Strategies for Playful Design when Gamifying Rehabilitation. A Study on User Experience

Oliver Korn
Offenburg University
Badstr. 24, 77652 Offenburg, Germany
oliver.korn@acm.org

Stefan Tietz
Offenburg University
Badstr. 24, 77652 Offenburg, Germany
stietz@stud.hs-offenburg.de

ABSTRACT
Gamifying rehabilitation is an efficient way to improve motivation and exercise frequency. However, between flow theory, self-determination theory or Bartle's player types there is much room for speculation regarding the mechanics required for successful gamification, which in turn leads to increased motivation. For our study, we selected a gamified solution for motion training (an exergame) where the playful design elements are extremely simple.

The contribution is three-fold: we show best practices from the state of the art, present a study analyzing the effects of simple gamification mechanics on a quantitative and on a qualitative level and discuss strategies for playful design in therapeutic movement games.

CCS Concepts
• Human-centered computing~User studies • Human-centered computing~Usability testing • Human-centered computing~ Mixed / augmented reality • Human-centered computing~ Empirical studies in HCI *• Human-centered computing~Field studies • Human-centered computing~User centered design • Human-centered computing~Activity centered design* **• Social and professional topics~People with disabilities • Applied computing~Health informatics** *• Applied computing~Computer-assisted instruction* **• Software and its engineering~Interactive games • Software and its engineering~Virtual worlds training simulations** *• Software and its engineering~Software design engineering*

Keywords
Rehabilitation; Gamification; Playful Design; Exergame.

1. INTRODUCTION
Many aspects in our life are redundant and potentially boring: shopping food, cleaning, and even several routine aspects of work. By using elements from game design, designers try to make such activities more interesting and rewarding. This application of "playful design" is called gamification [11]. While gamification originates from the area of education (serious games), it is also used in sports (games for health, exergames), work [15] and several other everyday contexts.

PETRA '17, June 21 - 23, 2017, Island of Rhodes, Greece

ACM 978-1-4503-5227-7/17/06…$15.00
DOI: http://dx.doi.org/10.1145/3056540.3056550

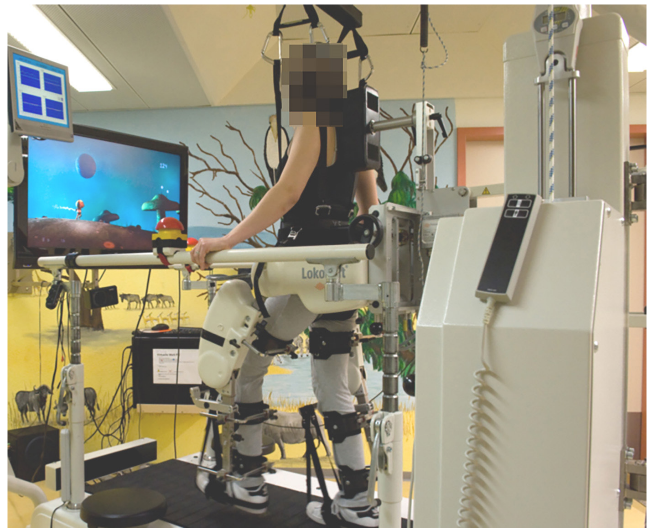

Figure 1: Integrating playful designs and gamification into rehabilitation can improve motivation and shorten the time to recovery. Here: The game *Gabarello* used with the Lokomat Pro. Picture: Zurich University of the Arts, Department of Design.

Rehabilitation is an area, which can profit tremendously from gamification (Figure 1). Typically, patients have to regain basic motoric and often also cognitive capabilities, e.g. moving and coordinating the right arm after a stroke. Due to the preceding accident or illness, the patient often has suffered an emotional trauma, which usually also affects motivation [18].

In consequence, full rehabilitation in many cases is not reached because the patients' attentional focus in reduced and they are not motivated enough to exercise continuously. Several studies have estimated that about 65 percent of patients do not adhere to rehabilitation programs [4]. These numbers get even worse when the rehabilitation program continues at home without regular observation by a therapist. Even without attentional or motivational problems, performing the same movements over and over again is a boring and tedious task for everyone.

