

AI-Enabled Playful Enhancement of Resilience and Self-Efficacy With Psychological Learning Theory

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ABSTRACT

The outbreak of COVID-19 has caused a global public health emergency with multifaceted severe consequences for people's lives and their mental health. Distress and anxiety are normal responses to such extreme circumstances. The Austrian research project AI-Refit aims at a radically innovative app prototype representing a digital care centre (i) to reinforce resilience by engaging into activities to prevent from depressive symptoms, severe anxiety and stress levels, (ii) to apply playful AI- and sensor-enabled assessment of mental health, (iii) to capture daily lifestyle data for a comprehensive contextual assessment from non-obtrusive wearables, and (iv) to adaptively promote self-efficacy of the individual, based on scientific psychological learning theory.

Keywords: Resilience, Artificial intelligence, Wearables, Psychological learning theory

INTRODUCTION

The outbreak of COVID-19 is a global public health emergency with multifaceted severe consequences for people's lives and their mental health. The horizon of daily lives, the ability to travel and interact freely had suddenly been limited. Distress and anxiety have been normal responses to such extreme circumstances. The Austrian project AI-Refit contributes to close a currently existing gap by strengthening resilience in a sustainable highly personalised way by engaging the individual person, reinforcing his or her self-efficacy in a radically innovative, highly adaptive, intelligent way. This technology aims at supporting a broad mass of people today suffering from the COVID-19 crisis but will also be suited to assist persons in individual crisis as well as in any globally affecting crisis in the future. AI-Refit

aims at developing a radically innovative app prototype in terms of a digital care centre for (i) playful AI- and sensor-enabled assessment of mental health, (ii) adaptively engaging into activities to prevent from depressive symptoms, severe anxiety, and stress levels, to reinforce resilience and to promote self-efficacy of the individual, based on scientific psychological models and theory. (iii) Wearables are integrated to capture daily lifestyle data for a comprehensive contextual assessment.

Firstly, AI-Refit applies state-of-the-art AI methodology for smart assessment of mental health from a suite of serious games. AI-Refit is based on the digitAAL Life app that estimates neuropsychological assessment. AI-Refit is extended by mental health based assessment. Secondly, psychological models and theory provide an overall framework for AI-enabled behaviour change with the ultimate objective to increase self-efficacy and self-control of the users from playing gamified exercises and motivated by feedback about self-initiated actions. Thirdly, the application of several wearables in the context of mental health will be evaluated for their efficiency and optional integration into the AI-enabled mental health analysis.

The indicative assessment of mental parameters, such as, executive function (inhibition), stress, emotion, and activity will be applied by AI-enabled decision support to define a global resilience and depression sensitised risk factor estimation for early alert and professional consulting. A tele-assistance module will enable fully remote care assistance via professional or informal caregivers, which is particularly suited for pandemic risk of social isolation.

MENTAL HEALTH APPS FOR RESILIENCE

Recent years have seen an exponential development of mobile technologies aimed at improving various mental health problems, as reported in recent meta-analysis of Lecomte et al. (2020). Such technologies are called mobile health (mHealth) referring to health (including mental health) supported by mobile technologies (Becker et al., 2014), considered as part of Digital Health (Moreno et al., 2020). A comprehensive review on smartphone-based interventions for mental health problems was provided by Linardon et al. (2019), including a meta-analysis of randomized controlled trials (RCT). The results convincingly demonstrate that smartphone interventions significantly outperformed control conditions in improving depressive interventions and generalised anxiety symptoms, stress levels, quality of life, general psychiatric distress, social anxiety symptoms, and positive affect. Most effects were robust even after adjusting for various possible biasing factors (type of control condition, risk of bias rating). Smartphone interventions did not differ significantly from active interventions (face-to-face, computerised treatment). Linardon et al. (2019) further remark that the present findings highlight the potential of apps to serve as a cost-effective, easily accessible, and low intensity intervention for those who cannot receive standard psychological treatment although mental health apps are not intended to replace professional clinical services. Numerous mental health apps are available, most prominent ones are Moodfit (mixed intervention with mindfulness, visual

