Mobile Mental Health Platforms and Gamification

Mobile Plattformen zur Stärkung der psychischen Gesundheit und Gamification

Inaugural-Dissertation
zur Erlangung des Doktorgrades der Philosophie
der Ludwig-Maximilians-Universität München

vorgelegt von

Silja Litvin

aus

Bonn

2024

Referent: Prof. Dr. Markus Maier

Korreferent: Priv.-Doz. Dr. Markos Maragkos

Korreferentin: Dr. Katharina Kugler

Tag der mündlichen Prüfung: 23.04.2024

Table of Contents

Introduction

Problem Statement

An increase in problems related to mental health and well-being (Storrie et al., 2010), coupled with a lack of access to supports (Twenge et al., 2019), has contributed to the fact that less than 35% of the population in need of interventions are receiving them (Kazdin, 2017). Barriers to access include inadequate financial resources from governments and national health care systems and the inability for individuals to pay for their own private mental health care (Kazdin, 2017). Other influences—such as rural living, stigma, and restricted business hours—also hinder otherwise-eligible people from receiving mental health care (Sickel et al., 2019). Although access to care has been a growing problem for some time now, the COVID-19 pandemic led to a spike in mental illness [5, 6], resulting in an accelerated demand for affordable and accessible mental health supports, in particular those that can be accessed remotely [7, 8]. Teens, adolescents, and young adults are a particularly underserved population with some of the fastest growing needs for mental health care [9]. This is especially alarming because mental illness diagnosed in adolescence can lead to long-term exclusion from education, employment, or training [10], with a devastating effect on the adolescent as an individual as well as their social circles.

These facts highlight an urgent need for affordable and easily accessible treatment options that do not rely on traditional face-to-face therapies.

In addition, research indicates that prevention and positive psychology as means of keeping people healthy and equipping them with the psychological resources to process mental and emotional stress in a beneficial way are not only highly effective [11]but can also significantly lower the suffering and emotional burden of managing mental illness.

In recent years, studies have emerged that show that different types of digital remote treatments, such as internet-delivered cognitive–behavioural therapies and a mix of guided and nonguided therapies, produce a significant reduction in psychopathology symptoms, especially depression and anxiety [12]. Although promising, early digital remote therapy options required individuals to own or have access to a computer or laptop and a robust internet connection, which is not always possible, despite increases in the number of households owning at least one

computer [13]. However, a greater proportion of individuals now own smartphones [14, 15], presenting a more accessible and convenient modality for digital remote therapy: the development of interventions in the form of mobile applications. In addition, teens, adolescents, and young adults appear to respond positively to digital remote therapy tools in form of apps because it resonates with their daily habits, needs, and digital expectations [16]

Today, the market is oversaturated with digital mental health remote therapy options, yet only 2% of products have undergone clinical trials, raising concerns about their legitimacy, safety, and effectiveness [17]. A recent review of 19 studies that investigated the use of gamified digital remote therapy for common mental health problems in young people revealed that 53% of the studies had no active control group, 16% used a wait-list condition, 21% used another digital remote therapy control group condition, and only 11% (2 studies, which used the same intervention) used face-to-face interventions [18,19]. The effect of the digital remote therapy tools was largest when they were compared with nonactive control conditions, and effects were small, or even nonexistent, when there was an active comparator [20,21]. Recent meta-analyses that have specifically explored studies involving mobile phone apps for depression and anxiety have suggested that they have the potential to reduce symptoms compared with inactive controls [22,23]. Unfortunately, only a few studies have involved active control groups, which is important when researching the effect of a particular intervention. It is also worth noting that many of the studies were underpowered. Insufficient sample sizes can promote favourable effects of interventions [24, 25, 26], reducing the likelihood that a statistically significant result reflects a true effect [27].

The evidence base also tells us that there is a key problem relating to engagement with digital mental health products: attrition. Although a certain level of attrition may be expected in any form of mental health intervention [20], rates appear to be higher with digital mental health products [sources]. This is concerning because many interventions require sustained engagement in order to get across their content or to give the intervention time to work.

The Problem Statement can therefore be distilled to the following four points:

1. Mental illness is on the rise.
2. Access to face-to-face therapeutic interventions remains problematic.

3. Most digital mobile remote therapies are inadequately backed by research.
4. Most digital mobile remote therapies fail to retain clients long enough to have an impact on their mental health.

Overall Theory

The Gesamttheorie of this paper is that evidence-based and gamified digital mental health interventions delivered by phones can be shown to be effective tools for improving mental health. The hypothesis is that the platform—mobile phones—allows for on-demand, affordable, and private service, and clinical trials prove their effectiveness and gamification solves retention challenges, at least for certain targeted audiences, such as young adults.

Latest State of the Research

Although the COVID-19 lockdown periods, and the restrictions around social interactions that came with them, has had an impact on the rise of mental health care needs [28], researchers are struggling to find conclusive reasons as to why mental health care needs were climbing even before the pandemic hit [29]. Whereas some suggest that growing medical treatments are possibly fueling a vicious cycle of mental ill health [30], others point towards changing lifestyles, such as being more sedentary [31], social media or tech use in general [32], or even a global identity crisis of younger generations [33] that may or may not be evolving in a negative direction. Although neither of these hypotheses alone can itself explain the rise of mental illness, data are being collected continuously, and many of the hypotheses could offer reasonable input into shaping governmental guidelines as well as educating institutions in the development of well-being–led practices. The health care space is also actively developing guidelines and regulations [34], and active calls for more funding of health care services are dominating the narrative [35].

Despite funding efforts, face-to-face therapy remains accessible only through thresholds of long waiting times [36] or considerable personal investment of private therapy sessions that can cost from 60€ to over 400€ [37], which is not feasible for everyone. Even if waiting and/or funding are not limiting factors, for young adults there may be further obstacles, such as a preference for self-reliance and the desire to avoid perceived stigmatisation [38, 36].

As a response to the glaring need for more accessible and on-demand mental health care, the private sector has created thousands of mobile mental health solutions in the past few years. Of the more than 10,000 health, psychosocial, and stress management apps claiming to alleviate mental distress available in app stores, only 2% have undergone randomised controlled trials (RCTs) to prove their effectiveness and feasibility [17]. RCTs are key to not only ensuring that the app is effective but also that it complies with ethical regulations and approved by means of an Ethics Application to a certified body whose purpose is to protect mobile remote therapy users against harmful or negligent practice. Most of these apps, 2%, consist of mindfulness and meditation applications, such as Headspace and Calm; and positive psychology programs that involve goal-setting and journaling and mood-monitoring tools; as well as a few tools that are connected to a real-life therapist or an AI bot, such as Wysa [17]. These applications were studied in 33 peer-reviewed publications that covered only 21 applications: Eight papers were about Headspace alone, which would reduce the actual number of evidence-based apps to 25. All of the studies were published between 2015 and 2020 and consisted of efficacy, feasibility, or usability studies; 2 were combined efficacy and feasibility studies [16]. This indicates a substantial lack of evidence-based care and highlights a large research–practice gap.

Most studies have revealed small to moderate effect sizes and positive outcomes, which could be due to the fact that trials without significant findings might not be published and/or that commercial interests prohibit the publication of unsupportive outcomes. Very few of the trials discussed participant retention, and meta-review studies that did mention trial attrition revealed very high attrition rates of up to 99% [39]. Not discussing retention allows for a huge blind spot within the research: If non-uptake and drop-off numbers are omitted, the true value of the intervention tool cannot be assessed because it is unclear whether it is suited to deliver an intervention. Even the app with the highest possible effect size will not be able to help if users don’t stick with it long enough to reap the benefits.

This latest state of research indicates that the current body of research concerning digital mental health solutions is developing, but there are clear limitations, including an overrepresentation of specific and unique apps that challenge generalisability and a lack of focus on uptake and retention as well as extremely arduous and rigid RCT protocols, which make it

difficult for mobile mental health care tool developers to design and develop evidence-based products that consumers will use enough to reap mental health benefits.

Mission Statement

While I was a full-time student at the Ludwig Maximilian Universität, I learned all about the history of psychology, diagnostic tools, statistics, treatments, and ethics. What I did not learn deeply enough to prepare me for a career in mental health care were all the barriers that clients face when trying to access the care they need. I was absolutely stunned to learn that waiting times of up to 6 months are considered normal, even short [36], and that people with below-threshold symptoms often could not find financial support from insurance companies. Clients would tell me they answered questionnaires citing symptoms stronger than they were actually experiencing because they were worried that care would otherwise be denied. In my internship at an ambulatory mental health care centre, NELFT [40], I would assess young adults who had been waiting months to see me, suffering in the meanwhile, with their symptoms getting worse over time more often than not. They reported the first symptoms years before they even considered looking for mental health care, and I was profoundly struck me by the knowledge that they would not be in the room with me if they had learned the psychological skills my colleagues and I were about to teach them (a Cognitive Behavioural Therapy (CBT)–led program) ***before*** they had developed their first symptoms. It was then that I decided to contribute differently to society than what I had originally foreseen for myself: Rather than helping a privileged few who had made it to our door, I would dedicate my academic and private career to the mission of preventing mental illness. I would use the new world technology of apps and video games to build a mobile intervention that would captivate young adults and teach them the psychological skills they need to build resilience as well as preclude developing anxiety and depression and bring them joy and entertainment. Personally, I believe that the journey of personal growth, healing, and self-understanding can be one of joy and fun—despite mental illness being impairing and painful. Why not harness the know-how of the gaming industry to ethically develop an intervention vehicle that resonates with the needs and habits of young adults? Thus, I began the journey of developing eQuoo, always making sure that I am developing an effective and reliable tool that education spaces can buy for their students, so

that young people do not also have to carry the financial burden of care. Right now, eQuoo has been translated into four languages, has more than 500,000 downloads worldwide, and is undergoing it's third RCT as well as multiple independent studies.

Presentation of Work

This dissertation revolves around the lack of *effective* mental health care resources; it subsequently proposes and tests an affordable, effective, and scalable solution called eQuoo. By 'effectiveness', I predominantly mean mental health care resources that clients stick with long enough to experience positive mental health changes.

This thesis outlines my academic journey and findings through the development of a gamified mobile mental health tool called eQuoo, the Emotional Fitness Game, Versions 1 (V1) and 3 (V3). In Paper 1, the eQuoo V1 was tested in a 5-week, three-armed RCT with 358 participants; it significantly raised the mental well-being metrics resilience, personal growth, and positive relationships with others, as well as lowering anxiety, over a 5-week period, showing low attrition, indicating that the use of gamification in mental health tools is an effective retention tool (Paper 1: 'Gamification as an Approach to Improve Mental Well-Being and Reduce Attrition in Mobile Mental Health Interventions: A Randomised Controlled Trial'). Paper 2 ('The Impact of a Gamified Mobile Mental Health App [eQuoo] on Resilience and Mental Health in a Student Population: Large-Scale Randomised Controlled Trial') is the follow-up trial, which explored the current eQuoo game, V3, which has undergone substantial updates after the feedback of thousands of players as well as my own understandings from the first trial. In a three-armed, 5-week RCT with 1,165 student participants, the game's effect on anxiety, depression, and resilience was measured, with attrition being an important secondary outcome. The trial successfully achieved significant on all, such as Last Observation Carried Forward and Intention to Treat.

Paper 1: 'Gamification as an Approach to Improve Mental Well-Being and Reduce Attrition in Mobile Mental Health Interventions: A Randomised Controlled Trial'

I partnered with a Los Angeles–based game development company to design eQuoo V1, a game that allows players to learn and practice psychological skills in a low-risk, low-cost environment.

eQuoo V1 was an interactive mobile game that could be found in all the app stores; the game was divided into five chapters (one chapter per week); each chapter taught two new psychological skills. Each skill is empirically based and implemented in CBT, positive psychology, and systemic psychology, including generalisation, catastrophising, and emotional bids. The skills were taught by the game's avatar, Joy, at the beginning of each chapter and, once a skill is mastered, the user was led through a choose-your-own adventure game in which the player needed to implement the skills in order to gain coins and level up to the next chapter. Each chapter is from a different genre and takes an average 15 to 25 min to play, depending on reading pace.

A three-armed RCT was conducted with 358 participants working at BOSCH UK over a 5-week period. The trial investigated whether the test group using eQuoo would significantly raise their resilience, interpersonal relationship skills, and personal growth and lower their anxiety. The treatment-as-usual control group was given a CBT app called 'CBT Journal,' and the wait-list group received no treatment over the 5 weeks.

The Adult Resilience Measure (ARM) [41], the one-item Anxiety Likert Scale [42], the Personal Growth Initiative Scale (PGIS), and Ryff's Scales of Psychological Well-Being (RPRS) [43] were administered to all participants on Days 1, 17, and 35. Repeated-measures analyses of variance (ANOVAs) revealed statistically significant increases in resilience in the test group compared with both the control and wait-list groups over the 5 weeks. The app also significantly increased personal growth and positive relations with others and lowered anxiety. With 90% adherence, eQuoo V1 retained 21% more participants than the control or wait-list groups. The intervention delivered via eQuoo V1 significantly raised mental well-being and decreased self-reported anxiety while enhancing adherence compared with the control conditions. The repeated-measures ANOVA of the primary outcome (ARM score) revealed a significant main effect of

intervention, $F(2,350) = 8.51$, $p < .001$, $\eta_p^2 = .046$, and a significant interaction between intervention and time, $F(4,698) = 3.34$, $p = .01$, $\eta_p^2 = .019$, but not a main effect of time, $F(2,350) = 2.66$, $p = .07$, $\eta_p^2 = .015$).

Despite attrition not being a primary outcome, the RCT emphasised the importance of retention in a digital mental health intervention and reported high retention rates of over 90% in the test group—an unusually large number in comparison with average RCT group retention rates [39], demonstrating that gamification and/or gamifying could be a valuable tool to enhance therapy adherence.

The RCT also raised more questions with its limitations: Despite eQuoo V1 being a relatively advanced digital tool, the data collected could have been much more comprehensive, such as on individual user engagement and the impacts of specific features on outcomes. As with most interventions, with eQuoo V1 there is a 'black box' effect that leaves it unclear which psychological skills taught in the game have the biggest impact. It would also be of interest to investigate the effect of eQuoo V1 on a clinical population using a more sensitive anxiety measurement.

Paper 2: The Impact of a Gamified Mobile Mental Health App (eQuoo) on Resilience and Mental Health in a Student Population: Large-Scale Randomised Controlled Trial

This paper is a follow-up study with the updated and current version of eQuoo, V3.

The updates were primarily player and user data led, addressing usability and user interface issues as well as adding more content to the game to provide a 52-week programme. The list of game changes included

- 47 more levels of game play, reaching 52 levels altogether;
- 5+ new stories of different genres that comprise 8 to 10 chapters each;
- a weekly lock that excludes players from playing more than one level a week, allowing for skill adoption during the lockdown time as well as making sure the game does not allow for potentially addictive abuse;
- a customisable avatar so that players would be playing as themselves instead of a fictional character presented by eQuoo V3;

- in-app mini-games to play during the main game lockdown;
- 42 additional psychological skills, all based on CBT, Systemic Therapy, and Positive Psychology; and
- an extensive library of every skill explained on a deeper level in form of a blog.

eQuoo V3 continues to be available on the Google and Apple app stores and has five levels of free game play before the player would hit a paywall, ensuring that self-payers knew what the game was about before purchasing a subscription. The app is planned to remain on the app stores despite the business model being business to business (B2B), with PsycApps selling to secondary schools, colleges, and universities. This pivot from business to consumer (B2C) to B2B was made after I decided that I wanted the burden of pay to be carried by someone other than the young clients themselves.

A three-armed large-scale RCT was supported by UniDays [444], a student discount platform that gave me access to more than 3 million potential participants in the United Kingdom. More than 1,000 students (n = 1,165) from more than 180 universities were randomly allocated into one of three groups: (1) eQuoo V3 users, (2) users of a treatment-as-usual evidence-based cognitive behavioural health app called Sanvello, and (3) a no-intervention wait list. The Rugged Resilience Scale [45], Generalized Anxiety Disorder–7 [46], and Patient Health Questionnaire–8 (PHQ–8) [47] were administered to all participants at baseline and every 7 days until completion.

A repeated-measures ANOVA revealed statistically significant increases in resilience scores in the test group (p < .001) compared with both control groups (Sanvello: p = .10, wait list: p = .82) over 5 weeks. The app also significantly decreased anxiety and depression scores (both ps < .001). With 64.5% (251/389) adherence, the eQuoo V3 group retained 42% more participants than the control groups.

The RCT outcome clearly indicates that gamified digital health interventions such as eQuoo V3 are effective, scalable, and low-cost solutions for supporting young adults and can be available on all leading mobile platforms.

Not all questions and limitations raised in Paper 1 could be addressed in Paper 2, and new ones were raised. The intervention arm and treatment-as-usual arm of the RCTs are not exactly comparable because they are two different digital products using similar but distinct intervention

techniques. A better comparison would be to give the treatment-as-usual group a nongamified version of eQuoo V3 instead. Another limitation is that no in-game player data were used to record exact game interactions. Relying exclusively on questions answered to prove engagement is not a sufficiently nuanced approach to give insights into how game play affects mental health outcomes. Last, but not least, all participants were self-selected, and therefore self-selection bias may have crept into the study outcomes.

Despite these limitations, the results and the fact that it was a very large participant group allow for population generalisation and offer promising support for the hypothesis that gaming mental health is, indeed, a good idea.

Overall Discussion

As established in the introduction, affordable, trustworthy, and effective gamified mobile interventions are emerging as solutions fit to support a large population in lieu of, or alongside, face-to-face therapy. I am on an ongoing journey of research, discovery, and iterative implementation of findings and am leveraging an up-'til-now unfathomable quantity of data to design more effective intervention tools.

Findings of the Randomised Controlled Trials

The RCTs established that the mobile interventions eQuoo V1 and eQuoo V3 are effective in lowering anxiety and depression in a nonclinical population as well as raising mental well-being metrics such as resilience. Poor retention was discovered to be a challenge for mobile tools in general, and gamification was explored as a remedy, which was supported by findings in the trial. The metrics were all significant, with effect sizes up to $d = 67$:

The One-Item Anxiety Likert Scale: PsycAppsE: eQuoo

- ARM
- RPRS
- PGIS
- Attrition in the eQuoo V1 and V3 test groups
- GAD7

- PHQ–8

Conclusion

The Importance of Engaging Mobile Interventions

Although early digital interventions successfully transitioned certain core elements of face-to-face therapies to a digital platform, attrition rates have made it clear that motivation is lacking when supporting motivators, such as the therapeutic alliance, are not replaced with another factor that supports adherence. If a client is struggling too much with symptoms of depression to get up and take a shower, for example, we cannot expect them to complete an autonomous therapy course online. It should also be remembered that a mental health application competes not only with other mental health applications but also with the client's time and all the other apps on their phones, many of which have had millions of dollars invested into their user experiences. The best mental health app is not going to help anyone if it cannot compel the client to use it a certain amount of time. Each target audience is different, with individual psychological needs and user behaviours, and thus responds more or less favourably to different methods used to keep them engaged. Because 70% of the population eQuoo was built for (16- to 35-year-olds) are casual gamers [48], it was probable that gamifying therapy would be a successful method to enhance adherence.

Future Steps in Providing Effective Mobile Interventions

Following the Food and Drug Administration's approval of Reset [49] and Akili [50], both of which report high effect sizes that rival other therapy types, it can be concluded that, for a receptive population, mobile therapies could be built to outperform other interventions for a much lower human capital and financial cost. It is my further goal to overcome the black box effect by applying data collection methods that allow ad hoc research with real-time data to research the effects of features on the players' mental well-being, therefore continuously being able to test, iterate, and enhance effect sizes. Because traditional RTCs are time and budget consuming, new methods, like micro-RCTs, could be a way to collect and process data in an ethically and empirically viable

fashion, allowing faster and more effective iterations. I am developing a data collection tool in the upcoming next generation version of eQuoo, V4, that is due to launch in September 2023. This tool will deliver voluntary questionnaires to the player population through a chatbot that can be placed before and after any other feature in the game. The real-time data will be assessed to measure the effect size of the corresponding feature, which can then be benchmarked against other features, leading to iterative enhancement of the effect size through replacement or correction of said features. The user data collected also provide player satisfaction and will be used to enhance the gaming experience, raising retention, which allows for the intervention to have a stronger impact. Finally, all the above data can lead to the establishment and implementation of predictive modelling algorithms and early machine leaning tools that will help personalise the intervention according to the player's mental health needs as well as the content to ensure an engaging user experience, further enhancing retention.

Already-scheduled follow-up clinical trials will ensure safe and evidence-based care for all those with access to eQuoo.

References

Storrie, K., Ahern, K., & Tuckett, A. (2010). A systematic review: Students with mental health problems—A growing problem. *International Journal of Nursing Practice*, *16*(1), 1–6. https://doi.org/10.1111/j.1440-172X.2009.01813.x

Twenge, J. M., Cooper, A. B., Joiner, T. E., Duffy, M. E., & Binau, S. G. (2019). Age, period, and cohort trends in mood disorder indicators and suicide-related outcomes in a nationally representative dataset, 2005–2017. *Journal of Abnormal Psychology*, *128*(3), 185–199. https://doi.org/10.1037/abn0000410

Kazdin, A. E. (2017). Addressing the treatment gap: A key challenge for extending evidence-based psychosocial interventions. *Behavior Research and Therapy*, *88*, 7–18. https://doi.org/10.1016/j.brat.2016.06.004

Sickel, A. E., Seacat, J. D., & Nabors, N. A. (2019). Mental health stigma: Impact on mental health treatment attitudes and physical health. *Journal of Health Psychology*, *24*(5), 586–599. https://doi.org10.1177/1359105316681430

O'Connor, R., Wetherall, K., Cleare, S., McClelland, H., Melson, A., Niedzwiedz, C., . . . Robb, K. (2021). Mental health and well-being during the COVID-19 pandemic: Longitudinal analyses of adults in the UK COVID-19 Mental Health & Wellbeing study. The British Journal of Psychiatry, 218(6), 326–333. doi:10.1192/bjp.2020.212

Jude Mary Cénat, Seyed Mohammad Mahdi Moshirian Farahi, Rose Darly Dalexis, Wina Paul Darius, Farid Mansoub Bekarkhanechi, Hannah Poisson, Cathy Broussard, Gloria Ukwu, Emmanuelle Auguste, Duy Dat Nguyen, Ghizlène Sehabi, Sarah Elizabeth Furyk, Andi Phaelle Gedeon, Olivia Onesi, Aya Mesbahi El Aouame, Samiyah Noor Khodabocus, Muhammad S. Shah, Patrick R. Labelle, The global evolution of mental health problems during the COVID-19 pandemic: A systematic review and meta-analysis of longitudinal studies, Journal of Affective Disorders, Volume 315, 2022, Pages 70–95, ISSN 0165-0327, https://doi.org/10.1016/j.jad.2022.07.011.

Cindy B. Veldhuis, Elizabeth D. Nesoff, Anna Laura W. McKowen, Dylan R. Rice, Hana Ghoneima, Angie R. Wootton, Elizabeth Lerner Papautsky, Danielle Arigo, Shoshona Goldberg,

Jocelyn C. Anderson, Addressing the critical need for long-term mental health data during the COVID-19 pandemic: Changes in mental health from April to September 2020, Preventive Medicine, Volume 146, 2021, 106465, ISSN 0091-7435,

Latoo J, Haddad PM, Mistry M, Wadoo O, Islam SMS, Jan F, Iqbal Y, Howseman T, Riley D, Alabdulla M. The COVID-19 pandemic: an opportunity to make mental health a higher public health priority. BJPsych Open. 2021 Sep 20;7(5):e172. doi: 10.1192/bjo.2021.1002. PMID: 34538286; PMCID: PMC8458855.

Benton, T., Njoroge, W. F., & Ng, W. Y. (2022). Sounding the alarm for children's mental health during the COVID-19 pandemic. JAMA pediatrics, e216295-e216295. (https://www.sciencedirect.com/science/article/pii/S0091743521000499)

Ringbom, I., Suvisaari, J., Kääriälä, A., Sourander, A., Gissler, M., Ristikari, T., & Gyllenberg, D. (2022). Psychiatric disorders diagnosed in adolescence and subsequent long-term exclusion from education, employment or training: Longitudinal national birth cohort study. The British Journal of Psychiatry, 220(3), 148–153. doi:10.1192/bjp.2021.146

Conley, C. S., Shapiro, J. B., Kirsch, A. C., & Durlak, J. A. (2017). A meta-analysis of indicated mental health prevention programs for at-risk higher education students. Journal of counseling Psychology, 64(2), 121.

Harith, S., Backhaus, I., Mohbin, N., Ngo, H. T., & Khoo, S. (2022). Effectiveness of digital mental health interventions for university students: an umbrella review. PeerJ, 10, e13111.

https://www.ibisworld.com/us/bed/percentage-of-households-with-at-least-one-computer/4068/ statista.com [Internet]. Number of smartphone users worldwide from 2016 to 2021; c2019 [cited 2019 Nov 11]. Available from:

https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/

https://www2.deloitte.com/uk/en/pages/consulting/articles/mental-health-and-employers-refreshing-the-case-for-investment.html

Vigerland S, Lenhard F, Bonnert M, Lalouni M, Hedman E, Ahlen J, et al. Internet-delivered cognitive behavior therapy for children and adolescents: a systematic review and meta-analysis. Clin Psychol Rev 2016 Dec;50:1–10 [https://linkinghub.elsevier.com/retrieve/pii/S0272-7358(15)30090-8] [CrossRef] [Medline]

Lau N, O'Daffer A, Colt S, Yi-Frazier JP, Palermo TM, McCauley E, Rosenberg AR. Android and iPhone Mobile Apps for Psychosocial Wellness and Stress Management: Systematic Search in App Stores and Literature Review. JMIR Mhealth Uhealth 2020;8(5):e17798 doi: 10.2196/17798

Halldorsson B, Hill C, Waite P, Partridge K, Freeman D, Creswell C. Annual research review: immersive virtual reality and digital applied gaming interventions for the treatment of mental health problems in children and young people: the need for rigorous treatment development and clinical evaluation. J Child Psychol Psychiatry 2021 May;62(5):584–605 [CrossRef] [Medline]

Grist R, Croker A, Denne M, Stallard P. Technology delivered interventions for depression and anxiety in children and adolescents: a systematic review and meta-analysis. Clin Child Fam Psychol Rev 2019 Jun;22(2):147–171 [https://europepmc.org/abstract/MED/30229343] [CrossRef] [Medline]

Linardon J, Cuijpers P, Carlbring P, Messer M, Fuller-Tyszkiewicz M. The efficacy of app-supported smartphone interventions for mental health problems: a meta-analysis of randomized controlled trials. World Psychiatry 2019 Oct;18(3):325–336 [https://europepmc.org/abstract/MED/31496095] [CrossRef] [Medline]

Hollis C, Falconer CJ, Martin JL, Whittington C, Stockton S, Glazebrook C, et al. Annual research review: digital health interventions for children and young people with mental health problems—a systematic and meta-review. J Child Psychol Psychiatry 2017 Apr;58(4):474-503 [CrossRef] [Medline]

Firth J, Torous J, Nicholas J, Carney R, Pratap A, Rosenbaum S, et al. The efficacy of smartphone-based mental health interventions for depressive symptoms: a meta-analysis of randomized controlled trials. World Psychiatry 2017 Oct;16(3):287–298 [https://europepmc.org/abstract/MED/28941113] [CrossRef] [Medline]

7Firth J, Torous J, Nicholas J, Carney R, Rosenbaum S, Sarris J. Can smartphone mental health interventions reduce symptoms of anxiety? A meta-analysis of randomized controlled trials. J Affect Disord 2017 Aug 15;218:15–22 [https://linkinghub.elsevier.com/retrieve/pii/S0165-0327(17)30015-0] [CrossRef] [Medline]

Ebert DD, Zarski AC, Christensen H, Stikkelbroek Y, Cuijpers P, Berking M, et al. Internet and computer-based cognitive behavioral therapy for anxiety and depression in youth: a meta-analysis of randomized controlled outcome trials. PLoS One 2015 Mar 18;10(3):e0119895 [https://dx.plos.org/10.1371/journal.pone.0119895] [CrossRef] [Medline]

Pennant ME, Loucas CE, Whittington C, Creswell C, Fonagy P, Fuggle P, Expert Advisory Group. Computerised therapies for anxiety and depression in children and young people: a systematic review and meta-analysis. Behav Res Ther 2015 Apr;67:1–18 [CrossRef] [Medline]

Ye X, Bapuji SB, Winters SE, Struthers A, Raynard M, Metge C, et al. Effectiveness of internet-based interventions for children, youth, and young adults with anxiety and/or depression: a systematic review and meta-analysis. BMC Health Serv Res 2014 Jul 18;14:313 [https://bmchealthservres.biomedcentral.com/articles/10.1186/1472-6963-14-313] [CrossRef] [Medline]

Ioannidis JP. Why most discovered true associations are inflated. Epidemiology 2008 Sep;19(5):640–648 [CrossRef] [Medline]

Pfefferbaum, B., & North, C. S. (2020). Mental health and the Covid-19 pandemic. New England Journal of Medicine.

