

Promoting prosocial behavior and well-being in adolescents through a gamified virtual reality intervention: A randomized controlled trial protocol

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ABSTRACT

Background: Adolescent well-being is an urgent global concern. While engaging in prosocial behavior has been shown to enhance well-being, traditional interventions are often resource-intensive, contextually limited, and typically delivered in 2D formats. Virtual Reality (VR) offers a novel and immersive alternative by allowing adolescents to experience lifelike social scenarios and practice prosocial behaviors across diverse, everyday contexts.

Objective: This protocol outlines a randomized controlled trial to evaluate the feasibility, acceptability, and preliminary effectiveness of a gamified VR-based prosocial intervention, *Cradle for Kids*, among adolescents.

Methods: A total of 396 adolescents aged 10 to 16 will be randomly assigned to one of the three groups: a five-week VR-based intervention, a video-based intervention, or a waitlist control group. Prosocial behaviors and well-being will be assessed at baseline, immediately post-intervention, and at a one-month follow-up, with parents also completing proxy reports of participants' well-being at baseline and post-intervention. Daily diary assessments will also be collected throughout the intervention period. Feasibility and acceptability will be examined via completion rate, retention rate, and participant satisfaction. Data will be analyzed using repeated-measures ANOVA and multilevel modeling.

Discussion: To our knowledge, this will be the first trial to evaluate a gamified VR intervention designed to promote prosocial behavior and well-being in adolescents. Theoretically, it will contribute empirical evidence on the potential of immersive VR-based interventions to enhance well-being through prosocial engagement. Practically, if found effective, the program may offer a scalable and resource-efficient tool for schools and community organizations seeking to foster prosocial development in youth.

1. Introduction

Adolescent mental health has become an increasing global concern in recent decades (Pitchforth et al., 2019). Studies indicate that approximately 10 %–20 % of children and adolescents experience various mental health difficulties that adversely affect their overall well-being (Benton et al., 2021; Kieling et al., 2011). Adolescence, a critical transition from childhood to adulthood, is marked by accelerated

psychological, physical, and social development, accompanied by unique changes and challenges (Cai et al., 2022; Patton and Viner, 2007). Notably, research suggests that nearly half of mental health problems begin during adolescence (Fusar-Poli et al., 2021; Kessler et al., 2005), highlighting this period as a key window for intervention. In response, global public health efforts increasingly emphasize early prevention and mental health promotion as essential strategies for reducing the incidence and long-term impact of mental disorders in

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youth (Fusar-Poli et al., 2021).

In recent years, there has been a notable shift from merely addressing psychological distress and treating mental disorders to actively fostering well-being and promoting positive mental health among adolescents (Freire et al., 2018; Mabaso et al., 2016). According to Ross et al. (2020), adolescent well-being is defined as a state in which young people have access to the necessary resources and support to thrive and reach their full potential. A high level of well-being is recognized as a central indicator of optimal functioning (Scafuto et al., 2024). Beyond its significance for individual development, adolescent well-being carries substantial economic and societal implications (Mohan et al., 2022; Patton et al., 2016). Investing in adolescent health and well-being is widely regarded as a strategic opportunity to foster societal prosperity and promote a sustainable future (Kleinert and Horton, 2016). Given its broad-reaching importance, there is an increasing focus on developing and implementing targeted strategies to enhance well-being among adolescents (Cilar et al., 2020; Tejada-Gallardo et al., 2020).

One promising approach to enhancing well-being is through engagement in prosocial behavior (Aknin et al., 2013; Memmott-Elison et al., 2020; Titova and Sheldon, 2020). Prosocial behavior is a broadly defined as voluntary actions intended to benefit others (Dovidio et al., 2006; Eisenberg et al., 2015; Hui, 2022) and can be classified into three subtypes: helping, sharing, and comforting (Dunfield, 2014). Helping behaviors address others' instrumental needs (e.g., assisting a classmate in cleaning up a mess), sharing behaviors meet material needs (e.g., donating money or resources), and comforting behaviors fulfill emotional needs (e.g., consoling a distressed friend). Prosocial behavior can be distinguished by its degree of formality. Formal prosocial behavior typically involves planned actions within organizational contexts, such as volunteering for charitable organizations or community service. In contrast, informal prosocial behavior refers to spontaneous, everyday acts of assistance in unorganized settings, such as helping an acquaintance with a minor task (Hui et al., 2020). A substantial body of evidence highlights its contribution of prosocial behavior to both individual well-being and society flourishing (Byrne et al., 2023; Dovidio et al., 2006; Hui et al., 2020). Furthermore, individuals with higher levels of well-being are more likely to engage in prosocial behaviors, reinforcing a positive feedback loop between prosocial behaviors and well-being (Aknin et al., 2018; Hui, 2022; Konrath, 2014; Layous et al., 2017; Lyubomirsky et al., 2005). Consequently, prosocial interventions are increasingly recognized as a promising public health strategy for promoting well-being (Hirani et al., 2022; Jenkinson et al., 2013).

From a developmental perspective, adolescence represents an opportune period for implementing prosocial intervention (Fulgini, 2019; Malti and Speidel, 2024). Compared to younger children, adolescents are cognitively, physically, and socially mature, enabling them to engage in a range of prosocial acts (Blakemore, 2019; Goddings et al., 2012; Steinberg, 2005). This stage is also a formative phase of identity formation, during which prosocial traits that become integrated into one's identity are likely to endure over time (Baumsteiger, 2019). Supporting this, research suggests that habitual prosocial behavior established during adolescence tends to persist into adulthood (Hirani et al., 2022; Matsuba and Walker, 2004). Accordingly, it is essential to develop effective strategies for promoting prosocial behavior among adolescents, as previous studies have demonstrated that such interventions can significantly enhance prosocial behavior and well-being during this life stage (Chan et al., 2021; Perkins et al., 2022; Shin and Lee, 2021; Tashjian et al., 2021).

Despite these promising findings, existing prosocial interventions face notable limitations. Many rely on traditional, face-to-face delivery formats situated in structured environments, such as schools or community centers (Hirani et al., 2022; Shin and Lee, 2021). These formats often require substantial resources and time commitments, thereby limiting their flexibility and accessibility in terms of scheduling, location, and cost (Laguna et al., 2020; Saleme et al., 2020). Moreover, most interventions tend to focus on a single prosocial domain—such as

charitable giving or expressions of kindness (Byrne et al., 2023)—which may constrain the transferability and development of prosocial behaviors across diverse real-time settings. Furthermore, these programs often emphasize formal volunteering opportunities, while neglecting the more common, informal settings—such as school or home—where adolescents frequently engage in prosocial acts (Baumsteiger, 2019). To address these gaps, there is a need for innovative, resource-efficient, and ecologically valid interventions that incorporate informal, everyday contexts, thereby enhancing both the transferability and long-term impact of prosocial behavior in adolescents' daily lives.

Recently, a growing number of prosocial interventions have adopted more flexible and cost-effective approaches by leveraging emerging technologies such as video and computer games (DeRosier and Thomas, 2019; Saleme et al., 2020). These game-based interventions allow participants to access contact anytime and anywhere, individually or collaboratively, through self-guided instructions embedded in the game interface. Due to their engaging and interactive nature (McNamara et al., 2010), game-based learning is more appealing to adolescents and more likely to sustain motivation compared to traditional, didactic approaches (Papastergiou, 2009). Theoretically, since prosocial behaviors tend to be self-reinforcing (Aknin et al., 2011; Layous et al., 2017), repeated engagement over time may reduce the cognitive effort required to plan and perform these behaviors, thereby promoting their automatic enactment. However, a key limitation of many existing game-based prosocial interventions lies in their reliance on two-dimensional (2D) environments with limited interactivity (Gentile et al., 2009; Greitemeyer and Osswald, 2010; Konrath et al., 2024), which often lack realism and contextual depth. This raises concerns about the ecological validity of these interventions—that is, the extent to which prosocial behavior performed in simplified, decontextualized settings can be meaningfully transferred to the complex, dynamic nature of real-life social situations. Consequently, there is a pressing need for more immersive and contextually rich digital interventions that can more accurately simulate everyday social dynamics and enhance the generalizability of prosocial behavior beyond the game environment.

