Protocol for a randomized and a non-randomized controlled trial testing Daily Growth: a personalised 'ecological momentary intervention' parenting app for parents and carers of children aged 2–5 years

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Abstract

Background Children's ability to regulate their emotions is a critical protective factor for early mental health and development and is strongly influenced by parenting. Parenting programs can improve these outcomes for children, however, most families, particularly those from diverse or disadvantaged backgrounds, never receive evidence-based support. There is a pressing need for parenting programs that are widely accessible and meaningfully tailored to individual needs and real-time parenting challenges to enhance parent engagement. This protocol outlines the design of two staged trials testing Daily Growth, a universal parenting app for parents/carers of children 2–5 years. The first trial will evaluate the app's effectiveness as implemented in a real-world community-based trial, while the second will develop and test a machine learning system for personalising support based on Trial 1 data.

Methods In Trial 1, parents/carers ($n = 1,650$) will be recruited and randomised to one of five groups: 150 to active control (government parenting website); 100 each to one of three programs (Emotion Coaching, Active Play, or Wayapa Wuurrk); 1,200 to a non-personalised random combination of all three. Trial 2 (non-randomised) will recruit 400 parents/carers to receive personalised support, with program content from the three programs allocated via a machine learning algorithm based on baseline data. Both trials will run for six weeks where participants will receive twice-daily prompts to complete a 1-min pre-ecological momentary intervention (pre-EMI) survey and non-control participants offered three-minute videos tailored to specific parenting challenges. A post-EMI survey will be delivered 15 min later to assess immediate outcomes. Participants in both trials will complete baseline, six-week,

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and six-month follow-up surveys. Outcomes from the non-personalised trial will be compared to the fully personalised app and control/single program groups via EMI and post/follow-up on parenting and parent/child emotion regulation.

Discussion This study introduces a novel digital program combining co-designed parenting content, real-time delivery, tailoring to ensure practical relevance, and algorithm-driven personalisation. By testing standardised and personalised app versions, it will evaluate whether real-time personalised parenting support improves parent/child emotion regulation, engagement, and program acceptability. Findings will inform future approaches to scalable, inclusive, and responsive parenting support in early childhood.

Trial registration This trial is registered with ANZCTR, registration number ACTRN12624000937516; ACTRN12624001023549, and includes all items from the WHO Trial Registration Data Set.

Keywords Daily Growth, Emotion coaching, Active play, Emotion socialisation, Intervention, Program, Parenting, Emotion regulation, Child development

Background

Supporting children's mental health is a global priority. There is growing recognition that early childhood is a key window for prevention of mental health problems as this is when foundational skills, such as emotion regulation, begin to develop [1]. Emotion regulation in early childhood helps lay the groundwork for long-term mental health, and parents and carers play a central role in supporting the development of these skills [2–4]. Despite strong evidence that parenting programs can improve parenting practices, support parent and child emotion regulation, and reduce child mental health problems [5, 6], most families never receive evidence-based support [1]. This gap is particularly pronounced among underserved families, such as those experiencing social or financial disadvantage, living in rural and remote settings, or from culturally and linguistically diverse or historically marginalised communities [7]. What remains unclear is how to deliver parenting programs that are widely accessible and personally engaging to time-poor parents and carers with diverse preferences and needs. The two trials described in this protocol address this gap through the evaluation of *Daily Growth*, an innovative, co-designed universal parenting app that delivers in-the-moment support through tailored micro-interventions (i.e., ecological momentary interventions). The first trial evaluates a combination of three distinct programs (Emotion Coaching, Active Play, and Wayapa Wuurrk, an earth connection well-being program grounded in Indigenous wisdom), designed to meet the diverse needs, preferences, and cultural backgrounds of parents and carers in the community. The second trial develops and tests a machine learning system for personalising support based on data from trial 1.