insights with actionable exercise), MoodMission for learning coping skills, Talkspace for therapy, Sanvello for stress relief, or happify for positive emotions and joyful life. The mHealth field is booming - there are currently somewhere between 10,000 and 20,000 mental health apps (Neary & Schuller, 2018) available - but it is estimated that only about 3% to 4% are actually evidence based. Usually only a small proportion of these technologies have undergone any form of empirical assessment (Martínez-Pérez et al., 2013). One remarkable mental health app that is proved in concrete evidence-based studies is MoodMission (Bakker et al., 2018). These studies demonstrated that users experienced decreases in depression and increased coping self-efficacy. eQuoo (Litvin et al., 2020), a gamified mobile mental health intervention on improvements in resilience, educates users about psychological concepts including emotional bids, generalisation, and reciprocity through psychoeducation, storytelling, and by gamification achieved 90% adherence. iFightDepression (Oehler et al., 2020) as an internet-based example of a self-management tool for depression provides self-administered tests as well as an online guided-self-management programme that helps people with limited to moderate depression to self-manage symptoms. Mental health apps have great potential to help people needing support to cope with distress or specific symptoms (Lecomte et al., 2020).

The German DiGA-Directory lists two apps in the field of mental health, which can be prescribed by doctors with reimbursement by social insurance. *deprexis* is an interactive online-based self-help program for therapy support of patients with depression and depressive moods. It is intended to be used in addition to an otherwise usual treatment and is based on established psychotherapeutic approaches and procedures, cognitive behavioural therapy (CBT). *Selfapy* offers sufferers of depression an individual online course based on evidence-based theories and techniques of CBT. In UK the platform *SilverCloud* is recommended by the National Health Service (NHS). *SilverCloud* is an online course helping to manage stress, anxiety, and depression. Users work through a series of topics selected by a therapist to address specific needs. *My Possible Self* provides learning modules to manage fear, anxiety and stress and tackle unhelpful thinking. Other *SilverCloud* apps focus on mindfulness or psychological skills. The European project *ECoWeB* develops an app to tackle anxiety, depression, and mental health problems among youth, applying mobile technologies to improve access to effective psychological interventions for prevention. *EMPOWER* aimed to reduce the impact of mental health problems at the workplace.

However, there is a lack of mental health apps that provide certified diagnostics, including sensor-based assessment and feedback with personalised targeted recommendations. *AI-Refit* intends to fill this gap with the proposed work.

THE AI-REFIT APP SUITE

The *AI-Refit* App represents a suite of Apps all of which are part of the training / intervention that aims at increasing the resilience of the user while at the same time assessing her status via sensor-based Apps. The main entry



Figure 1: Entry of the AI-Refit suite of apps. The user selects between different services: resilience training (“*Resilienz*”), brain training (“*BRAINMEE*”), app-based psychological tests (“*Reaktion*”, “*Erinnerung*”, “*MIRA*”, “*Mischen*”), and symptom checker (“*Symptoma*”).

page of the AI-Refit App (“Launcher App”) is depicted in Figure 1. The user who is interested in the empowerment of resilience and in the assessment of her own mental and cognitive state, is able to select between different services, i.e., resilience training (“*Resilienz*”), brain training (“*BRAINMEE*”), several gamified psychological tests (“*Reaktion*”, “*Erinnerung*”, “*MIRA*”, “*Mischen*”, and symptom-based diagnostic app (“*Symptoma*”).

RESILIENCE TRAINING APP

As part of the study, a multimodal approach to increase resilience is attempted. A short program to promote resilience is implemented in an app (Figure 2) based on (Engelmann, 2019). Engelmann (2019) assumes a seven-pillar model of resilience. These seven pillars consist of self-awareness, joie de vivre, self-efficacy, empathy, self-determination, optimism, and coping. In addition to the seven pillars, we implemented three additional pillars that we call AI-Refit+. In addition to this approach, there is also an emphasis on exercise & nutrition. However, no nutritional or sports medicine facts will be provided to the subject, but the knowledge already acquired in this area will be reminded. The app aims to motivate people to exercise and eat consciously. In addition, self-management and self-leadership are encouraged. Subjects should achieve the motivation to implement the training, but also to motivate the longest set personal goals. The third of the AI-Refit+ pillars is cognitive training. We assume that all exercises with improved attention or motivation to focus more are easier to implement. Therefore, motivation for cognitive training is carried out as part of the resilience app. The BRAINMEE app, which is integrated in the study, can be used here. But more focus should also be trained in everyday life and when working on the reflection tasks in the context of the resilience app.

