The Digitalisation of Reinforcement Learning and Token Economy in e-Health

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Abstract. This document addresses the problem of psychosis, a mental health condition that affects one's perception of reality. It delves into the symptoms, causes, and consequences of psychosis, which can lead to chronic conditions like schizophrenia. We specifically focus on its early stages, particularly on Ultra High Risk and First Episode of Psychosis patients. We propose a digital platform that integrates psycho-education, Cognitive Behavioral Therapy, and a Token Economy system to improve the treatment of psychosis. The platform comprises a web-based patient management platform, a predictive model and decision support system, and a smartphone application for patients. We explore how e-health and the Token Economy can enhance psychiatric care by providing access, effectiveness, motivation, and engagement while using evidence-based tasks, gamification, feedback, and rewards to help patients achieve their therapeutic goals.

Keywords: Token Economy · e-health · Another keyword

1 Introduction

The metaphorical concept of "losing one's sense of self" encapsulates the disorienting experience of individuals affected by psychosis, a complex mental health condition with silent and insidious progression. Early intervention is crucial to "reclaim life's coordinates", potentially reducing the risk and impact of psychosis. Globally, over 792 million [10] people are affected by mental disorders, highlighting the need for increased awareness and intervention. This is especially relevant in the cases of severe outcomes such as schizophrenia, which impacts 20 million individuals.

The rise of digital technologies in healthcare, known as Digital Health, offers innovative solutions for early intervention. Despite these technologies' immense potential, their full utilisation remains largely untapped. The healthcare industry is at a critical juncture where the integration of digital tools could significantly enhance patient outcomes, streamline processes, and improve overall healthcare delivery. While the potential of Digital Health is vast, its widespread adoption faces many challenges, and the full extent of its capabilities is not yet

G. Casalino et al. (Eds.): HELMeTO 2023, CCIS 2076, pp. 423–439, 2024.
https://doi.org/10.1007/978-3-031-67351-1_29

fully exploited. On a smaller scale, there are numerous encouraging experiments and initiatives that showcase the positive impact of these technologies. These small-scale experiments, often at the intersection of technology and healthcare, highlight the feasibility and efficacy of digital timely interventions. In psychiatry, Digital Health solutions enhance the overall quality of life by identifying and managing dysfunctional behaviours and symptoms. These interventions empower individuals to cultivate healthier habits, contributing to increased life expectancy for those with psychiatric disorders. The application of Digital Health technologies signifies a pivotal stride towards holistic well-being. As these initiatives continue to evolve and expand, there is a growing recognition of the need for a more comprehensive integration of digital technologies into mainstream healthcare practices.

In light of these considerations, we propose a technological solution called DIPPS (Digital Intervention in Psychiatric and Psychologist Services) composed of three main interconnected components:

1. PsitTools, a patient management platform for overseeing the entire therapeutic process, accessible through a web browser;
2. PEnguIN (Psychosis Early INtervention), a smartphone application employed by patients to access all information concerning their therapy, and to engage in instant communication with the therapist, including a chatbot that can assist the patient when the therapist is unavailable;
3. A predictive model and decision support system designed to aid professionals in guiding diagnoses based on data gathered through the digitalisation and administration of key psycho-diagnostic tools.

Within the scope of this study, we investigate how to use PEnguIN and the application of Token Economy (TE) and Gamification concepts to enhance the learning process and therapeutic adherence. In particular, we have:

– developed a platform through which therapists can create and manage a customised TE system for each patient;
– implemented a structured process for the creation of a TE transposed into a digital environment;
– developed an application through which patients can participate in the TE system through a gamified experience.

A TE entails employing tokens (physical objects or digital units) as incentives to strengthen desired behaviors. Similarly, Gamification involves integrating game-like elements, mechanics, and design principles into non-game contexts to enhance engagement, motivation, and participation. Further details on these concepts will be discussed in Sect. 3.

The rest of the paper is organised as follows: Sect. 2 provides a general overview of the target audience for the proposed technological solution and introduces the usage of novel digital technologies within the healthcare domain. Section 3 introduces the traditional TE applications by the therapists. Section 4 contains our proposal for the digitalisation of the TE, and eventually, Sect. 5 contains conclusions and possible future research directions on this topic.