Gaps in universal parenting programs

Mental disorders affect 43% of Australian adults over their lifetime and are a leading cause of disease burden globally [8–10]. Early indicators of mental disorder often emerge in childhood via developmental pathways that begin well before clinical diagnosis [11, 12]. Early childhood is therefore a critical window for prevention, as foundational emotional and social learning occurs during this time [5, 13]. Emotion regulation refers to the capacity to understand and manage emotional expression effectively and is a central mechanism in the development of mental health problems [14–16]. Poor emotion regulation skills are associated with mental health problems, social difficulties, and lower academic achievement [2, 14–17]. Supporting the development of these skills is foundational to lifelong wellbeing, coping, relationships, and mental health [18–22]. As parenting beliefs and behaviours are modifiable and influence child emotion regulation development, they represent a key target for early intervention and prevention.

There are well documented issues with the quality, availability, and uptake of parenting programs [5, 23, 24]. Parents' capacity to support their child's emotional development depends on their own emotion regulation and parenting skills, and is influenced by stress and the availability of external support [25]. Evidence-based programs can help build these skills, yet universal delivery of parenting programs remains severely limited, especially in the early years before school entry [26]. In Australia and internationally, fewer than 10% of parents and carers access evidence-based parenting support [1, 18, 27–29], with particularly low reach among fathers, single parents, culturally and linguistically diverse families, families in non-urban areas, and First Nations peoples [18–22].

Several barriers prevent parents from participating in parenting programs. These include difficulty attending in-person due to carer responsibilities; lack of relevance to individual needs or family contexts; and, for fathers, services that are perceived as mother-oriented [19, 30, 31]. In fact, fathers are much less likely to participate in parenting programs [22, 31], despite growing recognition

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of the importance of their role in child development [32–35]. One review of 25 eHealth parenting programs found that fathers from disadvantaged or regional backgrounds were the least likely to participate than other mothers and fathers, with overall low rates of adherence and retention [22]. Current programs often suffer from poor uptake and engagement because they are *constrained*—delivered face-to-face or in inflexible online modules—and *generic*, lacking tailoring to family context or personalisation to parent interests and abilities [18, 22]. Adaptations of parenting programs to online delivery have mostly clung to traditional formats, delivered via self-directed modules with limited tailoring to parenting context [36]. Parents are more likely to engage with programs that are tailored and contextually relevant to their lived experience [37–39]. Adjusting delivery methods to be more accessible and adaptable, with program content that is relevant to parents' unique contexts, and responsive to the dynamic realities of parenting may enhance program uptake and acceptability/engagement.

Harnessing technology to tailor & personalise parenting support

Digital technology, especially smartphone apps, presents an opportunity to overcome long-standing barriers to accessible, timely parenting support. Given that more than 96% of Australian households with children have smartphones, app-based delivery enables near-universal access, even in remote and under-resourced areas, and reduces common logistical barriers of travel and childcare [40, 41]. Apps can be updated in real time, allowing programs to evolve with new evidence and technology. One promising approach within app-based programs is ecological momentary interventions (EMI), also known as micro-interventions. These offer brief, in-the-moment support, triggered by real-time data from brief surveys assessing mood, behaviour, or other indicators [42]. Grounded in behaviour change theory, EMIs aim to enhance motivation, capability, and engagement by delivering timely, relevant tools when challenges arise [43]. In adult mental health programs, engagement is consistently higher when interventions are tailored to individual needs using real-time data, providing specific, immediately applicable strategies. This responsiveness fosters intrinsic motivation by helping users to feel that the support is directly relevant to their current experience and useful, promoting intrinsic motivation [38, 39, 44]. Evidence from parenting programs similarly shows that parents are more likely to engage when content is tailored and contextually relevant to their lived experience [37–39]. In this context, tailoring parenting content to real-time parenting challenges may improve the relevance and immediacy of parenting support, making it easier to understand and apply, and more likely to promote meaningful, sustained learning.