Virtual reality (VR) offers a promising avenue to address some of these barriers and further enhance the ecological validity of game-based interventions. VR is a computer-mediated technology that stimulates sensory input to create the illusion of presence within a virtual environment (Martingano et al., 2021), offering immersive experiences for participants to feel spatially present in a realistic context (Van Kerrebroeck et al., 2017). In addition to enhancing ecological validity, VR-based programs can be delivered flexibly through portable and relatively affordable devices, thereby improving accessibility and scalability (Radianti et al., 2020). Grounded in the situated learning theory (Lave and Wenger, 1991), which posits that knowledge is most effectively acquired and applied within its relevant context, VR provides an ideal platform for training prosocial behavior through experiential immersion. Unlike existing interventions that typically target a single prosocial domain, VR-based interventions can simulate diverse contexts, encompassing multiple forms of prosocial behavior, such as helping, sharing, and comforting. By recreating realistic social scenarios within a safe, controlled, and immersive setting, VR allows adolescents to repeatedly practice prosocial behavior in ways that are emotionally engaging and developmentally appropriate. Such scenarios can mirror ordinary environments, such as classrooms, family settings, or peer interactions, thereby reducing the overreliance on formal volunteering opportunities and situating prosocial practice within daily life. The more immersive the VR environment, the greater the sense of presence and realism, which may facilitate behavioral transfer from virtual to real-world settings (Wang et al., 2021).

Taken together, the present study will adopt and evaluate a realistic, game-based VR intervention designed to foster habitual prosocial behavior among adolescents. The primary objective is to assess the effectiveness of VR-based intervention in enhancing both prosocial behavior and well-being. The secondary objective is to evaluate the

feasibility and acceptability of the VR format for adolescents. To capture the nuanced, real-time dynamics of participants' daily experiences, the study also incorporates diary assessments of prosocial behavior and well-being, offering insightful perspectives on participants' daily experiences and facilitating a deeper understanding of the efficacy of each VR scenario. We hypothesize that the VR intervention will promote prosocial behaviors and well-being among adolescents. We also expect that the intervention will be both acceptable and feasible for adolescent participants.

2. Methods

2.1. Study design

This study is a three-arm, parallel-group randomized controlled trial (RCT) evaluating the effectiveness of a VR-based intervention to enhance prosocial behavior and well-being in adolescents. Participants aged 10–16 will be randomly assigned to a VR-based intervention group, a video-based intervention group, or a waitlist control group. Assessments will be conducted at three time points: baseline (T0), immediately post-intervention (T1), and one-month follow-up (T2). In addition, daily diary assessments will be used to capture fluctuations in prosocial behavior and well-being across the five-week intervention period (see Table 1 for an overview). This study has received ethical approval from the Institutional Review Board of the affiliated university of the corresponding author. The trial has been registered on [ClinicalTrials.gov](https://clinicaltrials.gov) (NCT06504069; registered on July 18, 2024) and will be conducted and reported in accordance with the CONSORT 2010 statement (Moher

et al., 2010). The study flow is illustrated in Fig. 1.

2.2. Participants

Eligible participants will be school students aged 10 to 16 years who are able to communicate in Chinese. The exclusion criteria are as follows: 1) uncorrected visual impairment; 2) self-reported severe motion sickness; and 3) cognitive impairment that would interfere with study participation.

A priori power analysis was conducted using GPower 3.1 (Faul et al., 2009) to detect a small-to-medium effect ($f = 0.175$) with $\alpha = 0.05$ and 80 % power, based on a mixed repeated-measures ANOVA design with one between-subject factor (group) and one within-subject factor (time). This analysis indicated that a minimum of 318 participants (106 per group) would be required. To further refine this estimate, a Monte Carlo simulation using the R package “simr” was conducted for multilevel modeling of daily diary data. This simulation suggested that 300 participants (35 repeated measures; 10,500 observations) would be needed to detect a small-to-medium cross-level interaction ($\gamma_{11.std.} = 0.175$) with 80 % power (ICC = 0.50, $\alpha = 0.05$) (Arend and Schäfer, 2019). Accounting for a projected 20 % attrition rate, a total of 396 participants will be recruited and randomly assigned to the VR group ($n = 132$), the video group ($n = 132$), and the waitlist control group ($n = 132$).

2.3. Recruitment, randomization, and blinding

We will recruit potential participants in Hong Kong through multiple ways, such as school-based presentations, community outreach, and

Table 1
Overview of study assessments.

Variable	Assessment points							
	Baseline (T0)	Post-test (T1)					Follow-up (T2)	
	W0	W1	W2	W3	W4	W5	W9	
Outcome measures								
Prosocial attitudes	X					X	X	
Prosocial identity	X					X	X	
Prosocial intention	X					X	X	
Attitudes toward helping others	X					X	X	
Altruism	X					X	X	
Empathy	X					X	X	
Life satisfaction	X					X	X	
Subjective happiness	X					X	X	
Affect	X					X	X	
Gratitude	X					X	X	
Subjective vitality	X					X	X	
Self-esteem	X					X	X	
Daily measures								
Daily prosocial behavior		←————→						
Daily overall well-being		←————→						
Daily subjective happiness		←————→						
Daily subjective vitality		←————→						
Daily affect		←————→						
Daily gratitude		←————→						
Daily self-esteem		←————→						
Feasibility and acceptability								
Feasibility of intervention						X		
Satisfaction of intervention						X		
Experience with VR						X		
Other measures								
Socio-demographic variables	X					X		