2 Ultra-High Risk (UHR) and First Episode Psychosis (FEP)

What distinguishes psychosis from other mental health conditions is its often silent and insidious progression. In fact, by frequently lurking in the shadows, it remains concealed and unacknowledged for extended periods of time, which in some cases can span multiple years. The silent nature of this disorder exacerbates the suffering of those struggling with it, allowing the condition to fester and worsen without timely intervention.

Firsthand experiences of psychosis entail a cascade of debilitating changes. Emotionally, individuals may struggle with intense fear, confusion, and a profound sense of detachment from reality. Physically and perceptually, their world can become distorted and unpredictable, making even mundane daily tasks a Herculean effort. Socially, psychosis frequently drives individuals away from their social circles, leading to isolation and loneliness. Cognitively, it often impairs thinking, decision-making, and the maintenance of a coherent sense of self.

Psychotic disorders generally have an early onset and a negative outcome that leads to the disease's chronicity, such as schizophrenia, making early interventions of the utmost importance. These interventions not only hold the potential to reduce the risk of initially developing psychosis, but also have a significant impact on the trajectory of the illness itself. Schizophrenia represents the most severe end of the schizophrenia spectrum disorders. Individuals diagnosed with schizophrenia face a notable reduction in their overall quality of life and a significant decrease in life expectancy, estimated to be around 15 to 20 years, less than that of the general population [15].

This reduced life expectancy is influenced by several factors. One primary contributor is the association of schizophrenia with other health issues, such as obesity, the early onset of cardiovascular disease, self-destructive and suicidal behaviours, and repeated substance abuse resulting in addiction. Such comorbidities, along with the core symptoms of schizophrenia, contribute to the overall health risks faced by individuals with this condition. Recognising certain interrelated factors is essential in developing comprehensive approaches to treatment and support that can ultimately educate about a healthy lifestyle.

This condition imposes a substantial burden on the healthcare system, as it necessitates the provision of prolonged medical support, including pharmacological, psychological, and social interventions. This, in turn, significantly influences healthcare expenditures and resource allocation in various countries. For instance, an economic analysis conducted in the United Kingdom has estimated the potential for substantial cost savings in the realm of mental healthcare. The research demonstrates that the implementation of early and preventive interventions can result in remarkable financial savings of £125 million over a three-year period [7].

Prior to the manifestation of the full-blown disease, it is noteworthy that adolescents and young adults can traverse through distinct phases characterised by prodromic or sub-threshold symptoms, which are denoted as UHR and FEP [2]. These phases serve as early indicators of more severe psychotic disorders, such

as schizophrenia, mentioned above, and are significant in the domain of mental health research and clinical practice.

It is of fundamental importance to explore and develop effective techniques and methodologies for identifying risk situations associated with UHR and FEP that can both encourage and facilitate early intervention. These efforts aim not only to alleviate the suffering and distress experienced by individuals in these at-risk populations, but also to mitigate the substantial economic impact that chronic psychotic disorders exert on healthcare systems and society at large. Such endeavours hold the potential to transform mental healthcare, enhancing its efficiency and cost-effectiveness while improving the overall well-being of affected individuals. By providing support, education, and therapeutic interventions, individuals can regain a semblance of stability and normalcy, mitigating the debilitating effects of psychosis on their lives. The key to addressing this challenge lies in recognising the signs, extending a helping hand, and fostering understanding and acceptance for those navigating the intricate terrain of psychosis [24].

In recent years, there has been a significant increase in the development and usage of innovative digital technologies within the domain of healthcare organisations on a global scale, as documented by the World Health Organization[1]. The term "Digital Health" includes the broad spectrum of technologies that are harnessed for patient care and the collection and dissemination of health-related data. Notable components of Digital Health encompass mobile applications, wearable devices, big data analytics, and artificial intelligence [6,10].

Within Digital Health field, a crucial component is telehealth, which serves as a bridge that spans various domains and engages multiple stakeholders. The combination of these cutting-edge technologies within the healthcare landscape holds considerable promise in revolutionising the provision of healthcare services. Digital transformation empowers healthcare organisations with the means to enhance patient care, streamline data collection and sharing, and ultimately improve the overall quality and accessibility of healthcare services on a global scale.