Machine learning offers a promising new avenue for delivering personalised parenting support. Machine learning algorithms discover the patterns hidden in data and use these insights to optimise recommendation processes, enabling personalised support based on individual needs, interests, and circumstances [45, 46]. Research shows that different parents are engaged with different types of content, and have different needs, highlighting the need for personalised approaches [30, 37, 39]. By drawing on individual-level data, such as user characteristics, prior behaviours, and responses, machine learning, combined with mobile technology, can empower decision-making about the types of support that are most likely to be effective in a given moment. Although this approach has demonstrated promise in adult mental health settings, with evidence for improved reach, efficacy, and value, it has not yet been tested in parenting programs [45, 46].

Co-designing the Daily Growth parenting app

Daily Growth is an innovative smartphone parenting app for parents and carers of children aged 2–5 years. The Daily Growth approach is grounded in emotion socialisation theory, which emphasises the pivotal role of parents and carers in shaping children's emotion regulation skills and broader socio-emotional development [3, 47–49]. As illustrated in Fig. 1, the conceptual model underpinning Daily Growth draws on evidence that parents and carers influence child emotion regulation through their own
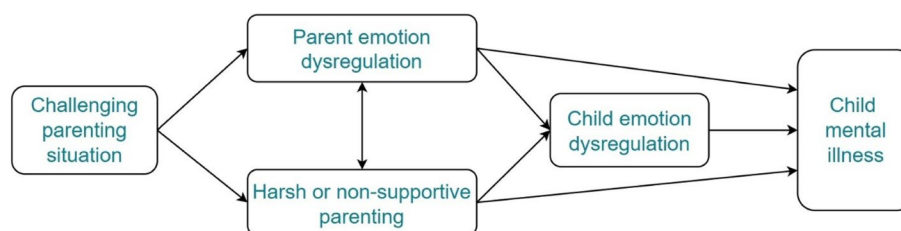

Fig. 1 Diagram Illustrating the Conceptual Model Underpinning the Daily Growth App Design

emotion regulation and through their emotion-related parenting beliefs and practices [47–51]. These aspects of parenting have been shown to be modifiable through evidence-based parenting programs, which have emerged as an effective strategy for supporting children's emotional development [5, 48]. In particular, programs that explicitly target parent and/or child emotion regulation have demonstrated improvements for parenting practices and child outcomes across mental health, emotional, behavioural, and relational domains [4, 5, 14, 52, 53].

Parents can foster children's emotion regulation skills in a variety of ways. Strong evidence supports parenting programs that directly teach via emotion-coaching, equipping parents with skills in emotion awareness, acceptance, empathy, and problem-solving [32, 54–56]. Emerging evidence also suggests that other approaches can help parents and children develop emotional regulation skills, such as through physical activity and imaginative active play [57–61], mindful parenting [62, 63], and Indigenous practices related to story-telling and connection to nature, community, family, and kinship [64, 65]. The Daily Growth parenting app has three innovative features to address limitations of existing resources, including (1) offering parents a variety of offerings via three types of parenting programs, (2) delivering real time support, and (3) the use of co-design to ensure all elements of Daily Growth meet the needs of diverse parents and carers.

Daily Growth provides three distinct types of parenting support: Emotion Coaching; Active Play; and Wayapa Wuurrk. The Emotion Coaching program is grounded in emotion socialisation theory [47] and draws on Gottman's five steps of emotion coaching for guiding children through emotional experiences [66], which emphasises parents' roles in supporting children through emotional experiences with empathy, emotional awareness, and responsive support. The Emotion Coaching program encourages parents to recognise children's emotions as opportunities for connection and learning, while strengthening their own emotion regulation and capacity to respond constructively to challenging moments. In developing the Daily Growth Emotion Coaching program, concepts were also drawn from the Tuning in to Kids program, an evidence-based parenting program that teaches parents emotion coaching skills to help their children understand and manage emotions effectively, with demonstrated benefits for both parenting practices and child emotional outcomes [67].