All pillars are processed within the framework of modules. Each module has the same content. Each module contains a psychoeducational unit intended to draw attention to the topic. Furthermore, the modules consist of a reflection exercise at the beginning and end of the module, which includes

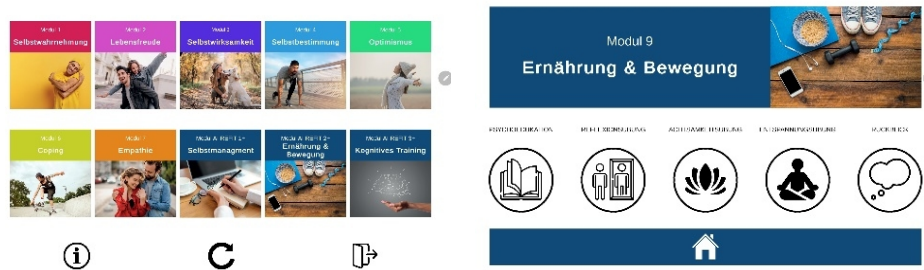


Figure 2: The resilience training app. (a) Entries for specifically targeted exercises on (from top left to bottom right) self-perception, joy of life, self-efficacy, self-determination, optimism, coping, empathy, self-management, nutrition and mobility, cognitive training. (b) Entry for ‘nutrition and mobility’ with options for psychoeducation, mindfulness training, reflection.

questions for self-reflection on all 10 topics. In addition, all topics will be trained with relaxation exercises and mindfulness exercises. The subjects are instructed to incorporate these exercises into their everyday lives to practice the psychological resources. When a module is completed, the test subjects decide themselves. With a confirmation of the completion of the module, another one can be started. When the 10 modules are completed, the training is over. The participants should take 2–4 days per module. In this way, subjects will be able to complete all modules within 2 months with minimal effort on the individual days.

SYMPTOM CHECKER

For the purpose of risk stratification in the context of resilience, a symptom checker has been implemented by Symptoma in the AI-Refit App. Symptoma’s symptom checker has been developed based on a large-scale proprietary ontology of clinical concepts and relationships. It has been validated by physicians and has shown promising results in detecting COVID-19 risk. The first prototype of Symptoma’s symptom checker detected COVID-19 risk with an accuracy of 96.32% (Martin et al., 2020; Munsch et al., 2020). This tool has also assisted the city of Vienna in efficiently screening COVID-19 cases (Munsch et al., 2022).

In the project, the symptom checker module focuses on resilience-related causes: Burnout and Long COVID. For each of these causes, the risk is assessed in a conversational chatbot implementation. Based on the outcome, further guidance and resources are provided to the user.

BRAINMEE APP

The BRAINMEE app (Figure 3) of digitAAL Life GmbH (“DLF”) is the only solution on the market that offers both personalised, multimodal training as therapy and tools - such as an assessment of cognitive performance by estimating the MoCA score - in a single, integrated solution and is currently being applied for resilience training. Data for the development of these

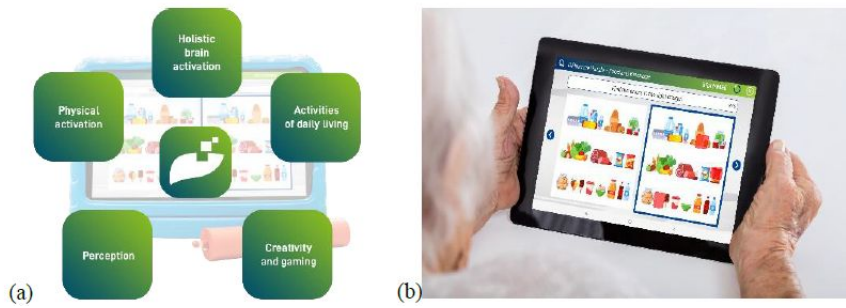


Figure 3: Concept and exercise implementation of the BRAINMEE app of digitAAL Life GmbH. (a) The multidomain concept of the digital app-based intervention. (b) Sample exercise, i.e., ‘spot-the-difference’ pictures for the training of visuospatial attention and short-term memory. Credits: digitAAL Life GmbH.

resilience components of the BRAINMEE app are being collected as part of these studies, but certification as a medical device is not currently planned.