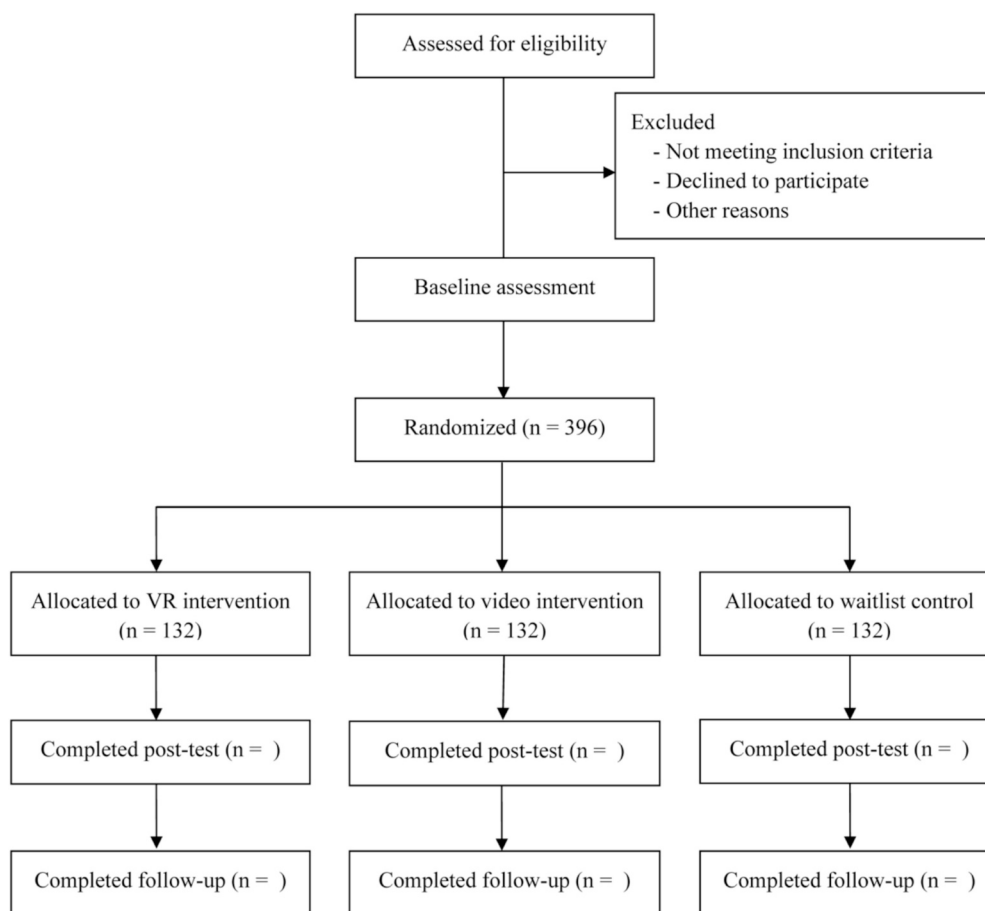


Fig. 1. Flow chart of the present study.

online advertisements. Recruitment materials will include basic information about the study and an online screening questionnaire. Individuals interested in participating can complete the screening questionnaire to express their willingness to enroll in the trial. Those who meet the inclusion criteria will be invited to take part in the research. Furthermore, written informed consent will be obtained from their parent or legal guardian.

Block randomization (block size = 6) will be used to assign participants to conditions using a computer-generated randomization sequence. Participants will be randomly allocated to one of the three groups in equal proportions (1:1:1 ratio). An independent researcher will carry out this randomization procedure, and the random allocation sequence will be concealed throughout the entire study. This will be a double-blind RCT in which participants will be unaware of group assignment, and the data analyst will also be unaware of the participants' group allocations throughout the study.

2.4. Procedure

After providing informed consent, participants will complete an online baseline assessment (T0), including demographic information and individual-level psychological measures. Eligible participants will then be randomized into the VR intervention group, the video intervention group, or the waitlist control group. Participants in the VR intervention group will participate in a 5-week VR-based intervention. Those in the video group will receive a 5-week video-based intervention, and individuals in the waitlist control group will receive no intervention during the study period. All groups will complete the post-intervention assessment (T1) and one-month follow-up assessment (T2). During the intervention period, participants will also complete daily diary

assessments using Longitudinax Pro, a specialized research app for diary or ecological momentary assessment. The app will send a daily assessment at 9:00 p.m. each day for the five weeks. If no response is recorded within one hour, an automatic reminder will be sent at 10:00 p.m. to prompt completion. One parent (or guardian) will complete a complementary evaluation of participants' well-being at baseline and post-intervention. All baseline, post-intervention, and follow-up assessments (except the daily diaries) will be administered online via Qualtrics.

2.5. Intervention

2.5.1. VR intervention

The gamified VR intervention, *Cradle for Kids*, has been fully developed and is ready for implementation. It is designed to cultivate prosocial behavior and enhance well-being among adolescents through immersive, scenario-based learning. The program is grounded in a comprehensive review of the literature and tailored to the cultural and contextual needs of the local adolescents. To ensure usability and developmental appropriateness, the intervention was pilot-tested with a small group of adolescents aged 10 to 16 years ($n = 15$). Participants provided feedback on navigation, task clarity, visual design, and overall comfort while using the VR system. Based on this feedback, minor refinements were made to task instructions, pacing, and user interface to improve engagement and reduce potential discomfort. Details of the pilot testing procedures and feedback are available from the corresponding author upon request.

The intervention spans five weeks and comprises five modules, each lasting approximately 15 to 20 min. Each module immerses participants in a distinct virtual environment—home, school, street, park, and

shopping mall—that mirrors everyday social settings commonly encountered by adolescents (see Fig. 2 for sample screenshots). Within these environments, participants engage in various interactive, scenario-based tasks specifically designed to promote prosocial behaviors by incorporating diverse forms (e.g., helping, sharing, and comforting) and reflecting both formal and informal manifestations (Dunfield, 2014; Hui et al., 2020; Weir and Duveen, 1981). For instance, in the “home” module, participants are required to complete tasks, such as preparing breakfast for their family, which reflects helping behavior, and comforting a distressed family member, which exemplifies comforting behavior. In the “school” module, helping a classmate clean up spilled water illustrates informal prosocial behavior, whereas in the “street” module, donating to a charity organization reflects formal prosocial behavior. Collectively, these examples demonstrate how the VR intervention systematically incorporates diverse subtypes and contexts of prosocial behavior, thereby enhancing its ecological validity and persuasiveness. To reinforce positive behavior and sustain motivation, gamified elements, such as prosocial points and virtual badges, are integrated throughout the program. A detailed breakdown of module

content and task details is presented in Table 2. While the visual style of the *Cradle for Kids* environment retains a stylized, youth-friendly aesthetic, the immersive VR format allows for greater interactivity, spatial presence, and contextual richness than traditional 2D game environments—enhancing ecological validity and engagement while maintaining accessibility for younger users.

Participants in the VR condition will be invited to the laboratory once a week for five consecutive weeks to undergo the VR intervention. To minimize bias, the experimenter administering the sessions is blinded to participants' group allocation. Upon arrival, the experimenter will first provide an overview of the experimental procedure and safety instructions, followed by an explanation of the functions and operations of the controller trigger buttons. Participants will then be instructed to wear a head-mounted display (HMD), which is adjusted by the experimenter to ensure that the visual content can be perceived clearly and comfortably. After these preparations, participants will begin experiencing the VR intervention. Upon completing all VR scenarios, participants will be asked to remove the HMD. Finally, the experimenter will inform them that the session has concluded and invite them to return to

a Main menu



Fig. 2. Sample screenshots of the intervention.

b Home



Fig. 2. (continued).

the laboratory the following week to continue their participation.

2.5.2. Video intervention

The video-based intervention is developed as a direct conversion of the VR intervention (i.e., *Cradle for Kids*), ensuring that the exposure frequency and duration are identical across conditions (Li et al., 2022). Specifically, the five VR modules—home, school, street, park, and shopping mall—are converted into five corresponding video clips at high resolution and frame rate. Each video module lasts approximately 15 to 20 min, matching the session length of the VR condition.

Participants in the video group will attend weekly sessions in a laboratory setting over a five-week period. At each session, they will be asked to sit in front of a computer monitor. The experimenter will then play one of the five video modules on the monitor, corresponding to the weekly theme of the VR program. After watching the video clip, participants will be reminded that the session has ended and asked to return to the laboratory the following week for the next session.

2.5.3. Waitlist control (WLC) condition

Participants in the WLC group will not receive the intervention during the study period. However, they will complete all assessments at the same time points as the intervention group (i.e., baseline, post-intervention, and follow-up). Upon completion of the trial, participants in the waitlist control group will be offered access to the full *Cradle for Kids* VR program.

2.6. Measures

2.6.1. Feasibility and acceptability measures

2.6.1.1. Feasibility. The feasibility of VR intervention will be evaluated using two key indicators: the completion rate and the retention rate. The completion rate will be calculated as the proportion of participants in the intervention group who complete all five VR sessions. The retention rate will be defined as the proportion of all enrolled participants who complete all three scheduled measurements (baseline, post-intervention, and follow-up) (Daniore et al., 2022).

C Park



Fig. 2. (continued).