Gamification is a well-suited method to enrich such boring exercises and thus ensure rehabilitation. However, how should the playful design process look like? What level of complexity is adequate to increase motivation without losing the focus on the correct movement and risk further damage? In this paper, we first discuss best practices of rehabilitation games in the state of the art (section 2). In section 3, we present a study analyzing the effects of simple gamification mechanics and discuss strategies for playful design in therapeutic movement games.

2. STATE OF THE ART

In this section, we briefly present the development of gamification as well as popular gamification methods. In the following sub-section, we discuss best practices of gamified exergames.

2.1 Gamification: History and Methods

Gamification is an umbrella term for “the use of video game elements to improve user experience and user engagement in non-game services and applications” [11]. However, gamification also is a new term for an established process. In education, gamified systems have been called “edutainment” in the nineties, and later “serious or applied games” [12]. Especially in this context, gamification already has a long tradition. Two recent meta-analyses of serious and educational games [2, 24] provide an excellent overview of definitions, comparison criteria and an extensive analysis of 39 [24] or 40 [2] studies.

After its long-term application, there are several established techniques of gamification. The most common examples are points and badges. Points are the simplest form of quantifying a user’s success and error rate: correct actions earn points while wrong actions may result in a reduced score. Badges are a less granular form of rewarding users – they can be awarded if certain thresholds of points are reached, or for the completion of specific tasks like the 100th post in a forum, 10,000 accumulated flying miles or 1,000 minutes of exercising.

However, methods like points and badges typically only relate to extrinsic motivational factors, so their effects can wear off quickly [7]. In contrast, Csíkszentmihályi’s flow theory [8, 10] focuses on the enjoyment and immersion experienced during a given activity, in a state of intense focus and concentration. Self-determination theory (SDT) is another framework [21] supporting that authentic (or intrinsic) motivation leads to optimal functioning, social development, and well-being. Like flow, SDT has been shown to be an excellent framework to discuss the motivational pull of video games [20] and gamified applications.

Ideally, gamified applications should support both extrinsic and intrinsic motivation. For gamification or gameful design this can be very challenging: in game studies it has been established that there are specific player types, e.g. in the famous model by Bartle [3]. However, collecting points or badges mainly suits the “achiever”. Amongst others there are players who preferably want to interact with other players and develop rich in-game relations (social players), players who want to discover virtual worlds (explorers) or players who just want to immerse themselves in the game and escape the real-life problems (immersion players) [23].

While addressing all of these types in a single game is already difficult, it might be impossible for an exergame and especially for a rehabilitation game: these applications also have to address body movement including potential injuries. Maybe, trying to address all desirable motivating elements is unrealistic in the area of exergames or rehabilitation. An interesting approach in this area is going bottom-up instead of top down, which means starting the design process with evaluating successful rehabilitation games instead of extracting attributes from motivation theories. A recent study based on three open-source games resulted in a clear set of factors that influence the patients’ motivation [19].

This background will provide helpful to judge the level of gameful design currently reached in gamified rehabilitation. In this area, the spectrum of methods used is still comparatively narrow – especially when compared to advanced methods like the user-specific adaptation of playful designs used in established areas of gamification, for example in education [16].

2.2 Gamification in Sports and Health

With the success of natural interaction, fueled by the Nintendo Wii using accelerometers and the Microsoft Kinect using depth sensors, gamification quickly spread to areas where human body motions are of great importance: the most obvious applications being health and sports. Gamified solutions in this area, where an exact control of movements or exercises is essential, are often called “games for health” or “exergames” [5]. Exergames can be used to increase motivation for regular sport activities, e.g. in the gym. However, in many cases they have been used for therapeutic purposes.

Although *motivotion60+* (see Figure 2) focuses on prevention rather than rehabilitation, it is a typical example of a therapeutic exergame [5]. The development goal was preventing falls of senior citizens; such accidents typically result in fractures permanently decreasing the elderly person’s autonomy while generating high costs for treatment and rehabilitation. Like other games for health, *motivotion60+* uses standard gaming hardware, in this case the Microsoft Kinect. As a result, its gamified balance and strength exercises are controlled by body movements only. Since this form of interaction makes a separate controller obsolete, it is also called “natural interaction”.

The movement exercises have been developed in cooperation with sports scientists and gerontologists. The system can adapt to an individual user’s performance (within the typical performance levels of older adults) which allows a comparison of motion-based assistance in health and work contexts [14].