Wiens, K., Bhattarai, A., Pedram, P., Dores, A., Williams, J., Bulloch, A., & Patten, S. (2020). A growing need for youth mental health services in Canada: Examining trends in youth mental health from 2011 to 2018. Epidemiology and Psychiatric Sciences, 29, E115. doi:10.1017/S2045796020000281

Richter, D., Wall, A., Bruen, A., & Whittington, R. (2019). Is the global prevalence rate of adult mental illness increasing? Systematic review and meta-analysis. Acta Psychiatrica Scandinavica, 140(5), 393–407.

Bort-Roig, J., Briones-Buixassa, L., Felez-Nobrega, M., Guàrdia-Sancho, A., Sitjà-Rabert, M., & Puig-Ribera, A. (2020). Sedentary behaviour associations with health outcomes in people with severe mental illness: a systematic review. European Journal of Public Health, 30(1), 150–157.

Naslund, J.A., Bondre, A., Torous, J. et al. Social Media and Mental Health: Benefits, Risks, and Opportunities for Research and Practice. J. technol. behav. sci. 5, 245–257 (2020). https://doi.org/10.1007/s41347-020-00134-x

Miller, R. L., & Collette, T. (2019). Multicultural identity development: Theory and research. Cross-cultural psychology: contemporary themes and perspectives, 614–631.

Torous, J., Andersson, G., Bertagnoli, A., Christensen, H., Cuijpers, P., Firth, J., ... & Arean, P. A. (2019). Towards a consensus around standards for smartphone apps and digital mental health. World psychiatry, 18(1), 97.

https://www.actformentalhealth.ca/why-funding-mental-health-care-is-the-smart-thing-to-do/

Hidden waits force more than three quarters of mental health patients to seek help from emergency services. Royal College of Psychiatrists. 2022. URL: https://www.rcpsych.ac.uk/news-and-features/latest-news/detail/2022/10/10/hidden-waits-force-more-than-three-quarters-of-mental-health-patients-to-seek-help-from-emergency-services [accessed 2023-06-16]

https://www.privatepracticehub.co.uk/how-much-is-private-counselling-therapy-uk-cost-prices/#:~:text=The%20cost%20can%20vary%20depending,48%20per%20week%2C%20with%20no

Ebert D, Mortier P, Kaehlke F, Bruffaerts R, Baumeister H, Auerbach RP, WHO World Mental Health-International College Student Initiative collaborators. Barriers of mental health treatment utilization among first-year college students: first cross-national results from the WHO World Mental Health International College student initiative. Int J Methods Psychiatr Res 2019 Jun;28(2):e1782 [https://europepmc.org/abstract/MED/31069905] [CrossRef] [Medline]

Nwosu, A., Boardman, S., Husain, M. M., & Doraiswamy, P. M. (2022). Digital therapeutics for mental health: Is attrition the Achilles heel?. Frontiers in Psychiatry, 13, 900615.

https://www.nelft.nhs.uk/

Liebenberg L, Moore JC. A social ecological measure of resilience for adults: The RRC-ARM. Soc Indic Res. 2018;136(1):1–9.

Davey HM, Barratt AL, Butow PN, Deeks JJ. A one-item question with a Likert or Visual Analog Scale adequately measured current anxiety. J Clin Epidemiol. 2007;60(4):356–60. pmid:17346609

Kafka GJ, Kozma A. The construct validity of Ryff's scales of psychological well-being (SPWB) and their relationship to measures of subjective well-being. Soc Indic Res. 2002;57(2):171–90. https://www.myunidays.com/

Jefferies P, Vanstone R, Ungar M. The rugged resilience measure: development and preliminary validation of a brief measure of personal resilience. Appl Res Qual Life 2021 May 06;17(2):985–1000 [https://link.springer.com/article/10.1007/s11482-021-09953-3] [CrossRef]

Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med 2006 May 22;166(10):1092–1097 [CrossRef] [Medline]

Kroenke, K., Strine, T. W., Spitzer, R. L., Williams, J. B., Berry, J. T., & Mokdad, A. H. (2009). The PHQ–8 as a measure of current depression in the general population. Journal of affective disorders, 114(1–3), 163–173. https://explodingtopics.com/blog/number-of-gamers

Kollins, S.H., Childress, A, Heusser, AC and Lutz, J. (2021). Effectiveness of a digital therapeutic as adjunct to treatment with medication in pediatric ADHD. npj Digit. Med. 4, 58. https://doi.org/10.1038/s41746-021-00429-0

Campbell AN, Nunes EV, Miele GM, Matthews A, Polsky D, Ghitza UE, Turrigiano E, Bailey GL, VanVeldhuisen P, Chapdelaine R, Froias A, Stitzer ML, Carroll KM, Winhusen T, Clingerman S, Perez L, McClure E, Goldman B, Crowell AR. Design and methodological considerations of an effectiveness trial of a computer-assisted intervention: an example from the NIDA Clinical Trials Network. Contemp Clin Trials. 2012 Mar;33(2):386–95. doi: 10.1016/j.cct.2011.11.001. Epub 2011 Nov 9. PMID: 22085803; PMCID: PMC3268951.

Paper 1 Print

PLOS ONE

RESEARCH ARTICLE

Gamification as an approach to improve resilience and reduce attrition in mobile mental health interventions: A randomized controlled trial

Silja Litvin[1]*, **Rob Saunders**[2], **Markus A. Maier**[1], **Stefan Lüttke**[3]

1 Department of General Psychology II (Emotion and Motivation), Ludwig Maximilian University of Munich, Munich, Germany, **2** Research Department of Clinical, Educational and Health Psychology, Centre for Outcomes Research and Effectiveness, University College London, London, United Kingdom, **3** Department of Clinical Psychology and Psychotherapy, University of Tübingen, Tübingen, Germany

* silja@psycapp.com

OPEN ACCESS

Citation: Litvin S, Saunders R, Maier MA, Lüttke S (2020) Gamification as an approach to improve resilience and reduce attrition in mobile mental health interventions: A randomized controlled trial. PLoS ONE 15(9): e0237220. https://doi.org/10.1371/journal.pone.0237220

Editor: Yutaka J. Matsuoka, National Cancer Center Japan, JAPAN

Received: December 25, 2019

Accepted: July 20, 2020

Published: September 2, 2020

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pone.0237220

Data Availability Statement: We have published our data with OSF under the link: https://osf.io/v6g3s/.

Abstract

Forty percent of all general-practitioner appointments are related to mental illness, although less than 35% of individuals have access to therapy and psychological care, indicating a pressing need for accessible and affordable therapy tools. The ubiquity of smartphones offers a delivery platform for such tools. Previous research suggests that gamification—turning intervention content into a game format—could increase engagement with prevention and early-stage mobile interventions. This study aimed to explore the effects of a gamified mobile mental health intervention on improvements in resilience, in comparison with active and inactive control conditions. Differences between conditions on changes in personal growth, anxiety and psychological wellbeing, as well as differences in attrition rates, were also assessed. The *eQuoo* app was developed and published on all leading mobile platforms. The app educates users about psychological concepts including emotional bids, generalization, and reciprocity through psychoeducation, storytelling, and gamification. In total, 358 participants completed in a 5-week, 3-armed (*eQuoo*, "treatment as usual" cognitive behavioral therapy journal app, no-intervention waitlist) randomized controlled trial. Relevant scales were administered to all participants on days 1, 17, and 35. Repeated-measures ANOVA revealed statistically significant increases in resilience in the test group compared with both control groups over 5 weeks. The app also significantly increased personal growth, positive relations with others, and anxiety. With 90% adherence, *eQuoo* retained 21% more participants than the control or waitlist groups. Intervention delivered via *eQuoo* significantly raised mental well-being and decreased self-reported anxiety while enhancing adherence in comparison with the control conditions. Mobile apps using gamification can be a valuable and effective platform for well-being and mental health interventions and may enhance motivation and reduce attrition. Future research should measure *eQuoo*'s effect on anxiety with a more sensitive tool and examine the impact of *eQuoo* on a clinical population.

Funding: there has been no financial funding or sources of financial support externally or internally for this work that could have influenced its outcome.

Competing interests: I have read the journal's policy and the authors of this manuscript have the following competing interests: I, Silja Litvin, am the majority shareholder of the company PsycApps Limited, which developed eQuoo, the game used in the test group for this trial. The corresponding authors have no other conflicts of interest associated with this publication, and there has been no significant financial support for this work that could have influenced its outcome. This does not alter our adherence to PLOS ONE policies on sharing data and materials.

Introduction

Mental disorders are highly prevalent and are a major contributor to years lived with disability [1]. Indeed, depression ranks as the single greatest contributor to disability worldwide [2]. Beyond individual burden, mental disorders entail considerable economic costs exceeding expenditures for other common diseases, such as cardiovascular diseases [3]. With the increasing trends in psychological distress, suicide, and self-harm among young people [4], effective treatment and prevention are urgently needed. Despite the high demand and need for services, the majority of individuals in need of mental health services receive no treatment [5, 6]. Moreover, although mental health promotion has long been advocated as a means of preventing mental disorders, prevention has been neglected [7, 8]. This is somewhat surprising given the fact that prevention reduces both economic costs [3] and risk of recurrence of symptoms [9]. This discrepancy between evidence-based interventions for serious mental health conditions and their lack of delivery and implementation in the healthcare system has been referred to as the "research-practice gap" [10].

mHealth (mobile health care), the delivery of mental health treatment using smartphones and wearables, presents an opportunity to narrow the research-practice gap by addressing barriers to treatment at the individual level. Indeed, recent research suggests that the most common reasons for not seeking mental health treatment are respondents' desire to manage their problems on their own, stigma associated with seeking psychological help, and perceptions of treatment as inconvenient or ineffective [11–13]. On the other hand, mobile health apps incorporate unique features that have the potential to circumvent the aforementioned barriers. Apps enable users to help themselves in a self-selected and anonymous setting, thereby enhancing empowerment and reducing stigma. In 2018, approximately 2.9 billion people owned a smartphone worldwide [14], making smartphones a promising and convenient platform from which to provide telemedical care, especially to those who have no or little access to conventional treatment. Consequently, the market for health-related mobile applications is rapidly expanding, with more than 318,000 health apps available when last counted [15].

Despite the utility of mobile health apps as a low-threshold mechanism to deliver treatment having been frequently praised [16], evidence for the efficacy of commercially available apps is scarce [10]. The paucity of such data notwithstanding, there is a growing body of randomized controlled trials (RCTs) showing the potential of mobile mental health apps to reduce symptoms of depression, anxiety, and stress [17, 18]. Further, many individuals show interest in technology to deal with health-related conditions. For example, survey data indicate that roughly three-quarters of psychiatric patients expressed an interest in using a smartphone to monitor their mental health and willingness to do so [19, 20]. However, translation from interest to actual use of apps to manage health-related concerns remains a challenge, as patients tend to use apps only rarely in their daily routine [21]. Examining objective app usage data, a systematic review by Baumel et al. revealed that only a small portion of individuals actually use apps targeting depression, anxiety, and emotional well-being over a long time period [22]. Moreover, smartphone-delivered interventions for mental health problems suffer from low engagement, with mean attrition rates ranging from 9.6% for interventions targeting general stress to 50.0% for apps focusing on insomnia relief [23]. High attrition rates have previously been reported for both web-based interventions and app-based interventions [24–27], implicating attrition as a considerable issue in remote healthcare delivery. Given the potential for mobile applications to restore and maintain mental health, it is vital that the research community investigate means of improving engagement and adherence.

Gamification (i.e., the application of game design elements and mechanisms in non-game contexts) [28–30] is an emerging field in the context of e-Health. There are a number of game

elements, and the most commonly used features in mental well-being apps are *levels/progress feedback*, *points/scoring/ranks*, *rewards/prizes* and *narrative/theme* [30]. With respect to the aim of this study, gamification has been acknowledged as a promising strategy to increase engagement with an intervention and thereby to reduce attrition and augment the intended treatment effects [28, 30, 31]. Although the specific psychological and neural mechanisms require further research, it is assumed that gamification enhances intrinsic motivation by satisfying basic psychological needs of autonomy, competence, and relatedness [30, 31]. Indeed, playing video games is related to fulfilment of these needs [32]. However, game elements, such as point accumulation are linked to socially mediated reinforcement, (i.e., obtaining a goal involves motivation via extrinsic factors). There is limited research on the impact of gamification on attrition in mobile health apps. In an RCT with type 2 diabetes patients, Höchsmann et al. [33] found significant increases in motivation and adherence to physical exercise in a gamified health app intervention group compared with a control group (one-time lifestyle counseling). Interestingly, the intervention group reported significantly higher enjoyment and perceived competence, which lends support to the assumption that gamification influences behavior change via intrinsic motivation. In contrast, a systematic review by Brown et al. [34] could not find a positive effect of gamification on program adherence to web-based mental health intervention. It is important to note, however, that in contrast to mobile mental health apps, most web-based interventions in the literature incorporated only one game element and that adherence has shown a positive correlation with number of game elements. Further, research on the effect of gamification in well-being interventions is scarce. A recent trial showed that playing a videogame may reduce treatment-resistant depressive symptoms in patients receiving antidepressant medication [35]. However, participants were not randomized in that trial, and the sample involved only a subgroup of those with major depression. To our knowledge, there is only one study directly testing the impact of gamified versus non-gamified versions of the same web-based-intervention on well-being [36]. Results of that study showed no difference between interventions on positive affect. However, participants in the gamified intervention group did exhibit elevated involvement, flow, interest, and inspiration.

Another factor to consider in the development of a mental health app is its purpose. Fostering mental health includes not only treatment but also prevention (universal, selective, and indicated) and maintenance interventions (relapse prevention and after-care) [7]. Although mental health, defined as hedonic and eudaimonic well-being [37], is not the opposite of mental illness, the two are interrelated [38]. This becomes more obvious when looking at the various features that constitute well-being (e.g., positive affect, personal growth, positive relations with others, and social integration) [38]. By contrast, negative affect and dysfunctional social relations have been identified as factors contributing to the development of mental disorder and to the persistence of symptoms. For instance, trait negative affect predicted symptoms of depression, social anxiety, panic, and worry in a momentary assessment study [39]. Depression has also frequently been linked to maladaptive social functioning [40, 41], and the risk of depression is significantly negatively correlated with social support and relationship quality [42]. On the other hand, a recent systematic review indicated that social support and a large, diverse social network serve a protective role against depression [43]. Resilience is an individual's ability to adapt and recover following adverse events [44] and is another psychological construct besides well-being worth considering in the context of mental health apps. Resilience may reduce susceptibility to depression and improve stress regulation [45]. Moreover, resilience has been linked to superior mental health and lower self-reported stress [46]. In summary, it is reasonable to assume that promoting well-being and resilience is relevant in the prevention of psychological burden and clinical symptoms.

Objectives and hypotheses

The purpose of this study was to examine the impact of gamification in a mobile mental health well-being app on self-reported resilience among those using mobile mental health services. Furthermore, we aimed to explore the effect of gamification on measures of well-being (positive relations with others, personal growth, and anxiety as a marker of negative affect) as well as attrition, in the context of a mobile mental health app. To achieve this goal, we conducted a randomized controlled trial in which participants used a gamified mobile mental health app, used a non-gamified mobile mental health app, or were assigned to the waitlist group.

The app *eQuoo* was designed to utilize the influence of gamification on psychoeducation, the internalization of learned concepts and their implementation in real-life settings, which is a large part of the therapeutic process [27]. The leap from learning psychological concepts within a game to learning the skills needed to enhance the user's well-being within a psychological intervention is not that broad [47]; thus, we hypothesized that users completing all elements would also benefit significantly from gamified interventions. In *eQuoo*, 8 gamification elements were implemented, as defined by Tondello and colleagues [48],: (1) *Levels*: one level a week where the player has to learn two skills and implement them correctly in a choose your own adventure story in order to unlock the following level; (2) *progress feedback* in the form of a "progress island map"; (3) *points* as coins; (4) varying *narratives* for each level; (5) *personalization* as generalized feedback of their Big Five personality type; (6) *customization* in allowing users to choose their own mini-avatar; (7) *mini games* where players can deepen skillsets, and finally (8) *badges* ranging from "beginner" to "self-aware". These are the same gamification tools used in video games and, increasingly, in mobile health technology [30]. These tools have been shown to enhance exposure to digital therapies, which has a direct link to effectiveness [49]. Thus, we hypothesized that participants in the *eQuoo* group would exhibit significantly increased self-reported resilience in using the mobile mental health game relative to participants in the cognitive behavioral therapy (CBT) app group. We further hypothesized significantly increased personal growth, positive relations with others, as well as decreased anxiety and attrition, in those receiving the eQuoo intervention compared to the control conditions.

Materials and methods

Sample and setting

Participants in this study were identified from among the population of Bosch UK employees and were recruited as part of their well-being benefit program between June 1 and July 30, 2019. To estimate the required sample size and *a priori* power calculation was conducted using G*Power software for a 3 (between-subjects) × 3 (within-subjects) design with an *a priori* effect size estimate of f = 0.1 (small) for the primary outcome (resilience, see below) and an achieved power of 0.80. The calculation indicated that an overall sample size of at least 327 participants would be needed to detect a time x group interaction effect with 80% probability if one was present. Considering the high rate of attrition reported in internet-based interventions [25] which is on average between 43–99%, emails were sent out to 2,500 participants with an invitation to participate in the study. This recruitment procedure was designed to best ensure that at least 327 participants would complete the 5-week trial, taking potentially low uptake and high attrition into consideration. In addition to the email, posters containing a QR code leading to the study's landing page were hung in the cafeterias of 20 Bosch UK locations.

This RCT was approved by the Ethics Committee of Ludwig Maximilian University of Munich, Germany, and is registered as trial DRKS00016039. The study was conducted according to the principles expressed in the Declaration of Helsinki.

Eligibility criteria

For the participants to be as representative of the general population as possible, the only eligibility criteria were (a) access to a smartphone or tablet device, (b) ability to read English, and (c) an iTunes or Google Play account. Information about previous mental health difficulties and previous treatment or use of well-being apps was not obtained. Only participants who completed the final assessment were included in the presented analyses.

Data collection

Data were collected using LimeSurvey, which is a highly certified and secure open source online scientific data collection software. All data collection processes were reviewed and approved by the Ethics Committee of Ludwig Maximilian University of Munich, Germany.

Measures

Well-being. To capture a range of constructs that have been related to well-being, we used a range of validated measures to capture resilience, personal growth, interpersonal relationship skills and anxiety.

Resilience Research Centre—Adult Resilience Measure. The Resilience Research Centre—Adult Resilience Measure (RRC-ARM), Section C is a 12-item scale developed by Ungar in 2002 [50]. The test offers ratings on a 5-point Likert-type scale *(1 = Not at All, 2 = A Little, 3 = Somewhat, 4 = Quite a Bit, 5 = A Lot)*, and is a screening tool designed to measure the resources (individual, relational, communal, and cultural) available to individuals that may bolster their resilience. Resilience has been identified as one of the major factors in maintaining mental well-being and dealing with stressors in a healthy way, as well as reducing risk-taking behaviors [51]. Because 4 questionnaires were to be administered and questionnaire fatigue was to be avoided, the short version was chosen, rather than the longer 28-item version. From that, the 5-item Likert scale was chosen, rather than the 3-item Likert scale. Cronbach's alpha reliability = 0.953 [52]. The ARM was considered the primary outcome in this study.

Positive relations with others subscale. Ryff's Scales of Psychological Well-Being (PWB) was developed in 1989 [53], and is a 6×14-item scale of psychological well-being (84 items total) designed to measure the dimensions of autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance. The test offers ratings on a 6-point Likert-type scale with positively and negatively scored items *(1 = strongly disagree, 2 = disagree somewhat, 3 = disagree slightly, 4 = agree slightly, 5 = agree somewhat, 6 = strongly agree)*. The subsection "Positive Relations with Others" was selected to avoid questionnaire fatigue while still addressing the isolation and feelings of personal disconnect that have been reported to be major factors in mental unhappiness [54] in the population targeted in this trial. Additional factors include inability to connect and build meaningful relationships, which raises doubts about the ability of an individual to make meaningful contributions to their community. Cronbach's alpha reliability = 0.88 [55].

Personal growth initiative scale. The Personal Growth Initiative Scale (PGIS) was designed by Robitschek in 1999 [56]. It is a 9-item Likert-type scale with 6 possible answers to each question *(1 = Definitely disagree, 2 = Mostly disagree, 3 = Somewhat disagree, 4 = Somewhat agree, 5 = Mostly agree, 6 = Definitely agree)*. One element of being a well-adjusted, functioning adult able to contribute to society is personal growth. Positive personal development allows people to achieve goals they have set, such as finishing college, maintaining employment, and advancing in their career. Cronbach's alpha reliability = 0.89 [56, 57]

One-item anxiety scale. The one-item anxiety scale measures the current anxiety level by asking how anxious someone feels at the moment [58]. The scale exhibits a high correlation

with the State-Trait Anxiety Inventory [59], which is a commonly used measure to assess state and trait anxiety [60]. The scale can be administered as a visual analog scale with higher scores indicating greater anxiety or a 5-point Likert scale (1 = not at all anxious, 2 = a little anxious, 3 = moderately anxious, 4 = very anxious, 5 = extremely anxious). In this study we used the 5-point Likert scale.

Attrition. Attrition was defined as not completing the assessments at both day 17 (t2) and day 35 (t3) of the trial. This is in line with previous research according to which attrition occurs when a participant fails to complete the study protocol associated with the intervention [24, 61].

Test group intervention

The test group was asked to download a free app called *eQuoo*, available on all major app platforms. The app has 5 levels and is intended to be used over a 5-week period. For each level, the player learns two psychological skills extracted from CBT therapies, positive psychology therapies, and systemic therapies. Each skill is taught in a tutorial format by an avatar named "Dr. Joy", who introduces the player to the game, and explains the processes and skills involved. Each skill is introduced in 3 steps: 1) Dr. Joy explains a skill while cartoon stick figures help visually represent the concepts, 2) possible reactions to the skill are laid out and explained by Dr. Joy using the stick figures, and 3) the player's knowledge of the skill is tested by two characters, Jasmine and Noah, who remain the same throughout the tutorials. Tutorials progress across a series of real-life scenarios such as applying for a job or feeling insecure about a relationship. Once the player masters two skills, a choose-your-own-adventure story opens up where the player is confronted with helping the story's characters complete a challenge. The stories are presented in different genres, including a fantasy story, a sci-fi story, an office story, a love story, and a family holiday story. Each story has two types of questions with three answers to choose from. The first type of question is the "concept question", which tests an individual's mastery of the skills learned in the tutorial, and the second is a personality question based on the Big Five Personality Test [62]. The concept question can be answered incorrectly twice before the story ends in a humorous disaster with feedback as to why the choices resulted in failure of that level. The OCEAN questions lead to feedback about the player's personality. The skills taught in *eQuoo* are as follows: emotional bids [63], generalization [64], action bias [65], confirmation bias [65], catastrophizing [66], halo effect [67], reciprocity [68], expectancy effect [69], courtesy bias [70], and self-serving bias [71]. Details of each skill and instance of personality feedback can be read in a library feature within the app.

Control group intervention

Different CBT techniques and positive psychology methods have been linked to mental well-being [72], including the constructs tested in this paper: resilience [73], interpersonal relationships skills—even in settings as dire as domestic abuse [74], personal growth and various types of anxiety [75]. The control group was asked to download a free app called *CBT Thought Diary*, which was developed by MoodTools, is an evidence-based tool and is available on all major app platforms. As there are currently no evidence-based mental health games targeting mental well-being, *CBT Thought Diary*, based on CBT and Positive Psychology, was chosen as "treatment as usual", being representative of the majority of existing mobile mental health apps. In the app, the client can track their mood by choosing one of 5 smiley icons, label their emotions, identify negative and distorted thinking patterns, perform a typical CBT exercise, and maintain a mood diary and gratitude journal [76]. Because the *eQuoo* group would be

spending an average of 10–15 min in the game each week, the control group was asked to use the *CBT Thought Diary* for 10 min per week.

Waitlist group

The waitlist group received no intervention but completed the questionnaires at the same time points as the control and test groups. After completion of the trial, they were debriefed on the trial results and were given a link to both *eQuoo* and the *CBT Thought Diary* app.

Design

A mixed factorial 3 (condition) ×3 (time) repeated measures design was applied. Participants were randomly assigned to a condition (test group vs. control vs. waitlist group). Across the study period, measures were conducted at the beginning (t1), and again at 17 (t2) and 35 (t3) days after the trial began.

Procedure

Two weeks before starting data collection, we sent a recruitment email to 2500 Bosch UK employees using their work email addresses provided by the company's HR department. Three days later, a reminder email was sent. The email contained a link to sign up for the trial that led to a landing page where the consent form was presented. Below the form was a button stating, "I understand and accept". When the button was clicked, participants were randomly assigned the test, control, or waitlist control group. Random assignment was achieved using a randomization generator provided by random.org. The randomness comes from atmospheric noise, which for many purposes is better than the pseudo-random number algorithms typically used in computer programs [77]. Moreover, the first enrollment form asked participants for their demographic data, as well as an email address so that they could be contacted at the beginning of the study. After a 2-week sign-up period, the study was launched, and 3 different emails were sent to each group asking them to download the app and fill out the 4 questionnaires. The test group was specifically asked to play only one level per week.

Each week, the test group was sent an email requesting them to play a single level of *eQuoo*, and the control group was asked to use the *CBT Thought Diary* for 10 min. This resulted in the test and control group receiving a total of 5 emails over the 5-week trial period. The waitlist group only received an email with the questionnaires alongside the other two groups: at the beginning (t1), on day 17 (t2), and on day 35 (t3) of the trial.

Statistical analyses

Statistical analysis was performed with SPSS 25.0 software. Characteristics of the three groups were compared using chi-square independence tests for categorical variables and one-way analysis of variance (ANOVA) models.