2.6.1.2. Acceptability. Acceptability will be assessed using the Client Satisfaction Questionnaire-8 (CSQ-8; Larsen et al., 1979), a validated measure of participant satisfaction with intervention programs. Each item is rated on a 4-point Likert scale, with higher scores reflecting greater satisfaction with the intervention.

2.6.1.3. User experience with VR intervention. Participants' experience of the VR intervention will be assessed across three dimensions: sense of immersion, levels of difficulty, and levels of interest (Hu et al., 2022). Sense of immersion and perceived difficulty will each be measured using two adapted items. In addition, participants' interest will be assessed using two items—"I like this game" and "This game is very interesting"—rated on a 6-point Likert scale.

2.6.2. Pretest, posttest, follow-up assessment measures

2.6.2.1. Prosocial behavior. Prosocial behavior will be measured through multiple indicators, including prosocial attitudes, prosocial identity, prosocial intention, attitude toward helping others, altruism,

and empathy. Measures to evaluate these indicators will include the Prosocial Orientation Questionnaire (Cheung et al., 1998), the Internalization subscale of the Self Importance of Moral Identity Scale (SIMIS; Aquino and Reed, 2002; Baumsteiger, 2019), the Prosocial Behavioral Intentions Scale (PBIS; Baumsteiger and Siegel, 2019), the Attitudes toward Helping Others Scale (AHO; Webb et al., 2000), the Preference Survey Module (PSM; Falk et al., 2023), and the Single Item Trait Empathy Scale (SITES; Konrath et al., 2018). Higher scores on these measures will indicate higher levels of prosocial behavior.

2.6.2.2. Well-being. Well-being will be assessed using the following validated measures: life satisfaction measured with the Satisfaction with Life Scale (SWLS; Diener et al., 1985); subjective happiness with the Subjective Happiness Scale (SHS; Lyubomirsky and Lepper, 1999); and subjective vitality assessed with three items from the Subjective Vitality Scale (SVS; Ryan and Frederick, 1997; Weinstein and Ryan, 2010). Moreover, affect will be measured using the Emmons Mood Indicator (Diener et al., 1985), gratitude with a single adapted item from the Gratitude Adjective Checklist (GAC; McCullough et al., 2002), and self-

d School



Fig. 2. (continued).

esteem with the Rosenberg Self-esteem Scale (RSE; Rosenberg, 1965).

2.6.2.3. Proxy-reported well-being. Proxy-reported well-being will be measured with the KIDSCREEN-10 proxy version (Ravens-Sieberer et al., 2010). The instrument comprises ten items that evaluate physical, psychological, and social dimensions of well-being in children and adolescents. In the present study, parents will complete the KIDSCREEN-10 proxy version at both baseline and post-intervention. Each item is rated on a five-point scale ranging from “not at all” to “extremely”, with higher scores reflecting greater well-being.

2.6.3. Daily measures

Daily measures will be conducted once per day during the 5-week intervention, beginning upon completion of the first intervention session.

2.6.3.1. Daily prosocial behavior. A single item adapted from previous research will be used to measure daily prosocial behavior (Hui and

Kogan, 2018): “In the past day, how many times did you help others or do something for a good cause?” Participants will choose a response from a range of 0 to 10+ to indicate the number of prosocial behaviors conducted and will also specify the types of prosocial behavior they engaged in.

2.6.3.2. Daily well-being. A single item from the Well-Being Manifestations Measure Scale (WBMMS) will be used to assess daily overall well-being (Massé et al., 1998). Furthermore, daily well-being will include: daily subjective happiness assessed using a two-item adaptation of the SHS (Lyubomirsky and Lepper, 1999); daily subjective vitality measured with three items from the SVS (Hui and Kogan, 2018; Ryan and Frederick, 1997); daily affect evaluated with the Emmons Mood Indicator (Diener et al., 1985); daily gratitude assessed with a single adapted item from the GAC (McCullough et al., 2002) and daily self-esteem with two items from RSE (Rosenberg, 1965).

e Shopping mall



Fig. 2. (continued).

2.7. Statistical analysis

Descriptive statistics (means, standard deviations, frequencies, and proportions) will be computed to summarize participant characteristics and to evaluate the feasibility and acceptability of the VR intervention. To examine the effectiveness of the intervention, a 3 (Group: VR intervention, video intervention, and WLC) \times 3 (Time: baseline, post-intervention, and one-month follow-up) mixed-design repeated-measures analysis of variance (ANOVA) will be conducted for all outcomes, including prosocial behavior and well-being measures. Group will serve as the between-subjects factor, and time as the within-subjects factor. Effect sizes (partial η^2) will be reported, and violations of sphericity will be addressed using the Greenhouse-Geisser correction where appropriate.

To analyze the diary assessment data, multilevel modeling (MLM) will be employed to account for the hierarchical structure, with diary assessment (level 1) nested within participants (level 2). Models will include random intercepts and random slopes where appropriate. The intervention condition will be modeled as a predictor of change

trajectories in prosocial behavior and well-being over time. Time will be treated as a continuous variable (i.e., day of intervention), and cross-level interactions will be examined to determine whether individual-level differences moderate intervention effects. Potential covariates, such as baseline levels of prosocial behavior, well-being, and demographic variables (e.g., age, gender), will be included in all models to control for confounding influences. All analyses will be conducted following the intention-to-treat (ITT) principle (Lachin, 2000). Missing data will be addressed using maximum likelihood estimation or multiple imputation, depending on the pattern and extent of missingness. Statistical significance will be set at $p < .05$ for primary outcomes, with adjustments for multiple comparisons applied where appropriate.

3. Discussion

This study protocol outlines a three-arm RCT designed to evaluate the feasibility, acceptability, and effectiveness of a gamified VR intervention designed to promote prosocial behavior and enhance well-being among adolescents. The study has been prospectively registered on

Table 2
Overview of the VR intervention.

Prosocial scene	Prosocial task	Task description
Session 1 (At home) “Today is Saturday, you are staying at home.”	Task 1.1	Assisting with household cleaning The player cleans the table and the floor.
	Task 1.2	Preparing breakfast for the family The player selects and uses various ingredients to prepare sandwiches for the family based on their preferences.
	Task 1.3	Helping wash dishes after breakfast The player washes all the dirty dishes.
	Task 1.4	Helping locate a missing item The player searches different areas to help the grandma find her glasses.
	Task 1.5	Comforting a sad family member The player selects a supportive and positive response to comfort a family member.
Session 2 (At school) “Today is Monday, you are attending school.”	After Class	
	Task 2.1	Helping a teacher in need The player helps the teacher pick up dropped books and stationery.
	Task 2.2	Helping a classmate who spilled water The player assists in cleaning the classroom table and floor after a classmate accidentally spills water.
	Task 2.3	Sharing stationery with classmates The player selects a positive response and shares pen with classmates.
	Task 2.4	Comforting a friend in a low mood The player selects a positive response to comfort a classmate.
Session 3 (On the street) “Today is Sunday, you are on the way to a supermarket.”	Task 2.5	Organizing sports equipment in the activity area before the next class The player helps arrange sports items (e.g., balls, rackets, skipping ropes) in their proper places.
	Task 3.1	Helping someone find a lost item The player searches various locations to help a woman find her lost pet.
	Task 3.2	Donating to a charity organization The player selects a positive response to donate.
	Task 3.3	Removing obstructions from the blind lane The player clears objects blocking the blind lane for a visually impaired pedestrian.
	Task 3.4	Donating to a beggar The player selects a positive response regarding donation.
Session 4 (In the park) “Today is Saturday, you are playing in the park.”	Task 3.5	Helping someone collect dropped items The player assists an elderly person in picking up dropped oranges.
	Task 4.1	Offering a seat on a play facility to another child The player chooses a positive type of response and gives up their seat on a play facility so that another child can have a turn
	Task 4.2	Cleaning the lawn. The player picks up the litter scattered on the lawn.
Task 4.3	Giving directions to someone who asks the way The player selects a positive response and guides the person to the toilet.	