The task types include, on the one hand, movement exercises for flexibility, strength and coordination, and on the other hand, exercises for long-term memory, short-term memory, spatial-visual memory, attention, orientation, fine motor skills, semantic memory, working memory, logical thinking, auditory perception, cognitive flexibility, visual differentiation, visual perception, seriality and measurement of everyday activity.

Game-based training combines joyful experiences with the app to increase adherence with assessment of the individual user’s neuropsychological profile (NPP; Paletta et al., 2021). The state of the NPP can indicate what kind of cognitive functionalities should be strengthened through training in order to avoid cognitive deficits. The exercises in the digitAAL Life app can be carried out by the users as often as they like - either with a trainer or without supervision.

SENSOR AND SERIOUS GAME BASED ANALYTICS

A subgroup of the suite relates to gamified psychological tests that provide various assessment parameters. These components should be applied by the user following a usage plan for continuous monitoring but at the same time not impacting the adherence rate of the resilience and BRAINMEE app. In the following, the individual components are motivated and described.

n-back Task. This app-based gamified test (Figure 4a) estimates the official continuous performance task used in psychology to measure part of working memory and working memory capacity (Kirchner, 1958). The subject is presented with a sequence of stimuli and the task is to indicate whenever the current stimulus would match the stimulus from $n = 2$ previous steps in the sequence. The app presents a series of visual stimuli and evaluates the user’s cognitive performance.

MIRA Task. Recent models suggest that inhibitory control (IC), the executive control function that supports our goal-directed behaviour and regulates our emotional responses, may underlie resilience (Afek et al., 2021). The

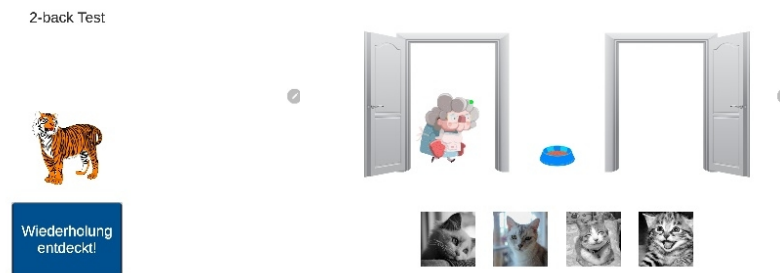


Figure 4: Gamified and serious game-based psychological tests. (a) App representing the n-back test (Kirchner, 1958) by presenting a series of images and querying for repetition detection. (b) The MIRA serious game (Paletta et al., 2020) realises a gaze-based test about the efficiency of inhibitory control (Crawford et al., 2005; green point: user's eye gaze).

MIRA (Mobile Instrumental Review of Attention; Paletta et al., 2020; see Figure 4b) app enables a quasi-continuous assessment supported by game-like interaction with a gaze interface to estimate the cognitive screening MoCA. It represents a gamified version of the anti-saccade task, using an eye-tracking camera embedded in the device to capture and analyse eye movements during play. The anti-saccade task is known to detect problems of IC as seen in neurodegenerative executive function disorders (Crawford et al., 2005).

Sustained attention. Personal resilience was significantly related to the reduction of fatigue in studies during the COVID-19 pandemic (Hassan et al., 2022). The assessment of sustained attention and fatigue is implemented with the 3 minute version of the Psychomotor Vigilance Test (PVT; Basner et al., 2011).

Mental state. Emotion management involves the ability to be open to feelings and modulate them to promote growth, even under duress. Schneider et al. (2013) showed that emotional intelligence promotes stress resilience. The mental state is indicatively assessed by a serious game (Paletta et al., 2019) in the AI-Refit app.

Wearables. In addition to the use of the AI-Refit suite of apps, participants of the resilience training are recommended to wear a biosensor armband (Garmin vivosmart 5). The data (heart rate, heart rate variability, sleep, motion) are transferred to the Fitrockr¹ server for a comprehensive contextual assessment.