Figure 2: motivotion60+ is an exergame for fall prevention. To increase the acceptance of its elderly users, it uses natural interaction: motion tracking without markers.

Another frequent manifestation of exergames are those developed for a specific medical device. A good example is the game *Gabarello* [17], developed for Hocoma’s Lokomat Pro, a common system for functional robotic gait therapy (see Figure 3).

A team of the Zurich University of the Arts developed the game as an alternative to the standard “motivating augmented performance feedback”. The system aims to “turn therapy into a stimulating, self-motivated, fun experience, supporting both patients and therapists”. While the game is very well designed and visually pleasing, the simple Jump and Run gameplay in spatially confined levels will not address all player types. In a second version, the developers added little tasks and made the levels circular to address these issues. Clearly, this explorative approach shows the artistic potentials of exergame design and serves as a design reference.

Figure 3: ***Gabarello*** **is an alternative immersive gamification for the Lokomat Pro, a system for functional robotic gait therapy. Picture: Zurich University of the Arts, Department of Design.**

An alternative to developing dedicated exergames applications is using commercial games and putting them into a new context or even change the interface. An example for this common approach is an interface to the famous video game *Guitar Hero* based on surface electromyography (EMG). Thus a novel training and evaluation device for upper-extremity amputees was created [1].

While the approaches differ, the positive effects of exergames have been documented since the first days of use: already in 2008, an analysis of efficacy between traditional and video game based balance exercises showed positive evidence for the latter [6]. Seven years later, the effectiveness of "videogame-based rehabilitation interventions on the motivation and health outcomes of stroke patients" has been analyzed in detail again [22]: using a systematic literature review of 18 articles the authors conclude that videogame-based interventions are a promising tool to motivate stroke patients' engagement in effective rehabilitation activities.

3. STUDY

When examining gamification in exergames and especially in rehabilitation, we wanted to investigate a system with wide distribution and simple gamification mechanisms. However, after complex solutions like *motivotion60+* and visually pleasing games like *Gabarello* – why should we focus on simple gamification?

The reason for investigating an example with simple gamification mechanisms leads to an important research question. Flow theory and self-determination theory (SDT) both indicate that permanent motivation requires intrinsic components (see section 2.1). However, it is not evident that this can only be achieved by a complex solution addressing several player types.

It is possible that in rehabilitation (or prevention) exercises, a very simple game can already create a substantial increase in motivation. So important questions for the study are: Do simple gamification mechanisms suffice to increase motivation? What strategies should be applied for playful design in therapeutic movement games?

3.1 Setup

We chose the "HUMAC NORM Testing & Rehabilitation System" (see Figure 4), a universal solution for measuring and improving human performance which is used both in therapy and in training. It is a guided exercising machine offering 22 isolated-joint movement patterns with four resistance modes: isokinetic, isotonic, isometric, and passive [13].

Figure 4: The HUMAC NORM is a universal solution for motion training and analysis used in therapy and in sports. Picture: Fájdalom Ambulancia, Hungary.

The "HUMAC NORM" system was already in use at the place where we conducted the study: the "Ambulant Rehabilitation Center" in Offenburg, Germany.

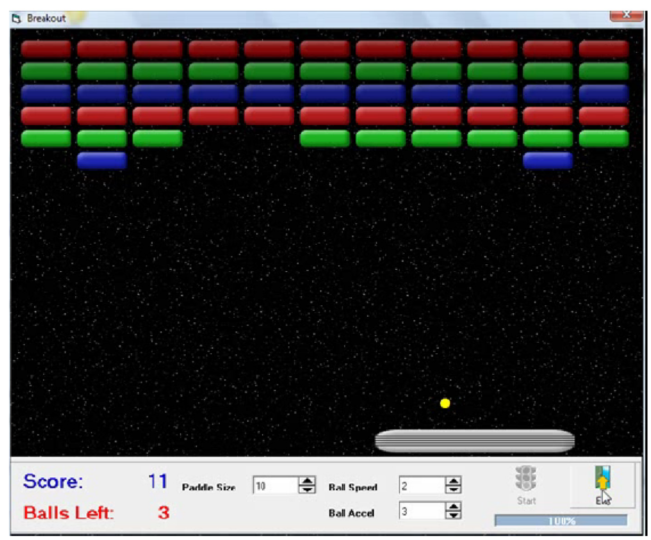

Figure 5: The gamification mechanism of the HUMAC NORM is very simple: it is based on the classic videogame ***Breakout*****. The patient controls the movement of the paddle.**