Regarding the psychology domain, the integration of self-management and remote monitoring solutions derived from Digital Health holds the potential to yield substantial advantages for individuals seeking assistance, particularly in terms of improving their overall quality of life [17]. These innovative approaches in the treatment of psychiatric disorders provide a wide variety of benefits. They enable the identification and management of dysfunctional behaviours and symptoms improving the understanding of their condition by patients and their families.

It is critical to recognise that the adoption of such innovative solutions represents a significant stride forward in the domain of mental healthcare. These interventions ease individuals' immediate distress by efficiently addressing dysfunctional behaviours and symptoms, and have the potential to mitigate the long-term repercussions of mental illnesses [15,25].

[1] Source: www.who.int/publications/i/item/9789241511780.

Furthermore, by intervening in the patient's lifestyle, Digital Health solutions go beyond mere symptom management. They have the capacity to empower individuals with the tools and support needed to cultivate healthier habits and choices. This proactive approach fosters resilience and contributes to an increase in the life expectancy of individuals struggling with psychiatric disorders. As such, the application of Digital Health technologies in psychiatry represents a pivotal step towards the comprehensive and holistic improvement of this population's well-being.

3 Token Economy in Cognitive Behavioural Therapy

In the pursuit of this perspective aimed at educating towards healthier habits and, overall, an increase in the duration and quality of life for patients, Cognitive Behavioural Therapy (CBT) and Psychoeducation emerge as indispensable tools for clinicians, allowing them to intervene to either avert the complete development of psychosis in at-risk individuals or facilitate recovery in those who have already experienced an initial episode of psychosis. By addressing and managing symptoms and behaviours in the early stages of the disease, CBT and Psychoeducation contribute significantly to the overarching goal of preventing the exacerbation of mental illnesses and promoting a better quality of life for those affected.

On the one hand, Psychoeducation is an educational approach rooted in clinical research aimed at providing families of individuals with psychiatric illnesses vital information and training. Its primary purpose is to equip these families with the knowledge and skills necessary to collaborate effectively with mental health professionals, thereby becoming an integral part of the comprehensive clinical treatment plan for their afflicted family members. Research has shown that psychoeducation delivers tangible benefits in terms of improving the outcomes of patients dealing with conditions such as schizophrenia and other significant mental illnesses and behavioural disorders. The immediate goals of psychoeducation include preventing recurrent and debilitating episodes of illness in individuals with severe mental conditions. This is achieved by focusing on medication adherence, ensuring compliance with treatment regimens, and facilitating the reintegration of patients into their home communities, with specific attention to their social and occupational functioning [28].

On the other hand, CBT operates on the principle that thoughts, feelings, and behaviours are interconnected, reciprocally influencing each other. The fundamental premise is that altering maladaptive thought patterns and behaviours can lead to positive changes in emotional well-being [29]. CBT has consistently shown its effectiveness in addressing a spectrum of issues, including depression, anxiety disorders, substance abuse problems, marital conflicts, eating disorders, and severe other mental illnesses. An array of research studies underscores the significant enhancement in functioning and the overall quality of life achieved through CBT. Notably, in numerous investigations, CBT has demonstrated its equivalence or even superiority in efficacy compared with alternative forms of psychological therapy or psychiatric medications [8].

CBT therapists strategically deliver interventions that emerge from a personalised case formulation based on the patient's clinical presentation. These interventions involve collaborative efforts with the patient, are meticulously designed to propel patients toward meeting their treatment goals, and are seen through in their entirety to evaluate their effectiveness through the "data" collected by the patient [29]. Often, these interventions are implemented through the assignment of homework, which is one of the core features of CBT. In general terms, homework refers to any activity outside the therapy session that is discussed with the therapist and is designed to yield therapeutic benefits when undertaken as part of the therapeutic process [18]. The initial assignment given to the patients and families frequently involves a straightforward self-monitoring task. Patients might be instructed to observe and record their feelings, thoughts, or behaviours. Self-monitoring serves to sensitise the patient to specific cues or patterns that might contribute to the persistence of the problem. Additionally, it offers valuable insights to the therapist regarding the problem's frequency and severity from the patient's perspective [19].