The Active Play program in Daily Growth is grounded in emotion socialisation theory [47] and supported by growing research evidence showing that physical activity and imaginative play can support the development of emotion regulation in early childhood [57, 60, 68]. While many parenting programs focus on verbal strategies, Active Play offers a non-verbal, embodied approach to emotion regulation that may better resonate with some families, particularly fathers, who often prefer connecting through play and physical activity, and those who are less comfortable with emotional discussion [67]. Physical activity provides immediate mood-enhancing and emotion-regulatory benefits, alleviates distress, and produces therapeutic effects on the autonomic nervous system. With regular engagement, it supports long-term improvements in emotion regulation and emotional wellbeing [57, 60, 69–72]. In addition, physical activity has been shown to strengthen executive function skills, such as cognitive flexibility, working memory, and inhibitory control, which are closely tied to emotion regulation [73, 74].

Emerging evidence suggests that different types and intensities of physical activity, such as aerobic exercise compared to co-ordinated movement, may influence regulatory functioning through different neurological and physiological processes. This provides an opportunity to tailor movement-based activities to meet the needs of specific parenting situations [68, 69, 75, 76]. In early childhood, physical activity primarily takes the form of unstructured, play-based movement, such as running, jumping, or dancing, which helps children develop the emotional and cognitive skills required to manage stress and regulate behaviour [77, 78]. These activities often incorporate imaginative play, offering opportunities for children to express emotions, explore perspectives, and practise self-control [79, 80].

In developing the Active Play program, we drew foundational concepts from three digital programs that demonstrate how movement could be used intentionally to support emotional development in early childhood. The first was the Active Early Learning program, a childcare centre-based physical activity intervention shown to improve early childhood executive function and expressive vocabulary [81, 82]; the INFANT program, which provides strategies through community-based group sessions and take home resources for parents of children 4–19 months to promote anticipatory guidance for a healthy diet, physical activity, and reduced sedentary behaviour [83]; and the Let's Grow program, a family-focused mHealth program for parents of toddlers, incorporating evidence-based behaviour change strategies to promote active play, sleep, and reduced sedentary behaviour.

Wayapa Wuurrk is an internationally accredited Indigenous Wellness Modality which combines earth mindfulness; storytelling; a physical movement practice of 14 elements; and taking action to look after the environment to create Earth, mind, body, spirit wellbeing [84].

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The Wayapa Wuurrk program within Daily Growth was developed in response to the ongoing lack of parenting resources that reflect and value Indigenous ways of knowing, being, and doing in child-rearing and family life [85–87]. A recent systematic review of 109 published evaluations of parenting programs in Australia found that only nine reported the number of Aboriginal or/and Torres Strait Islander participants, and just two were specifically designed for Aboriginal families [87]. This significant gap presents a barrier to the access and cultural relevance of parenting programs for Aboriginal and/or Torres Strait Islander parents and carers [85–87].

Wayapa Wuurrk draws on embodied mindfulness practices and reconnection to Country, offering an approach that aligns with Indigenous knowledge systems. Wayapa Wuurrk was included in Daily Growth as a culturally informed, alternative approach to supporting children's emotion regulation. It encourages parents and carers to draw on nature's elements, cycles, and seasons to help themselves and their children feel more connected and grounded. These teachings are also used to help reframe and diffuse common parenting challenges by encouraging families to re-focus on shared values and goals. This is particularly important for families who may face barriers to engaging with conventional Western parenting programs due to intergenerational trauma, cultural differences, historical mistrust, and systemic barriers [86]. The Wayapa videos support parents/carers to regulate their own emotions by inviting moments of pause, grounding, and reflection, often guided by imagery from nature. This embodied mindfulness approach is designed to reduce reactivity, foster calm, and support attunement with the child. Although few studies have examined mindfulness from Indigenous perspectives, there is emerging evidence that nature-based and embodied mindfulness practices, such as those used in Wayapa Wuurrk, can support adult emotion regulation, reduce distress, and improve overall health and wellbeing [88–95].