To evaluate the impact of the intervention conditions on changes in the primary outcome (resilience–ARM), as well as secondary outcomes (PRWO, PGIS, and Anxiety), 3 (intervention) × 3 (time) repeated-measures ANOVA models were conducted. Bonferroni-corrected pairwise comparisons were conducted to explore the differences between interventions. Paired sample t-tests (two-tailed) were conducted using pre-post (t1 vs. t3), as well as mid-point and post (t2 vs t3) data within each intervention to explore the impact of the interventions on change in the measures of interest and effect sizes (Cohen's d) were calculated. The odds of attrition were calculated for each intervention, and odds ratios (as well as the p-value and 95%

confidence intervals) were estimated by comparing the odds between interventions. A p-value of less than 0.05 was considered statistically significant.

Results

Participants

Details of enrollment organized according to the CONSORT guidelines are shown in Fig 1. Descriptive statistics of participants who completed the final questionnaire administration are presented in Tables 1 and 2. Most participants were 35–44 years of age, male, and white.

Effects of treatment

Primary outcome. To test the effect of the intervention on resilience, 3 (intervention groups) × 3 (time points) repeated-measures ANOVA was performed. Bonferroni-corrected post hoc tests were conducted to explore the differences between the interventions.

The repeated-measures ANOVA of the primary outcome (ARM score) yielded a significant main effect of intervention ($F(2,350) = 8.51$, $p < 0.001$, $\eta p2 = 0.046$) and a significant interaction between intervention and time ($F(4,698) = 3.34$, $p = 0.01$, $\eta p2 = 0.019$), but not a main effect of time ($F(2,350) = 2.66$, $p = 0.07$, $\eta p2 = 0.015$). Mean ARM scores over time for each intervention group are presented in Fig 2. *eQuoo* participants exhibited greater increases in scores compared with the CBT journal and waitlist control groups. Bonferroni-corrected post hoc comparisons indicated a significant difference in means between the *eQuoo* and waitlist group ($p < 0.001$), but not between *eQuoo* and the CBT journal group, or the waitlist control and CBT journal group. Within intervention pre (t1)–post (t3) effect sizes were calculated, indicating a small effect for the *eQuoo* group (M(SD)pre = 49.32(5.60), and M(SD) post = 50.87(5.31), $d_{rm} = -0.37$), compared with a limited effect for the CBT journal (M(SD) pre = 48.56(6.68), and M(SD) post = 48.82(6.70), $d_{rm} = -0.06$) and waitlist groups (M(SD) pre = 47.35(7.36), and M(SD) post = 47.08(7.51), $d_{rm} = 0.06$). Further Bonferroni-corrected post hoc tests indicated significant differences in scores between the *eQuoo* group and the waitlist group at t1 ($p = 0.049$), t2 ($p < 0.001$), and t3 ($p < 0.001$), whereas the difference between the CBT journal and *eQuoo* (or the waitlist group) was not statistically significant at any time point ($p > 0.05$).

Secondary outcomes. Repeated-measures ANOVAs were also conducted for each of the three secondary outcome measures (personal growth, interpersonal relationship skills and anxiety). For each outcome 3 (intervention groups) × 3 (time points) repeated-measures ANOVA was performed., with bonferroni-corrected post hoc tests were conducted to explore the differences between the interventions.

ANOVA of Ryff's Scales of Psychological Well-Being (RPRS) score yielded a significant main effect of intervention ($F(2,342) = 3.26$, $p = 0.04$, $\eta p2 = 0.019$) and a significant interaction between intervention and time ($F(4,682) = 6.73$, $p < 0.001$, $\eta p2 = 0.038$), but not a main effect of time ($F(2,341) = 2.82$, $p = 0.06$, $\eta p2 = 0.016$). Mean RPRS score over time for each intervention group is presented in Fig 3. Results indicated that *eQuoo* participants displayed greater increases in scores compared to the CBT journal and waitlist control groups. Bonferroni-corrected post hoc comparisons showed that the main effect of intervention came from the significant difference in means between the *eQuoo* and waitlist group ($p = 0.03$), but not between *eQuoo* and the CBT journal group or the waitlist control and CBT journal group. Within intervention pre (t1)–post (t3) effect sizes were calculated, indicating a small effect for the *eQuoo* group (M(SD)pre = 61.67(11.73), and M(SD) post = 64.53(10.74), $d_{rm} = -0.42$), compared to a limited effect for the CBT journal (M(SD)pre = 61.08(12.18), and M(SD) post = 61.15(12.71), $d_{rm} = -0.01$) and waitlist groups (M(SD)pre = 58.88(13.93), and M(SD) post = 58.35(13.111),

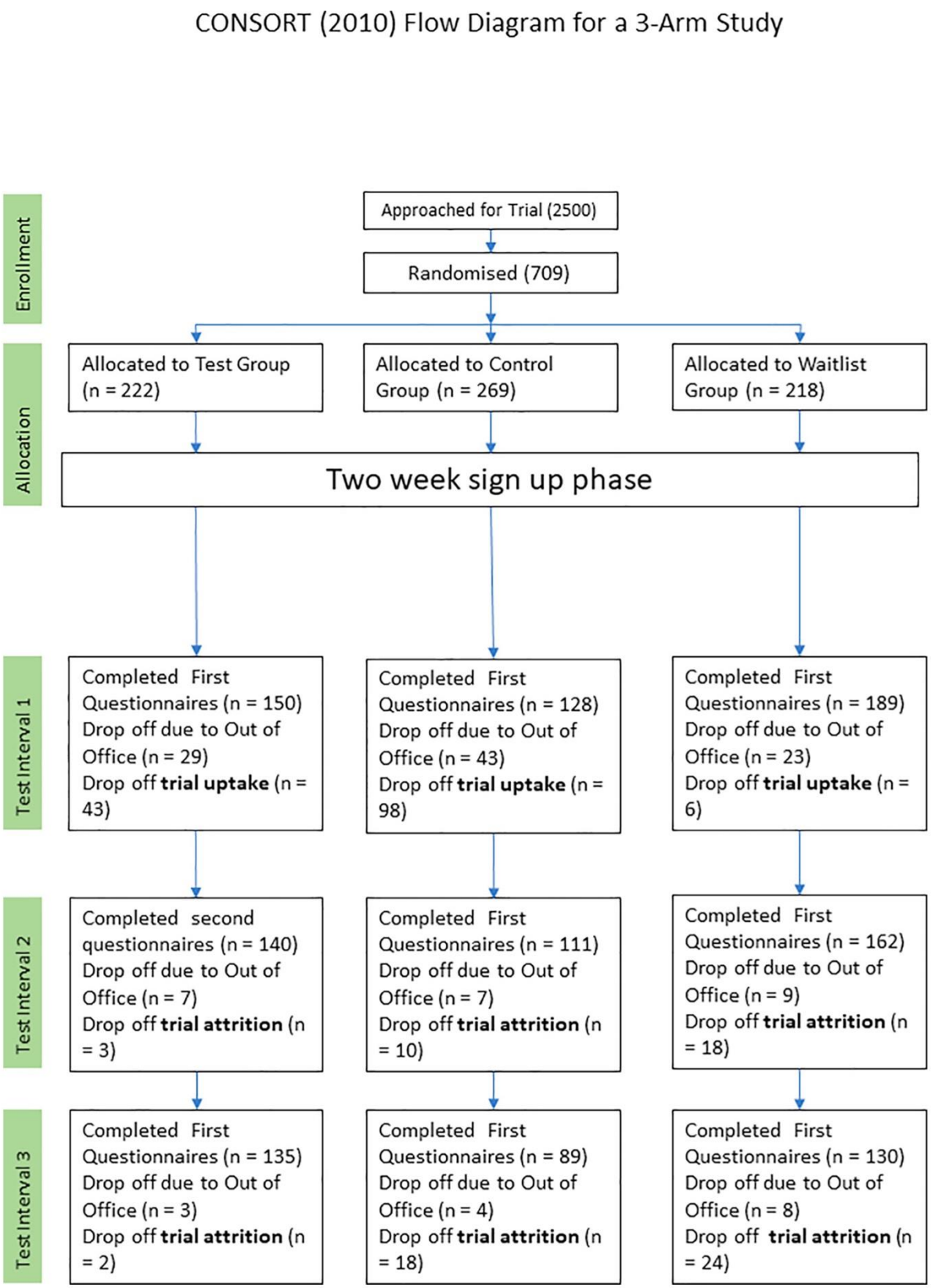


Fig 1. CONSORT flow diagram for a 3-arm study.

https://doi.org/10.1371/journal.pone.0237220.g001

Table 1. Outcome measures of the sample.

Outcome Measures		Mean	Sd	Mean	Sd	Mean	Sd	p-value^
ARM	Time 1	49.32	5.60	48.56	6.68	47.35	7.36	0.051
	Time 3	50.66	5.53	48.79	6.16	47.13	7.45	<0.001
	Time 5	50.87	5.31	48.82	6.70	47.08	7.51	<0.001
RPRS	Time 1	61.61	11.79	61.08	12.18	58.82	13.89	0.180
	Time 3	61.89	11.11	61.00	11.89	59.29	13.85	0.231
	Time 5	64.53	10.66	61.15	10.66	58.44	13.11	<0.001
PGIS	Time 1	38.43	8.07	37.21	8.88	36.41	7.74	0.129
	Time 3	39.51	6.90	37.82	8.23	37.02	8.15	0.030
	Time 5	42.15	6.43	39.42	7.78	37.70	7.99	<0.001
Anxiety	Time 1	1.05	0.96	1.07	1.15	1.32	1.15	0.078
	Time 3	0.90	0.96	0.99	1.00	1.25	1.00	0.012
	Time 5	0.88	0.98	0.88	0.85	1.21	1.07	0.011

ARM, Adult Resilience Measure; Anxiety, a One-Item Likert Scale; PGIS, Personal Growth Initiative Scale; RPRS, Ryff's Scales of Psychological Well-Being; SD, standard deviation.

*From chi-square tests of independence.

^From one-way ANOVAs.

https://doi.org/10.1371/journal.pone.0237220.t001

d_{rm} = 0.09). Further Bonferroni-corrected post hoc tests indicated significant differences in scores between the *eQuoo* group and the waitlist group at t3 only ($p < 0.001$).

ANOVA of the PGIS score revealed a significant main effect of intervention ($F(2,348) = 5.81$, $p = 0.003$, $\eta p2 = 0.03$) and time ($F(2,347) = 40.32$, $p < 0.001$, $\eta p2 = 0.19$) and a significant interaction between intervention and time ($F(4,694) = 3.99$, $p = 0.003$, $\eta p2 = 0.02$). Mean PGIS score over time for each intervention group is presented in Fig 4. These data suggest that *eQuoo* participants had greater increases in scores compared with the CBT journal and waitlist control groups, and Bonferroni-corrected post hoc comparisons showed that the main effect of intervention came from the significant difference in means between the *eQuoo* and waitlist group ($p = 0.002$), but not between *eQuoo* and the CBT journal group or the waitlist control and CBT journal group. Within-intervention pre (t1)–post (t3) effect sizes were calculated,

Table 2. Characteristics of the sample.

Demographics		eQuoo(n = 135)		CBT Journal(n-95)		Waitlist(n = 130)		
		n	%	n	%	n	%	p-value*
Age	16–24	20	14.8%	11	12.4%	14	10.8%	0.43
	25–34	27	20.0%	21	23.6%	41	31.5%	
	35–44	46	34.1%	22	24.7%	35	26.9%	
	45–54	33	24.4%	28	31.5%	29	22.3%	
	55–64	9	6.7%	7	7.9%	10	7.7%	
	64+	0	0.0%	0	0.0%	1	0.8%	
Gender	Female	60	44.4%	26	29.2%	54	41.5%	0.119
	Male	74	54.8%	63	70.8%	76	58.5%	
	Missing	1	0.7%	0	0.0%	0	0.0%	
Ethnicity	White	119	88.2%	78	87.6%	113	86.9%	0.769
	Asian	7	5.2%	5	5.6%	8	6.2%	
	Black	2	1.5%	1	1.1%	0	0.0%	
	Other	7	5.2%	5	5.6%	9	6.9%	

https://doi.org/10.1371/journal.pone.0237220.t002

Fig 2. ARM results at each time period.

https://doi.org/10.1371/journal.pone.0237220.g002

indicating a medium effect for the *eQuoo* group (M(SD)pre = 38.42(8.07), and M(SD) post = 42.15(6.43), d_{rm} = -0.67), compared with a small effect for both the CBT journal group (M(SD)pre = 37.21(8.88), and M(SD) post = 39.42(7.78), d_{rm} = -0.48) and the waitlist group (M(SD)pre = 36.36(7.75), and M(SD) post = 37.7(7.99), d_{rm} = -0.25).

Further Bonferroni-corrected post hoc tests indicated significant differences in scores between the *eQuoo* group and the waitlist group at t2 (p = 0.02) and t3 ($p < 0.001$), and between the CBT journal and *eQuoo* at t3 (p = 0.032).

ANOVA of the single-item anxiety score revealed a significant main effect of intervention (F(2,342) = 4.972, p = 0.007, ηp2 = 0.03) and time (F(2,341) = 4.74, p = 0.009, ηp2 = 0.03), but not an interaction between intervention and time (F(4,682) = 0.44, p = 0.78, ηp2 = 0.003). Fig 5 shows the change in mean anxiety score across groups, indicating that anxiety was highest for the waitlist group, and the change was uniform across groups. The within-intervention pre (t1)–post (t3) effect sizes were small or limited for each group (*eQuoo* group: (M(SD) pre = 1.05(0.97), M(SD) post = 0.88(0.98), d_{rm} = 0.20); CBT journal: (M(SD)pre = 1.07(1.04), M(SD) post = 0.88(0.85), d_{rm} = 0.19); waitlist control: (M(SD)pre = 1.33(1.14), M(SD) post = 1.21(1.08), d_{rm} = 0.12)).

Fig 3. RPRS scores at each time point.

https://doi.org/10.1371/journal.pone.0237220.g003

Further Bonferroni-corrected post hoc tests indicated significant differences in scores between the *eQuoo* group and the waitlist group at t1 ($p = 0.009$) and t2 ($p = 0.037$), and differences between the CBT journal and waitlist at t3 ($p = 0.038$).

Attrition

It is important to note that 225 potential participants were lost due to their use of their business email addresses for initial sign up, resulting in their inability to receive the trial reminder emails with the questionnaires during their annual leave. These attrition numbers have been excluded from the trial attrition numbers, as the attrition was imposed by external factors. The attrition results for participants in the test group, control group, and waitlist group are shown in Fig 6.

Of the 222 participants in the test group, the questionnaire was answered by 150 participants at t1, 140 at t2, and 135 at t3, corresponding to attrition of 6.7% and 10%, respectively.

Of the 269 participants in the control group, the questionnaire was answered by 128 participants at t1, 111 at t2, and 89 at t3, corresponding to attrition of 13.3% and 30.5%, respectively.

Of the 218 participants in the waitlist group, the questionnaire was answered by 89 participants at t1, 162 at t2, and 130 at t3, corresponding to attrition of 14.3% and 31.2%, respectively.

Fig 4. PGIS scores at each time point.

https://doi.org/10.1371/journal.pone.0237220.g004

The odds of remaining in the study were calculated for each intervention group. Overall, the odds of remaining in the study at t3 for those who completed the t1 questionnaire were 3.94 times higher in the test group compared with the control group (odds ratio = 3.944, 95% confidence interval [CI] = 2.053–7.576, $p < 0.001$; 10% vs. 30.5% attrition) and 4.08 times higher in the test group compared with the waitlist group (odds ratio = 4.084, 95% CI = 2.207 to 7.561, $p < 0.001$; 10% vs. 31.2% attrition).

Because the trial was conducted during the summer, when many Bosch UK associates took their annual leave, 225 "out of office" emails were received in response to the emails sent during the 3 time periods. The owners of the accounts sending those messages had no access to their accounts while out of the office and were not evaluated. This resulted in a 31% external attrition rate of participants who otherwise might have completed the trial.

Discussion

This randomized controlled study investigated the impact of a mental well-being mobile app, *eQuoo*, which incorporates gamification in order to (1) reduce attrition in mobile health services and (2) improve mental health well-being—defined as resilience, personal growth, interpersonal skills, and current anxiety level. Consistent with our hypothesis, results indicated a

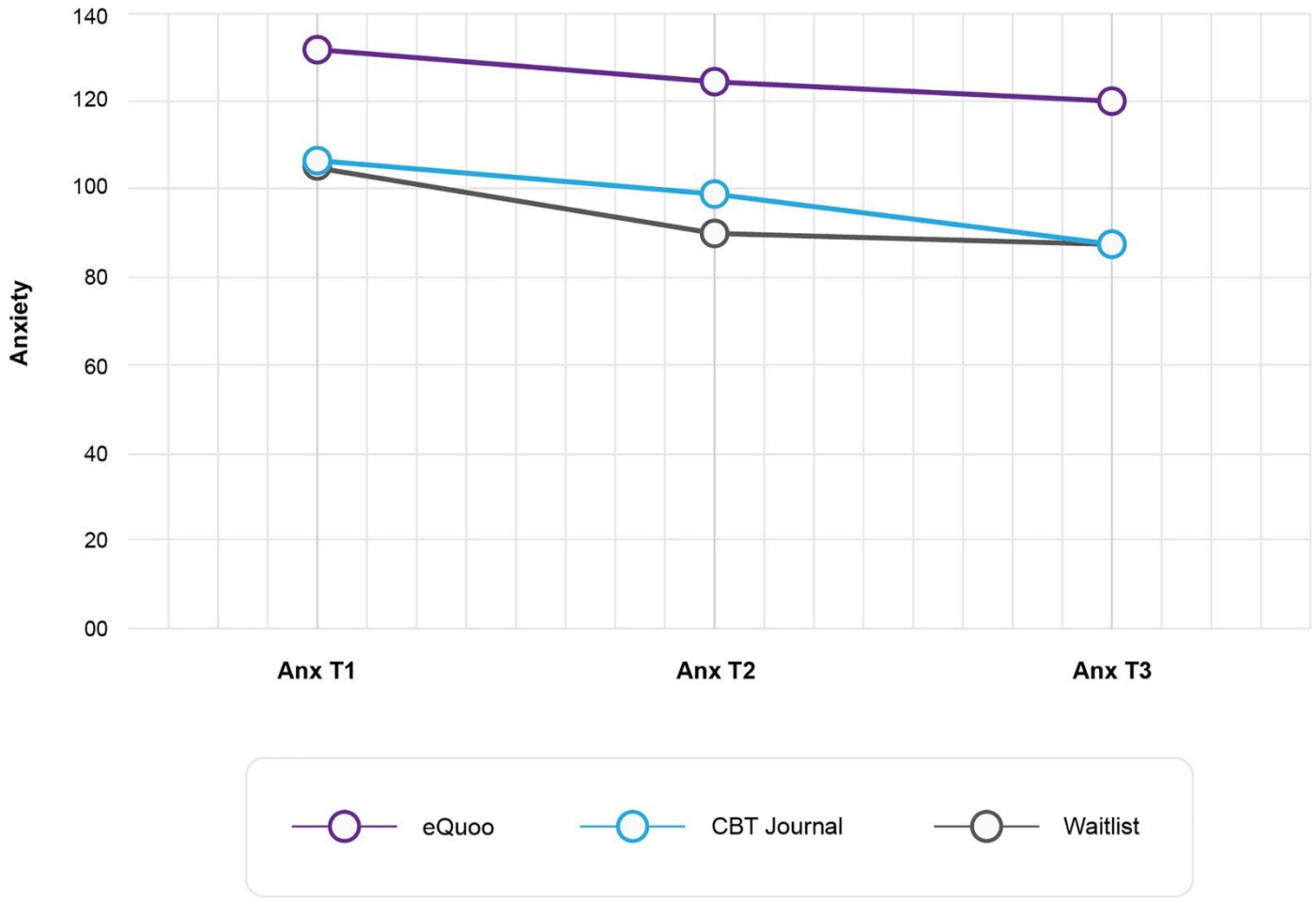


Fig 5. Anxiety scores at each time point.

https://doi.org/10.1371/journal.pone.0237220.g005

significantly lower attrition rate in the *eQuoo* app group compared with both the control intervention group (CBT journal app) and the no-intervention waitlist group. The odds of study protocol adherence was approximately 4 times higher in the *eQuoo* app group, suggesting that using a gamified mental well-being app is associated with a higher adherence to the study protocol than using a non-gamified mental health app or receiving no active treatment.

We also found partial evidence for the efficacy of gamification on well-being. Participants in the *eQuoo* app group exhibited higher scores on positive relations with others in comparison with participants in either the CBT journal app or waitlist group. However, this effect was driven by the difference between the *eQuoo* app group and the waitlist group. Participants using the *eQuoo* app did not significantly differ in relationships with others compared with those using the CBT journal app. Moreover, substantial gains in the *eQuoo* group occurred in the final two weeks of app usage, but not during the initial weeks of the study. Personal growth scores were higher in the *eQuoo* app group compared with both control groups. Importantly, personal growth differed significantly between participants in the *eQuoo* app versus waitlist control group at t2 and t3, whereas the difference in personal growth between *eQuoo* app and CBT journal app groups was significant at t3 only. Beyond a main effect of intervention, we also found a main effect of time on personal growth. Specifically, personal growth increased

Fig 6. Percentage of participants who submitted questionnaire responses at each time point.

https://doi.org/10.1371/journal.pone.0237220.g006

from t1 to t3 in all groups. Anxiety showed a uniform decrease across time. In line with our hypothesis, participants using the gamified *eQuoo* app showed a significant decline in anxiety compared with the waitlist group. However, there was no significant difference between the two active intervention groups. Finally, participants in the *eQuoo* group exhibited gains in resilience over the course of the study, but similar to other well-being measures, this effect was only significant for the *eQuoo* app versus waitlist group. In contrast to other well-being measures, resilience measures in the *eQuoo* app group showed significant improvement between t1 and t2, and subsequently remained stable. In summary, participants in the *eQuoo* app group exhibited improvements on all well-being measures during the course of the study. However, apart from a significantly higher personal growth score in the *eQuoo* app group compared with the CBT journal app group at t3, participants using the *eQuoo* app did not perform significantly better in terms of well-being than participants who used a non-gamified mental health app. Thus, we cannot rule out the possibility that the effects were based on not only the use of gamification, but also exposure to the underlying intervention.

Attrition is a major problem in online interventions, and gamification has been suggested as a promising strategy to foster adherence. In a meta-analysis investigating attrition and adherence in smartphone-based mental health interventions, Linardon and Fuller-Tyszkiewicz [61] reported attrition rates of approximately 33% and 42% for short-term and long-term follow-up interventions, respectively. Their results resemble the attrition we found for the CBT journal app group in our study. Importantly, the attrition rate in the group using a gamified mental well-being app was significantly reduced, supporting the idea that gamification may indeed strengthen adherence when using mental health apps. This is in line with a study by Kelders et al. [36], who investigated the impact of a gamified versus a non-gamified web-based well-being intervention. According to the authors, gamification increased involvement and flow when using the intervention. Although we did not test this directly, based on the results by Kelders et al. [36], it is also reasonable to suggest that higher involvement and flow led to a reduced attrition rate in the gamified app group in our study. Importantly, however, that Kelders et al. found that gamification did not increase behavioral engagement in terms of time spent with the intervention or exercises completed [36]. Moreover, there are other potential explanations for the significantly lower attrition rate in the gamified app group, such as the purpose of the app itself. For instance, approximately 83% of participants did not complete the study protocol in a recent app-based mood diary study with a follow-up period of 1-month (similar to the present study) [78]. However, the app in this study was limited to tracking individuals' emotional states and the context in which a specific emotion occurred, whereas both apps used in the present study encompassed more psychoeducational elements. Other research indicates that factors such as personal guidance in internet-delivered interventions [79], sociodemographic factors [80], confidence in the effectiveness of the online intervention [80], usability of the service [25], and perception of the intervention as personally relevant [81] play an important role in understanding attrition in eHealth. In addition, reasons for discontinuation of an intervention vary depending on the stage within the process. Usability is pivotal when considering whether to use a service at all, whereas positive attitudes toward technology, and experiencing a positive impact of the intervention are crucial to long-term adherence [82]. In conclusion, we cannot directly attribute our results to the impact of gamification. Future research should investigate a gamified versus non-gamified version of the same app intervention and control for the aforementioned factors to rule out alternative explanations.

Gamification and well-being

To date, only a few studies have explored the impact of mobile apps that incorporate gamification to promote well-being. For instance, Lin et al. found a substantial reduction of smoking after use of a CBT-based mobile app employing game elements aimed to boost participants hedonic well-being, inspiration, and empowerment [83]. Although the authors suggest that gamification increased hedonic well-being, in fact, this conclusion cannot be drawn based on the study design with no control condition. Other research has pointed out that playing mobile games can also positively affect individuals' psychological well-being [84]. As in our study, Ahtinen et al. reported positive effects of a gamified mobile app targeting working-aged people to reduce stress and enhance satisfaction with life in a 1-month field study [85]. However, in contrast to our study, neither of the aforementioned studies was an RCT, leaving open the question of whether game elements or other factors caused the gains in well-being. In addition, these were pilot studies with small sample sizes of 6 participants [84] and 15 participants [85], respectively.

Although studies applying gamification in mobile apps for fostering well-being are scarce, there is an emerging body of literature on the use of gamification to treat mental disorders

such as depression and anxiety [86]. The primary aim of gamification is to improve adherence to and motivation in the intervention [86]. For example, a mobile application incorporating ratings and feedback on progress as game elements significantly reduced depressive symptoms [87]. It is important to note that, compared with the majority of other studies, the interventions in this research were personalized based on context features derived from the interactions of each participant with the smartphone, such as location (home vs. work) or level of current physical activity [87]. Thus, the effects revealed in this study may arise from meaningful recommendations of interventions according to personal context rather than gamification of the intervention. To test the effect that gamification would have on mental health, it is necessary to directly compare a gamified versus a non-gamified version of the same intervention. Recent studies implementing such a design have found promising results in favor of gamification. For instance, adding common game elements such as a reward system to a standard web-based intervention to reduce alcohol consumption significantly increased the efficacy of the treatment over a 2-week course [88]. In another study, Kelders et al. [36] found evidence for significantly higher personal involvement and flow in participants who used a gamified versus non-gamified web-based intervention designed to improve well-being in the general population. Moreover, the gamified interventions enhanced positive affect and intrinsic motivation, though these effects were marginally significant [36]. Interestingly, this effect occurred only in a real-life experiment, not in lab conditions, thus highlighting the importance of considering the context in which a gamified treatment is to be used.

Strengths and limitations

The present study had several strengths. To our knowledge, this is the first follow-up RCT investigating the impact of gamification on improving resilience, mental well-being and adherence in the context of a smartphone app. Notably, compared with prior research, we were able to investigate the effects in a large sample of approximately 470 participants at the beginning of the study. Given that evidence on the effectiveness of mobile apps on well-being in real-life settings is scarce, this study contributes to the literature on smartphone applications for mental health.