It is not unusual to encounter challenges in implementing homework tasks, with one particular hardship being compliance. Several strategies can be employed to increase the likelihood of patient adherence. Using rewards is one of them. The therapist can start the process with simple tasks to shape compliance and reinforce positive behaviour upon completing each homework assignment. The therapist assesses the patient's homework at the beginning of each session. The patient receives a pre-negotiated reward if the assigned task has been accomplished. Implementing a TE is an option wherein the patient earns points or tokens for fulfilling homework requirements, subsequently exchanging them for a more substantial reward. Additionally, the therapist employs social reinforcement by acknowledging and praising the patient for either full or partial completion of the tasks. These approaches significantly motivate the patient to fulfil their homework assignments [19].

The behavioural principles used in token systems primarily rely on the concept of operant conditioning. In a TE, tokens typically take the form of neutral stimuli, similar to "points" or tangible items, which are then awarded to participants for completing target behaviours. In a token-reinforcement system, the neutral token is presented alongside or immediately before the reinforcing stimulus. Tokens serve as a way to provide back-up rewards, which are items that participants have indicated they are willing to work for [12].

TE has proven effective in treating severely mentally ill patients in inpatient (hospitalised) settings [3,4,20,21,23], although some trials did not identify distinct benefits from the program [5,15]. However, the seamless transition of TE strategies from inpatient environments to community programs (long-term case facilities) has been impeded by various obstacles. Despite the widespread use and examination of token economies in inpatient settings, there is a scarcity of publications that describe their usefulness and effectiveness in community settings [11]. The absence of studies in this domain may be attributed to vari-

ous barriers that can reduce the effectiveness of token economies in community settings. As depicted in Table 1, significant differences between inpatient and outpatient settings exist, which can undermine the effectiveness of the TE in an uncontrolled environment [9].

Table 1. Differences between Inpatient and Outpatient Settings in the Implementation of Token Economy Principles. Based on [9].

Inpatient Programs	Outpatient Programs
1 Strong control over milieu	1 Weak control over patients' responses or environmental contingencies
2 Highly restrictive treatment policy	2 Weak restrictive policy
3 Limited access to rewards	3 No limits to reinforcers
4 No supplemental income	4 Supplemental income
5 Cannot avoid aversive response costs	5 Can quit if program is aversive
6 24-hour contingency control	6 Day treatment only
7 Infinite range of behavioural targets	7 Narrow range of targets
8 Little collateral interference	8 Family/friends disrupt contingencies
9 Large staff-patient ratio	9 Small staff-patient ratio
10 Coordinated treatment plan	10 Several independent plans across separate community services

Despite precautions designed to facilitate the application of the TE system in an outpatient setting [9], another challenge is associated with its implementation in a non-restrictive context due to its underlying mechanism, namely, operant conditioning. Operant conditioning [27] is the process through which behaviours are influenced by the consequences they generate, either reinforcing and strengthening the behaviours or punishing and suppressing them. Feedback (such as receiving a token) must be contingent to optimise the reinforcement of positive and desired behaviours. Immediate feedback enhances the individual's likelihood of associating the behaviour with the rewarding sensation derived from obtaining the token. However, the limited frequency and duration of weekly sessions, along with fragmented patient information, complicates the reinforcement process. This complexity is further heightened by memory lapses, mood fluctuations, and emotional dysregulation, making recalling information from previous sessions challenging.

4 Digitalisation of Token Economy

A recent comprehensive review [13] suggests an optimistic perspective regarding the intersection of psychosis and technology, particularly in premorbid contexts and early stages such as UHR and FEP. The review highlights that the youthful age of the patients and the non-disabling nature of symptoms during these stages create a conducive environment for leveraging technology, especially on mobile devices.

In the ever-evolving setting of accessibility and availability of technology resources, the previously mentioned review focuses on effectively executing several interventions that revolve around mobile application interactions. The interventions designed to address psychosis-related challenges have yielded positive outcomes. Notably, reducing symptoms has emerged as a significant achievement, with some cases demonstrating great improvements. This positive trend is attributed to various factors, including the efficacy of self-monitoring and self-management strategies, continuous support and assistance facilitated through technological means, and enhanced connectivity with health services.

The examination stresses the fundamental role that mobile applications play in achieving therapeutic goals. The integration of self-monitoring and self-management tools within these applications has proven effective in empowering individuals to engage in the management of their symptoms actively. Moreover, the constant support and assistance improve symptom control and overall well-being.