Table 2 (continued)

Prosocial scene	Prosocial task	Task description
Session 5 (In a shopping mall) “Today is Sunday, you are shopping in a mall.”	Task 4.4	Assisting in a first aid situation The player chooses a positive type of response and helps bring an AED device.
	Task 4.5	Helping someone to retrieve a balloon stuck in a tree The player chooses a positive type of response and retrieves the balloon from a tree.
	Task 5.1	Helping someone pick up dropped items The player will help a man in wheelchair pick up dropped things.
	Task 5.2	Holding the elevator door for an elderly person The player chooses a positive type of response and press the elevator button.
	Task 5.3	Returning a lost phone The player picks up a lost phone and returns it to its owner.
Task 5.4	Buying a birthday gift. The player chooses an appropriate gift for a family member.	
Task 5.5	Donating by purchasing charity items The player donates by buying charity candies using spare change.	

intervention is distinctively designed to encompass a range of informal, everyday settings—including home, school, the street, a park, and a shopping mall—thereby increasing its ecological validity. By situating prosocial tasks within multiple real-world contexts, the program encourages the generalization and internalization of prosocial behavior beyond the environment. Third, this study extends beyond the conventional RCT designs by incorporating intensive longitudinal data through daily assessments. While prior research has typically relied on a limited number of retrospective assessments (Layous et al., 2012; Miles et al., 2022; Nelson et al., 2015), this approach may obscure short-term fluctuations and nuanced intervention effects (Russell and Gajos, 2020). Our use of daily diary assessments allows for the capture of real-time changes in prosocial behavior and well-being in naturalistic settings. This methodology offers two key benefits: (1) it enables the identification of which specific intervention sessions or contexts are most effective, providing a foundation for real-time intervention optimization (Bell et al., 2017; Wenzel and Miller, 2010); and (2) it may enhance participant engagement and adherence by fostering a sense of ongoing progress and reflection (Myin-Germeys et al., 2018; Smith and Juarascio, 2019).

Despite its strengths, this study has several limitations. First, although VR offers a compelling medium for behavior change, it may induce cybersickness (e.g., dizziness, nausea) in a subset of participants (Chung et al., 2023). To address this, all adverse effects will be systematically recorded, monitored, and reviewed, with appropriate adjustments made to optimize the user experience. Second, the intervention is designed specifically for adolescents, which may limit the generalizability of the findings to other age groups. If found effective, future studies should explore adaptations for other populations. Finally, this study does not directly examine the underlying mechanisms driving the intervention's effects. Further research is needed to investigate the potential mechanisms to refine the intervention and facilitate its broader application (Emmelkamp et al., 2014).

In sum, this study protocol outlines the first known evaluation of a gamified VR intervention targeting prosocial behavior and well-being in adolescents using both traditional and real-time assessments. If successful, the findings will contribute to the development of scalable, immersive interventions for youth mental health promotion. By cultivating psychologically resilient and socially responsible individuals, this work has the potential to benefit not only individuals but also the broader community—contributing to a more compassionate, connected,

and flourishing society.

CRedit authorship contribution statement

Bryant P.H. Hui: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Supervision. **Tao Zhang:** Writing – original draft, Writing – review & editing. **Jeffrey C.F. Ho:** Methodology, Writing – review & editing. **Sophie Kai Lam Cheng:** Methodology. **Chen Li:** Writing – review & editing. **Rosetta Wong:** Writing – review & editing. **Sylvia Xiaohua Chen:** Writing – review & editing.

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Declaration of competing interest

There are no conflicts of interest by any author.

Data availability

The data generated during this study will include detailed documentation of the protocols and analytical procedures to ensure reproducibility and enable future research by other investigators. We fully support the principles of data sharing. Data supporting the findings of this study, along with intervention materials, will be made available from the corresponding author upon reasonable request.

References

- Aknin, L.B., Dunn, E.W., Norton, M.I., 2011. Happiness runs in a circular motion: evidence for a positive feedback loop between prosocial spending and happiness. *J. Happiness Stud.* 13 (2), 347–355. <https://doi.org/10.1007/s10902-011-9267-5>.
- Aknin, L.B., Barrington-Leigh, C.P., Dunn, E.W., Helliwell, J.F., Burns, J., Biswas-Diener, R., Kemeza, I., Nyende, P., Ashton-James, C.E., Norton, M.I., 2013. Prosocial spending and well-being: cross-cultural evidence for a psychological universal. *J. Pers. Soc. Psychol.* 104 (4), 635–652. <https://doi.org/10.1037/a0031578>.
- Aknin, L.B., Van de Vondervoort, J.W., Hamlin, J.K., 2018. Positive feelings reward and promote prosocial behavior. *Curr. Opin. Psychol.* 20, 55–59. <https://doi.org/10.1016/j.copsyc.2017.08.017>.
- Aquino, K., Reed, A., 2002. The self-importance of moral identity. *J. Pers. Soc. Psychol.* 83 (6), 1423–1440. <https://doi.org/10.1037/0022-3514.83.6.1423>.
- Arend, M.G., Schäfer, T., 2019. Statistical power in two-level models: a tutorial based on Monte Carlo simulation. *Psychol. Methods* 24 (1), 1–19. <https://doi.org/10.1037/met0000195>.
- Baumsteiger, R., 2019. What the world needs now: an intervention for promoting prosocial behavior. *Basic Appl. Soc. Psychol.* 41 (4), 215–229. <https://doi.org/10.1080/01973533.2019.1639507>.
- Baumsteiger, R., Siegel, J.T., 2019. Measuring prosociality: the development of a prosocial behavioral intentions scale. *J. Pers. Assess.* 101 (3), 305–314. <https://doi.org/10.1080/00223891.2017.1411918>.
- Bell, I.H., Lim, M.H., Rossell, S.L., Thomas, N., 2017. Ecological momentary assessment and intervention in the treatment of psychotic disorders: a systematic review. *Psychiatr. Serv.* 68 (11), 1172–1181. <https://doi.org/10.1176/appi.ps.201600523>.
- Benton, T.D., Boyd, R.C., Njoroge, W.F.M., 2021. Addressing the global crisis of child and adolescent mental health. *JAMA Pediatr.* 175 (11), 1108–1110. <https://doi.org/10.1001/jamapediatrics.2021.2479>.
- Blakemore, S.J., 2019. Adolescence and mental health. *Lancet* 393 (10185), 2030–2031. [https://doi.org/10.1016/s0140-6736\(19\)31013-x](https://doi.org/10.1016/s0140-6736(19)31013-x).