Some limitations of this study need to be acknowledged. One is that the mobile mental health apps used in the study had different purposes, making it difficult to directly evaluate the impact of gamification on attrition and well-being. The focus of the app *eQuoo* is to strengthen resilience by implementing gamification. A virtual character accompanies the user as he or she learns skills associated with well-being. In contrast, the app *CBT Thought Journal* aims to reveal the association between dysfunctional thinking and mood, a typical CBT exercise, and it can be used to document initial distress, emotions, and thoughts with respect to a given situation. Subsequently, the user identifies cognitive distortions within their thoughts and writes an alternative interpretation of the situation. Thus, we cannot exclude possibility that the effects we found in this study were attributable not solely to gamification but also to the different purposes of the apps. Moreover, since we did not record the degree to which participants were engaged with the app (e.g. time of usage) it is not possible to evaluate the impact of gamification on nonusage attrition. Although dropout and nonusage attrition may be substantially correlated [24], future studies should seek to consider both attrition outcome measures to increase internal validity. Another limitation is that the external validity of the study is limited for the following reasons. First, since the sample comprised employees of BOSCH UK, the results should be generalized with caution although we found no indication that the sample differs from the general population. Also, although the primary outcome for the study was resilience, the secondary well-being outcomes of the present study, namely, personal growth,

relationships with others, and anxiety, are somewhat restricted compared with the rather broad construct of well-being, and further studies exploring the impact of dropouts would be crucial to the understanding of mHealth interventions. In this study, only completers were included in the measurements, possibly leading to a neglect of data significant to the development of effective mobile interventions.

The platform limitations of a mobile game also contribute to the limitations, as treatment choices were dictated by the usage of gamification on a developer platform called UNITY as much as research on effective interventions. Lastly, there has been a deviation from the original protocol: In the time from first submission of the study protocol on 5.12.2017 until the acceptance on 13.11.2018 the leading author, Silja Litvin, continued research in the field and came to the conclusion that exchanging the wellbeing questionnaire from the Happiness Scale, to The Resilience Research Centre—Adult Resilience Measure (RRC-ARM), would benefit the study's applicable value to society. The changes were appraised not to warrant a re-submission to the ethics committee, as the psychological dimensions remain the same. The study was shortened to 5 weeks from 6 weeks as the app which was being developed at the time of the ethics submission, only made it to 5 levels instead of the planned six due to funding issues.

Implications

This study provides the first evidence that gamification has the potential to enhance the effects of mobile health and well-being interventions. However, further research should examine the mechanisms by which gamification impacts mental health and well-being in the real world. To do so, an experimental study should be conducted in a field-study setting. Specifically, to attribute causal effects to gamification, it is necessary to utilize a gamified versus a non-gamified version of the same intervention in an RCT. Another direction of future research is to compare different game elements to determine whether specific gamification strategies are associated with more benefits than others. This is in line with Cheng et al. [89], who advocated dissecting gamification features in order to shine light into the "black box". Therefore, it is vital to position future research within theoretical frameworks such as self-determination theory and hypothesized mechanisms for how game elements influence outcomes of interest [89]. We suggest a multimethod approach for well-being, that is, use of various validated outcome measures such as the 5-item World Health Organization Well-Being Index [90], the Positive and Negative Affect Schedule [91] and the Psychological Distress Scale [92]. Moreover, to establish a meaningful relationship between gamification and mental well-being we suggest monitoring well-being using an ambulatory assessment approach in a longitudinal design [93]. For instance, participants could be prompted to answer short surveys on their well-being immediately after they used the respective intervention. Also, it would be possible to ask participants after an event if they applied strategies taught in the intervention. For attrition, we propose incorporating adherence measures that are directly linked to use of the intervention, such as number of logins, usage duration, and completion of modules or levels.

Conclusion

This study's objective was to investigate the potential of a gamified mobile app to improve psychological resilience compared with a non-gamified mental health intervention app and a waitlist group. We found superiority of the gamified versus non-gamified app in increasing self-reported resilience. The gamified app also increased other measures of wellbeing, as well as reducing anxiety and attrition rates. Future research should compare a gamified versus non-gamified version of the same mobile app as well as incorporate a multimethod approach and ambulatory assessment to study well-being and attrition in real-world settings.

Supporting information

S1 Checklist. CONSORT 2010 checklist of information to include when reporting a randomised trial*.
(DOC)

S1 Protocol.
(DOCX)

S2 Protocol.
(DOCX)

Author Contributions

Conceptualization: Silja Litvin, Markus A. Maier.

Data curation: Silja Litvin.

Formal analysis: Silja Litvin, Rob Saunders, Markus A. Maier.

Investigation: Silja Litvin.

Methodology: Silja Litvin, Rob Saunders.

Project administration: Silja Litvin, Stefan Lüttke.

Resources: Silja Litvin, Markus A. Maier.

Software: Silja Litvin.

Supervision: Silja Litvin.

Validation: Rob Saunders, Stefan Lüttke.

Visualization: Rob Saunders.

Writing – original draft: Silja Litvin, Stefan Lüttke.

Writing – review & editing: Markus A. Maier.

References

1. Institute for Health Metrics and Evaluation. Findings from the global burden of disease study 2017. Seattle (WA); 2018.
2. World Health Organization. Depression and other common mental disorders: global health estimates. Geneva: World Health Organization; 2017.
3. McDaid D, Park AL, Wahlbeck K. The economic case for the prevention of mental illness. Ann Rev Pub Health. 2019; 40:373–89.
4. Twenge JM, Cooper AB, Joiner TE, Duffy ME, Binau SG. Age, period, and cohort trends in mood disorder indicators and suicide-related outcomes in a nationally representative dataset, 2005–2017. J Abnorm Psychol. 2019; 128(3):185–99. https://doi.org/10.1037/abn0000410 PMID: 30869927
5. Davies SC. Annual report of the Chief Medical Officer 2013. Public mental health priorities: investing in the evidence. London: Department of Health; 2014.
6. Kazdin AE. Addressing the treatment gap: a key challenge for extending evidence-based psychosocial interventions. Behav Res Ther. 2017; 88:7–18. https://doi.org/10.1016/j.brat.2016.06.004 PMID: 28110678
7. National Academies of Sciences, Engineering, and Medicine. Fostering healthy mental, emotional, and behavioral development in children and youth: a national agenda. Washington, DC: The National Academies Press; 2019.
8. Ormel J, Cuijpers P, Jorm AF, Schoevers R. Prevention of depression will only succeed when it is structurally embedded and targets big determinants. World Psychiatry. 2019; 18(1):111. https://doi.org/10.1002/wps.20580 PMID: 30600627

9. Cuijpers P, van Straten A, Smit F, Mihalopoulos C, Beekman A. Preventing the onset of depressive disorders: a meta-analytic review of psychological interventions. Am J Psychiatry. 2008; 165(10):1272–80. https://doi.org/10.1176/appi.ajp.2008.07091422 PMID: 18765483

10. Livingston NA, Shingleton R, Heilman ME, Brief D. Self-help smartphone applications for alcohol use, PTSD, anxiety, and depression: addressing the new research-practice Gap. J Tech Behav Sci. 2019: 4 (2);139–51.

11. Mojtabai R, Olfson M, Sampson NA, Jin R, Druss B, Wang PS, et al. Barriers to mental health treatment: results from the National Comorbidity Survey Replication. Psychol Med. 2011; 41(8):1751–61. https://doi.org/10.1017/S0033291710002291 PMID: 21134315

12. Ebert DD, Mortier P, Kaehlke F, Bruffaerts R, Baumeister H, Auerbach RP, et al. Barriers of mental health treatment utilization among first-year college students: first cross-national results from the WHO World Mental Health International College Student Initiative. Int J Meth Psych Res. 2019; 28(2):e1782.

13. Sickel AE, Seacat JD, Nabors NA. Mental health stigma: impact on mental health treatment attitudes and physical health. J Health Psychol. 2019; 24(5):586–99. https://doi.org/10.1177/1359105316681430 PMID: 27909162

14. statista.com [Internet]. Number of smartphone users worldwide from 2016 to 2021; c2019 [cited 2019 Nov 11]. Available from: https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/

15. Aitken M, Clancy B, Nass D. The growing value of digital health: evidence and impact on human health and the healthcare system. IQVIA Institute for Human Data Science; 2017 [cited 2019 Nov 23]. Available from: https://www.iqvia.com/-/media/iqvia/pdfs/institute-reports/the-growing-value-of-digital-health.pdf?_=1574511957790

16. Bry Laura Jane, Chou Tommy, Miguel Elizabeth, and Comer Jonathan S. "Consumer smartphone apps marketed for child and adolescent anxiety: A systematic review and content analysis." *Behavior therapy* 49, no. 2 (2018): 249–261.

17. Donker T, Petrie K, Proudfoot J, Clarke J, Birch MR, Christensen H. Smartphones for smarter delivery of mental health programs: a systematic review. J Med Internet Res. 2013; 15(11):e247. https://doi.org/10.2196/jmir.2791 PMID: 24240579

18. Rathbone AL, Prescott J. The use of mobile apps and SMS messaging as physical and mental health interventions: systematic review. J Med Internet Res. 2017; 19(8):e295. https://doi.org/10.2196/jmir.7740 PMID: 28838887

19. Torous J, Chan SR, Tan SY, Behrens J, Mathew I, Conrad EJ, et al. Patient smartphone ownership and interest in mobile apps to monitor symptoms of mental health conditions: a survey in four geographically distinct psychiatric clinics. JMIR Mental Health. 2014; 1(1):e5. https://doi.org/10.2196/mental.4004 PMID: 26543905

20. Beard C, Silverman AL, Forgeard M, Wilmer MT, Torous J, Björgvinsson T. Smartphone, social media, and mental health app use in an acute transdiagnostic psychiatric sample. MIR mHealth uHealth. 2019; 7(6):e13364.

21. Torous J, Wisniewski H, Liu G, Keshavan M. Mental health mobile phone app usage, concerns, and benefits among psychiatric outpatients: comparative survey study. JMIR Ment Health. 2018; 5(4): e11715. https://doi.org/10.2196/11715 PMID: 30446484

22. Baumel A, Muench F, Edan S, Kane JM. Objective user engagement with mental health apps: systematic search and panel-based usage analysis. J Med Internet Res. 2019; 21(9):e14567. https://doi.org/10.2196/14567 PMID: 31573916

23. Torous J, Nicholas J, Larsen ME, Firth J, Christensen H. Clinical review of user engagement with mental health smartphone apps: evidence, theory and improvements. Evid Based Ment Health. 2018; 21 (3):116–9. https://doi.org/10.1136/eb-2018-102891 PMID: 29871870

24. Eysenbach G. The law of attrition. J Med Internet Res. 2005; 7(1):e11. https://doi.org/10.2196/jmir.7.1.e11 PMID: 15829473

25. Torous J, Lipschitz J, Ng M, Firth J. Dropout rates in clinical trials of smartphone apps for depressive symptoms: a systematic review and meta-analysis. J Affect Disord. 2020; 263:413–19. https://doi.org/10.1016/j.jad.2019.11.167 PMID: 31969272

26. Farvolden P, Denisoff E, Selby P, Bagby RM, Rudy L. Usage and longitudinal effectiveness of a Web-based self-help cognitive behavioral therapy program for panic disorder. J Med Internet Res. 2005; 7 (1):e7. https://doi.org/10.2196/jmir.7.1.e7 PMID: 15829479

27. Salvatori Penny. "Implementing a problem-based learning curriculum in occupational therapy: A conceptual model." *Australian Occupational Therapy Journal* 47, no. 3 (2000): 119–133.

28. Sardi L, Idri A, Fernández-Alemán JL. A systematic review of gamification in e-Health. J Biomed Inform. 2017; 71:31–48. https://doi.org/10.1016/j.jbi.2017.05.011 PMID: 28536062

29. Deterding S, Dixon D, Khaled R, Nacke L. From game design elements to gamefulness: Defining gamification. Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments; 2011 Sep 28–30; Tampere, Finland: New York: ACM; 2011. 10.1145/2181037.2181040

30. Cheng VW, Davenport T, Johnson D, Vella K, Hickie IB. Gamification in apps and technologies for improving mental health and well-being: systematic review. JMIR Ment Health. 2019; 6(6):e13717. https://doi.org/10.2196/13717 PMID: 31244479

31. Johnson D, Deterding S, Kuhn KA, Staneva A, Stoyanov S, Hides L. Gamification for health and wellbeing: A systematic review of the literature. Internet Interv. 2016; 6:89–106. https://doi.org/10.1016/j.invent.2016.10.002 PMID: 30135818

32. Ryan RM, Rigby CS, Przybylski A. The motivational pull of video games: A self-determination theory approach. Motiv Emot. 2006; 30(4):344–60.

33. Höchsmann C, Infanger D, Klenk C, Königstein K, Walz SP, Schmidt-Trucksäss A. Effectiveness of a behavior change technique–based smartphone game to improve intrinsic motivation and physical activity adherence in patients with type 2 diabetes: randomized controlled trial. JMIR Serious Games. 2019; 7(1):e11444. https://doi.org/10.2196/11444 PMID: 30758293

34. Brown M, O'Neill N, van Woerden H, Eslambolchilar P, Jones M, John A. Gamification and adherence to web-based mental health interventions: a systematic review. JMIR Ment Health. 2016; 3(3):e39. https://doi.org/10.2196/mental.5710 PMID: 27558893

35. Russoniello CV, Fish MT, O'Brien K. The efficacy of playing videogames compared with antidepressants in reducing treatment-resistant symptoms of depression. Games Health J. 2019; 8(5):332–8. https://doi.org/10.1089/g4h.2019.0032 PMID: 31216188

36. Kelders SM, Sommers-Spijkerman M, Goldberg J. Investigating the direct impact of a gamified versus nongamified well-being intervention: an exploratory experiment. J Med Internet Res. 2018; 20(7):e247. https://doi.org/10.2196/jmir.9923 PMID: 30049669

37. Ryan R.M., & Deci E.L. (2001). On happiness and human potentials: a review of research on hedonic and eudaimonic well-being. Ann Rev Psychol. 2001; 52:141–66.

38. Keyes CL. Mental illness and/or mental health? Investigating axioms of the complete state model of health. J Consult Clin Psychol. 2005; 73(3):539. https://doi.org/10.1037/0022-006X.73.3.539 PMID: 15982151

39. Naragon-Gainey K. Affective models of depression and anxiety: Extension to within-person processes in daily life. J Affect Disord. 2019; 243:241–8. https://doi.org/10.1016/j.jad.2018.09.061 PMID: 30248635

40. Hirschfeld R, Montgomery SA, Keller MB, Kasper S, Schatzberg AF, Möller HJ, et al. Social functioning in depression: a review. J Clin Psychiatry. 2000; 61(4):268–75. https://doi.org/10.4088/jcp.v61n0405 PMID: 10830147

41. Bora E, Berk M. Theory of mind in major depressive disorder: a meta-analysis. J Affect Disord. 2016; 191:49–55. https://doi.org/10.1016/j.jad.2015.11.023 PMID: 26655114

42. Teo AR, Choi H, Valenstein M. Social relationships and depression: ten-year follow-up from a nationally representative study. PloS One. 2013; 8(4):e62396. https://doi.org/10.1371/journal.pone.0062396 PMID: 23646128

43. Santini ZI, Koyanagi A, Tyrovolas S, Mason C, Haro JM. The association between social relationships and depression: a systematic review. J Affect Disord. 2015; 175:53–65. https://doi.org/10.1016/j.jad.2014.12.049 PMID: 25594512

44. Shrivastava A, Desousa A. Resilience: A psychobiological construct for psychiatric disorders. Indian J Psychiatry. 2016; 58(1):38. https://doi.org/10.4103/0019-5545.174365 PMID: 26985103

45. Akeman E, Kirlic N, Clausen AN, Cosgrove KT, McDermott TJ, Cromer LD, et al. A pragmatic clinical trial examining the impact of a resilience program on college student mental health. Depress Anxiety. 2019. https://doi.org/10.1002/da.22969 PMID: 31682327

46. Kermott CA, Johnson RE, Sood R, Jenkins SM, Sood A. Is higher resilience predictive of lower stress and better mental health among corporate executives? PloS one. 2019; 14(6):e0218092. https://doi.org/10.1371/journal.pone.0218092 PMID: 31185049

47. Reppucci N. D., & Saunders J. T. (1974). Social psychology of behavior modification: Problems of implementation in natural settings. Am Psychol, 1974; 29(9):649–60. https://doi.org/10.1037//0003-066x.29.9.649 PMID: 4415799

48. Tondello GF, Mora A, Nacke LE. Elements of gameful design emerging from user preferences. Proceedings of the Annual Symposium on Computer-Human Interaction in Play; 2017 Oct 15; Amsterdam, The Netherlands. New York: ACM; 2017. p. 129–42. ACM.

75. Eng W, Coles ME, Heimberg RG, Safren SA. Domains of life satisfaction in social anxiety disorder: relation to symptoms and response to cognitive-behavioral therapy. J Anxiety Disord. 2005; 19(2):143–56. https://doi.org/10.1016/j.janxdis.2004.01.007 PMID: 15533701

76. Ducasse D, Dassa D, Courtet P, Brand-Arpon V, Walter A, Guillaume S, et al. Gratitude diary for the management of suicidal inpatients: A randomized controlled trial. Depression and anxiety. 2019 May; 36(5):400–11. https://doi.org/10.1002/da.22877 PMID: 30657226

77. Donkin L, Christensen H, Naismith SL, Neal B, Hickie IB, Glozier N. A systematic review of the impact of adherence on the effectiveness of e-therapies. J Med Internet Res. 2011; 13(3):e52. https://doi.org/10.2196/jmir.1772 PMID: 21821503

78. Bakker D, Rickard N. Engagement in mobile phone app for self-monitoring of emotional wellbeing predicts changes in mental health: MoodPrism. J Affect Disord. 20181; 227:432–42. https://doi.org/10.1016/j.jad.2017.11.016 PMID: 29154165

79. Forand NR, Feinberg JE, Barnett JG, Strunk DR. Guided internet CBT versus "gold standard" depression treatments: an individual patient analysis. J Clin Psychol. 2019; 75(4):581–93. https://doi.org/10.1002/jclp.22733 PMID: 30597551

80. Fuhr K, Schröder J, Berger T, Moritz S, Meyer B, Lutz W, et al. The association between adherence and outcome in an Internet intervention for depression. J Affect Disord. 2018; 229:443–9. https://doi.org/10.1016/j.jad.2017.12.028 PMID: 29331706

81. Price M, Gros DF, McCauley JL, Gros KS, Ruggiero KJ. Nonuse and dropout attrition for a web-based mental health intervention delivered in a post-disaster context. Psychiatry. 2012; 75(3):267–84. https://doi.org/10.1521/psyc.2012.75.3.267 PMID: 22913502

82. Chiu TM, Eysenbach G. Stages of use: consideration, initiation, utilization, and outcomes of an internet-mediated intervention. BMC Med Inform Decis Mak. 2010; 10(1):73.

83. Lin Y, Tudor-Sfetea C, Siddiqui S, Sherwani Y, Ahmed M, Eisingerich AB. Effective behavioral changes through a digital mHealth app: exploring the impact of hedonic well-being, psychological empowerment and inspiration. JMIR mHealth uHealth.2018; 6(6):e10024. https://doi.org/10.2196/10024 PMID: 29907557

84. Li N, Chen W. A mobile game for the social and cognitive well-being of elderly people in China. Stud Health Technol Inform. 2017; 242:614–21. PMID: 28873861

85. Ahtinen A, Mattila E, Välkkynen P, Kaipainen K, Vanhala T, Ermes M, et al. Mobile mental wellness training for stress management: feasibility and design implications based on a one-month field study. JMIR mHealth uHealth. 2013; 1(2): e11. https://doi.org/10.2196/mhealth.2596 PMID: 25100683

86. Dias LPS, Barbosa JLV, Vianna HD. Gamification and serious games in depression care: a systematic mapping study. Telemat. inform. 2018; 35(1):213–24. https://doi.org/10.1016/j.tele.2017.11.002

87. Wahle F, Kowatsch T, Fleisch E, Rufer M, Weidt S. Mobile Sensing and support for people with depression: a pilot trial in the wild. JMIR mHealth uHealth, 2016; 4(3):e111. https://doi.org/10.2196/mhealth.5960 PMID: 27655245

88. Boyle SC, Earle AM, LaBrie JW, Smith DJ. PNF 2.0? Initial evidence that gamification can increase the efficacy of brief, web-based personalized normative feedback alcohol interventions. Addict behav. 2017; 67:8–17. https://doi.org/10.1016/j.addbeh.2016.11.024 PMID: 27978426

89. Cheng VWS, Davenport T, Johnson D, Vella K, Hickie IB. Gamification in apps and technologies for improving mental health and well-being: systematic review. JMIR Ment Health. 2019; 6(6):e13717. https://doi.org/10.2196/13717 PMID: 31244479

90. Topp CW, Østergaard SD, Søndergaard S, Bech P The WHO-5 Well-Being Index: a systematic review of the literature. Psychother Psychosom. 2015; 84(3):167–76. https://doi.org/10.1159/000376585 PMID: 25831962

91. Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: the PANAS scales. J Pers Soc Psychol. 1988; 47:1063–70.

92. Kessler RC, Mroczek D. Final versions of our non-specific psychological distress scale [memo dated March 10, 1994]. Institute for Social Research, Survey Research Center, The University of Michigan, 1994.

93. Fahrenberg J, Myrtek M, Pawlik K, Perrez M. Ambulatory assessment-monitoring behavior in daily life settings. Eur J Psychol Assess. 2007; 23(4):206–13.

Paper 2 Print

Original Paper

The Impact of a Gamified Mobile Mental Health App (eQuoo) on Resilience and Mental Health in a Student Population: Large-Scale Randomized Controlled Trial

Silja Litvin[1], MSc; Rob Saunders[2], PhD; Philip Jefferies[3], PhD; Hayley Seely[4], MSc; Patrick Pössel[4], PD; Stefan Lüttke[5], Dipl-Psych

[1]Department Psychologie, Ludwig-Maximilians-Universität, München, Germany

[2]Division of Psychology and Language Sciences, Clinical Education and Health Psychology, University College London, London, United Kingdom

[3]Resilience Research Centre, Faculty of Health, Dalhousie University, Halifax, NS, Canada

[4]Department of Counseling and Human Development, College of Education and Human Development, University of Louisville, Kentucky, KY, United States

[5]Department für Klinische Psychologie und Psychotherapie, Institute für Psychologie, Universität Greifswald, Greifswald, Germany

Corresponding Author:
Silja Litvin, MSc
Department Psychologie
Ludwig-Maximilians-Universität
Geschwister-Scholl-Platz 1
München, 80539
Germany
Phone: 49 89 21800
Email: silja@psycapps.com

Abstract

Background: With many digital mental health interventions failing to engage clients for enough time to demonstrate substantive changes to their well-being and with only 2% of all digital solutions on app stores having undergone randomized controlled trials, the rising demand for mental health prevention and early intervention care is not being met. Young adults in particular struggle to find digital well-being apps that suit their needs.

Objective: This study explored the effects of eQuoo, an evidence-based mental health game that teaches psychological skills through gamification, on resilience, depression, anxiety, and attrition in a student population.

Methods: In total, 1165 students from 180 universities in the United Kingdom participated in a 5-week, 3-armed randomized controlled trial. Participants were randomly allocated into 1 of 3 groups: eQuoo users, users of a treatment-as-usual evidence-based cognitive behavioral health app called Sanvello, and a no-intervention waitlist. The Rugged Resilience Scale, Generalized Anxiety Disorder–7, and Patient Health Questionnaire–8 were administered to all participants at baseline and every 7 days until completion.

Results: A repeated measures–ANOVA revealed statistically significant increases in resilience scores in the test group (P<.001) compared with both control groups (Sanvello: P=.10 and waitlist: P=.82) over 5 weeks. The app also significantly decreased anxiety and depression scores (both P<.001). With 64.5% (251/389) adherence, the eQuoo group retained 42% more participants than the control groups.

Conclusions: Digital health interventions such as eQuoo are effective, scalable, and low-cost solutions for supporting young adults and are available on all leading mobile platforms. Further investigation could clarify the extent to which specific elements of the eQuoo app (including gamification) led to better outcomes.

Trial Registration: German Clinical Trials Register (DRKS) DRKS00027638; https://drks.de/search/en/trial/DRKS00027638

(JMIR Ment Health 2023;10:e47285) doi: 10.2196/47285

KEYWORDS

mobile health; mHealth; gamification; resilience; randomized controlled trial; RCT; mental health; apps; mobile health; mobile game; mobile games; serious game; depression; anxiety; university; college; student; students; controlled trial; controlled trials; young adult; mobile phone

Introduction

Background

Digital health interventions (DHIs) have repeatedly been shown to be effective in improving mental well-being and relieving the symptoms of depression [1-4] and anxiety [1-3,5,6] in young people. They are efficacious in young people exhibiting elevated symptoms of anxiety and depression as well as in those who have been diagnosed with an anxiety or depressive disorder [2]. Randomized controlled trials (RCTs) have also revealed that DHIs can improve mood and promote emotional resilience in adolescents in the general populations [7,8].

DHIs may have other potential benefits for adolescents and young adults. For example, even when barriers to health systems are low (eg, health insurance coverage or free health care services) and individuals report elevated depression or anxiety symptoms, the rates of engagement with mental health support are low [9,10]. This suggests that there may be further obstacles, including attitudinal barriers, such as a preference for self-reliance and the desire to avoid perceived stigmatization [9-12], and off-putting aspects related to the delivery of the service, such as physical access issues [11], in addition to long waitlist times [12,13]. DHIs may help address these barriers, as research has shown that young people are drawn to digital health solutions [14,15], especially those on mobile phones [16].

DHIs delivered via mobile phones present a promising route for supporting the mental health of young people. For example, the ownership of mobile phones has grown enormously in recent years, with a national US survey finding that in 2019, approximately 90% of 16- to 18-year-olds possessed a smartphone, compared with 75% in 2015 [17]. There is also a high motivation to use mobile phone apps to improve mental health [18], which may stem from not only their convenience but also their control in terms of when and how much an individual chooses to engage with a DHI.

DHIs delivered by mobile phones typically take the form of "unguided" apps. Although numerous systematic reviews have found that DHIs for young people were effective when they incorporated some sort of human support [4,6,9,19], such as professional feedback or a live link to a professional, their superiority over unguided DHI approaches [20] has not been confirmed conclusively. For instance, in some studies, the effect in favor of guided DHIs was small [20] or not statistically significant when only studies with a low risk of bias were considered [19]. For smartphone-based interventions for depressive symptoms, a recent meta-analysis of RCTs by Firth et al [21] found that only apps without professional feedback produced moderate positive effects. Another meta-analysis found larger effect sizes on stress levels and quality of life when apps provided professional guidance [22].

Despite the convenience, appeal, and promise of DHIs delivered by mobile phones, evidence for their efficacy remains unsatisfactory. For example, review studies can neglect the modality of a DHI, which is important when the current bulk of studies involve comparisons of guided internet-based or computer-based cognitive behavioral therapy (CBT) with inactive controls [2,23]. Furthermore, in a recent review of 19 studies that investigated the use of serious games and virtual reality for the treatment of common mental health problems in children and young people, 10 (53%) had no comparison group, 3 (16%) used a waitlist condition, 4 (21%) used another DHI control group condition, and only 2 (11%; investigating the same DHI) used face-to-face interventions [3,4]. The effect of DHIs was largest when DHIs were compared with nonactive control conditions and was small or even nonexistent when there was an active comparator [4,22,23]. Recent meta-analyses that have specifically explored studies involving mobile phone apps for depression and anxiety have suggested that they have the potential to reduce symptoms when compared with inactive controls [21,24], and a recent meta-review by Goldberg et al [25] supports these findings. The authors noted that there are few studies involving active controls, which is important for establishing the effect of using a particular intervention.