Its gamification mechanisms (Figure 5) are very simple: it uses a version of the classic 1976 videogame *Breakout* (or a similar classic, the game *Pong*). In the game, a layer of bricks lines the top of the screen. A ball travels across the screen, bouncing off the top and sidewalls. When a brick is hit, the ball bounces away and the brick is destroyed. The player loses when the ball touches the bottom of the screen. To prevent this from happening, the player has a movable paddle to bounce the ball upward, keeping it in play.

The device uses the movement of the patient to control the movement of the paddle. The therapist can adjust the size of the paddle, as well as the speed and the acceleration of the ball to adapt the challenge.

3.2 Population

The population consisted of 22 patients in rehabilitation. They had problems with different body parts: knee (14), shoulder (4), and hip (4). Thirteen patients were male and nine female with a mean age of 47.4 years (Standard Deviation SD = 17.7 years, Median M = 47.5 years).

3.3 Data Gathering

We used a deliberately simple questionnaire based on a five-point Likert scale with just four statements:

1. The training with the device without games is fun.
2. The training with the device with games is fun.
3. The training with the games improves my rehabilitation success.
4. The training with the games improves my motivation.

For those patients who also had to do rehabilitation exercises at home (15 of 22 subjects), we added three additional statements:

5. The training at home is fun, too.
6. I would prefer training with games at home, too.
7. If I could train with games at home, I would train longer.

Additionally, to gain qualitative data, we conducted interviews with several patients as well as with the medical head of the rehabilitation center.

3.4 Quantitative Data

In this sub-section, we will present the data, followed by a quick analysis using Student's t-tests. As the sample is quite small (22 patients), we wanted to make sure that the approval rates are roughly normally distributed. We used the mean of the four questions and distributed it over five classes.

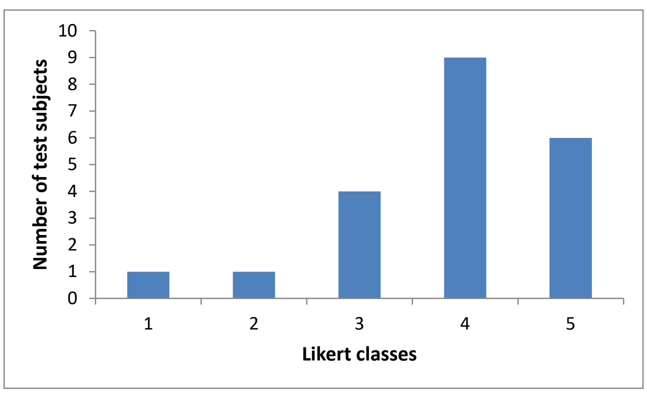

Figure 6: Histogram: Number of participants per Likert class.

While the curve is shifted to the right (high approval), the approval data is roughly normally distributed (Figure 6).

In the subsequent analysis, we compare the answers to questions 1 and 2: the perceived level of fun during rehabilitation training.

As Figure 7 illustrates, the mean approval rate on the five-point Likert scale for the training without games is 3.0 (SD = 1.2), while the mean assessment of training with games is 3.9 (SD = 1.0). A t-test shows that this result is statistically highly significant ($p < .0004$) and the hypothesis that users perceive gamified rehabilitation training as "more fun" is supported.

Obviously, the simple gamification mechanisms used in this device (which only address the player type "achiever") did not prevent the patients from accepting the gamification.

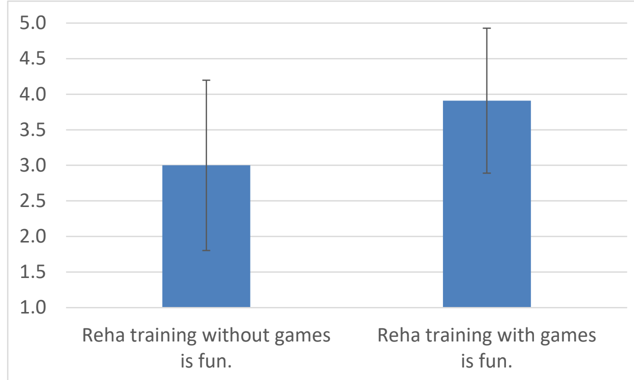

Figure 7: Perceived level of fun during rehabilitation training without games (left) and with games (right). The error indicators show the standard deviation (SD).