The assessment also points out the improved contact with health services made possible by using technology. This improved communication improves people's overall interaction with health professionals, creating a collaborative and supportive therapeutic environment. The general retention rate, which indicates the proportion of users who have successfully participated in treatments and follow-ups, further shows the beneficial effects of these interventions. Surprisingly, this retention rate is estimated to be around 90%, as is adherence to the interventions (considering variables such as the frequency of applications or services provided via smartphone) [13].

The potential benefits of using technology in the early stages of psychosis are numerous and include symptom reduction, active self-management, increased support, and improved connectivity with health services. In light of these findings, as mentioned in the Introduction Sect. 1, a suggestion is made to fully digitising the therapeutic process to optimise the patient's care journey. This includes integrating content from CBT and behavioural medicine, such as goal setting and assigning tasks to be completed outside therapy sessions.

Focusing on the patient-centred aspect of our proposal, we introduce a mobile application (PEnguIN—Psychosis Early INtervention) to address the challenges posed by the implementation of the TE in an outpatient setting. Among other features (like Reminder and Agenda, fully digitised psychodiagnostic tests, and Chatbot), it allows patients to complete assigned tasks, receive prompt feedback, and progress through gamification and a TE system created in partnership with their therapist. Within the mobile application, the patient earns points through

task completion, such as maintaining a daily journal, effectively reflecting their therapeutic progress. The amount of tokens earned for each action varies from patient to patient and is defined by the therapist based on the patient's previous abilities and therapeutic goals. These earned points are visually represented on a scale embodied by a growing tree, evolving from a seed to a flourishing cherry tree. This creative depiction illustrates the patient's current position and offers positive reinforcement upon reaching noteworthy milestones. The points accumulated throughout the therapeutic journey can be expended within the application through a gamification system. The application enables the creation of a personalised avatar, enhancing patient engagement. Earned points can be used to purchase accessories for the avatar. This interactive component actively involves patients, making the experience enjoyable, rewarding, and mitigating dropout risk. Creating and personalising the avatar also allows the therapist to comprehend and understand how the patient self-represents [22].

When major objectives are met, the therapist gives the patient a planned tangible recognition in collaboration with the family. This acknowledgement amplifies patient motivation, fostering a heightened commitment towards achieving and sustaining therapeutic objectives. This integration of digital gamification and tangible rewards enhances patient engagement and contributes to a more comprehensive and personalised therapeutic experience [1].

The framework proposed in [14] has been chosen for implementing our TE system, which outlines the key elements (Fig. 1) for properly implementing a TE and describes the possible alternatives for each point. Our goal has been the transposition of this process into a digital environment where a therapist or a team can customise the system following a predefined schema. As mentioned in the introduction, the proposed technological solution consists of three highly interconnected components. The customisation of the TE system by the therapist occurs through the Web-Based PsitTools platform, while the interaction with the TE system by the user/patient takes place through the PEnguIN application.

For each point, a description will be provided as per the framework and our proposed implementation:

i) Develop objectives and select relevant target responses with clarity and precision. It is important to distinguish between intervention objectives and the specific responses needed to achieve those objectives. In the context of a TE for a young person, the objective may be *to be ready for school each morning*, with corresponding responses such as *waking up earlier*, *grooming faster*, and *dressing quicker*. Developing objectives and selecting responses is individualised, ongoing, and guided by concerns for the person's health, welfare, and happiness. The goals include maximizing positive reinforcement, promoting independence, opening new opportunities for positive reinforcement, and replacing undesirable behaviors. In our application context, the idea is to enhance therapeutic adherence. At the beginning of therapy, the clinician has the option to set goals in the form of milestones and responses in the form of tasks to be performed through the application. Examples of tasks could include filling out a food diary or a psychodiagnostic questionnaire.