A further limitation affecting recent studies on the efficacy of DHIs on mental health in young people (including DHIs delivered via mobile phones) was highlighted by Grist et al [4] in their meta-analysis of the efficacy of DHIs for depression and anxiety in children and adolescents. The authors found that many of the studies were underpowered. Insufficient sample sizes can promote favorable effects of particular interventions [1,2,5], reducing the likelihood that a statistically significant result reflects a true effect [26,27].

Aside from evaluation issues, a further issue troubles DHI research. In 2005, Eysenbach [28] noted that a considerable number of study participants stopped engaging with them (ie, nonuse attrition or nonadherence) or dropped out; therefore, they could not be followed up (dropout attrition). For example, Linardon et al [22] found that approximately 25% of participants using smartphone-delivered DHIs for common mental health problems dropped out before short-term follow-up (≤8 weeks) and up to 33% dropped out before long-term follow-ups. Similarly, Hollis [23] found that for DHIs targeting depression in young people, attrition ranged from 0% for a computerized in-house attention bias modification [29] to 42.5% for a synchronous chat intervention [30]. Although this is potentially problematic for evaluating the efficacy of DHIs, the lack of or diminishing engagement is troubling, given the benefits of engaging with such interventions. Developers of non–practitioner-led (unguided) DHIs face an overarching challenge: how to engage clients long enough for interventions to have an impact.

One approach to combating attrition and nonengagement in DHI design is the use of game design elements in nongaming contexts or "gamification" [31]. Although the gamification of software and technology in a behavior change context has gained traction over the past few years [32], it is still in the early stages in terms of methodology, classification, and implementation. In total, 2 relevant research streams have emerged: (1) persuasive systems and technology and (2) gamification as a tool that enables playful experiences and enhances engagement [33]. Persuasive systems are geared toward using software and technology to instigate behavioral change regarding preset goals, such as weight loss, developing beneficial psychological coping mechanisms, or even environmental sustainability actions [34].

Persuasive strategies can be implemented endogenously; software can be developed via game mechanics, which are intrinsically inherent to the gaming experience [35]. Endogenous games are designed to enhance the gaming experience to the highest degree possible; external goals of persuasive systems, where game mechanics rules are coupled with outcome goals, are likely to hinder or complicate the process. This is sometimes referred to as gamifying rather than gamification. The more commonly used gamification development procedure for persuasive games, where elements are layered on an existing framework of information exchange geared toward a predefined goal (such as weight loss), is exogenous [35]. Although it makes sense to implement evidence-based strategies, such as CBT, as the foundation of a persuasive system for a DHI, it can be at odds with the second research stream: playful experiences and enhanced engagement. Poorly implemented exogenous factors, such as badges or rewards that are not connected to the gameplay, have reportedly had the opposite effect on the playing population, leading to the rejection of the tool [36]. An example of an endogenous game would be eQuoo, where the intervention is woven into a story framework that is appealing in and of itself, whereas an exogenous element would be a badge given after a CBT exercise is successfully completed.

In addition to gamification, interventions aimed at building skills associated with improved mental health may help enhance mental health overall. As conceptualizations of mental health expand beyond the pathogenic to the salutogenic [37], researchers have started to investigate mental health in terms of both the capacity to manage difficulties and the absence of illness [38]. Resilience is widely considered to be a protective factor against negative mental health outcomes. Resilience is the capacity to overcome or adapt to adversity and thus stay mentally healthy or regain one's mental health following significant challenges [39]. Previously thought to reflect the presence of personality characteristics, such as *grit*, resilience is now more commonly understood as a process in which various modifiable protective factors are drawn upon. This leads to positive outcome trajectories [40]. Protective factors exist at various systemic levels, including psychological (eg, self-efficacy and motivation) and social (eg, supportive peer relationships and a sense of community belonging) [41]. The realization that many individuals experience significant adversity during their lifetime [42] has led to an increasing demand for resilience-building programs aimed at promoting mental health [34].

This Study

In summary, research has shown that DHIs can be effective in promoting mental well-being and reducing symptoms of depression and anxiety in young people. However, the evidence base is lacking, and given their unique qualities, there is a need to specifically test the advantages of using DHIs involving gamification and through sufficiently powered 3-armed RCTs (DHIs vs active controls vs nonactive controls) that also report on trial completion and attrition.

Primary Outcome Hypothesis—Resilience Levels

We hypothesized that resilience levels would increase significantly over the course of the intervention period in the gamified intervention group and that resilience would be significantly higher in the intervention group than in the active control and waitlist control groups.

Secondary Outcome Hypotheses—Depressive and Anxiety Symptoms and Attrition

We also hypothesized that depression and anxiety symptoms would decrease significantly over the course of the intervention period in the gamified intervention group and that depression and anxiety symptoms would be reduced significantly in the gamified intervention group compared with both the active control and waitlist control groups.

Finally, we hypothesized that rates of attrition would be significantly lower in the gamified intervention group at the last assessment than in the active control and waitlist control groups.

Methods

Inclusion and Exclusion

Participants had to be aged ≥18 years and enrolled as college or university students. They had to have access to a smartphone or tablet device and an app store (App Store or Google Play) to install the eQuoo app. No further exclusion criteria were applied.

Sampling Procedure and Participant Consent

Recruitment took place in 2 waves between March and April 2021 using the UNiDAYS subscriber database, a global student discount platform. To qualify for UNiDAYS, people must provide a valid college or university email address. In the first wave, 9000 people who were then registered on the platform with their University College London affiliation were emailed an invitation to participate in a trial exploring the effects of a mental health app on resilience with a link to the trial landing page; 443 people signed up for the trial and completed the baseline assessment. This figure represented 8.6% of those emailed. On the landing page, the study goal was explained briefly, the study protocol was shared, and a consent box needed to be clicked that read "I have understood the trial terms and I consent." This checkbox needed to be checked for participants to join the trial; without it, they could not gain access to the questionnaires and information on what to test, thus ensuring consent. In the second wave, 100,000 randomly selected UNiDAYS subscribers were emailed the same invitation; 724 participants completed the baseline assessment. This figure represented 1.6% of those emailed. The trial was completed and closed, and all participants were debriefed in June 2021.

Ethics Approval

The study (an RCT) was approved by the University College London Ethics Committee (0501/001), and the authors confirm that all ongoing and related trials are registered with the German Clinical Trials Register (DRKS00027638). This study was conducted in accordance with the principles of the Declaration of Helsinki.

Sample Size, Power, and Precision

An a priori power analysis using G*Power 3.1.9.4 revealed that a sample size of 207 participants was required to detect a within-between interaction for the primary outcome (input

parameters: repeated measures [RM]–ANOVA, effect size *f*=0.10; Cronbach α=.05; power=0.95; number of groups=3; number of measurements=6; RM intercorrelation=0.50; nonsphericity correction=1). However, given the high attrition rates reported in previous research (eg, 40%-60% [28]), we aimed to enroll a minimum of 850 participants.

Measures and Instruments

Primary Outcome: Resilience

As eQuoo exists primarily in the digital space of prevention and early intervention, resilience was considered the primary outcome. To assess resilience, we used the Rugged Resilience Measure (RRM). The RRM is a 10-item self-report questionnaire designed to measure key psychologically protective factors that foster resilience [43]. Participants respond to the items on a 5-point Likert-type scale (1=*not at all*, 2=*a little*, 3=*somewhat*, 4=*quite a bit*, and 5=*a lot*). The questionnaire was initially validated with a sample of young adults (aged 16-30 years), which matched the population of the study. As the understanding of resilience has shifted from a fixed trait to a process encompassing the development and application of skills and resources that support positive outcomes despite the experience of distress [44,45], the RRM taps the key internal resources necessary to initiate said development. In this study, the internal consistency of the RRM was .87 (Cronbach α).

Secondary Outcomes: Anxiety, Depression, and Attrition

The secondary outcomes in this study were mental health (the level of anxiety and depression symptoms in particular) and attrition. The generalized anxiety disorder–7 (GAD-7)-item scale was used to assess anxiety. This is a widely applied 7-item measure of generalized anxiety symptoms [46]. Each item was scored from 0 to 3 (0=*notat all*, 1=*several days*, 2=*more than half the days*, and 3=*nearly every day*). The internal consistency of the GAD-7 was high (Cronbach α=.83). We also used the Patient Health Questionnaire–8 (PHQ-8). The PHQ-8 is a well-established screening measure for depressive symptoms in large clinical studies [47] and encompasses the American Psychological Association's *Diagnostic and Statistical Manual of Mental Disorders* (5th edition) criteria for a depressive episode (with the exception of the item regarding self-harm). It was preferred to the more widely known PHQ-9 [27] because the study design did not allow us to intervene in the event of reporting self-injurious behavior. In the PHQ-8, participants are asked to rate how far they have been bothered by each symptom over the previous 2 weeks on a 4-point Likert-type scale (0=*not at all*, 1=*several days*, 2=*more than half the days*, and 3=*nearly every day*). The internal consistency of the PHQ-8 in this study was high (Cronbach α=.88). Finally, it was hypothesized that attrition would be significantly lower for the gamified group intervention at the last assessment (t5) than for other groups. In addition to measures of resilience, anxiety, and depression, participants provided demographic information regarding their age, sex, living situation, and level of study.

Design

A mixed factorial 3 (condition) × 6 (time) RM design was used. Participants were randomly assigned to a condition (eQuoo vs active control vs waitlist group, the details of which are described in the subsequent section) using a randomization generator provided by random.org [48], which randomizes based on atmospheric noise [49]. Across the study period, measurements were taken at the beginning (t0, baseline assessment), week 1 (t1), week 2 (t2), week 3 (t3), week 4 (t4), and week 5 (t5, end point).

Gamified Group Intervention (eQuoo)

The original version of the emotional fitness app eQuoo was a 5-week mental health game that presented psychoeducational material and psychological exercises based on the principles of CBT, systemic psychology, and positive psychology [50]. It combined a mix of endogenous and exogenous design features designed to maximize engagement. The game was played on mobile phone only and was available internationally on the Google Play store and the Apple App Store. It was designed to be a prevention and early intervention (preclinical threshold) tool. In a recent trial, the app was found to significantly reduce anxiety while improving resilience, perceived growth skills, and interpersonal relationships [51]. After examining feedback from thousands of users through clinical trials, focus groups, case studies, and players offering their opinions on the app stores and via email, the developers of eQuoo sought to revise the app to enhance enjoyment, immersion, and retention. This resulted in eQuoo, the Next Generation [50] (hereafter, eQuoo), and it is the version of the app that was tested in this study.

The app begins by explaining the player's role as a Lodestar. Each page has a picture with characters in it and a speech bubble with a maximum of 160 characters per screen. The player moves to the next page by tapping on the screen. They can also click a back button to reread the previous screen. The type of introduction used in eQuoo is commonly known as game lore, a game-specific mythology, or the so-called backstory of the general narrative within a game. Lore in video games has been proven to motivate players to read and learn more, making it more likely that they will engage, read, and therefore learn the skills presented [52]. In eQuoo, Lodestars travel through time and space to fight against the Quavering by growing their inner light. The following is the onboarding text:

> *For centuries, the Lodestars have watched over this world, and they would love for YOU to join them. Get ready for the ultimate adventure.*
>
> *You'll journey to different times in history, become friends with people from all walks of life. You'll learn skills that will set you on a path towards personal growth. And you'll help to counter a massive threat.*
>
> *This threat is called The Quavering. A force created from all the greed and negativity in the world. Whenever someone's inner light grows dim, The Quavering grows stronger. You may have experienced this? If you join the Lodestars, you will help fight the battle against The Quavering.*
>
> *So, here you are. You have been given a chance to grow your inner light. And to shine that light on others. Welcome... to the Lodestars.*

The game consists of multiple books of different genres (eg, fantasy, historical drama, and teen drama). Each book consists

of 8 to 10 chapters where the player can learn and repractice up to 4 skills. Before each new chapter of a book in the game, they are led through a gamified skill tutorial by the game's guide, Joy, who is introduced to have been a player themselves and is now a Lodestar, thanks to having completed the game. Once they have successfully learned the skills, they continue into the book where they—playing themselves via an avatar that they customized at the beginning of their journey—meet the characters of the game and are thrown into various situations where they need to correctly use the psychological skills that they learned in the tutorial. To facilitate between-session learning and incorporation of the necessary skills, users must wait 7 days until the next chapter unlocks. This allows them to practice the skills in real-life settings, which has a positive impact on the therapeutic outcomes [53]. The weekly lock is also to protect players from addictive patterns and not flood them with too much information that they have retained after only one session.

Of the 18 gamification elements named by Cheng et al [54], 11 have been incorporated into eQuoo:

1. Levels
2. Points—in the form of gem shards
3. Rewards—in the form of unlocking levels and completing gems
4. Narratives
5. Personalisation—in the form of the story choices
6. Customisation—in the form of the avatar
7. Mini games
8. Quests and challenges—in the form of stories
9. Badges—in the form of personality types
10. Artificial assistance—in the form of the guide, Joy
11. Unlockable content—in the form of a free trial

The intervention group was instructed to download eQuoo via the Apple or Google Play Store and install it on their digital device. Participants were informed at the start of the study that they could stop using the app at any time. After starting the game, the player is introduced to the game's lore. Participants are asked to design an avatar that resembles themselves as a virtual person in the game. The content of the application is divided into multiple multigenre stories that consist of 8 to 10 chapters presented as levels. In the chapters, users are first presented with 1 to 4 lessons that teach them psychological concepts, such as emotional bids [55], generalization [56], catastrophization [57], beliefs [58], and 52 psychological skills commonly used in therapeutic sessions for anxiety and depression (as well as prevention programs designed to increase resilience). After each lesson, the players can test their mastery of skills using a simple multiple-choice scenario. They are then either debriefed on why their choice was not the most beneficial (and are invited to choose another answer) or allowed to enter an interactive adventure story where they play themselves while practicing the skills in a low-cost environment. A low-cost environment means that the failure to succeed comes at a low cost, such as having to replay a level. All prompts during the psychoeducational part of the game to check whether the player has understood the skill are divided into 3 responses: (1) beneficial—the skill has been implemented by the player in a way that is beneficial for the player's mental health; (2) neutral—the skill has been ignored and not used, and the counter indication was not chosen; and (3) unbeneficial—the player chose an answer that is considered unbeneficial for the player's mental health.

The onboarding of the game consists of 3 levels of introduction to the lore; the building of the avatar; and the first in-app baseline assessment of the RRM, GAD-7, and PHQ-8 in the form of a pop-up chatbot where the player can chat with the game's guide, Joy, and fill out the questionnaires. After acquiring their second skill, they play the first chapter of the first story and hit the level lock until the next week. This ensures that they play only 1 level per week for 5 weeks of the clinical trial. Each survey includes a question that players can answer only if they have completed the level for the week. Biweekly in-app nudges and weekly emails pull the participants back into the game.

Active Control Group Intervention (Sanvello)

Participants in the active control group were instructed to download an evidence-based mental health app called *Sanvello*, which was used as treatment-as-usual or active control group. It was chosen specifically to explore the secondary hypothesis of attrition, as the app has already been tested in another RCT [59] and is associated with a reduction in depression [60] and anxiety [61]. Sanvello is based on CBT and includes psychoeducation, CBT exercises, notifications, and a diary. It includes free access to multiple modules, which was sufficient to cover the 5-week trial. We requested that the participants use it for a minimum of 10 minutes per week. Participants were informed at the start of the study that they could stop using the app at any time.

Waitlist Control Group

The waitlist group received no intervention but completed the questionnaires at the same time points as the control and intervention groups. After completing the trial, they were debriefed on the results and provided with a link to both the eQuoo and the Sanvello apps. The study information was available via the link.

Data Collection

Participants were reminded via weekly emails to complete the questionnaires at t1 to t5. In addition to the questionnaires, the participants in the eQuoo group were asked a question to prove that they had completed their level, and the participants in the active control group were asked if they had spent 10 minutes on the Sanvello app. Data were collected using LimeSurvey, a widely used secure open-source tool.

Statistical Analysis

Differences in participant characteristics between each intervention arm were first compared using chi-square tests of independence (for categorical variables) and one-way ANOVAs (for continuous variables).

Attrition rates and the number of participants who completed the levels at all time points were compared across groups. Attrition was defined as not completing the assessments past t0. This is consistent with previous studies that defined attrition as the failure to complete the study protocol associated with the

intervention [22]. To compare the likelihood of attrition between intervention arms, logistic regression models were constructed, with both unadjusted and adjusted (for sex, age, living situation, and baseline measures) odds ratios (ORs) and 95% CIs reported.

A standardized outcome was then created using the last available measure, even if it was only the participant's baseline, and this was carried forward (*intention to treat*) [62]. Initially, paired sample 2-tailed *t* tests were conducted within each intervention arm to assess statistically significant changes in the primary and secondary outcomes. Pre-post effect sizes (Cohen *d*) were calculated using 0.2, 0.5, and 0.8, which were used as thresholds to signify small, medium, and large effects, respectively. Differences between intervention arms in end point (t5) scores were explored using linear regression models (for each outcome) with a baseline measure, and age, sex, living situation, and study level (ie, undergraduate or postgraduate) were entered as covariates. Adjusted end point means were estimated, and the magnitude of between-group differences was explored by calculating Cohen *d*.

To assess differences between interventions over time points, initial analyses used RM-ANOVAs with time (6 levels) entered alongside the intervention group (3 levels). To assess the impact of listwise deletion on these models, further analysis was conducted using mixed effects models exploring changes in the primary and secondary outcomes over time, entering the intervention arm as an independent variable and age, sex, and living situation as covariates. These mixed effects models, using restricted maximum likelihood estimation, used all available data at each time point. The survey was programmed so that all fields were mandatory, that is, participants either filled out the entire questionnaire or did not participate. The data were published using the Open Science Framework [63].

Results

Attrition and Characteristics by Group

Of the 1167 individuals who were recruited for the study, 2 individuals reported being aged <18 years and were excluded; therefore, the final sample comprised 1165 participants. These individuals were then randomly allocated to the study groups: 389 (33.39%) were placed in the eQuoo group, 384 (32.96%) were placed in the Sanvello group, and 392 (33.65%) were placed in the waitlist group. Figure 1 shows the participant flow diagram and the proportion of participants providing data at each time point. All participants (except 1 individual in the eQuoo group) completed baseline (t0) measures, and end point (t5) measures were available for 251 (64.5%) out of 389 participants in the eQuoo group, 77 (20%) out of 384 participants in the Sanvello group, and 101 (25.8%) out of 392 participants in the waitlist group. Of the eQuoo participants, 349 completed at least one measure after baseline (but potentially not t5), and 123 of the Sanvello participants completed at least one nonbaseline measure, as did 211 of the waitlist group.

The likelihood of attrition (defined as completing only the baseline measures) was compared for the intervention conditions. Although only 10.3% (40/389) of the participants in the eQuoo group met the criteria for attrition, the rates for the Sanvello and waitlist groups were 67.9% (261/384) and 46.2% (181/392), respectively. The odds of attrition were significantly higher in the Sanvello group than in the eQuoo group (OR 18.51, 95% CI 12.52-27.38) as well as in the waitlist group (OR 7.48, 95% CI 5.10-10.97). After adjusting for age, sex, living situation, study level, and all 3 baseline measures, Sanvello was compared with eQuoo (OR 19.27, 95% CI 12.91-28.77), as was the waitlist (OR 7.34, 95% CI 4.96-10.85).

Table 1 presents differences in participant characteristics between intervention arms. The comparative statistics suggest the groups were balanced in terms of age, sex, and baseline resilience scores but not living situation, study level, or initial depression and generalized anxiety symptom scores.

Figure 1. Study procedure and number of completers at each stage of the assessment.

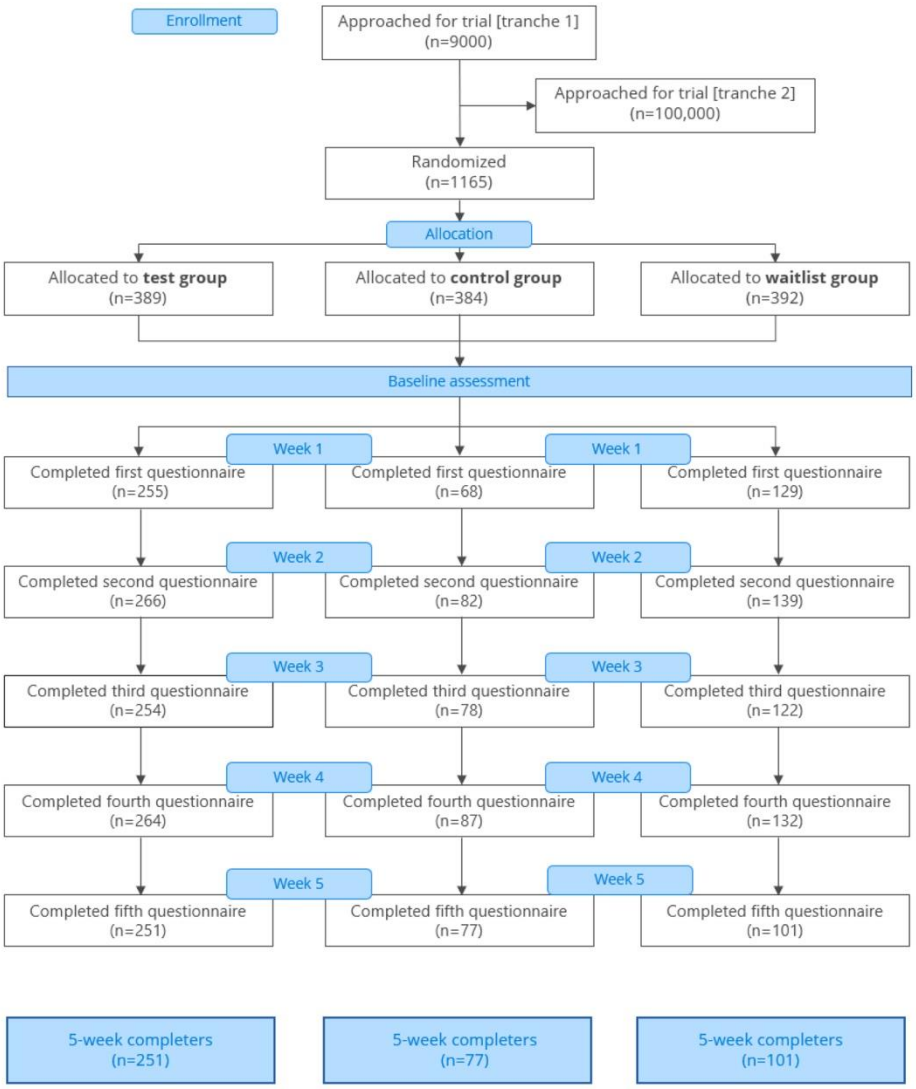


Table 1. Participant characteristics between the intervention arms.

Characteristic	Total (n=1165)	eQuoo (n=389)	Sanvello (n=384)	Waitlist (n=392)	*P* value
Wave, n (%)					.91
Wave 1	443 (38)	145 (37.3)	149 (38.8)	149 (38)	
Wave 2	722 (62)	244 (62.7)	235 (61.2)	243 (62)	
Sex, n (%)					.43
Female	891 (76.5)	285 (73.3)	297 (77.3)	309 (78.8)	
Male	251 (21.5)	95 (24.4)	79 (20.6)	77 (19.6)	
Other	18 (1.5)	6 (1.5)	6 (1.6)	6 (1.5)	
Missing	5 (0.4)	3 (0.8)	2 (0.5)	0 (0)	
Living situation, n (%)					.03
Close family or relatives	471 (40.4)	142 (36.5)	170 (44.3)	159 (40.6)	
Student apartment	234 (20.1)	83 (21.3)	75 (19.5)	76 (19.4)	
Own apartment	329 (28.2)	126 (32.4)	102 (26.6)	101 (25.8)	
Other	124 (10.6)	36 (9.3)	32 (8.3)	56 (14.3)	
Missing	7 (.6)	2 (0.5)	5 (1.3)	0 (0)	
Level of education, n (%)					.02
Undergraduate	717 (61.5)	217 (55.8)	246 (64.1)	254 (64.8)	
Postgraduate	446 (38.3)	170 (43.7)	138 (35.9)	138 (35.2)	

Effects of Treatment on Primary Outcome (Resilience)

Pre- and posttest scores for resilience are presented in Table 2. There was a significant improvement (medium effect size) in resilience among eQuoo participants (t_{387}=18.35; *P*<.001; Cohen *d*=0.58) but not among Sanvello or waitlist participants (*P*=.10 and .82, respectively).

Differences in end point scores were then compared using linear regression models, controlling for baseline resilience score, age, sex, living situation, and study level. Significantly higher resilience scores were observed in the eQuoo condition compared with Sanvello (*b*=–4.41, 95% CI –5.09 to –3.74; *P*<.001) and in eQuoo compared with the waitlist condition (*b*=–4.78, 95% CI –5.46 to –4.10; *P*<.001).

RM-ANOVA models were then used to compare resilience scores at each time point between the intervention arms, and mixed effects models were constructed to explore the change between the intervention arms. A total of 174 participants (n=78, 44.8% eQuoo; n=37, 21.3% Sanvello; and n=59, 33.9% waitlist) completed the measures at all time points and were included in the RM-ANOVA. A significant effect was observed for time ($F_{5,855}$=18.51; *P*<.001), intervention arm ($F_{2,171}$=8.68; *P*<.001), and intervention interaction ($F_{10,855}$=9.69; *P*<.001). Mixed effects models, including age, sex, living situation, and study level as covariates led to a significant intervention-in-time interaction: scores were significantly lower over time for participants in the Sanvello arm (*b*=–0.86, 95% CI –1.06 to –0.66; *P*<.001) and waitlist arm (*b*=–1.25, 95% CI 1.42 to –1.08; *P*<.001), compared with the eQuoo arm (Figure 2).

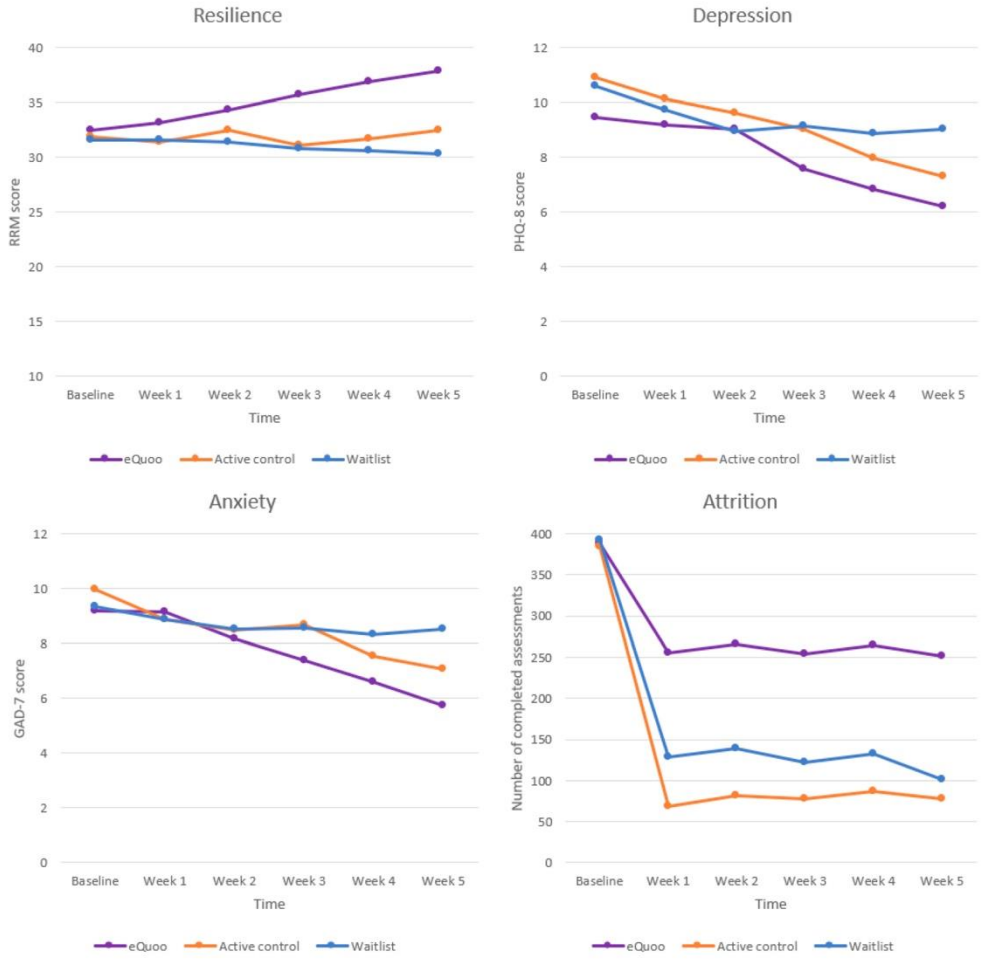
Table 2. Pre- and postoutcome scores between intervention arms.