The next two questions focused the perceived effects of the gamified rehabilitation training.

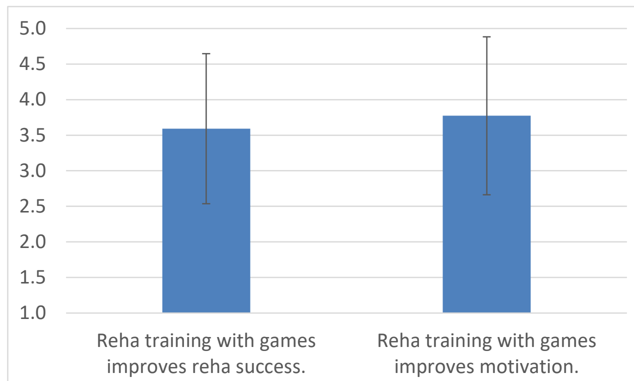

Figure 8: Perceived effect of gamified reha training on reha success (left) and personal motivation (right).

As Figure 8 illustrates, the claim that "gamified reha improves reha success" receives a mean approval of 3.6 (SD = 1.1) while the claim that "gamified reha improves the personal motivation" scores a mean approval of 3.8 (SD = 1.1). Thus, both claims were supported – but not as strong as the claim that the games are fun (mean approval of 3.9). Obviously, there are still doubts, especially with regard to the medical impact of gamified rehabilitation.

Finally, we analyze the patients' reported attitudes towards training at home (15 patients).

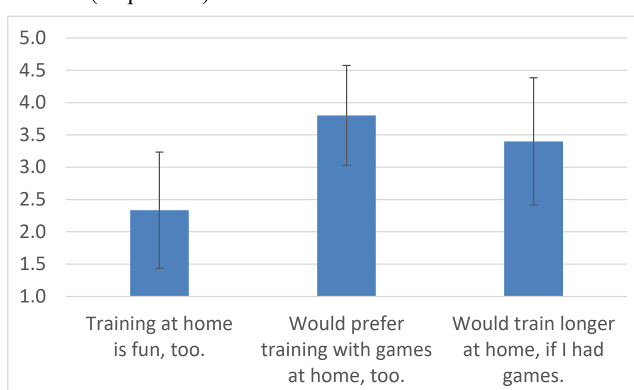

Figure 9: Attitudes towards training at home: perceived fun (left), preference for games (middle) and prediction to train longer (right).

Figure 9 illustrates interesting attitudes: with an acceptance of only 2.3 (SD = .9) most patients do not perceive training at home as fun. Compared with the approval rate of question 1 (the training with the device without games is fun) of 3.0 (SD = 1.2), training at home is perceived as much worse. While the patients might miss the medical setting and the supervision by trainers as much or even more than the games, training at home clearly is not attractive.

As the high mean approval of 3.8 (SD = .8) in the second question illustrates, the patients are bored by the training at home. However, as already the results of question 2 in the first block indicate (reha training with games is fun; mean approval 3.9, SD = 1.0), not every patient is fully in favor of gamified rehabilitation. Especially with the boring training at home, an even higher demand for gamified exercises would not have been surprising.

The claim that patients would train longer if they had gamified rehabilitation at home receives a mean approval of 3.4 (SD = 1.0) – less approval than the previous question. Therefore, this last question shows that the patients are self-critical or at least skeptical regarding the effect of gamified exercises without supervision.

Clearly, gamification helps to support motivation, but cannot compensate strong internal motives like the fear of pain, the avoidance of boredom or just human laziness. This corresponds to the findings discussed in section 2.1: both flow theory and self-determination theory (SDT) indicate that permanent motivation requires intrinsic components.

3.5 Qualitative Findings

During our study, we did not only gather quantitative data but also discussed the use of the rehabilitation device with the patients as well as the medical head of the Ambulant Rehabilitation Center.

The qualitative findings support the quantitative data: there was a broad consensus that the gamification increases motivation with this system. In fact, patients who used the gamified exercises visited the rehabilitation center more often – and once they trained, they asked explicitly to use the gamified exercises.