Together, these three programs offer distinct, evidence-informed approaches to supporting children's emotion regulation. By drawing on diverse theoretical foundations and modes of interaction—including verbal, embodied, relational, and cultural practices—the programs are designed to reflect the varied ways families understand and engage with parenting support. This diversity is intended to increase the relevance and accessibility of the Daily Growth for a wide range of parents and carers, supporting broader engagement by aligning with different needs, preferences, and cultural values.

The second key innovation in Daily Growth is its real time delivery of support, which aims to strengthen parents' emotion regulation and parenting practices in-the-moment as challenges arise, thereby supporting children's emotional development and mental health. As illustrated in Fig. 2, the Daily Growth app prompts parents twice daily (morning/evening), and if they request support, offers brief 3-min video 'micro-intervention' resources that provide immediate parenting support that is tailored to a recent parenting situation (e.g., going to bed; child won't sit for meals; conflict between children). These short, tailored videos deliver bite-sized, practical strategies that parents can easily absorb and use when needed. By breaking down complex concepts into simple, context-specific guidance, this approach is intended to reduce the cognitive load of traditional parenting
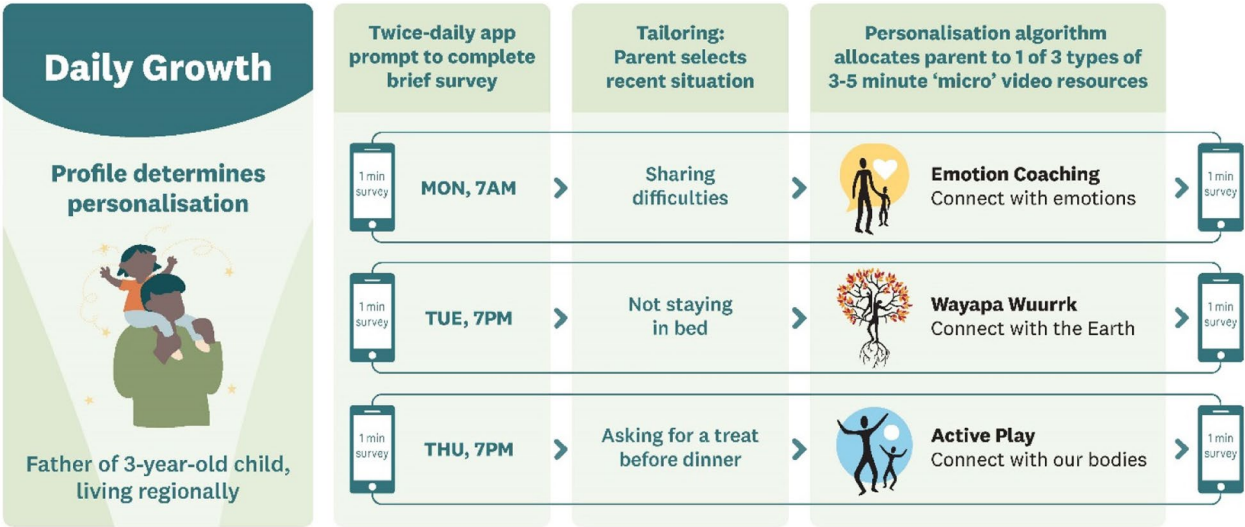

Fig. 2 Tailoring and Personalising Brief, In-the-Moment Micro-Interventions

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programs and support parents to confidently apply new skills in everyday interactions with their child.

The third key innovation in Daily Growth is the use of co-design, ensuring the app is meaningfully shaped by the voices and experiences of diverse parents, carers, and community partners. Co-design offers a powerful approach to creating programs that are responsive to the needs and preferences of diverse families [96]. The Daily Growth app was developed using our purpose-designed Design Mapping framework [96], a co-design approach that integrates creative user engagement tools within a systematic, evidence-based methodology. The framework draws on three iterative phases.