Outcome or intervention	Sample, n (%)	Baseline, mean (SD)	End point[a], mean (SD)	*t* test (*df*)	*P* value
Resilience					
eQuoo[b]	388 (99.74)	32.47 (8.35)	37.88 (7.17)	−18.35 (387)	<.001
Sanvello	384 (100)	31.86 (7.66)	32.42 (7.94)	−1.65 (383)	.10
Waitlist	392 (100)	31.60 (8.67)	30.34 (9.01)	0.22 (391)	.82
Anxiety					
eQuoo	388 (99.74)	9.17 (6.91)	5.75 (4.26)	12.09 (387)	<.001
Sanvello	384 (100)	9.98 (5.62)	7.06 (5.49)	5.77 (383)	<.001
Waitlist	392 (100)	9.33 (5.68)	8.51 (5.82)	1.97 (391)	.049
Depression					
eQuoo	388 (99.74)	9.44 (5.61)	6.18 (4.59)	20.91 (387)	<.001
Sanvello	384 (100)	10.89 (5.61)	7.30 (5.39)	5.45 (383)	<.001
Waitlist	392 (100)	10.59 (5.78)	9.02 (5.75)	3.45 (391)	.001

[a]End point scores included last observation carried forward for participants who did not complete an end point measure.

[b]One individual did not complete a baseline assessment.

Figure 2. Average (unadjusted) weekly outcome scores by week (95% CIs) for resilience, depression, and anxiety. All available scores are included. GAD-7: generalized anxiety disorder–7; PHQ-8: Patient Health Questionnaire–8; RRM: Rugged Resilience Measure.



Effects of Treatment on Secondary Outcomes

Generalized Anxiety

In the pre-post analysis, GAD-7 scores significantly decreased within all 3 conditions (eQuoo: t_{386}=22.86, *P*<.001; Cohen *d*=0.60; Sanvello: t_{347}=5.77, *P*<.001; Cohen *d*=0.16; and waitlist: t_{391}=1.97, *P*=.049; Cohen *d*=0.08; Table 2). Linear regression models demonstrated significantly lower GAD-7 end point scores in the eQuoo condition compared with the Sanvello (*b*=2.28, 95% CI 1.83-2.73; *P*<.001) and waitlist conditions (*b*=2.54, 95% CI 2.08-2.99; *P*<.001).

The RM-ANOVAs, including only those participants who completed every time point, showed that although there was a significant main effect of time ($F_{5, 855}$=29.337; *P*<.001), there was no main effect of condition (*P*=.35) or a condition-by-time interaction (*P*=.10). Further analysis performed using mixed effects models (which included the covariates listed earlier) indicated a significant time-by-condition interaction; over time, GAD-7 scores were lower in the eQuoo group compared with the waitlist group (*b*=0.56, 95% CI 0.40-0.71; *P*<.001). The difference between the eQuoo and Sanvello conditions was not significant (*b*=0.12, 95% CI 0.06-0.30; *P*=.20; Figure 2).

Depression

In the pre-post analysis, the PHQ-8 scores significantly decreased in all 3 groups (*P*≤.001). However, although changes in depression scores produced a medium effect (Cohen *d*=0.58), they were small for the Sanvello and waitlist groups (Cohen *d*=0.14 and 0.13, respectively; Table 2).

As with the GAD-7 results, the linear regression demonstrated significantly lower PHQ-8 end point scores in the eQuoo condition compared with the Sanvello group (*b*=2.47, 95% CI 2.91-2.93; *P*<.001) and in the eQuoo condition compared with the waitlist group (*b*=2.46, 95% CI 2.00-2.91; *P*=.15).

The RM-ANOVAs for PHQ-8 scores, including only those individuals who completed every time point, indicated that although there was a significant main effect of time ($F_{5,855}$=55.392; *P*<.001), there was no main effect of condition (*P*=.22) or a condition-by-time interaction (*P*=.11). The mixed effects models (which included the covariates listed earlier) indicated a significant time-by-condition interaction, showing that over time, PHQ-8 scores remained lower for the eQuoo group compared with waitlist group (*b*=0.40, 95% CI 0.25-0.55; *P*<.001). The difference between the eQuoo and Sanvello conditions was not significant (*b*=0.09, 95% CI −0.09 to 0.27; *P*=.31).

Discussion

Principal Findings

The results suggest that using the gamified mental health app, eQuoo is an effective pathway for improving mental health and resilience. In particular, the use of eQuoo was related to increased resilience scores over time; this was not the case for the nongamified or waitlist groups. Participants using eQuoo also reported lower depression and anxiety scores at the end of the intervention compared with the other 2 groups and were significantly less likely to drop out of treatment. The findings indicated that both apps were effective in reducing anxiety and depression symptoms, although the larger effect sizes associated with the improvements suggest that eQuoo was more effective in this regard.

Mental health issues are pervasive and particularly impactful in student populations [64,65]. Unfortunately, the gap between mental health treatment needs and access to care continues to grow [66,67]. Although DHIs have been identified as meaningful alternatives to face-to-face therapy in student populations [9,11], they have significant shortcomings [68-70] in terms of motivation, interest, and engagement [69]. As the prevalence of mental health issues [69] and the demand for digital mental health solutions, such as telehealth and internet therapy [71] have increased, research investigating digital, app-based interventions is especially timely. This study contributes to the quest for solutions by presenting eQuoo as a gamified DHI that can improve mental health by reducing depression and anxiety symptoms while building resilience and compares favorably with a well-established, nongamified mental health app.

Implications

Gamification using mobile mental health apps has been suggested as a way to increase engagement in mental health services [72-74]. This study supports this suggestion by highlighting the benefits of DHIs incorporating gamification and resilience training (particularly when eQuoo was used). Although further research that distinguishes the effects of gamification and includes more diverse populations is necessary, the results of this study suggest that mobile mental health apps can assist in mental health treatment and resilience building.

Furthermore, our findings are particularly relevant, given the current events. Global factors, such as the 2019 COVID-19 pandemic and the accompanying restrictions, have been linked to an increased prevalence of mental health issues and difficulties in accessing support [75]. According to a recent World Health Organization survey, the pandemic has disrupted critical mental health services in 93% of countries worldwide while increasing demand for them [50]. Our findings suggest that DHIs may be a meaningful option in lieu of traditional mental health services for those seeking help.

The finding that resilience scores improved for eQuoo users is also promising, as this suggests that the impact and lingering effects of future adversity on mental health may be less for those with higher scores [74,76], among other benefits [77]. In other words, the inclusion of resilience training elements in DHIs such as eQuoo can facilitate a reduction in psychopathology symptoms such as depression and anxiety but may also serve a protective function against these symptoms for users when encountering difficulties later on. This would be especially important for young adults who experience many stressful transitions in different life domains [78]. Further longitudinal research is needed to explore this empirically, capturing both the long-term impact of eQuoo and the impact of subsequent stressors.

With continued research, DHIs that incorporate gamification and resilience training may play a pivotal role in improving access to mental health services and preventing mental health issues. They could be integrated into standard face-to-face treatment as part of the client's homework, offered as a pretreatment option, or used as a mental health resource for all college students as part of an intervention and prevention strategy.

Strengths and Limitations

This study has several strengths. It is one of only a few follow-up RCTs involving a gamified mental health app [51]. Its large participant pool enables calculations to be performed with a large power size, thus ensuring the reliability of the outcome. This study is based on past research on the efficacy of the same gamified app that has been tested and shown to increase resilience and positive relations with others and decrease anxiety symptoms in a very different sample (employed adults) [51]. Given this (and the similarities in findings between the present and previous studies), the benefits of eQuoo may be generalized to different populations. Finally, the study included 3 treatment arms, including a treatment-as-usual active control condition using a nongamified app that has been tested [59] and shown to be efficacious [59,61]. Including this treatment-as-usual active control condition allowed the gamified app and nongamified app to be usefully compared. In addition, unlike previous studies, we have explicitly reported on dropout and nonuse using engagement data.

This study has some limitations. Although including a treatment-as-usual active control condition was important to evaluate eQuoo, the 2 apps were not structurally equivalent interventions. Ordinarily, structurally equivalent interventions are identical in terms of the number and duration of sessions, settings (group vs individual), level of therapists' experience, and adaptability of the therapy to the client [79]. The 2 apps used in this study have different purposes and use different interventions. Although the eQuoo is designed to teach psychological skills to decrease depression and anxiety and increase resilience, and many of these skills are based on CBT principles that overlap with the structure of Sanvello, the latter relies exclusively on CBT psychoeducation and exercises [59]. In other words, there were meaningful differences between the 2 apps, in addition to gamification. A meta-analysis comparing in-person psychotherapies found no differences between programs when they had structural equivalence [79]. Thus, it may be that the differences between eQuoo and Sanvello were not solely caused by gamification. In light of this, future studies might compare structurally equivalent gamified and nongamified apps, although a robust comparison would involve a version of the experimental app with gamification features removed, to ensure that there were no other explanatory variables, such as the look or interface of the app.

Another limitation of this study is that it did not record the duration of participants' use. Hence, it was not possible to examine whether the level of use was linked to attrition, an important phenomenon discussed in eHealth research [28]. In other words, although the attrition among participants using the gamified app was lower than that in the nongamified app and waitlist groups, it was not possible to examine the influence of active engagement. This could have been accomplished by including time-of-use data from the apps.

A further limitation was the lack of follow-up; therefore, we could not draw conclusions about the stability of the observed effects. As such, future researchers should investigate the impact of gamification on nonuse attrition, engagement, long-term attrition, and mental health.

Similarly, it was unclear which aspects of the intervention resulted in the observed effects. As the eQuoo was created as a skills training app, it may have been that the development of resilience and reduction in mental health symptomatology was the result of skills acquisition. However, specific skill acquisition was not examined. Studies in which individual skills were trained were excluded to investigate the mechanisms of the observed effects. Future researchers might, therefore, want to include pre- and postmeasures of trained skills.

The participants in this study were self-selecting; therefore, a self-selection bias may have influenced our findings. In addition, the study was fully reliant on self-report, which may have also affected the results through both response bias [80] and shared variance [81].

Given these sample-specific and method-specific limitations, future researchers might want to investigate the effects of gamification using more diverse samples and additional measures of efficacy, such as sleep duration and quality (objective measures related to depression) and clinical interviews. In addition, the authors are aware that using the traditional "gold standard" of RCTs may not be the best method for evaluating the effectiveness of an app such as eQuoo. Such studies can take years from inception to publication, and developers will have real-time feedback and data that would influence app improvements more quickly than they could be tested [82]. The authors are investigating current research possibilities that would help address this issue and will be implementing them in the coming years while documenting the results for peer review.

Conclusions

This study aimed to investigate the effect of the gamified mobile mental health game eQuoo on levels of resilience, anxiety, depression, and attrition (one of digital mental health's Achilles heels [83]) in a student population. Compared with the active control and waitlist groups, we found a significant increase in resilience scores, a decrease in depression and anxiety scores, and a significantly lower attrition rate. The results suggest that eQuoo is an engaging and effective means to support students' mental health and build their resilience.

Acknowledgments

The study received no financial funding or sources of financial support externally or internally that might have influenced its outcome. S Litvin could not have undertaken this journey without the support and guidance of Professor Steve Pilling of the University College London, whose deep interest in student well-being made this trial possible. S Litvin is also thankful to Manuel Holihan, who helped shape this paper.

Conflicts of Interest

S Litvin is a shareholder of the company PsycApps Limited, which developed the intervention tested in this trial (eQuoo). S Lüttke, along with a group of other scientists, has received public funding for a project on an app-based aftercare for adolescents and young adults with depression. He has received consultancy fees from companies for offering advice on study design and interventions as well as payments for lectures from psychotherapy associations in the context of e–mental health matters.

Multimedia Appendix 1

CONSORT-EHEALTH checklist (V 1.6.1).
[PDF File (Adobe PDF File), 3273 KB-Multimedia Appendix 1]

References

1. Ebert DD, Zarski AC, Christensen H, Stikkelbroek Y, Cuijpers P, Berking M, et al. Internet and computer-based cognitive behavioral therapy for anxiety and depression in youth: a meta-analysis of randomized controlled outcome trials. PLoS One 2015 Mar 18;10(3):e0119895 [FREE Full text] [doi: 10.1371/journal.pone.0119895] [Medline: 25786025]
2. Pennant ME, Loucas CE, Whittington C, Creswell C, Fonagy P, Fuggle P, Expert Advisory Group. Computerised therapies for anxiety and depression in children and young people: a systematic review and meta-analysis. Behav Res Ther 2015 Apr;67:1-18 [doi: 10.1016/j.brat.2015.01.009] [Medline: 25727678]
3. Halldorsson B, Hill C, Waite P, Partridge K, Freeman D, Creswell C. Annual research review: immersive virtual reality and digital applied gaming interventions for the treatment of mental health problems in children and young people: the need for rigorous treatment development and clinical evaluation. J Child Psychol Psychiatry 2021 May;62(5):584-605 [doi: 10.1111/jcpp.13400] [Medline: 33655534]
4. Grist R, Croker A, Denne M, Stallard P. Technology delivered interventions for depression and anxiety in children and adolescents: a systematic review and meta-analysis. Clin Child Fam Psychol Rev 2019 Jun;22(2):147-171 [FREE Full text] [doi: 10.1007/s10567-018-0271-8] [Medline: 30229343]
5. Ye X, Bapuji SB, Winters SE, Struthers A, Raynard M, Metge C, et al. Effectiveness of internet-based interventions for children, youth, and young adults with anxiety and/or depression: a systematic review and meta-analysis. BMC Health Serv Res 2014 Jul 18;14:313 [FREE Full text] [doi: 10.1186/1472-6963-14-313] [Medline: 25037951]
6. Vigerland S, Lenhard F, Bonnert M, Lalouni M, Hedman E, Ahlen J, et al. Internet-delivered cognitive behavior therapy for children and adolescents: a systematic review and meta-analysis. Clin Psychol Rev 2016 Dec;50:1-10 [FREE Full text] [doi: 10.1016/j.cpr.2016.09.005] [Medline: 27668988]
7. Calear AL, Christensen H, Mackinnon A, Griffiths KM, O'Kearney R. The YouthMood Project: a cluster randomized controlled trial of an online cognitive behavioral program with adolescents. J Consult Clin Psychol 2009 Dec;77(6):1021-1032 [doi: 10.1037/a0017391] [Medline: 19968379]
8. David OA, Cardo RA, Matu S. Changes in irrational beliefs are responsible for the efficacy of the REThink therapeutic game in preventing emotional disorders in children and adolescents: mechanisms of change analysis of a randomized clinical trial. Eur Child Adolesc Psychiatry 2019 Mar;28(3):307-318 [doi: 10.1007/s00787-018-1195-z] [Medline: 29987559]
9. Ebert D, Mortier P, Kaehlke F, Bruffaerts R, Baumeister H, Auerbach RP, WHO World Mental Health-International College Student Initiative collaborators. Barriers of mental health treatment utilization among first-year college students: first cross-national results from the WHO World Mental Health International College student initiative. Int J Methods Psychiatr Res 2019 Jun;28(2):e1782 [FREE Full text] [doi: 10.1002/mpr.1782] [Medline: 31069905]
10. Eisenberg D, Golberstein E, Gollust SE. Help-seeking and access to mental health care in a university student population. Med Care 2007 Jul;45(7):594-601 [doi: 10.1097/MLR.0b013e31803bb4c1] [Medline: 17571007]
11. Gulliver A, Griffiths KM, Christensen H. Perceived barriers and facilitators to mental health help-seeking in young people: a systematic review. BMC Psychiatry 2010 Dec 30;10:113 [FREE Full text] [doi: 10.1186/1471-244X-10-113] [Medline: 21192795]
12. Hidden waits force more than three quarters of mental health patients to seek help from emergency services. Royal College of Psychiatrists. 2022. URL: https://www.rcpsych.ac.uk/news-and-features/latest-news/detail/2022/10/10/hidden-waits-force-more-than-three-quarters-of-mental-health-patients-to-seek-help-from-emergency-services [accessed 2023-06-16]
13. Improving Access to Psychological Therapies (IAPT) waiting times guidance and FAQ's. National Health Service England. 2015. URL: https://www.england.nhs.uk/wp-content/uploads/2015/02/iapt-wait-times-guid.pdf [accessed 2023-06-28]

14. Pretorius C, Coyle D. Young people's use of digital tools to support their mental health during COVID-19 restrictions. Front Digit Health 2021 Dec 01;3:763876 [FREE Full text] [doi: 10.3389/fdgth.2021.763876] [Medline: 34927133]
15. Lupton D. Young people's use of digital health technologies in the global north: narrative review. J Med Internet Res 2021 Jan 11;23(1):e18286 [FREE Full text] [doi: 10.2196/18286] [Medline: 33427684]
16. Rich E, Miah A, Lupton D, Lewis SC. Digital health generation? Young people's use of 'healthy lifestyle' technologies. University of Bath. URL: https://www.researchgate.net/profile/Andy-Miah/publication/343335783_Digital_Health_Generation_Young_People's_Use_of_'Healthy_Lifestyle'_Technologies/links/5f23e5ac458515b729f5ed49/Digital-Health-Generation-Young-Peoples-Use-of-Healthy-Lifestyle-Technologies.pdf [accessed 2023-03-07]
17. The common sense census: media use by tweens and teens, 2021. Common Sense Media. 2019. URL: https://www.commonsensemedia.org/research/the-common-sense-census-media-use-by-tweens-and-teens-2021 [accessed 2023-03-07]
18. Beard C, Silverman AL, Forgeard M, Wilmer MT, Torous J, Björgvinsson T. Smartphone, social media, and mental health app use in an acute transdiagnostic psychiatric sample. JMIR Mhealth Uhealth 2019 Jun 07;7(6):e13364 [FREE Full text] [doi: 10.2196/13364] [Medline: 31199338]
19. Bennett S, Cuijpers P, Ebert DD, McKenzie Smith M, Coughtrey AE, Heyman I, et al. Practitioner review: unguided and guided self-help interventions for common mental health disorders in children and adolescents: a systematic review and meta-analysis. J Child Psychol Psychiatry 2019 Aug;60(8):828-847 [doi: 10.1111/jcpp.13010] [Medline: 30775782]
20. Baumeister H, Reichler L, Munzinger M, Lin J. The impact of guidance on internet-based mental health interventions — a systematic review. Internet Interv 2014 Oct;1(4):205-215 [FREE Full text] [doi: 10.1016/j.invent.2014.08.003]
21. Firth J, Torous J, Nicholas J, Carney R, Pratap A, Rosenbaum S, et al. The efficacy of smartphone-based mental health interventions for depressive symptoms: a meta-analysis of randomized controlled trials. World Psychiatry 2017 Oct;16(3):287-298 [FREE Full text] [doi: 10.1002/wps.20472] [Medline: 28941113]
22. Linardon J, Cuijpers P, Carlbring P, Messer M, Fuller-Tyszkiewicz M. The efficacy of app-supported smartphone interventions for mental health problems: a meta-analysis of randomized controlled trials. World Psychiatry 2019 Oct;18(3):325-336 [FREE Full text] [doi: 10.1002/wps.20673] [Medline: 31496095]
23. Hollis C, Falconer CJ, Martin JL, Whittington C, Stockton S, Glazebrook C, et al. Annual research review: digital health interventions for children and young people with mental health problems - a systematic and meta-review. J Child Psychol Psychiatry 2017 Apr;58(4):474-503 [doi: 10.1111/jcpp.12663] [Medline: 27943285]
24. Firth J, Torous J, Nicholas J, Carney R, Rosenbaum S, Sarris J. Can smartphone mental health interventions reduce symptoms of anxiety? A meta-analysis of randomized controlled trials. J Affect Disord 2017 Aug 15;218:15-22 [FREE Full text] [doi: 10.1016/j.jad.2017.04.046] [Medline: 28456072]
25. Goldberg SB, Lam SU, Simonsson O, Torous J, Sun S. Mobile phone-based interventions for mental health: a systematic meta-review of 14 meta-analyses of randomized controlled trials. PLOS Digit Health 2022;1(1):e0000002 [FREE Full text] [doi: 10.1371/journal.pdig.0000002] [Medline: 35224559]
26. Button KS, Ioannidis JP, Mokrysz C, Nosek BA, Flint J, Robinson ES, et al. Power failure: why small sample size undermines the reliability of neuroscience. Nat Rev Neurosci 2013 May;14(5):365-376 [doi: 10.1038/nrn3475] [Medline: 23571845]
27. Ioannidis JP. Why most discovered true associations are inflated. Epidemiology 2008 Sep;19(5):640-648 [doi: 10.1097/EDE.0b013e31818131e7] [Medline: 18633328]
28. Eysenbach G. The law of attrition. J Med Internet Res 2005 Mar 31;7(1):e11 [FREE Full text] [doi: 10.2196/jmir.7.1.e11] [Medline: 15829473]
29. Yang W, Ding Z, Dai T, Peng F, Zhang JX. Attention bias modification training in individuals with depressive symptoms: a randomized controlled trial. J Behav Ther Exp Psychiatry 2015 Dec;49(Pt A):101-111 [FREE Full text] [doi: 10.1016/j.jbtep.2014.08.005] [Medline: 25245928]
30. Kramer J, Conijn B, Oijevaar P, Riper H. Effectiveness of a web-based solution-focused brief chat treatment for depressed adolescents and young adults: randomized controlled trial. J Med Internet Res 2014 May 29;16(5):e141 [FREE Full text] [doi: 10.2196/jmir.3261] [Medline: 24874006]
31. Deterding S, Dixon DH, Khaled R, Nacke LE. From game design elements to gamefulness: defining "gamification". In: Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments. 2011 Presented at: MindTrek '11; September 28-30, 2011; Tampere, Finland p. 9-15 URL: https://dl.acm.org/doi/10.1145/2181037.2181040 [doi: 10.1145/2181037.2181040]
32. Koivisto J, Hamari J. The rise of motivational information systems: a review of gamification research. Int J Inf Manage 2019 Apr;45:191-210 [FREE Full text] [doi: 10.1016/j.ijinfomgt.2018.10.013]
33. Fogg BJ. Persuasive Technology: Using Computers to Change What We Think and Do. Burlington, MA, USA: Morgan Kaufmann; Dec 2002:2
34. Detoni AM, Lourenço JE, Pacheco LP, Gomes LA, de Brito TC, da Silveira Madalena T. Prevenção e intervenção em saúde mental: resiliência e psicologia positiva. ANALECTA-Centro Universitário Academia 2022;7(2) [FREE Full text]
35. Floryan MR, Ritterband LM, Chow PI. Principles of gamification for internet interventions. Transl Behav Med 2019 Nov 25;9(6):1131-1138 [doi: 10.1093/tbm/ibz041] [Medline: 30944933]
36. Nicholson S. A RECIPE for meaningful gamification. In: Reiners T, Wood LC, editors. Gamification in Education and Business. Cham, Switzerland: Springer; 2015:1-20

37. Mental health. World Health Organization. URL: https://www.who.int/news-room/fact-sheets/detail/mental-health-strengthening-our-response [accessed 2022-06-17]
38. Wren-Lewis S, Alexandrova A. Mental health without well-being. J Med Philos 2021 Dec 02;46(6):684-703 [FREE Full text] [doi: 10.1093/jmp/jhab032] [Medline: 34668012]
39. Ungar M. Resilience, trauma, context, and culture. Trauma Violence Abuse 2013 Jul;14(3):255-266 [doi: 10.1177/1524838013487805] [Medline: 23645297]
40. Egeland B, Carlson E, Sroufe LA. Resilience as process. Dev Psychopathol 2009 Sep 09;5(4):517-528 [FREE Full text] [doi: 10.1017/s0954579400006131]
41. Ungar M, Theron L. Resilience and mental health: how multisystemic processes contribute to positive outcomes. Lancet Psychiatry 2020 May;7(5):441-448 [doi: 10.1016/S2215-0366(19)30434-1] [Medline: 31806473]
42. Bellis MA, Hughes K, Leckenby N, Perkins C, Lowey H. National household survey of adverse childhood experiences and their relationship with resilience to health-harming behaviors in England. BMC Med 2014 May 02;12:72 [FREE Full text] [doi: 10.1186/1741-7015-12-72] [Medline: 24886026]
43. Jefferies P, Vanstone R, Ungar M. The rugged resilience measure: development and preliminary validation of a brief measure of personal resilience. Appl Res Qual Life 2021 May 06;17(2):985-1000 [FREE Full text] [doi: 10.1007/s11482-021-09953-3]
44. Ungar M. The social ecology of resilience: addressing contextual and cultural ambiguity of a nascent construct. Am J Orthopsychiatry 2011 Jan;81(1):1-17 [doi: 10.1111/j.1939-0025.2010.01067.x] [Medline: 21219271]
45. Van Breda AD. A critical review of resilience theory and its relevance for social work. Soc Work 2018 Apr;54(1):1-18 [FREE Full text] [doi: 10.15270/54-1-611]
46. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med 2006 May 22;166(10):1092-1097 [doi: 10.1001/archinte.166.10.1092] [Medline: 16717171]
47. Kroenke K, Strine TW, Spitzer RL, Williams JB, Berry JT, Mokdad AH. The PHQ-8 as a measure of current depression in the general population. J Affect Disord 2009 Apr;114(1-3):163-173 [doi: 10.1016/j.jad.2008.06.026] [Medline: 18752852]
48. Random.org: True Random Number Service. RANDOM.ORG. URL: https://www.random.org/ [accessed 2023-06-28]
49. Haahr M. Introduction to randomness and random numbers. Random. 2023. URL: https://www.random.org/randomness/ [accessed 2023-06-16]
50. Litvin S. A review on digital mental health applications types, PsycappsE and eQuoo. Neurol Neurosurg 2019;2(1):1-4 [FREE Full text] [doi: 10.15761/nns.1000119]
51. Litvin S, Saunders R, Maier MA, Lüttke S. Gamification as an approach to improve resilience and reduce attrition in mobile mental health interventions: a randomized controlled trial. PLoS One 2020 Sep 02;15(9):e0237220 [FREE Full text] [doi: 10.1371/journal.pone.0237220] [Medline: 32877425]
52. Cantallops MM, Sicilia MA. Motivations to read and learn in videogame lore: the case of league of legends. In: Proceedings of the 4th International Conference on Technological Ecosystems for Enhancing Multiculturality. 2016 Presented at: TEEM '16; November 2-4, 2016; Salamanca, Spain p. 585-591 URL: https://dl.acm.org/doi/10.1145/3012430.3012578 [doi: 10.1145/3012430.3012578]
53. Haller E, Watzke B. The role of homework engagement, homework-related therapist behaviors, and their association with depressive symptoms in telephone-based CBT for depression. Cognit Ther Res 2021;45(1):224-235 [FREE Full text] [doi: 10.1007/s10608-020-10136-x]
54. Cheng VW, Davenport T, Johnson D, Vella K, Hickie IB. Gamification in apps and technologies for improving mental health and well-being: systematic review. JMIR Ment Health 2019 Jun 26;6(6):e13717 [FREE Full text] [doi: 10.2196/13717] [Medline: 31244479]
55. Rajaei A, Daneshpour M, Robertson J. The effectiveness of couples therapy based on the Gottman method among Iranian couples with conflicts: a quasi-experimental study. J Couple Relatsh Ther 2019;18(3):223-240 [FREE Full text] [doi: 10.1080/15332691.2019.1567174]
56. Laufer O, Israeli D, Paz R. Behavioral and neural mechanisms of overgeneralization in anxiety. Curr Biol 2016 Mar 21;26(6):713-722 [FREE Full text] [doi: 10.1016/j.cub.2016.01.023] [Medline: 26948881]
57. Sullivan MJ, D'Eon JL. Relation between catastrophizing and depression in chronic pain patients. J Abnorm Psychol 1990 Aug;99(3):260-263 [doi: 10.1037//0021-843x.99.3.260] [Medline: 2145334]
58. Syafryadin S, Nurkamto J, Linggar DA, Mujiyanto J. Active, belief, and consequence (ABC) model technique in minimizing students' speech anxiety. In: Proceedings of the 5th International Seminar on English Language and Teaching. 2017 Presented at: ISELT-5 '17; August 17, 2017; Sumatra, Indonesia p. 320-324 URL: https://ejournal.unp.ac.id/index.php/selt/article/viewFile/8021/6123
59. Petrinec A, Wilk C, Hughes JW, Zullo MD, Chen YJ, Palmieri PA. Delivering cognitive behavioral therapy for post-intensive care syndrome-family via a mobile health app. Am J Crit Care 2021 Nov 01;30(6):451-458 [doi: 10.4037/ajcc2021962] [Medline: 34719716]
60. Kaltenthaler E, Parry G, Beverley C, Ferriter M. Computerised cognitive-behavioural therapy for depression: systematic review. Br J Psychiatry 2008 Sep;193(3):181-184 [doi: 10.1192/bjp.bp.106.025981] [Medline: 18757972]