- Byrne, M., Tan, R.K.J., Wu, D., Marley, G., Hlatshwako, T.G., Tao, Y., Bissram, J., Nachman, S., Tang, W., Ramaswamy, R., Tucker, J.D., 2023. Prosocial interventions and health outcomes: a systematic review and meta-analysis. *JAMA Netw. Open* 6 (12), e2346789. <https://doi.org/10.1001/jamanetworkopen.2023.46789>.
- Cai, H., Bai, W., Liu, H., Chen, X., Qi, H., Liu, R., Cheung, T., Su, Z., Lin, J., Tang, Y.L., Jackson, T., Zhang, Q., Xiang, Y.T., 2022. Network analysis of depressive and anxiety symptoms in adolescents during the later stage of the COVID-19 pandemic. *Transl. Psychiatry* 12 (1), 98. <https://doi.org/10.1038/s41398-022-01838-9>.
- Chan, H.H.-K., Kwong, H.Y.C., Shu, G.L.F., Ting, C.Y., Lai, F.H.-Y., 2021. Effects of experiential learning programmes on adolescent prosocial behaviour, empathy, and subjective well-being: a systematic review and meta-analysis. *Front. Psychol.* 12. <https://doi.org/10.3389/fpsyg.2021.709699>.
- Cheung, P.C., Ma, H.K., Shek, D.T., 1998. Conceptions of success: their correlates with prosocial orientation and behaviour in Chinese adolescents. *J. Adolesc.* 21 (1), 31–42. <https://doi.org/10.1006/jado.1997.0127>.
- Chung, O.S., Dowling, N.L., Brown, C., Robinson, T., Johnson, A.M., Ng, C.H., Yücel, M., Segrave, R.A., 2023. Using the theoretical domains framework to inform the implementation of therapeutic virtual reality into mental healthcare. *Adm. Policy Ment. Health* 50 (2), 237–268. <https://doi.org/10.1007/s10488-022-01235-w>.
- Cilar, L., Stiglic, G., Kmetec, S., Barr, O., Pajnkihar, M., 2020. Effectiveness of school-based mental well-being interventions among adolescents: a systematic review. *J. Adv. Nurs.* 76 (8), 2023–2045.
- Daniore, P., Nittas, V., von Wyl, V., 2022. Enrollment and retention of participants in remote digital health studies: scoping review and framework proposal. *J. Med. Internet Res.* 24 (9), e39910. <https://doi.org/10.2196/39910>.
- DeRosier, M.E., Thomas, J.M., 2019. Hall of heroes: a digital game for social skills training with young adolescents. *Int. J. Comput. Games Technol.* 2019 (1), 6981698. <https://doi.org/10.1155/2019/6981698>.
- Diener, E., Emmons, R.A., Larsen, R.J., Griffin, S., Diener, E., Emmons, R.A., Larsen, R.J., Griffin, S., 1985. The satisfaction with life scale. *J. Pers. Assess.* 49 (1), 71–75. <https://doi.org/10.1207/s15327752jpa490113>.
- Dovidio, J.F., Piliavin, J.A., Schroeder, D.A., Penner, L., 2006. *The Social Psychology of Prosocial Behavior*, 1st ed. Psychology Press.
- Dunfield, K.A., 2014. A construct divided: prosocial behavior as helping, sharing, and comforting subtypes. *Front. Psychol.* 5, 958. <https://doi.org/10.3389/fpsyg.2014.00958>.
- Eisenberg, N., Eggum-Wilkens, N.D., Spinrad, T.L., 2015. The development of prosocial behavior. In: *The Oxford Handbook of Prosocial Behavior*. Oxford University Press, pp. 114–136. <https://doi.org/10.1093/oxfordhb/9780195399813.001.0001>.
- Emmelkamp, P.M., David, D., Beckers, T., Muris, P., Cuijpers, P., Lutz, W., Andersson, G., Araya, R., Banos Rivera, R.M., Barkham, M., Berking, M., Berger, T., Botella, C., Carlbring, P., Colom, F., Essau, C., Hermans, D., Hofmann, S.G., Knappe, S., Vervliet, B., 2014. Advancing psychotherapy and evidence-based psychological interventions. *Int. J. Methods Psychiatr. Res.* 23 (Suppl. 1), 58–91. <https://doi.org/10.1002/mpr.1411>.
- Falk, A., Becker, A., Dohmen, T., Huffman, D., Sunde, U., Falk, A., Becker, A., Dohmen, T., Huffman, D., Sunde, U., 2023. The preference survey module: a validated instrument for measuring risk, time, and social preferences. *Manag. Sci.* 69 (4), 1935–1950. <https://doi.org/10.1287/mnsc.2022.4455>.
- Faul, F., Erdfelder, E., Buchner, A., Lang, A.G., 2009. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behav. Res. Methods* 41 (4), 1149–1160. <https://doi.org/10.3758/brm.41.4.1149>.
- Freire, T., Lima, I., Teixeira, A., Araújo, M.R., Machado, A., 2018. Challenge: to be+ . A group intervention program to promote the positive development of adolescents. *Child Youth Serv. Rev.* 87, 173–185.
- Fulgini, A.J., 2019. The need to contribute during adolescence. *Perspect. Psychol. Sci.* 14 (3), 331–343. <https://doi.org/10.1177/1745691618805437>.
- Fusar-Poli, P., Correll, C.U., Arango, C., Berk, M., Patel, V., Ioannidis, J.P.A., 2021. Preventive psychiatry: a blueprint for improving the mental health of young people. *World Psychiatry* 20 (2), 200–221. <https://doi.org/10.1002/wps.20869>.
- Gentile, D.A., Anderson, C.A., Yukawa, S., Ihori, N., Saleem, M., Ming, L.K., Shibuya, A., Liau, A.K., Khoo, A., Bushman, B.J., Rowell Huesmann, L., Sakamoto, A., 2009. The effects of prosocial video games on prosocial behaviors: international evidence from correlational, longitudinal, and experimental studies. *Pers. Soc. Psychol. Bull.* 35 (6), 752–763. <https://doi.org/10.1177/0146167209333045>.
- Goddings, A.L., Burnett Heyes, S., Bird, G., Viner, R.M., Blakemore, S.J., 2012. The relationship between puberty and social emotion processing. *Dev. Sci.* 15 (6), 801–811. <https://doi.org/10.1111/j.1467-7687.2012.01174.x>.
- Greitemeyer, T., Osswald, S., 2010. Effects of prosocial video games on prosocial behavior. *J. Pers. Soc. Psychol.* 98 (2), 211–221. <https://doi.org/10.1037/a0016997>.
- Hirani, S., Ojukwu, E., Bandara, N.A., 2022. Understanding the role of prosocial behavior in youth mental health: findings from a scoping review. *Adolescents* 2 (3), 358–380. <https://doi.org/10.3390/adolescents2030028>.
- Hu, F., Lee, I.C., Chang, H.L., Lin, C.P., Huang, W.H., 2022. Helping others in virtual reality increases prosocial self-understanding among adolescents. *J. Youth Adoles.* 51 (10), 1873–1885. <https://doi.org/10.1007/s10964-022-01652-y>.
- Hui, B.P.H., 2022. Prosocial behavior and well-being: shifting from the 'chicken and egg' to positive feedback loop. *Curr. Opin. Psychol.* 44, 231–236. <https://doi.org/10.1016/j.copsyc.2021.09.017>.
- Hui, B.P.H., Kogan, A., 2018. Daily ups and downs: an event-sampling study of the mediated moderation of prosocial engagement on well-being. *Soc. Psychol. Personal. Sci.* 9 (6), 675–688. <https://doi.org/10.1177/1948550617722197>.
- Hui, B.P.H., Ng, J.C.K., Berzaghi, E., Cunningham-Amos, L.A., Kogan, A., 2020. Rewards of kindness? A meta-analysis of the link between prosociality and well-being. *Psychol. Bull.* 146 (12), 1084–1116. <https://doi.org/10.1037/bul0000298>.