The medical head also pointed out that concentrating on the (simple) games is helpful for the eye-joint-coordination: when moving in real-life we do not concentrate on the joints either, so the distraction is welcome. As a result, the movement data acquired when gamification is active are more "natural" or realistic than the movement data when exercises are not gamified. However, the expert also explicitly mentioned the limits of this positive effect. If the distraction from the joint movement is too strong, the user might fail to recognize pain signals. This can lead to additional damages in the joint. If physiological sensors do not measure pain directly, the distraction of the game has to be kept at an adequate level.

3.6 DISCUSSION

An important research question in this study was: Do simple gamification mechanisms suffice to increase motivation? While the data suggest some "reservations" (question 2) or a skeptical attitude (question 7) towards the effects of playful design in rehabilitation, especially if used at home, the overall increase in motivation is evident. Although the users did not know other more refined gamified rehabilitation or health systems, it is doubtful that their use would dramatically change the acceptance rates towards the better or the worse.

Obviously, the patients' demand regarding the quality of the user experience is comparatively low. The injury or the illness probably have already decreased their expectations with regard to the "quality" of the rehabilitation experience – so even simple methods to make the exercises less boring are appreciated.

Nevertheless, more complex and visually attractive gamification systems for rehabilitation would surely increase the motivation – if not dramatically, then at least slightly. However, the qualitative data show something interesting: unlike in entertainment games, rehabilitation games (and exergames) need to limit the amount of "fun" and thus distraction. Probably reaching a flow state would be dangerous, at least for two of its six characteristics [9]:

- loss of reflective self-consciousness
- a sense that one can control one's actions; that is, a sense that one can in principle deal with the situation because one knows how to respond to whatever happens next

Both characteristics are problematic, as rehabilitation is a highly artificial situation where the belief that "things are under control" can lead to additional injury or damage. Thus, all therapeutic movement games have the dilemma that too much fun can harm the patients. As the perception of fun is highly individual – as already the player types discussed in section 2.1 show – an individual adaptation of the game design to the users would be ideal. However, such a user-specific dynamic adaption of gameplay is not even reached by most commercial entertainment games.

The only economically feasible solution with regard to development costs is probably to offer a bundle of simple therapeutic mini games (as in *motivotion60+* discussed in section 2.2). However, the selection of the right games should then be made by the therapist based on the movement data gathered with each game, as the patient would naturally chose the one he or she likes most, with the potential of overexerting.

4. CONCLUSION

In this work, we first presented best practices from the state of the art of gamified rehabilitation. However, while it is agreed that adding playful design to rehabilitation can improve the patients' motivation and exercise frequency, there is hardly guidance on how complex the designs and gamification mechanisms should be. Between the requirements of flow theory, self-determination theory or Bartle's player types there is much room for speculation.

To help developing strategies for playful design in rehabilitation, we presented a study on the user experience with a therapeutic device using very simple gamification elements. The results indicate that already such simple gamification mechanisms help to support motivation. However, they cannot compensate strong internal motives like the fear of pain, the avoidance of boredom or just human laziness.

While more immersive gamified solutions for rehabilitation could increase motivation even further, the qualitative findings show that this might be a move into the wrong direction: if the immersion (or from a therapist's view: the distraction) is too strong, pain signals might be unrecognized by the user and the exercise might even lead to additional damage and injury.

As long as pain is not measured directly, the distraction by playful design has to be kept at an adequate level. We proposed a solution to this quandary: offering a selection of simple games, where the therapist choses the one with the optimal combination of therapeutic movements and motivational increase.

5. LIMITATIONS AND FUTURE WORK

The current experiment design is not optimal: an "ideal" study would feature two improvements: (1) a set of games with different levels of complexity and immersion; (2) measurement of impact not only by self-assessment but also by actual rehabilitation success and health improvements based on external assessment by medical staff. While such a study would help to substantiate the findings, it needs substantial backing in a larger clinical environment, which was not the case in this comparatively small project.

6. ACKNOWLEDGMENTS

Our thanks go to the head, the team and the patients of the "Ambulant Rehabilitation Center" in Offenburg, Germany. Without their support, the study could not have been conducted. We also want to thank the anonymous reviewers for their helpful suggestions for improvement.

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