82. Marshall JM, Dunstan DA, Bartik W. Smartphone psychology: new approaches towards safe and efficacious mobile mental health apps. Prof Psychol Res Pr 2020 Jun;51(3):214-222 [doi: 10.1037/pro0000278]
83. Nwosu A, Boardman S, Husain MM, Doraiswamy PM. Digital therapeutics for mental health: is attrition the Achilles heel? Front Psychiatry 2022 Aug 05;13:900615 [FREE Full text] [doi: 10.3389/fpsyt.2022.900615] [Medline: 35982936]

Abbreviations

CBT: cognitive behavioral therapy
DHI: digital health intervention
GAD-7: generalized anxiety disorder–7
OR: odds ratio
PHQ-8: Patient Health Questionnaire–8
RCT: randomized controlled trial
RM: repeated measures
RRM: Rugged Resilience Measure

Edited by J Torous; submitted 14.03.23; peer-reviewed by S Dix, J Marshall; comments to author 06.04.23; revised version received 02.06.23; accepted 20.06.23; published 21.07.23

Please cite as:
Litvin S, Saunders R, Jefferies P, Seely H, Pössel P, Lüttke S
The Impact of a Gamified Mobile Mental Health App (eQuoo) on Resilience and Mental Health in a Student Population: Large-Scale Randomized Controlled Trial
JMIR Ment Health 2023;10:e47285
URL: https://mental.jmir.org/2023/1/e47285
doi: 10.2196/47285
PMID:

German Translation of Cover Paper

Einleitung

Problemstellung

Wachsende Fallzahlen im Bereich der psychischen Gesundheit und des psychischen Wohlbefindens (Storrie et al., 2010), einhergehend mit einer nicht in ausreichendem Maße zugänglichen Unterstützung (Twenge et al., 2019), haben dazu beigetragen, dass weniger als 35 % der Menschen, die Bedarf an einer Intervention haben, diese auch erhalten (Kazdin, 2017). Zugangshindernisse sind unter anderem unzureichende finanzielle Mittel von staatlicher Seite und seitens nationaler Gesundheitssysteme und die Tatsache, dass Einzelne nicht in der Lage sind, für eine Behandlung finanziell selbst aufzukommen (Kazdin, 2017). Weitere Einflüsse — etwa eine ländliche Wohnlage, Stigmatisierung oder eingeschränkte Sprechzeiten — verhindern ebenfalls, dass Menschen im Bereich der psychischen Gesundheit die Hilfe erhalten, derer sie eigentlich bedürfen (Sickel et al., 2019). Zwar ist die mangelnde Versorgung bereits seit längerer Zeit ein wachsendes Problem, durch die Corona-Pandemie ist jedoch die Zahl psychischer Erkrankungen in die Höhe geschnellt (O'Connor et al., 2020, Cenat et al., 2022), was zu einer erhöhten Nachfrage nach erschwinglicher, leicht zugänglicher Unterstützung geführt hat, insbesondere solcher, die aus der Distanz möglich ist (Veldhuiset al, 2020, Latoo et al., 2021). Teenager, Heranwachsende und junge Erwachsene sind besonders schlecht versorgt, gleichzeitig haben sie zum Teil den höchsten Bedarf im Bereich der psychischen Gesundheitsfürsorge (Benton et al., 2022). Das ist besonders alarmierend, da eine im Jugendalter diagnostizierte psychische Erkrankung leicht zu langen Fehlzeiten in Schule oder Universität oder zu Brüchen in der Erwerbs- oder Ausbildungsbiografie führen kann (Ringbom et al., 2021), mit katastrophalen Folgen für die Jugendlichen als Individuen wie auch für ihr Umfeld.

Diese Fakten machen deutlich, wie dringend der Bedarf an bezahlbaren und leicht zugänglichen Behandlungsoptionen ist, bei denen es sich nicht um klassische Face-to-Face-Therapie handelt.

Darüber hinaus zeigt die Forschung, dass Prävention und Positive Psychologie als Wege zur Gesunderhaltung, und um Menschen mit den zu einem guten Umgang mit mentalem und emotionalem Stress notwendigen psychologischen Ressourcen auszustatten, nicht nur hoch

wirksamConley at al., 2017), sondern auch in der Lage sind, das Leid und die emotionale Last des Lebens mit einer psychischen Erkrankung deutlich zu lindern.

In den letzten Jahren haben Studien gezeigt, dass unterschiedliche Formen digitaler Remote-Behandlungen, etwa über das Internet bereitgestellte kognitive Verhaltenstherapien und eine Mischung aus angeleiteter und nicht angeleiteter Therapie, zu einer signifikant verringerten psychopathologischen Symptomatik führen, speziell bei Depression und Ängsten (Harith et al., 2022). Ein vielversprechender Ansatz, jedoch setzten die ersten digitalen Optionen einer Remote-Therapie bei den Beteiligten den Besitz eines Computers oder Laptops oder den Zugang dazu sowie eine stabile Internetverbindung voraus. Nicht in jedem Fall ist das möglich, auch wenn immer mehr Haushalte über mindestens einen Computer verfügen (Ibisworld.com, internet). Eine wachsende Anzahl Menschen hat jedoch inzwischen ein Smartphone (statista.com, internet, deloitte.com, internet), was einen niedrigschwelligeren und bequemeren Weg zu digitaler Remote-Therapie eröffnet: die Entwicklung von Interventionsangeboten über mobil nutzbare Apps. Noch dazu scheinen Teenager, Heranwachsende und junge Erwachsene positiv auf digitale Tools für Remote-Therapien in Form von Apps anzusprechen, da diese nahtlos an ihre täglichen Gewohnheiten, ihren Bedarf und ihre digitale Erwartungen anknüpfen (Vigerland et al., 2016).

Der Markt ist heute mit digitalen Remote-Therapie-Angeboten für psychische Gesundheit geradezu überflutet. Aber nur 2 % der Produkte haben klinische Prüfungen durchlaufen. Das wirft Fragen bezüglich ihrer Legitimität, Sicherheit und Wirksamkeit auf (Lau et al., 2020). Eine Überprüfung von 19 Studien, in denen die Nutzung digitaler Remote-Therapie mit Gamification-Elementen bei häufigen psychischen Problemen junger Menschen untersucht wurde, ergab jüngst, dass es bei 53 % der Studien keine aktive Kontrollgruppe gab, 16 % arbeiteten mit einer Wartelisten-Bedingung, 21 % mit einer Kontrollgruppe, die eine andere Form digitaler Remote-Therapie erhielt, und bei nur 11 % (2 Studien, die sich auf dasselbe Angebot bezogen) waren es Face-to-Face-Interventionen (Halldorssom et al., 2021, Grist et al., 2019). Der Effekt der digitalen Remote-Therapietools war dort am größten, wo ein Vergleich mit nicht aktiven Kontrollbedingungen erfolgte. Die Effekte waren klein bis gar nicht vorhanden, wenn ein aktiver Komparator vorlag (Linardon et al., 2019, Hollis et al., 2017). Jüngste Metaanalysen, die speziell Studien zum Thema Mobiltelefon-Apps gegen Depression und Ängste in den Blick nahmen, legen

nahe, dass Letztere das Potenzial bieten, im Vergleich mit inaktiven Kontrollgruppen Symptome zu lindern (Firth et al., 2017, Firth et al., 2017). Leider waren nur in wenige Studien aktive Kontrollgruppen eingebunden. Dies wäre jedoch wichtig, um den Effekt einer bestimmten Intervention zu erforschen. Auch sei hier erwähnt, dass viele der Studien eine zu geringe Anzahl Probanden umfassten. Eine unzureichende Stichprobengröße kann günstigen Effekten von Interventionen mehr Gewicht verleihen (Ebert et al., 2015, Pennant et al., 2015, Ye et al., 2014), wodurch es unwahrscheinlicher wird, dass ein statistisch signifikantes Ergebnis für eine tatsächliche Wirkung steht (Ioannidis, 2008).

Die Evidenzbasis zeigt ferner, dass es bei digitalen Produkten für psychische Gesundheit in der Frage des Engagements ein Kernproblem gibt: Schwund. Zwar ist bei jeder Form einer Intervention im Bereich der psychischen Gesundheit mit einer gewissen Schwundquote zu rechnen (Linardon, 2019), bei digitalen Produkten für psychische Gesundheit scheint diese jedoch höher zu liegen [Quellen]. Das ist bedenklich, da viele Interventionen ein anhaltendes Engagement voraussetzen, um ihre Inhalte zu vermitteln bzw. damit die Intervention über die Zeit ihre Wirkung entfalten kann.

Die Problemstellung umfasst somit vier Kernpunkte:

1. Psychische Krankheiten sind auf dem Vormarsch.
2. Der Zugang zu Face-to-Face-Therapie bleibt problematisch.
3. Für die meisten digital über mobile Apps angebotenen Remote-Therapien fehlt eine ausreichend wissenschaftlich fundierte Basis.
4. Bei den meisten digital über mobile Apps angebotenen Remote-Therapien bleiben die Klienten nicht lange genug dabei, damit sich eine Wirkung auf ihre psychische Gesundheit einstellt.

Gesamttheorie

Die Gesamttheorie dieser wissenschaftlichen Arbeit lautet, dass evidenzbasierte digitale Interventionen für psychische Gesundheit mit Gamification-Elementen, die über Mobiltelefone bereitgestellt werden, nachweislich wirksame Werkzeuge für eine verbesserte psychische Gesundheit sein können. Die Hypothese lautet, dass die Plattform – Mobiltelefone – die

Möglichkeit einer erschwinglichen, persönlichen Dienstleistung bietet, die auf Abruf zur Verfügung steht, dass klinische Prüfungen deren Wirksamkeit nachweisen und Gamification die herausfordernde Frage der Bindung an das Angebot löst, zumindest in Bezug auf bestimmte Zielgruppen, etwa junge Erwachsene.

Stand der Forschung

Die Lockdowns während der Coronakrise und die Einschränkungen des sozialen Lebens, die damit einhergingen, hatten Einfluss auf den Anstieg des Bedarfs im Bereich der psychischen Gesundheitsfürsorge (Pfefferbaum et al., 2020). Es fällt der Forschung jedoch nach wie vor schwer, schlüssig zu erklären, warum bereits vor Corona ein wachsender Versorgungsbedarf zu verzeichnen war (Wiens et al., 2020). Eine Vermutung lautet, dass die Zunahme medizinischer Behandlungen unter Umständen einen Teufelskreis einer schlechteren psychischen Verfassung befeuert Richter et al., 2019), andere verweisen auf veränderte Lebensgewohnheiten, etwa das viele Sitzen (Bort-Roig et al., 2020), die Nutzung sozialer Medien oder von Technik im Allgemeinen (Naslund et al., 2020) oder auch eine globale Identitätskrise der jüngeren Generationen (Miller et al., 2019), die ins Negative kippen könnte. Auch wenn keine dieser Hypothesen allein den Anstieg psychischer Erkrankungen erklären kann, werden kontinuierlich Daten erhoben, und viele der Hypothesen könnten nutzbringend in staatliche Leitlinien einfließen, oder auch auf institutioneller Seite zur Entwicklung von am Wohlbefinden orientierten Praktiken beitragen. Auch im Gesundheitssektor werden aktiv Leitlinien und Regelungen erarbeitet (Torous et al., 2019), und Rufe nach mehr Geld zur Finanzierung von Gesundheitsdienstleistungen sind laut vernehmlich (actformentalhealth.ca, internet).

Trotz verbesserter finanzieller Ausstattung ist Face-to-Face-Therapie nach wie vor nur über das Nadelöhr langer Wartezeiten (rcpsych.ac, internet) oder zu erheblichen, selbst getragenen Kosten für private Therapiesitzungen in Höhe von 60 € bis über 400 € (privatepracticehun.co.uk, internet), was sich längst nicht jeder leisten kann, zugänglich. Und selbst wenn weder Wartezeit noch Kosten der limitierende Faktor sind, gibt es doch für junge Erwachsene weitere Hürden, etwa den Wunsch, selbst mit der Situation fertig zu werden und eine vermeintliche Stigmatisierung zu vermeiden (Ebert et al. 2019, rcpsych.ac, internet).

Der private Sektor hat auf den unübersehbaren Bedarf an einer zugänglicheren und auf Abruf verfügbaren Versorgung im Bereich der psychischen Gesundheit reagiert: In den letzten Jahren wurden Tausende mobil nutzbarer Lösungen für psychische Gesundheit entwickelt. Von den über 10.000 Apps im Bereich Gesundheit, Psychosoziales und Stressmanagement in den App Stores, die von sich behaupten, psychische Belastungen zu lindern, wurden nur bei 2 % randomisierte kontrollierte klinische Studien (RCTs) zum Nachweis ihrer Wirksamkeit und Machbarkeit durchgeführt (Lau et al., 2020). RCTs sind zentral wichtig, nicht nur um festzustellen, dass eine App wirkt, sondern auch, dass sie ethischen Richtlinien entspricht und nach Antrag auf ethische Bewertung durch eine Zertifizierungsstelle anerkannt ist, deren Aufgabe es ist, die Benutzer von Remote-Therapien über Mobilgeräte vor jeder schädlichen oder fahrlässigen Praxis zu schützen. Bei den meisten dieser Apps handelt es sich um Mindfulness- und Meditationsanwendungen wie Headspace and Calm; und um Programme Positiver Psychologie, zu denen gehört, sich Ziele zu setzen und Tagebuch zu führen, inklusive Tools zur Überwachung der eigenen Stimmungslage; sowie um einige Tools, hinter denen ein echter Therapeut oder ein KI-Bot steht, etwa Wysa (Lau et al., 2020). Diese Apps waren Gegenstand von 33 peer-reviewten Veröffentlichungen, die sich jedoch nur auf 21 Apps bezogen: Davon acht Paper allein zu Headspace, sodass sich die Anzahl der tatsächlich evidenzbasierten Apps im Grunde auf 25 reduziert. Alle diese Studien erschienen zwischen 2015 und 2020 und es handelte sich um Studien zur Wirksamkeit, Machbarkeit oder Nutzbarkeit; zwei davon waren kombinierte Wirksamkeits- und Machbarkeitsstudien (Vigerland et al., 2016). Das deutet auf einen signifikanten Mangel an evidenzbasierter Versorgung hin und legt offen, dass zwischen Forschung und Praxis eine große Lücke klafft.

Überwiegend gehen aus den Studien Effektstärken und positive Outcomes im kleinen bis mittleren Bereich hervor, was daran liegen könnte, dass klinische Prüfungen ohne signifikante Ergebnisse unter Umständen nicht publiziert werden und/oder dass die Veröffentlichung von Outcomes, die ein erhofftes Ergebnis nicht stützen, aufgrund kommerzieller Interessen unterbleibt. Sehr wenige der Studien befassten sich mit der Frage der Teilnehmerbindung, und Meta-Reviews, die den Schwundaspekt thematisierten, offenbarten sehr hohe Schwundquoten von bis zu 99 % (Nwosu et al., 2022). Wird die Frage der Bindung nicht untersucht, entsteht ein riesiger blinder

Fleck in der Forschung: Fließen Nicht-Inanspruchnahme und Abbrüche nicht in die Betrachtung ein, lässt sich der wirkliche Wert des Interventionstools nicht einschätzen, weil unklar bleibt, ob es für die Bereitstellung einer Intervention geeignet ist. Selbst eine App mit höchstmöglicher Effektstärke wird keine Hilfe sein, wenn die Benutzer nicht so lange dabei bleiben, bis sich ihr Nutzen einstellt.

Dieser jüngste Stand zeigt, dass sich die Forschungslage im Bereich der digitalen Lösungen für psychische Gesundheit gerade entwickelt, jedoch deutliche Schwächen hat, unter anderem einer Überrepräsentation bestimmter, einzelner Apps, was die Verallgemeinerbarkeit infrage stellt, die fehlende Datenlage zur Inanspruchnahme und Bindung sowie extrem umständliche und starre RTC-Protokolle, was es für Entwickler mobiler Tools für psychische Gesundheit erschwert, evidenzbasierte Produkte zu planen und zu entwickeln, die von Verbrauchern so lange genutzt werden, bis sich positive Effekte für ihre psychische Gesundheit einstellen.

Mission Statement

Während meiner Studienzeit an der Ludwig-Maximilians-Universität lernte ich alles über Psychologiegeschichte, Diagnosetools, Statistik, Behandlungen und Ethik. In der Praxis traf es mich jedoch unvorbereitet, wie viele Hürden im Bereich der psychischen Gesundheitsfürsorge bestehen, auf die Klienten stoßen, wenn sie versuchen, sich Hilfe zu holen. Ich war entsetzt, als ich erfuhr, dass Wartezeiten von bis zu 6 Monaten als normal, geradezu kurz angesehen werden (rcpsych.ac, internet) und dass sich Versicherungen bei Krankheitssymptomen unterhalb einer gewissen Schwelle häufig weigern, die Behandlungskosten zu übernehmen. Klienten erzählten mir, dass sie in Fragebögen stärkere Symptome angaben, als der Wahrheit entsprach, weil sie Sorge hatten, dass ihr Gesuch anderenfalls abgelehnt würde. Während meines Praktikums in einer ambulanten Versorgungseinrichtung für psychisch Kranke, NELFT ([nelft.nhs.uk, internet), saßen mir junge Erwachsene zum Erstgespräch gegenüber, die monatelang auf diesen Termin gewartet hatten. Ihr Leid und ihre Symptome hatten sich in dieser Zeit häufig weiter verschlimmert. Sie berichteten mir, dass die ersten Symptome bereits Jahre vor dem Entschluss, sich Hilfe zu suchen, aufgetreten seien, und der Gedanke traf mich wie ein Schlag, dass sie nicht bei mir säßen, wenn

sie das psychologische Rüstzeug erhalten hätten, das ihnen nun vermittelt würde (ein auf kognitive Verhaltenstherapie (CBT) gestütztes Programm), noch ***bevor*** sich die ersten Symptome zeigten. Das war der Punkt, an dem ich entschied, mich als Psychologin anders einzubringen als ursprünglich geplant: Anstatt nur einigen Privilegierten zu helfen, die es bis zu uns geschafft hatten, würde ich meine akademische und persönliche Laufbahn auf die Prävention psychischer Krankheiten ausrichten. Ich würde die neue Welt der App- und Videospiel-Technologien zur Entwicklung einer Intervention nutzen, die mobil zugänglich und für junge Erwachsene attraktiv ist und die ihnen die zum Aufbau von Resilienz notwendigen psychologischen Skills vermittelt. Eine Intervention, die verhindert, dass Ängste und Depression überhaupt erst entstehen, und die auch Unterhaltungswert hat. Ich bin überzeugt, dass der Weg, persönlich zu wachsen, zu heilen und sich selbst besser zu verstehen, Spaß machen kann — trotz allen Leids, das mit psychischen Krankheiten einhergeht. Warum sollte man sich nicht das Know-how der Gaming-Industrie zunutze machen, um ein ethisch verantwortbares Interventionswerkzeug zu entwickeln, das junge Erwachsene dort abholt, wo sie mit ihren Bedürfnissen und Gewohnheiten stehen? So begann mein Weg mit eQuoo, immer im Bestreben, ein wirksames und zuverlässiges Tool zu entwickeln, das Bildungsinstitutionen für ihre Schüler und Studierende erwerben können, sodass junge Menschen nicht auch noch finanziell belastet werden, wenn sie Hilfe brauchen. Aktuell ist eQuoo bereits in vier Sprachen übersetzt. Es ist weltweit bereits über 500.000 Mal heruntergeladen worden, durchläuft gerade die dritte randomisierte kontrollierte klinische Prüfung (RTC) und ist Gegenstand verschiedener unabhängiger Studien.

Darstellung der Arbeiten

Diese Dissertation fußt darauf, dass es einen Mangel an *wirksamen* Ressourcen für psychische Gesundheit gibt; im Anschluss wird eine erschwingliche, effektive und skalierbare Lösung namens eQuoo präsentiert und getestet. Mit „Wirksamkeit“ meine ich vorrangig Ressourcen für psychische Gesundheitsfürsorge, die von den Klienten so lange genutzt werden, dass sie eine positive Veränderung ihrer psychischen Gesundheit feststellen.

Diese Dissertation zeichnet meinen akademischen Weg und meine Erkenntnisse im Rahmen der Entwicklung eines mobil nutzbaren Tools für psychische Gesundheit mit Gamification-

Elementen namens eQuoo, the Emotional Fitness Game, Versionen 1 (V1) und 3 (V3) nach. In Paper 1 wurde eQuoo V1 im Rahmen einer 5-wöchigen, dreiarmigen RCT mit 358 Teilnehmern getestet. Es erhöhte sich – über einen 5-wöchigen Zeitraum – signifikant die Kennzahl für psychisches Wohlbefinden in Form von Resilienz, Persönlichkeitsentwicklung und positivem Beziehungsaufbau und Ängste milderten sich ab. Ferner war die Schwundquote niedrig, was darauf hindeutet, dass der Einsatz von Gamification in Tools für psychische Gesundheit geeignet ist, um Benutzer zu halten (Paper 1: Gamification as an Approach to Improve Mental Well-Being and Reduce Attrition in Mobile Mental Health Interventions: A Randomised Controlled Trial). Paper 2 (The Impact of a Gamified Mobile Mental Health App [eQuoo] on Resilience and Mental Health in a Student Population: Large-Scale Randomised Controlled Trial) ist die Folgestudie zur Untersuchung des aktuellen eQuoo Game, V3, das auf Basis des Feedbacks Tausender Spieler sowie meiner eigenen Schlüsse aus der ersten Studie ein umfassendes Update erhielt. In einer dreiarmigen 5-wöchigen RCT mit 1.165 Studierenden wurde die Wirkung des Spiels auf Ängste, Depression und Resilienz gemessen. Ein zweiter, wichtiger sekundärer Outcome war der Schwund. Die Studie erzielte in allen Analysebereichen signifikante Werte, etwa bei Last Observation Carried Forward und Intention to Treat.

Paper 1: Gamification as an Approach to Improve Mental Well-Being and Reduce Attrition in Mobile Mental Health Interventions: A Randomised Controlled Trial

In Partnerschaft mit einem Spieleentwickler mit Sitz in Los Angeles entwarf ich eQuoo V1 – ein Spiel, das es Benutzern erlaubt, in einer risikoarmen, kostengünstigen Umgebung psychologische Skills zu erlernen und einzuüben.

eQuoo V1 war ein interaktives Spiel für Mobilgeräte und in allen App Stores erhältlich. Das Spiel war in fünf Kapitel unterteilt (ein Kapitel pro Woche); jedes Kapitel vermittelte zwei neue psychologische Skills. Jede dieser Fertigkeiten ist empirisch verankert und ein Element von CBT, Positiver und Systemischer Psychologie, darunter Verallgemeinerung, Katastrophisierung und emotionale Beziehungsangebote. Jeweils zu Beginn des Kapitels führte ein spieleigener Avatar, Joy, in die Skills ein, und anschließend, nach dieser Vermittlung, erwartete die Benutzer ein nach „Choose your own“-Prinzip aufgebautes Abenteuerspiel, in dem die Spieler ihre neu erworbenen

Fertigkeiten einsetzen mussten, um Coins zu erhalten und ein Level aufzusteigen. Jedes Kapitel basierte auf einem anderen Literatur-Genre und es brauchte, je nach Lesegeschwindigkeit, etwa 15 bis 25 Minuten Zeit, um es durchzuspielen.

Über einen 5-wöchigen Zeitraum fand eine dreiarmige RCT mit 358 Arbeitnehmern von BOSCH UK statt. In der Studie wurde untersucht, ob die Versuchsgruppe, die eQuoo nutzte, einen deutlichen Anstieg ihrer Resilienz, zwischenmenschlichen Beziehungsfähigkeit und Persönlichkeitsentwicklung feststellen und ob ihre Angst abnehmen würde. Die Kontrollgruppe, die eine Standardbehandlung erhielt, wurde mit einer CBT-App namens „CBT Journal“ versorgt, und die Wartelisten-Gruppe erhielt in den 5 Wochen keine Behandlung.