Develop objectives and select relevant target responses with clarity and precision ***i***	Measure the target behaviour repeatedly, accurately, and reliably ***ii***	Choose when, where, and with whom the Token Economy will operate. ***iii***
Pick out tokens ***iv***	Stockpile backup reinforcers ***v***	Establish tokens as generalised conditioned reinforcers ***vi***
Specify the schedule of reinforcement ***vii***	Decide when to exchange tokens ***viii***	Phase out the Token Economy ***ix***

Fig. 1. Schema rapresenting the key elements of the framework.

ii) Measure the target behaviour repeatedly, accurately, and reliably. It is important to adopt an accurate and reliable measurement system. The measurement system, designed with accuracy and validity in mind, serves various purposes, such as modifying TE parameters, tracking behaviour change across settings, and facilitating the transition away from contrived contingencies. Through PsitTools, the therapist can monitor their patient's progress in relation to the assigned task. They can check if the patient has started the task, completed it, and the time it took them. During an in-person therapy session, the therapist can use the combination of these metrics to track any progress over time and discuss with the patient the motivations behind their actions.

iii) Choose when, where, and with whom the Token Economy will operate. A person's behaviour is influenced by the context of time and place. Therefore, it is crucial to clearly define when, where, and with whom the TE will be and will not be in effect. It might operate continuously throughout the day and across all individuals and environments, depending on the situation. Alternatively, restrictions may apply, such as specific times (*e.g.*, mornings, weekends), particular activities (*e.g.*, evening routines, household chores), designated environments (*e.g.*, stores, parks), or specific individuals (*e.g.*, parents, teachers) responsible for token delivery or exchange. These parameters are personalised within a TE and aligned with the specific objectives set for an individual. It is important to note that all stakeholders, including those for whom the TE is implemented, receive clear instructions about when, where, and under what circumstances the system is active. Considering the digital nature of the patient's interaction with assigned tasks, it is impossible to predict the context in which these tasks will be carried out. However, the timing is regulated through events saved by the therapist in the patient's agenda. The patient receives a notification on their smartphone alerting them that

it is time to complete a specific task. The notification serves as a reminder, but ultimately, it is up to the patient to decide whether and when to perform the task. The fact of not completing a task itself is a useful element for the therapist to understand the patient's progression in therapy.

iv) Pick out tokens. Tokens in a TE, initially considered conditioned reinforcers, function more like generalised conditioned reinforcers in practice. Similar to coins in traditional currency, tokens are earned and can be exchanged for many items or experiences that act as multiple reinforcers. They should be inconspicuous and tailored to individual preferences to minimise stigma. The tokens are represented in the form of digital coins. The patient and the therapist decide the image that should be displayed on the face of the coin (Fig. 2). Studies on the use of digital tokens demonstrate how they can be a valid alternative to physical tokens [16,26,30].

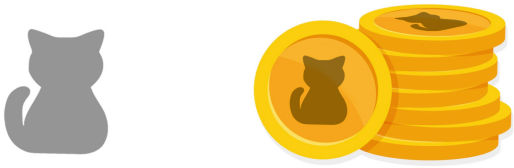

Fig. 2. Selecting the image on the left the resulting coin will be like the image on the right.

v) Stockpile backup reinforcers. Backup reinforcements, or "backups", in a TE are preferred items, activities, or privileges that individuals can obtain with tokens. The reinforcing value of a token is closely tied to the value of its associated backups. It is crucial to select ethical and well-established backups and manage their availability to align with the TE's objectives. However, preferences do not guarantee reinforcement, so it is essential to consider variables like deprivation level, effort required, backup availability, and backup characteristics. Regularly evaluating preferences, staying attentive to individual changes, and maintaining a diverse backup menu are key strategies, emphasizing that the value of a token corresponds to the value of its backups in a TE. There will be two types of backups: digital ones mediated by the application and tangible ones agreed upon in advance. Digital backups are represented by various types of accessories available for customising the avatar. These will always be available for purchase at a standardised price independently of the patient (Fig. 3). The second type of backups, the tangible one, is obtained upon reaching a specific milestone. The therapist arbitrarily decides the achievement of a particular milestone and involves obtaining a specific quantity of tokens, regardless of the stored quantity (*i.e.*, each time the patient earns tokens, they get closer to the milestone, and by spending tokens, their distance from reaching the milestone does not change). This type of backup is decided in agreement with the family and represents the

patient's tangible desire, such as purchasing a bicycle, a new smartphone, or a PlayStation.