ANALYTICS BASED ON PSYCHOLOGICAL MODELS AND LEARNING THEORY

“Man is a creature of habit” (Dewey, 2002, p. 125) – and while reinforcing habitual behaviour through reward strategies is relatively achievable, inhibiting or changing existing habits, as everyday experiences already show, is a challenge that is difficult to achieve. It is a well-known fact that even

¹<https://www.fitrockr.com/research/>

motivated persons with appropriate knowledge often do not decide and behave according to his/her attitudes, values, emotions, and cognitive insights (Courtenay-Hall & Rogers, 2002). This is often called the *knowledge-behaviour gap*. This gap induces that understanding the underlying cognitive and affective dimensions of behaviour (e.g., motivation, cognitions, potentials, and barriers) is necessary for successful interventions supporting people's behavioural change.

To this end, a set of different approaches will be applied to investigate these underlying factors and find ways to individually optimize the app's features. A first interesting insight might come from understanding differences and similarities between the persons using the app. Here, an approach that has proven useful in various health settings, recently also regarding the effects of COVID-19 on stress and resilience (Yalçın et al., 2022), is latent profile analysis (Williams & Kibowski, 2016). This method allows a data-driven capturing of different sub-groups within a sample, based on markers from questionnaires (e.g., social support, perceived stress) and app usage (e.g., cognitive data, gaze markers). Furthermore, it will be interesting to utilize models of human behavior as a basis to assess the relevance of different factors for behavioral change. In the recently finished CODALoop project (Savini et al., 2019), a diverse set of cognitive models on behavioral change has been explored and investigated by Bedek & Albert (2019) to predict energy-related behavioral changes. This methodological approach is also promising with regard to shaping resilience-oriented behavior, especially since most of the examined models and theories have been successfully applied in the health sector (DeJoy, 1996; Schwarzer, 2008). Especially the Health-Belief-Model (HBM; see Janz & Becker, 1984) and the Transtheoretical Model (TTM; see Grimley et al., 1994) seem promising and will be in the focus of the AI-Refit project using structural equation modelling methods to determine the relationships between various factors and, for example, app usage. Additionally, psychological learning theories, like the knowledge space theory (KST, e.g. Falmagne et al., 2013), are planned to be applied in order to provide an additional adaptive framework. This might be especially worthwhile in regards of the cognitive training, but will be tested with other aspects as well, for instance resilience exercises.

Based on this comprehensive approach, a framework for an activity recommender will be derived. In future iterations, this recommender will help strengthen the users' resilience by targeting and adaptively optimizing the app's content and it will help transforming this knowledge into behaviour and behaviour change in daily life.

STUDY PLAN

The study protocol (ethical approval confirmed by the Medical University of Graz under No. 34–297 ex 21/22) foresees a usability study to get usability and user experience feedback from experts and potential practitioners and an RCT of type intervention study. An important aspect of a usability study is the expert evaluation of the psychological questionnaires. The data to be collected serve as a main source for sub-group analyses and as basis for

applying the behavioural models (as HBM, TTM, KST). Furthermore, general questionnaires regarding, for example, the users' health behaviour and coping strategies, will be presented.

The RCT measures the effectiveness of the app-based intervention. We aim at recruiting for this purpose 90 participants for an intervention duration of 2 months. 30 participants should only receive the diagnostic elements and not the intervention. 60 participants are expected to switch from the intervention group (IG) to the control group (CG) in a cross-over design, using both the app and the pre-set resilience training. In terms of the RCT each person will be randomly assigned to either the IG or the CG. $N = 60$ participants of the IG would apply the AI-Refit app content and complete psychological questionnaires on stress and resilience at the beginning of participation. New stress diagnostics would be applied after 2 and 4 months, respectively. The waiting group (CG, $n = 30$) would complete the psychological questionnaires before participation and after 2 months, but cannot use any further functions of the AI-Refit app. However, they will be offered the opportunity to use the tablet training at the end of their participation in the study. The study will be conducted in 2023.

CONCLUSION AND FUTURE WORK

The presented work plan and initial results of the project AI-Refit provide first insights in the vision and developments of a radically innovative prototype of a digital care center for the reinforcement of resilience that would be applicable for a large part of the population. The interplay between resilience training, cognitive stimulation, mobile sensor- and app-based assessment, and symptom-based, AI-driven recommender should engage into activities to strengthen resilience in healthy individuals after the COVID-19 pandemic in order to prevent from depressive symptoms, severe anxiety and increasing stress levels. The RCT study has started and the results will discover the actual impact of the intervention.

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