,05	75,93	0,001
10	3,72	1,03	47,93	0,001

TABLE IV. Friedman-Test for the Game Design Element Related Questions

No.	GDE	μ	σ	χ^2_F	α
11	Avatar	3,28	1,24		
	Points	3,23	1,15		
	Badges	3,38	1,20		
	Performance graph	3,32	1,12		
				3,86	$> 0,05$
12	Avatar	3,02	1,38		
	Points	3,16	1,23		
	Badges	3,19	1,48		
	Performance graph	3,57	1,34		
				6,48	$> 0,05$
13	Avatar	3,15	1,34		
	Points	3,00	1,27		
	Badges	3,28	1,34		
	Performance graph	3,13	1,23		
				0,46	$> 0,05$

Further questions served to examine differences in the effect size of the individual GDEs in the generation of motivation. However, the Friedman used showed no significant difference in the evaluation of the individual GDEs by the subjects ($p > 0.05$) as depicted in Table IV.

With the help of the user survey could be shown that through the use of the tested GDEs, as provided in the draft concept, Flow is enabled. From this, the usability of GDEs to increase motivation in medication adherence was derived. Hypothesis II could be falsified with the results of the survey, Hypothesis I on the other hand not.

However, the assumption of the different effects of the GDEs has not been confirmed. A possible explanation for this is that the effect on motivation is significantly dependent on the combination of the GDEs and their interaction in the field of dynamics, rather than on the individual elements. From this, it can be deduced that GDEs should not be used in isolation, but rather develop their effect in interaction with other GDEs. An affirmation of this thesis would also support the requirements created in Section IV.

One last question was aimed at the general acceptance of the demonstrator by the respondents. Of the 53 respondents, 34 (64.15%) stated, they would consider using a full version of the demonstrator when taking their own medication. The Pearson Chi-Square-Test shows a significant deviation ($p < 0.05$) of the actual distribution towards the readiness for use with an expected equal distribution.

VI. Conclusion and Future Work

The task and objective of this work was the analysis and testing of which GDEs are particularly suitable for increasing motivation in the mHealth domain. The focus was on increasing medical adherence.

First of all, a rating scheme for GDEs was designed, followed by categories for classifying GDEs and application concept requirements. Appropriate GDEs were considered to be *points*, *badges*, *levels*, *progress indicators*, *avatars*, and *performance graphs*. As a result, a WebApp was implemented as a proof-of-concept, including the conceptual motivational module. This demonstrator was tested by a user survey.

We found that using GDEs enables Flow. From this, the usability of the tested GDEs can be derived to increase motivation in the use of medication intake. However, the various GDEs studied are not significantly different in their individual effect on user motivation.

Further future research is indicated. In this work, we focused on the motivation module. For a more comprehensive evaluation and assessment of the concept, the implementation of a full-featured prototype, including an information module and other functional requirements, would be expedient. As part of the user survey, no impression of the duration of effect on the user motivation could be obtained. However, medications often have to be taken over a longer period of at least several days. To evaluate the long-term motivation, a study over a longer period would be necessary. To improve the long-term motivation, an extension with additional GDEs like *missions* or a *narrative* could be useful.

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