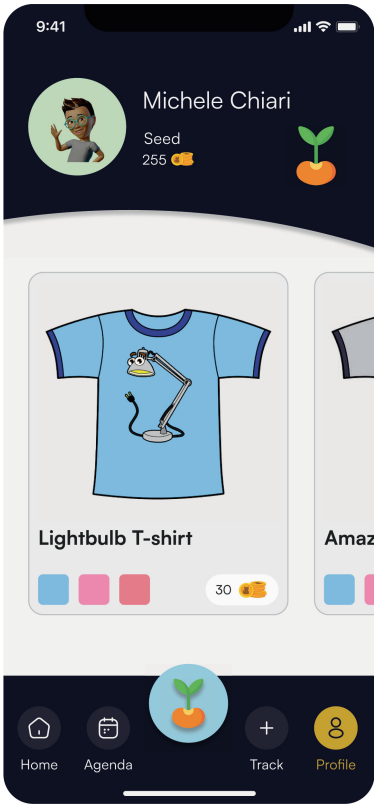

Fig. 3. Example of an accessory purchasable in exchange for the earned tokens.

vi) Establish tokens as generalised conditioned reinforcers. In behaviour analysis, a token in a TE is defined as a conditioned reinforcer, acquiring the ability to reinforce due to its contingent relation to another reinforcer. While a token is often associated with multiple reinforcers, the term "generalised conditioned reinforcement" refers to a conditioned reinforcer backed up by various sources, namely the discussed backups. Establishing a token as a generalised conditioned reinforcer enhances its value, allowing it to reinforce numerous responses across different circumstances. Two methods for establishing a token as a conditioned reinforcer are outlined: the first involves describing the token's value about a token reinforcement schedule, particularly for language-able individuals. The second method, "stimulus pairing", associates a token closely in time and space with a backup, accelerating the process of establishing the token as a conditioned generalised reinforcer.

The second method was chosen for the construction of the TE system. As described in the previous point, the relationship between earning a token and the purchasable backup is immediate and is represented by a store where accessories for customising one's avatar can be purchased. Additionally, the relationship between tokens and tangible backups obtainable upon reaching a milestone is explicitly outlined in the visually represented progression system with levels. In this system, the levels are represented by the growth state of the cherry tree, and the distance from the next level is indicated by a progress bar (Fig. 4). Every action performed by the patient will be accompanied by an action of their avatar, which, in the application, will take care of the plant (*e.g.*, watering, pruning, shading from the sun) that metaphorically represents their therapy and health (Fig. 5).

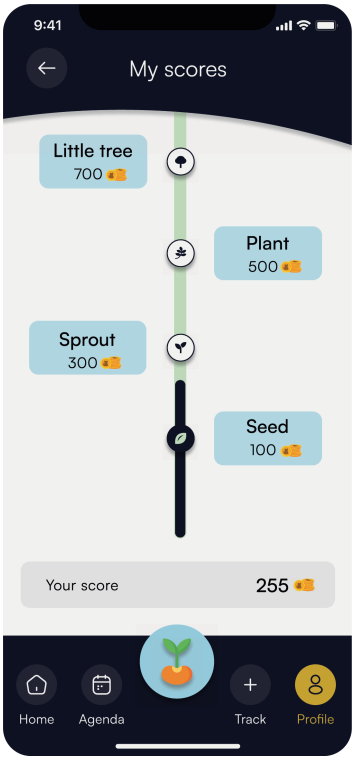

Fig. 4. Representation of the therapeutic journey through a progress bar indicating the achieved level and the distance to the next one.

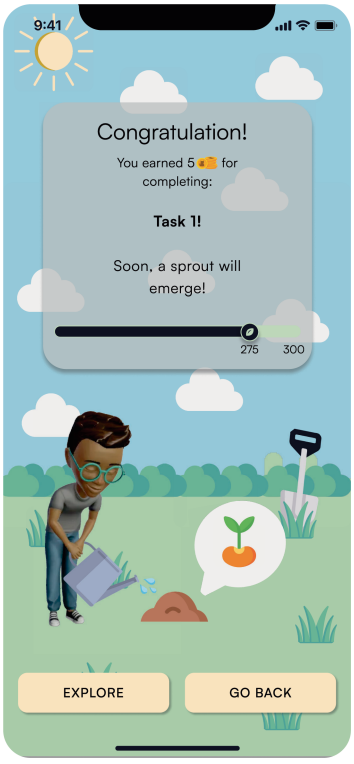

Fig. 5. Patient's avatar taking care of the plant after completing a task.