(1) Understand Phase

In the Understand phase, a needs assessment was undertaken through a review of relevant literature and 17 one-hour interviews with parents, alongside four one-hour interviews with professionals [97]. Findings from thematic template analysis suggested that parents and carers want practical, timely support that feels relevant, respectful, and reflects their lived experiences, while retaining autonomy over which advice they engage with.

(2) Co-develop Phase

The Co-develop phase involved collaborating with parents and carers and community/professional stakeholders to develop the program's user journey and content, while ensuring that selected concepts were grounded in theoretical and empirical research. This process involved three co-design workshops with parent end-users and multiple ideation workshops with the program development team [97]. Additionally, an ecological momentary assessment study involving 89 parents/carers was conducted to inform the protocol for delivering daily surveys [98].

(3) Prototype Phase

The Prototype phase is ongoing and involves iterative development, testing, and refinement of program concepts and components in collaboration with end users to optimise feasibility, engagement, and effectiveness. To-date, three studies have been completed; a pilot randomised controlled trial of a prototype version of Daily Growth (*n*=184), qualitative interviews with pilot participants (*n*=9), and a non-randomised pilot study testing a revised delivery method with the same prototype version of Daily Growth (*n*=108). The first pilot randomised controlled trial evaluated the feasibility and acceptability of the EMI survey delivery method and a small-scale prototype of the Daily Growth program (10

resources delivered via a web platform). Australian parents of children 2–4 years were recruited online and randomised to Daily Growth prototype (*n*=96) or active control (*n*=88). Over two weeks, participants received twice-daily 1-minute EMI surveys via email. When parents reported negative affect or emotion dysregulation (in themselves or their child), they were randomised to receive a 3-minute video resource (Emotion Coaching or Active Play), while control participants received a link to the Raising Children Network, an Australian Government parenting resource website. Results indicated strong feasibility and acceptability, with most parents finding Daily Growth easy to use (77%) and saying they would recommend it to others (83%), despite technical challenges.

The second study involved one-hour qualitative interviews with nine pilot participants, analysed using thematic template analysis. Findings from both studies indicated that parents strongly preferred greater flexibility—specifically, the ability to self-initiate micro-interventions rather than rely solely on survey-triggered delivery. In response, the EMI protocol was updated to include an item asking parents whether they would like support in that moment. A third non-randomised pilot study (*n*=108) tested this revised approach using the same prototype content. Findings again showed high satisfaction and acceptability, supporting the value of greater user control over intervention timing.

Together, findings from the co-design studies highlight the feasibility, acceptability, and promise of the Daily Growth approach. The next step (also forming part of the Prototype phase) is to evaluate the outcomes of both standardised and personalised versions of Daily Growth under real-world conditions. The two trials outlined in this protocol are therefore designed as effectiveness trials, aimed at assessing the impact of Daily Growth when implemented in a community setting.

The current study

This protocol describes two sequential trials involving a combined total of 2,050 parents and carers of children aged 2–5 years. Rather than testing the app under ideal, tightly controlled conditions, these trials are designed to evaluate the Daily Growth program as it would be used in everyday contexts—via place-based and online recruitment, through early childhood education settings, family services, and social media outreach. Participants will be allocated into six groups across the two studies, as outlined in Fig. 3.