- Jenkinson, C.E., Dickens, A.P., Jones, K., Thompson-Coon, J., Taylor, R.S., Rogers, M., Bamba, C.L., Lang, I., Richards, S.H., 2013. Is volunteering a public health intervention? A systematic review and meta-analysis of the health and survival of volunteers. *BMC Public Health* 13, 773. <https://doi.org/10.1186/1471-2458-13-773>.
- Kessler, R.C., Berglund, P., Demler, O., Jin, R., Merikangas, K.R., Walters, E.E., 2005. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the national comorbidity survey replication. *Arch. Gen. Psychiatry* 62 (6), 593–602. <https://doi.org/10.1001/archpsyc.62.6.593>.
- Kieling, C., Baker-Henningham, H., Belfer, M., Conti, G., Ertem, I., Omigbodun, O., Rohde, L.A., Srinath, S., Ulkuer, N., Rahman, A., 2011. Child and adolescent mental health worldwide: evidence for action. *Lancet* 378 (9801), 1515–1525. [https://doi.org/10.1016/s0140-6736\(11\)60827-1](https://doi.org/10.1016/s0140-6736(11)60827-1).
- Kleinert, S., Horton, R., 2016. Adolescent health and wellbeing: a key to a sustainable future. *Lancet* 387 (10036), 2355–2356.
- Konrath, S., 2014. The Power of philanthropy and volunteering. In: *Wellbeing*, pp. 1–40. <https://doi.org/10.1002/9781118539415.wbwell046>.
- Konrath, S., Meier, B.P., Bushman, B.J., 2018. Development and validation of the single item trait empathy scale (SITES). *J. Res. Pers.* 73, 111–122. <https://doi.org/10.1016/j.jrp.2017.11.009>.
- Konrath, S., Martingano, A.J., Tolman, R.M., Winslow, M., Bushman, B.J., 2024. Random app of kindness: evaluating the potential of a smartphone intervention to impact adolescents' empathy, prosocial behavior, and aggression. *Psychol. Pop. Media* 13 (3), 338–352. <https://doi.org/10.1037/ppm0000478>.
- Lachin, J.M., 2000. Statistical considerations in the intent-to-treat principle. *Control. Clin. Trials* 21 (3), 167–189. [https://doi.org/10.1016/s0197-2456\(00\)00046-5](https://doi.org/10.1016/s0197-2456(00)00046-5).
- Laguna, M., Mazur, Z.M., Kędra, M., Ostrowski, K., 2020. Interventions stimulating prosocial helping behavior: a systematic review. *J. Appl. Soc. Psychol.* 50 (11), 676–696. <https://doi.org/10.1111/jasp.12704>.
- Larsen, D.L., Attkisson, C.C., Hargreaves, W.A., Nguyen, T.D., 1979. Assessment of client/patient satisfaction: development of a general scale. *Eval. Program Plann.* 2 (3), 197–207. [https://doi.org/10.1016/0149-7189\(79\)90094-6](https://doi.org/10.1016/0149-7189(79)90094-6).
- Lave, J., Wenger, E., 1991. *Situated learning: Legitimate peripheral participation*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511815355>.
- Layous, K., Nelson, S.K., Oberle, E., Schonert-Reichl, K.A., Lyubomirsky, S., 2012. Kindness counts: prompting prosocial behavior in preadolescents boosts peer acceptance and well-being. *PLoS ONE* 7 (12), e51380. <https://doi.org/10.1371/journal.pone.0051380>.
- Layous, K., Nelson, S.K., Kurtz, J.L., Lyubomirsky, S., 2017. What triggers prosocial effort? A positive feedback loop between positive activities, kindness, and well-being. *J. Posit. Psychol.* 12 (4), 385–398. <https://doi.org/10.1080/17439760.2016.1198924>.
- Li, C., Lo Kon, A.L., Shing Ip, H.H., 2022. Use virtual reality to enhance intercultural sensitivity: a randomised parallel longitudinal study. *IEEE Trans. Vis. Comput. Graph.* 28 (11), 3673–3683. <https://doi.org/10.1109/tvcg.2022.3203091>.
- Lyubomirsky, S., Lepper, H.S., 1999. A measure of subjective happiness: preliminary reliability and construct validation. *Soc. Indic. Res.* 46 (2), 137–155. <https://doi.org/10.1023/A:1006824100041>.
- Lyubomirsky, S., King, L., Diener, E., 2005. The benefits of frequent positive affect: does happiness lead to success? *Psychol. Bull.* 131 (6), 803–855. <https://doi.org/10.1037/0033-2909.131.6.803>.
- Mabaso, Z., Erogbogbo, T., Toure, K., 2016. Young people's contribution to the global strategy for women's, children's and adolescents' health (2016-2030). *Bull. World Health Organ.* 94 (5), 312. <https://doi.org/10.2471/blt.16.174714>.
- Malti, T., Speidel, R., 2024. Development of prosociality and the effects of adversity. *Nat. Rev. Psychol.* <https://doi.org/10.1038/s44159-024-00328-7>.
- Martingano, A.J., Herrera, F., Konrath, S., 2021. Virtual reality improves emotional but not cognitive empathy: a meta-analysis. *Technol. Mind Behav.* 2 (1). <https://doi.org/10.1037/umb0000034>. No Pagination Specified-No Pagination Specified.
- Massé, R., Poulin, C., Dassa, C., Lambert, J., Bélair, S., Battaglini, A., 1998. The structure of mental health: higher-order confirmatory factor analyses of psychological distress and well-being measures. *Soc. Indic. Res.* 45 (1), 475–504. <https://doi.org/10.1023/A:1006992032387>.
- Matsuba, M.K., Walker, L.J., 2004. Extraordinary moral commitment: young adults involved in social organizations. *J. Pers.* 72 (2), 413–436. <https://doi.org/10.1111/j.0022-3506.2004.00267.x>.
- McCullough, M.E., Emmons, R.A., Tsang, J.A., 2002. The grateful disposition: a conceptual and empirical topography. *J. Pers. Soc. Psychol.* 82 (1), 112–127. <https://doi.org/10.1037/0022-3514.82.1.112>.
- McNamara, D.S., Jackson, G.T., Graesser, A.C., 2010. *Intelligent Tutoring and Games (ITaG)*.
- Memmott-Elison, M.K., Holmgren, H.G., Padilla-Walker, L.M., Hawkins, A.J., 2020. Associations between prosocial behavior, externalizing behaviors, and internalizing symptoms during adolescence: a meta-analysis. *J. Adolesc.* 80, 98–114. <https://doi.org/10.1016/j.adolescence.2020.01.012>.
- Miles, A., Andiappan, M., Upenieks, L., Orfanidis, C., 2022. Using prosocial behavior to safeguard mental health and foster emotional well-being during the COVID-19 pandemic: a registered report of a randomized trial. *PLoS ONE* 17 (7), e0272152. <https://doi.org/10.1371/journal.pone.0272152>.
- Mohan, A., Kostecky, S.M., Sivakumar, A., Khalil, M., Clark, H., 2022. Improving adolescent wellbeing is an urgent global priority, 379. *British Medical Journal Publishing Group*.
- Moher, D., Hopewell, S., Schulz, K.F., Montori, V., Gøtzsche, P.C., Devereaux, P.J., Elbourne, D., Egger, M., Altman, D.G., 2010. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. *Bmj* 340, c869. <https://doi.org/10.1136/bmj.c869>.
- Myin-Germeys, I., Kasanova, Z., Vaessen, T., Vachon, H., Kirtley, O., Viechtbauer, W., Reininghaus, U., 2018. Experience sampling methodology in mental health research: new insights and technical developments. *World Psychiatry* 17 (2), 123–132. <https://doi.org/10.1002/wps.20513>.
- Nelson, S.K., Della Porta, M.D., Jacobs Bao, K., Lee, H.C., Choi, I., Lyubomirsky, S., 2015. 'It's up to you': experimentally manipulated autonomy support for prosocial behavior improves well-being in two cultures over six weeks. *J. Posit. Psychol.* 10 (5), 463–476. <https://doi.org/10.1080/17439760.2014.983959>.