vii) Specify the schedule of reinforcement. A TE consists of three interconnected schedules of reinforcement: the token *production schedule*, the token *exchange schedule*, and the *exchange-production schedule*. The token production schedule dictates the contingency between tokens and responses, offering various options such as fixed or variable ratio and interval schedules. Target responses with unique qualities are often reinforced more frequently and with a larger number of tokens. Different schedules have known effects on response rates and patterns, with variable-ratio schedules generally yielding higher rates. Managing the number of tokens in circulation is crucial to prevent accumulation or scarcity, striking a balance to maintain motivation and conditioned reinforcing value. Adjustments to the token production schedule or modifications to exchange-related schedules may be necessary to address issues of too many or too few tokens in circulation. The therapist sets the quantity of tokens awarded to the patient for a specific task based on the patient's difficulties. For instance, if a patient has no issues completing a psychodiagnostic test (*e.g.*, the wheel of emotions) but struggles to take medication consistently, the therapist can set a higher reward for each instance the patient takes the medication correctly and consistently. The patient's condition is not static over time, and the therapist can always review these quantities in agreement with the patient when a particular task becomes more complex or simpler.

viii) Decide when to exchange tokens. The *exchange-production schedule* outlines the conditions for exchanging tokens for backups, offering response-based and time-based options. In response-based exchanges, individuals can trade tokens at any time, providing immediate access to backups. Time-based exchanges, on the other hand, introduce delays in obtaining backups. It is noted that a response-based schedule with a short exchange delay is most suitable for young children and individuals with limited language abilities. Long delays can be challenging, even for older children and adults, potentially diminishing the positive effects of a TE. Research highlights the importance of both awarding tokens and frequent exchanges for the success of a TE. As mentioned, both approaches are adopted: the response-based approach provides access to in-app purchases for customising the avatar, while the time-based approach grants access to "larger" rewards achievable upon reaching a specific milestone.

ix) Phase out the Token Economy. A TE differs significantly from naturally occurring reinforcement contingencies in daily environments. Planning to phase out a TE is analogous to the initial decision to implement one.

Schedule thinning can be intricate in a TE due to the three schedules: token *production*, token *exchange*, and *exchange-production*. Altering the token production schedule involves systematically increasing response requirements or implementing intermittent token delivery schedules. Adjusting the token exchange schedule entails gradually raising the cost of preferred backups, especially those lacking natural equivalents. Thinning the exchange-production schedule involves reducing the frequency of token exchanges for backups.

Several procedures, though not specific to phasing out a TE, are promising for this purpose. These include implementing a "level system" where individuals progress through tiers culminating in the termination of contrived contingencies, reducing the number and type of token-specific backups and replacing them with natural reinforcers, and establishing a self-monitoring repertoire. The latter is exactly the approach pursued in our solution. The patient progresses along a path marked by a series of milestones. At the beginning of therapy, the patient is likely to face larger and more generalized challenges in completing tasks, so it is normal to have greater reinforcement to stimulate adherence and reward effort. As therapy progresses (as the tree grows), the distance between milestones will become larger and more challenging to reach. This distance can be adjusted by the therapist, always considering the patient's performance. Regarding the store for avatar customization items, both cheaper and more expensive items will be simultaneously available. Ideally, at the end of therapy (when the cherry tree blossoms), the TE system will no longer be necessary and will be used by the patient more for recreational purposes than for obtaining a reward.

5 Conclusions and Future Works

The initial phase of our endeavour marks the commencement of our journey towards the comprehensive digitalisation of the therapeutic process. Due to the specific nature of our target demographic, rigorous testing of our solution remains pending. However, through collaborative efforts with esteemed institutions like CPS "Giovani di Niguarda"[2] and proactive engagement with early intervention-focused associations such as AIPP[3] and Cambiare la Rotta[4], both of whom have expressed their willingness to participate in future experimentation, we anticipate gathering invaluable data on the efficacy of our proposal in the immediate future. This forthcoming phase holds the promise of shedding light on our digital therapeutic approach's practical implementation and impact in real-world settings.

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[2] The CPS "Giovani di Niguarda" is the Psychosocial Center of the "ASST Grande Ospedale Metropolitano Niguarda" (www.ospedaleniguarda.it), one of the most significant public hospital facilities in Milan, assisting approximately 500 patients each year with varying degrees of severity.

[3] www.aipp-italia.com.

[4] www.associazionecambiarelarotta.it.

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