Alle Teilnehmer wurden an Tag 1, 17 und 35 dem Adult Resilience Measure (ARM) (Liebenberg et al.2018), der Likert-Angst-Skala mit einer Frage (Davey at al., 2007), der Personal Growth Initiative Scale (PGIS) und den Ryff’s Scales of Psychological Well-Being (RPRS) (Kafka et al. 2002) unterzogen. Varianzanalysen mit wiederholten Messungen (ANOVAs) zeigten über die 5 Wochen statistisch signifikante Zuwächse bei der Resilienz in der Versuchsgruppe im Vergleich zu sowohl der Kontroll- als auch der Wartelisten-Gruppe. Die App stärkte ferner signifikant die Persönlichkeitsentwicklung und positive zwischenmenschliche Beziehungen und verminderte Ängste. Mit 90 % Adhärenz hielt eQuoo V1 21 % mehr Teilnehmer bei der Stange als die Kontroll- oder Wartelisten-Gruppe. Die über eQuoo V1 bereitgestellte Intervention erhöhte das psychische Wohlbefinden deutlich und verminderte das selbst eingeschätzte Angstempfinden. Gleichzeitig verbesserte sich die Adhärenz im Vergleich zu den Kontrollbedingungen. Die ANOVA mit Messwiederholung in Bezug auf den primären Outcome (ARM-Score) zeigte einen signifikanten Haupteffekt der Intervention, $F(2,350) = 8,51$, $p < 0,001$, $\eta_p^2 = 0,046$, und eine signifikante Interaktion zwischen Intervention und Zeit, $F(4,698) = 3,34$, $p = 0,01$, $\eta_p^2 = 0,019$, aber keinen zeitlichen Haupteffekt, $F(2,350) = 2,66$, $p = 0,07$, $\eta_p^2 = 0,015$).

Obwohl der Schwund nicht zum primären Outcome zählte, machte die RCT deutlich, wie wichtig im Fall einer digitalen Intervention für psychische Gesundheit die Bindung an das Angebot ist, und es ergaben sich hohe Bindungsraten von über 90 % in der Versuchsgruppe — ein ungewöhnlich hoher Wert im Vergleich mit durchschnittlichen Bindungsraten einer RTC-Gruppe

Nwosu et al., 2022), was zeigt, dass Gamification und/oder der Einbau spielerischer Elemente für eine höhere Therapie-Adhärenz wertvoll sein kann.

Die RCT warf aufgrund ihrer Limitiertheit auch weitere Fragen auf: Obwohl eQuoo V1 digital bereits relativ weit entwickelt war, hätte die Datenausbeute wesentlich umfangreicher sein können, etwa zum individuellen Benutzer-Engagement und zur Auswirkung bestimmter Funktionen auf die Outcomes. Wie bei den meisten Interventionen gibt es auch bei eQuoo V1 einen „Black-Box"-Effekt, durch den unklar bleibt, welche im Spiel vermittelten psychologischen Skills die größte Wirkung entfalten. Es wäre zudem von Interesse, mittels einer feiner abgestuften Messung des Angstempfindens den Effekt zu untersuchen, den eQuoo V1 auf eine klinische Population hat.

Paper 2: The Impact of a Gamified Mobile Mental Health App (eQuoo) on Resilience and Mental Health in a Student Population: Large-Scale Randomised Controlled Trial

Das Paper ist eine Folgestudie mit der aktualisierten, aktuellen Version V3 von eQuoo.

Die Updates erfolgten vorrangig auf Grundlage von Spieler-Feedback und Benutzerdaten. Verbessert wurden die Nutzbarkeit und die Benutzeroberfläche. Auch ging es darum, mehr Inhalte zum Spiel hinzuzufügen, damit daraus ein 52-wöchiges Programm wird. Die Liste der Änderungen des Spiels umfasste

- 47 weitere Spiel-Level, sodass es insgesamt 52 Level sind;
- 5+ neue Geschichten anderer Genres mit je 8 bis 10 Kapiteln;
- eine Wochensperre, die verhindert, dass Spieler mehr als ein Level pro Woche spielen. Das fördert die Aneignung der Skills während der Sperrzeit und verhindert zudem, dass das Spiel mit Suchttendenz gespielt wird;
- ein individualisierbarer Avatar, sodass die Spieler sich selbst statt eine fiktionale Spielfigur, die eQuoo V3 anbietet, spielen;
- in die App integrierte Mini-Spiele für die Zeiten, in denen das Hauptspiel gesperrt ist;
- 42 weitere psychologische Skills, sämtlich basierend auf CBT, Systemischer Therapie und Positiver Psychologie; und

- eine umfassende Bibliothek zu jedem Skill mit Hintergrundinformationen in Form eines Blogs.

eQuoo V3 ist weiterhin im Google und Apple App Store erhältlich und bietet fünf kostenfreie Spiel-Level, bevor eine Paywall die Nutzung stoppt, sodass Selbstzahler sich zunächst ein Bild von dem Spiel machen können, bevor sie ein Abonnement erwerben. Es ist geplant, dass die App auch in Zukunft in den App Stores erhältlich bleibt, obwohl das Geschäftsmodell auf B2B (Business-to-Business, Geschäftskunden) ausgerichtet ist: PsycApps vermarktet die App an Sekundarschulen, Hochschulen und Universitäten. Dieser Schwenk von B2C (Business-to-Consumer, Privatkunden) zu B2B erfolgte, weil es mein Wunsch ist, dass die Kosten nicht von den jungen Klienten, sondern von anderer Stelle getragen werden.

UniDays (myunidays.com, internet), eine Rabatt-Plattform für Studierende, die mir Zugang zu über 3 Millionen potenziellen Teilnehmern im Vereinigten Königreich verschaffte, unterstützte eine groß angelegte, dreiarmige RCT. Über 1.000 Studierende (n = 1.165) von über 180 Universitäten wurden per Zufallsprinzip einer von drei Gruppen zugeordnet: (1) Benutzer von eQuoo V3, (2) Benutzer einer evidenzbasierten, auf kognitive Verhaltenstherapie gestützten Standard-App namens Sanvello, und (3) eine Warteliste ohne Intervention. Alle Teilnehmer wurden eingangs und alle 7 Tage bis zum Abschluss des Programms der Rugged Resilience Scale (Jefferies et al., 2021), Generalized Anxiety Disorder–7 (Spitzer et al. 2006) und dem Patient Health Questionnaire–8 (PHQ–8) Kroenke et al., 2009) unterzogen.

Eine ANOVA mit Messwiederholung zeigte signifikant höhere Resilienz-Scores in der Versuchsgruppe (p < 0,001) im Vergleich zu beiden Kontrollgruppen (Sanvello: p = 0,10, Warteliste: p = 0,82) über 5 Wochen. Die App reduzierte auch signifikant die Messwerte für Angst und Depression (beide ps < 0,001). Mit einer Adhärenz von 64,5 % (251/389) blieben in der Gruppe eQuoo V3 42 % mehr Teilnehmer dabei als in den Kontrollgruppen.

Der Outcome der RCT zeigt deutlich, dass digitale Gesundheitsinterventionen mit Gamification-Elementen wie eQuoo V3 wirksame, skalierbare und kostengünstige Lösungen zur Unterstützung junger Erwachsener sind, die sich für alle führenden mobilen Plattformen eignen.

Nicht alle in Paper 1 aufgeworfenen Fragen und erkannten Grenzen konnten im Rahmen von Paper 2 behandelt werden, und neue kamen hinzu. Der Arm „Intervention“ und der Arm

„Standardbehandlung“ der RCTs sind nicht vollständig vergleichbar, weil es sich um zwei unterschiedliche digitale Produkte handelt, die mit ähnlichen, aber doch verschiedenen Interventionstechniken arbeiten. Besser vergleichbar wäre es, wenn die Standardbehandlungsgruppe stattdessen eine Version von eQuoo V3 ohne Gamification erhielte. Ein weiterer limitierender Faktor: Es wurden keine In-Game-Spielerdaten herangezogen, um konkrete Spielinteraktionen zu erfassen. Sich allein auf Fragen zu stützen, um ein Engagement nachzuweisen, ist kein ausreichend nuancierter Ansatz, um Erkenntnisse zu gewinnen, wie das Spielen die Outcomes für psychische Gesundheit beeinflusst. Nicht zuletzt haben sich alle Teilnehmer selbst zur Teilnahme entschieden, daher kann es sein, dass die Outcomes der Studie womöglich durch die Selbstselektion verzerrt sind.

Trotz dieser Einschränkungen erlauben die Ergebnisse und die Tatsache, dass die Teilnehmergruppe sehr groß war, eine Generalisierung und stützen auf vielversprechende Weise die Hypothese, dass der Ansatz, die psychische Gesundheit spielerisch zu stärken, eine gute Idee ist.

Gesamtdiskussion

Wie eingangs bereits festgestellt, kommen erschwingliche, vertrauenswürdige und wirksame Interventionen für eine mobile Nutzung mit Gamification-Elementen als Lösungen auf den Markt, die geeignet sind, eine breite Bevölkerung zu unterstützen, anstelle oder ergänzend zu einer Face-to-Face-Therapie. Ich bin weiterhin auf dem Weg, zu forschen, zu entdecken und Erkenntnisse iterativ umzusetzen, und mache mir dabei eine bisher unermesslich große Menge an Daten zunutze, um noch wirksamere Interventionstools zu gestalten.

Erkenntnisse aus den randomisierten Kontrollstudien

Durch die RCTs wurde festgestellt, dass die mobilen Interventionstools eQuoo V1 und eQuoo V3 dahingehend effektiv sind, dass sie in einer nicht klinischen Population Ängste und Depression mindern und Kennzahlen des psychischen Wohlbefindens erhöhen, etwa die Resilienz. Es wurde erkannt, dass eine mangelnde Bindung an mobil nutzbare Tools generell eine Herausforderung darstellt, und es wurde untersucht, ob Gamification hier Abhilfe schaffen kann,

was durch Ergebnisse der Studien gestützt wurde. Die Kennzahlen waren ohne Ausnahme signifikant, mit Effektstärken bis Cohen's *d* = 67:

- Likert-Angst-Skala mit einer Frage: PsycAppsE: eQuoo
- ARM
- RPRS
- PGIS
- Schwund in den eQuoo V1- und V3-Versuchsgruppen
- GAD7
- PHQ–8

Fazit

Die Bedeutung ansprechender mobiler Interventionen

Obwohl frühe digitale Interventionen bereits erfolgreich bestimmte Kernelemente von Face-to-Face-Therapien in eine digitale Plattform überführt haben, zeigten hohe Schwundquoten, dass es an Motivation fehlt, wenn begleitende Motivatoren, etwa die therapeutische Beziehung, nicht durch einen anderen Faktor ersetzt werden, der die Adhärenz fördert. Wenn einem Klienten die Symptome seiner Depression so sehr zusetzen, dass er nicht einmal aufstehen und duschen kann, lässt sich nicht erwarten, dass er in der Lage ist, eine Online-Therapie selbständig konsequent durchzuführen. Es sollte auch bedacht werden, dass eine App für psychische Gesundheit nicht nur mit anderen Apps gleicher Ausrichtung konkurriert, sondern auch um die Zeit des Klienten und mit allen anderen Apps auf dem Mobiltelefon, in deren User Experience ggf. viele Millionen Dollar geflossen sind. Die beste App für psychische Gesundheit wird nicht helfen, wenn sie nicht so attraktiv ist, dass Klienten sie eine gewisse Zeit lang nutzen. Jede Zielgruppe ist anders, hat eigene psychologische Bedürfnisse und ein eigenes Nutzerverhalten, und reagiert damit mehr oder weniger positiv auf verschiedene Engagement-Methoden. Da 70 % der Population, für die eQuoo entwickelt wurde (16- bis 35-Jährige), Gelegenheitsspieler sind (explodingtopics.com, internet), war die Wahrscheinlichkeit hoch, dass eine Therapie mit Gamification-Elementen ein erfolgreicher Weg zur Stärkung der Adhärenz sein würde.

Künftige Schritte für ein Angebot mobil nutzbarer, wirksamer Interventionen

Angesichts der Zulassung, durch die Food and Drug Administration, von Reset (Kollins et al., 2021) und Akili (Campbell et al., 2012), die beide hohe Effektstärken melden, die mit anderen Therapieformen mithalten können, lässt sich der Schluss ziehen, dass es – eine aufnahmebereite Population vorausgesetzt – möglich ist, Therapien für eine mobile Nutzung zu entwickeln, die leistungsfähiger sind als andere Interventionen, und das bei viel niedrigerem Einsatz von Humankapital und Kosten. Es ist ein weiteres meiner Ziele, den Black-Box-Effekt durch Datenerhebungsmethoden zu beseitigen, die eine Ad-Hoc-Forschung mit Echtzeitdaten ermöglichen, um den Effekt der Funktionen des Spiels auf das psychische Wohlbefinden der Spieler zu erforschen, und so Effektstärken kontinuierlich prüfen, wiederholen und verbessern zu können. Weil klassische RTCs zeit- und kostenaufwendig sind, könnten neue Methoden, etwa Mikro-RCTs, ein Weg sein, Daten ethisch und empirisch einwandfrei zu erheben und zu verarbeiten, sodass schnellere und effizientere Iterationen möglich sind. Für V4, die nächste Generation von eQuoo, die im September 2023 an den Start gehen soll, entwickle ich ein Datenerhebungstool. Bei diesem Tool werden der Spieler-Population, wahlweise vor bzw. nach dem eigentlichen Spiel, über einen Chatbot freiwillige Fragebögen präsentiert. Die Echtzeitdaten werden ausgewertet, um die Effektstärke der jeweiligen Funktion zu messen, sodass sich anschließend ein Vergleich mit anderen Funktionen ziehen lässt, was iterativ zu einer Verbesserung der Effektstärke durch Ersatz oder Korrektur besagter Funktionen führt. Die erhobenen Benutzerdaten geben zudem Auskunft über die Zufriedenheit der Spieler und werden dafür genutzt, die Gaming-Erfahrung zu verbessern, was die Bindung an das Tool stärkt, sodass die Intervention eine höhere Wirkung zeigt. Letztlich können alle genannten Daten zum Aufbau und zur Implementierung prädiktiver Modellierungsalgorithmen und erster Tools für maschinelles Lernen führen, die dazu beitragen, die Intervention entsprechend dem psychischen Versorgungsbedarf der Spieler sowie inhaltlich so anzupassen, dass eine packende User Experience entsteht, die die Bindung weiter stärkt.

Bereits geplante klinische Folgestudien werden sicherstellen, dass alle, die Zugang zu eQUoo haben, eine sichere und evidenzbasierte Versorgung erhalten.

Literatur

Storrie, K., Ahern, K., & Tuckett, A. (2010). A systematic review: Students with mental health problems—A growing problem. *International Journal of Nursing Practice*, *16*(1), 1–6. https://doi.org/10.1111/j.1440-172X.2009.01813.x

Twenge, J. M., Cooper, A. B., Joiner, T. E., Duffy, M. E., & Binau, S. G. (2019). Age, period, and cohort trends in mood disorder indicators and suicide-related outcomes in a nationally representative dataset, 2005–2017. *Journal of Abnormal Psychology*, *128*(3), 185–199. https://doi.org/10.1037/abn0000410

Kazdin, A. E. (2017). Addressing the treatment gap: A key challenge for extending evidence-based psychosocial interventions. *Behavior Research and Therapy*, *88*, 7–18. https://doi.org/10.1016/j.brat.2016.06.004

Sickel, A. E., Seacat, J. D., & Nabors, N. A. (2019). Mental health stigma: Impact on mental health treatment attitudes and physical health. *Journal of Health Psychology*, *24*(5), 586–599. https://doi.org10.1177/1359105316681430

O'Connor, R., Wetherall, K., Cleare, S., McClelland, H., Melson, A., Niedzwiedz, C., . . . Robb, K. (2021). Mental health and well-being during the COVID-19 pandemic: Longitudinal analyses of adults in the UK COVID-19 Mental Health & Wellbeing study. The British Journal of Psychiatry, 218(6), 326–333. doi:10.1192/bjp.2020.212

Jude Mary Cénat, Seyed Mohammad Mahdi Moshirian Farahi, Rose Darly Dalexis, Wina Paul Darius, Farid Mansoub Bekarkhanechi, Hannah Poisson, Cathy Broussard, Gloria Ukwu, Emmanuelle Auguste, Duy Dat Nguyen, Ghizlène Sehabi, Sarah Elizabeth Furyk, Andi Phaelle Gedeon, Olivia Onesi, Aya Mesbahi El Aouame, Samiyah Noor Khodabocus, Muhammad S. Shah, Patrick R. Labelle, The global evolution of mental health problems during the COVID-19 pandemic: A systematic review and meta-analysis of longitudinal studies, Journal of Affective Disorders, Volume 315, 2022, Pages 70–95, ISSN 0165-0327, https://doi.org/10.1016/j.jad.2022.07.011.

Cindy B. Veldhuis, Elizabeth D. Nesoff, Anna Laura W. McKowen, Dylan R. Rice, Hana Ghoneima, Angie R. Wootton, Elizabeth Lerner Papautsky, Danielle Arigo, Shoshona Goldberg,

Jocelyn C. Anderson, Addressing the critical need for long-term mental health data during the COVID-19 pandemic: Changes in mental health from April to September 2020, Preventive Medicine, Volume 146, 2021, 106465, ISSN 0091-7435,

Latoo J, Haddad PM, Mistry M, Wadoo O, Islam SMS, Jan F, Iqbal Y, Howseman T, Riley D, Alabdulla M. The COVID-19 pandemic: an opportunity to make mental health a higher public health priority. BJPsych Open. 2021 Sep 20;7(5):e172. doi: 10.1192/bjo.2021.1002. PMID: 34538286; PMCID: PMC8458855.

Benton, T., Njoroge, W. F., & Ng, W. Y. (2022). Sounding the alarm for children's mental health during the COVID-19 pandemic. JAMA pediatrics, e216295-e216295. (https://www.sciencedirect.com/science/article/pii/S0091743521000499)

Ringbom, I., Suvisaari, J., Kääriälä, A., Sourander, A., Gissler, M., Ristikari, T., & Gyllenberg, D. (2022). Psychiatric disorders diagnosed in adolescence and subsequent long-term exclusion from education, employment or training: Longitudinal national birth cohort study. The British Journal of Psychiatry, 220(3), 148–153. doi:10.1192/bjp.2021.146

Conley, C. S., Shapiro, J. B., Kirsch, A. C., & Durlak, J. A. (2017). A meta-analysis of indicated mental health prevention programs for at-risk higher education students. Journal of counseling Psychology, 64(2), 121.

Harith, S., Backhaus, I., Mohbin, N., Ngo, H. T., & Khoo, S. (2022). Effectiveness of digital mental health interventions for university students: an umbrella review. PeerJ, 10, e13111. https://www.ibisworld.com/us/bed/percentage-of-households-with-at-least-one-computer/4068/ statista.com [Internet]. Number of smartphone users worldwide from 2016 to 2021; c2019 [cited 2019 Nov 11]. Available from: https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/ https://www2.deloitte.com/uk/en/pages/consulting/articles/mental-health-and-employers-refreshing-the-case-for-investment.html

Vigerland S, Lenhard F, Bonnert M, Lalouni M, Hedman E, Ahlen J, et al. Internet-delivered cognitive behavior therapy for children and adolescents: a systematic review and meta-analysis. Clin Psychol Rev 2016 Dec;50:1–10 [https://linkinghub.elsevier.com/retrieve/pii/S0272-7358(15)30090-8] [CrossRef] [Medline]

Lau N, O'Daffer A, Colt S, Yi-Frazier JP, Palermo TM, McCauley E, Rosenberg AR. Android and iPhone Mobile Apps for Psychosocial Wellness and Stress Management: Systematic Search in App Stores and Literature Review. JMIR Mhealth Uhealth 2020;8(5):e17798 doi: 10.2196/17798

Halldorsson B, Hill C, Waite P, Partridge K, Freeman D, Creswell C. Annual research review: immersive virtual reality and digital applied gaming interventions for the treatment of mental health problems in children and young people: the need for rigorous treatment development and clinical evaluation. J Child Psychol Psychiatry 2021 May;62(5):584–605 [CrossRef] [Medline]

Grist R, Croker A, Denne M, Stallard P. Technology delivered interventions for depression and anxiety in children and adolescents: a systematic review and meta-analysis. Clin Child Fam Psychol Rev 2019 Jun;22(2):147–171 [https://europepmc.org/abstract/MED/30229343] [CrossRef] [Medline]

Linardon J, Cuijpers P, Carlbring P, Messer M, Fuller-Tyszkiewicz M. The efficacy of app-supported smartphone interventions for mental health problems: a meta-analysis of randomized controlled trials. World Psychiatry 2019 Oct;18(3):325–336 [https://europepmc.org/abstract/MED/31496095] [CrossRef] [Medline]

Hollis C, Falconer CJ, Martin JL, Whittington C, Stockton S, Glazebrook C, et al. Annual research review: digital health interventions for children and young people with mental health problems—a systematic and meta-review. J Child Psychol Psychiatry 2017 Apr;58(4):474-503 [CrossRef] [Medline]

Firth J, Torous J, Nicholas J, Carney R, Pratap A, Rosenbaum S, et al. The efficacy of smartphone-based mental health interventions for depressive symptoms: a meta-analysis of randomized controlled trials. World Psychiatry 2017 Oct;16(3):287–298 [https://europepmc.org/abstract/MED/28941113] [CrossRef] [Medline]

7Firth J, Torous J, Nicholas J, Carney R, Rosenbaum S, Sarris J. Can smartphone mental health interventions reduce symptoms of anxiety? A meta-analysis of randomized controlled trials. J Affect Disord 2017 Aug 15;218:15–22 [https://linkinghub.elsevier.com/retrieve/pii/S0165-0327(17)30015-0] [CrossRef] [Medline]

Ebert DD, Zarski AC, Christensen H, Stikkelbroek Y, Cuijpers P, Berking M, et al. Internet and computer-based cognitive behavioral therapy for anxiety and depression in youth: a meta-analysis of randomized controlled outcome trials. PLoS One 2015 Mar 18;10(3):e0119895 [https://dx.plos.org/10.1371/journal.pone.0119895] [CrossRef] [Medline]

Pennant ME, Loucas CE, Whittington C, Creswell C, Fonagy P, Fuggle P, Expert Advisory Group. Computerised therapies for anxiety and depression in children and young people: a systematic review and meta-analysis. Behav Res Ther 2015 Apr;67:1–18 [CrossRef] [Medline]

Ye X, Bapuji SB, Winters SE, Struthers A, Raynard M, Metge C, et al. Effectiveness of internet-based interventions for children, youth, and young adults with anxiety and/or depression: a systematic review and meta-analysis. BMC Health Serv Res 2014 Jul 18;14:313 [https://bmchealthservres.biomedcentral.com/articles/10.1186/1472-6963-14-313] [CrossRef] [Medline]

Ioannidis JP. Why most discovered true associations are inflated. Epidemiology 2008 Sep;19(5):640–648 [CrossRef] [Medline]

Pfefferbaum, B., & North, C. S. (2020). Mental health and the Covid-19 pandemic. New England Journal of Medicine.

Wiens, K., Bhattarai, A., Pedram, P., Dores, A., Williams, J., Bulloch, A., & Patten, S. (2020). A growing need for youth mental health services in Canada: Examining trends in youth mental health from 2011 to 2018. Epidemiology and Psychiatric Sciences, 29, E115. doi:10.1017/S2045796020000281

Richter, D., Wall, A., Bruen, A., & Whittington, R. (2019). Is the global prevalence rate of adult mental illness increasing? Systematic review and meta-analysis. Acta Psychiatrica Scandinavica, 140(5), 393–407.

Bort-Roig, J., Briones-Buixassa, L., Felez-Nobrega, M., Guàrdia-Sancho, A., Sitjà-Rabert, M., & Puig-Ribera, A. (2020). Sedentary behaviour associations with health outcomes in people with severe mental illness: a systematic review. European Journal of Public Health, 30(1), 150–157.

Naslund, J.A., Bondre, A., Torous, J. et al. Social Media and Mental Health: Benefits, Risks, and Opportunities for Research and Practice. J. technol. behav. sci. 5, 245–257 (2020). https://doi.org/10.1007/s41347-020-00134-x

Miller, R. L., & Collette, T. (2019). Multicultural identity development: Theory and research. Cross-cultural psychology: contemporary themes and perspectives, 614–631.

Torous, J., Andersson, G., Bertagnoli, A., Christensen, H., Cuijpers, P., Firth, J., ... & Arean, P. A. (2019). Towards a consensus around standards for smartphone apps and digital mental health. World psychiatry, 18(1), 97.

https://www.actformentalhealth.ca/why-funding-mental-health-care-is-the-smart-thing-to-do/

Hidden waits force more than three quarters of mental health patients to seek help from emergency services. Royal College of Psychiatrists. 2022. URL: https://www.rcpsych.ac.uk/news-and-features/latest-news/detail/2022/10/10/hidden-waits-force-more-than-three-quarters-of-mental-health-patients-to-seek-help-from-emergency-services [accessed 2023-06-16]

https://www.privatepracticehub.co.uk/how-much-is-private-counselling-therapy-uk-cost-prices/#:~:text=The%20cost%20can%20vary%20depending,48%20per%20week%2C%20with%20no

Ebert D, Mortier P, Kaehlke F, Bruffaerts R, Baumeister H, Auerbach RP, WHO World Mental Health-International College Student Initiative collaborators. Barriers of mental health treatment utilization among first-year college students: first cross-national results from the WHO World Mental Health International College student initiative. Int J Methods Psychiatr Res 2019 Jun;28(2):e1782 [https://europepmc.org/abstract/MED/31069905] [CrossRef] [Medline]

Nwosu, A., Boardman, S., Husain, M. M., & Doraiswamy, P. M. (2022). Digital therapeutics for mental health: Is attrition the Achilles heel?. Frontiers in Psychiatry, 13, 900615.

https://www.nelft.nhs.uk/

Liebenberg L, Moore JC. A social ecological measure of resilience for adults: The RRC-ARM. Soc Indic Res. 2018;136(1):1–9.

Davey HM, Barratt AL, Butow PN, Deeks JJ. A one-item question with a Likert or Visual Analog Scale adequately measured current anxiety. J Clin Epidemiol. 2007;60(4):356–60. pmid:17346609

Kafka GJ, Kozma A. The construct validity of Ryff's scales of psychological well-being (SPWB) and their relationship to measures of subjective well-being. Soc Indic Res. 2002;57(2):171–90. https://www.myunidays.com/

Jefferies P, Vanstone R, Ungar M. The rugged resilience measure: development and preliminary validation of a brief measure of personal resilience. Appl Res Qual Life 2021 May 06;17(2):985–1000 [https://link.springer.com/article/10.1007/s11482-021-09953-3] [CrossRef]

Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med 2006 May 22;166(10):1092–1097 [CrossRef] [Medline]

Kroenke, K., Strine, T. W., Spitzer, R. L., Williams, J. B., Berry, J. T., & Mokdad, A. H. (2009). The PHQ–8 as a measure of current depression in the general population. Journal of affective disorders, 114(1–3), 163–173. https://explodingtopics.com/blog/number-of-gamers

Kollins, S.H., Childress, A, Heusser, AC and Lutz, J. (2021). Effectiveness of a digital therapeutic as adjunct to treatment with medication in pediatric ADHD. npj Digit. Med. 4, 58. https://doi.org/10.1038/s41746-021-00429-0

Campbell AN, Nunes EV, Miele GM, Matthews A, Polsky D, Ghitza UE, Turrigiano E, Bailey GL, VanVeldhuisen P, Chapdelaine R, Froias A, Stitzer ML, Carroll KM, Winhusen T, Clingerman S, Perez L, McClure E, Goldman B, Crowell AR. Design and methodological considerations of an effectiveness trial of a computer-assisted intervention: an example from the NIDA Clinical Trials Network. Contemp Clin Trials. 2012 Mar;33(2):386–95. doi: 10.1016/j.cct.2011.11.001. Epub 2011 Nov 9. PMID: 22085803; PMCID: PMC3268951.