- Papastergiou, M., 2009. Digital game-based learning in high school computer science education: impact on educational effectiveness and student motivation. *Comput. Educ.* 52 (1), 1–12. <https://doi.org/10.1016/j.compedu.2008.06.004>.
- Patton, G.C., Viner, R., 2007. Pubertal transitions in health. *Lancet* 369 (9567), 1130–1139. [https://doi.org/10.1016/s0140-6736\(07\)60366-3](https://doi.org/10.1016/s0140-6736(07)60366-3).
- Patton, G.C., Sawyer, S.M., Santelli, J.S., Ross, D.A., Afifi, R., Allen, N.B., Arora, M., Azzopardi, P., Baldwin, W., Bonell, C., 2016. Our future: a lancet commission on adolescent health and wellbeing. *Lancet* 387 (10036), 2423–2478.
- Perkins, N., Sehmbi, T., Smith, P., 2022. Effects of kindness- and compassion-based meditation on wellbeing, prosociality, and cognitive functioning in children and adolescents: a systematic review. *Mindfulness* 13 (9), 2103–2127. <https://doi.org/10.1007/s12671-022-01925-4>.
- Pitchforth, J., Fahy, K., Ford, T., Wolpert, M., Viner, R.M., Hargreaves, D.S., 2019. Mental health and well-being trends among children and young people in the UK, 1995-2014: analysis of repeated cross-sectional national health surveys. *Psychol. Med.* 49 (8), 1275–1285. <https://doi.org/10.1017/s0033291718001757>.
- Radianti, J., Majchrzak, T.A., Fromm, J., Wohlgenannt, I., 2020. A systematic review of immersive virtual reality applications for higher education: design elements, lessons learned, and research agenda. *Comput. Educ.* 147, 103778. <https://doi.org/10.1016/j.compedu.2019.103778>.
- Ravens-Sieberer, U., Erhart, M., Rajmil, L., Herdman, M., Auquier, P., Bruil, J., Power, M., Duer, W., Abel, T., Czemy, L., Mazur, J., Czimbalmos, A., Tountas, Y., Hagquist, C., Kilroe, J., the European, K. G., 2010. Reliability, construct and criterion validity of the KIDSCREEN-10 score: a short measure for children and adolescents' well-being and health-related quality of life. *Qual. Life Res.* 19 (10), 1487–1500. <https://doi.org/10.1007/s11136-010-9706-5>.
- Rosenberg, M., 1965. *Society and the adolescent self-image*. Princeton University Press. <https://www.jstor.org/stable/j.ctt1183pjjh>.
- Ross, D.A., Hinton, R., Melles-Brewer, M., Engel, D., Zeck, W., Fagan, L., Herat, J., Phaladi, G., Imbago-Jacome, D., Anyona, P., Sanchez, A., Damji, N., Terki, F., Baltag, V., Patton, G., Silverman, A., Fogstad, H., Banerjee, A., Mohan, A., 2020. Adolescent well-being: a definition and conceptual framework. *J. Adolesc. Health* 67 (4), 472–476. <https://doi.org/10.1016/j.jadohealth.2020.06.042>.
- Russell, M.A., Gajos, J.M., 2020. Annual research review: ecological momentary assessment studies in child psychology and psychiatry. *J. Child Psychol. Psychiatry* 61 (3), 376–394. <https://doi.org/10.1111/jcpp.13204>.
- Ryan, R.M., Frederick, C., 1997. On energy, personality, and health: subjective vitality as a dynamic reflection of well-being. *J. Pers.* 65 (3), 529–565. <https://doi.org/10.1111/j.1467-6494.1997.tb00326.x>.
- Saleme, P., Pang, B., Dietrich, T., Parkinson, J., 2020. Prosocial digital games for youth: a systematic review of interventions. *Comput. Hum. Behav. Rep.* 2, 100039. <https://doi.org/10.1016/j.chbr.2020.100039>.
- Scafuto, F., Ghiroldi, S., Montecucco, N.F., De Vincenzo, F., Quinto, R.M., Presaghi, F., Iani, L., 2024. Promoting well-being in early adolescents through mindfulness: a cluster randomized controlled trial. *J. Adolesc.* 96 (1), 57–69. <https://doi.org/10.1002/jad.12252>.
- Shin, J., Lee, B., 2021. The effects of adolescent prosocial behavior interventions: a meta-analytic review. *Asia Pac. Educ. Rev.* 22 (3), 565–577. <https://doi.org/10.1007/s12564-021-09691-z>.
- Smith, K.E., Juarascio, A., 2019. From ecological momentary assessment (EMA) to ecological momentary intervention (EMI): past and future directions for ambulatory assessment and interventions in eating disorders. *Curr. Psychiatry Rep.* 21 (7), 53. <https://doi.org/10.1007/s11920-019-1046-8>.
- Steinberg, L., 2005. Cognitive and affective development in adolescence. *Trends Cogn. Sci.* 9 (2), 69–74. <https://doi.org/10.1016/j.tics.2004.12.005>.
- Tashjian, S.M., Rahal, D., Karan, M., Eisenberger, N., Galván, A., Cole, S.W., Fuligni, A.J., 2021. Evidence from a randomized controlled trial that altruism moderates the effect of prosocial acts on adolescent well-being. *J. Youth Adolesc.* 50 (1), 29–43. <https://doi.org/10.1007/s10964-020-01362-3>.
- Tejada-Gallardo, C., Blasco-Belled, A., Torrelles-Nadal, C., Alsinet, C., 2020. Effects of school-based multicomponent positive psychology interventions on well-being and distress in adolescents: a systematic review and meta-analysis. *J. Youth Adolesc.* 49 (10), 1943–1960.
- Titova, L., Sheldon, K.M., 2020. Thwarted beneficence: not getting to help lowers mood. *J. Posit. Psychol.* 17 (1), 21–33. <https://doi.org/10.1080/17439760.2020.1858339>.
- Van Kerrebroeck, H., Brengman, M., Willems, K., 2017. When brands come to life: experimental research on the vividness effect of virtual reality in transformational marketing communications. *Virtual Reality* 21 (4), 177–191. <https://doi.org/10.1007/s10055-017-0306-3>.
- Wang, Q.J., Barbosa Escobar, F., Alves Da Mota, P., Velasco, C., 2021. Getting started with virtual reality for sensory and consumer science: current practices and future perspectives. *Food Res. Int.* 145, 110410. <https://doi.org/10.1016/j.foodres.2021.110410>.
- Webb, D.J., Green, C.L., Brashear, T.G., Webb, D.J., Green, C.L., Brashear, T.G., 2000. Development and validation of scales to measure attitudes influencing monetary donations to charitable organizations. *J. Acad. Mark. Sci.* 28 (2), 299–309. <https://doi.org/10.1177/0092070300282010>.

- Weinstein, N., Ryan, R.M., 2010. When helping helps: autonomous motivation for prosocial behavior and its influence on well-being for the helper and recipient. *J. Pers. Soc. Psychol.* 98 (2), 222–244. <https://doi.org/10.1037/a0016984>.
- Weir, K., Duveen, G., 1981. Further development and validation of the prosocial behaviour questionnaire for use by teachers. *J. Child Psychol. Psychiatry* 22 (4), 357–374. <https://doi.org/10.1111/j.1469-7610.1981.tb00561.x>.
- Wenze, S.J., Miller, I.W., 2010. Use of ecological momentary assessment in mood disorders research. *Clin. Psychol. Rev.* 30 (6), 794–804. <https://doi.org/10.1016/j.cpr.2010.06.007>.
- Zhang, F., Zhang, Y., Li, G., Luo, H., 2024. Using virtual reality interventions to promote social and emotional learning for children and adolescents: a systematic review and meta-analysis. *Children* 11 (1), 41. <https://doi.org/10.3390/children11010041>.