The first trial, a randomised controlled trial (Australian Trial Registration ACTRN12624000937516;
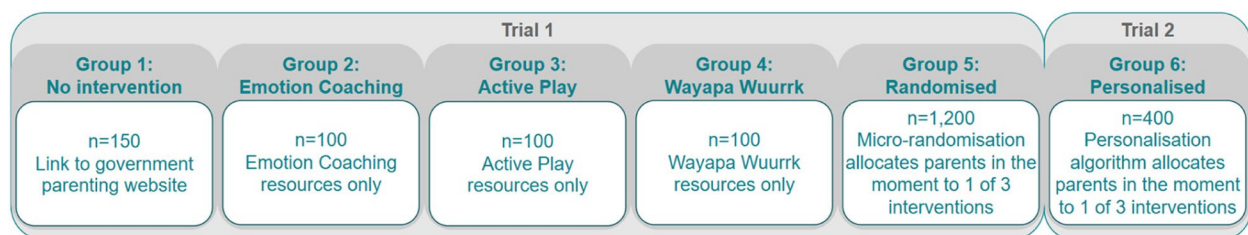
Trial 1					Trial 2
Group 1: No intervention	**Group 2:** Emotion Coaching	**Group 3:** Active Play	**Group 4:** Wayapa Wuurrk	**Group 5:** Randomised	**Group 6:** Personalised
n=150 Link to government parenting website	n=100 Emotion Coaching resources only	n=100 Active Play resources only	n=100 Wayapa Wuurrk resources only	n=1,200 Micro-randomisation allocates parents in the moment to 1 of 3 interventions	n=400 Personalisation algorithm allocates parents in the moment to 1 of 3 interventions

Fig. 3 Trial 1 and 2 Research Designs Enabling Comparison Across 5 Randomised (Groups 1–5) and 1 Non-Randomised Group (Group 6)

1/08/2024), will recruit 1,650 parents and carers to investigate whether offering a combination of three different types of parenting programs (Emotion Coaching; Active Play; Wayapa Wuurrk) improves outcomes, engagement, and retention compared to a standard control group. Participants allocated to the control group will be referred to the Australian Government website, Raising Children Network, which is the current recommended parenting advice available in the community. Specifically, we aim to:

1. Compare the effectiveness of an active control ($n = 150$) to parents/carers receiving a single type of parenting program (3 groups of $n = 100$) or a random combination of three different types of parenting programs ($n = 1,200$).
2. Develop a machine learning algorithm for personalising programs to determine the type of program most likely to be acceptable and beneficial to a parent in a given moment.
3. Compare the effectiveness of parents/carers receiving a personalised combination of three different types of parenting programs (from Trial 2, $n = 400$) to an active control (from Trial 1, $n = 150$); parents/carers receiving a single type of parenting program (from Trial 1, 3 groups of $n = 100$); or a random combination of three different types of parenting programs (from Trial 1, $n = 1,200$).

The second non-randomised trial (Australian Trial Registration ACTRN12624001023549; 22/08/2024) will recruit an additional 400 parents and carers, and aims to compare participant outcomes, engagement, and retention for Group 5 from Trial 1 ($n = 1,200$) with Group 6 from Trial 2 ($n = 400$). The only difference between the two groups will be the method of program allocation: randomised in Group 5, versus personalisation via machine learning algorithm in Group 6. Specifically, Trial 2 aims are to:

Personalisation effectiveness will be examined across two sets of outcomes: (1) in-the-moment changes, i.e., improvements in parent/child emotional state and regulation after a micro-intervention event; and (2) long-term changes, i.e., group differences at post 6-weeks of intervention; and 6-months follow-up. Given that Daily Growth provides parenting support, the primary outcomes assessed will be in-the-moment and long-term parent emotion regulation; and long-term emotion-focussed parenting practices. A range of long-term secondary outcomes will also be assessed in both trials, including child emotion regulation, child and parent mental health, and family functioning. Our aims are exploratory as no previous study has directly assessed the provision of multiple types of programs within a single parenting platform.

Method
Study design
Participants will be recruited into two sequential trials with a combined total sample of 2,050 parents and carers of children aged 2–5 years. The first trial will be a randomised controlled trial recruiting 1,650 parents and carers who will be randomly allocated into one of five groups. Group 1 participants will not receive any of the Daily Growth programs, but instead be directed to an Australian government parenting website, the Raising Children Network (raisingchildren.net.au), a free website overseen by the Department of Social Services providing age-appropriate and evidence-based parenting advice for the Australian public. Groups 2–4 ($n = 100$ each) will be assigned to receive a single program, i.e., one of three Daily Growth programs (Emotion Coaching, Active Play, or Wayapa Wuurrk). Group 5 ($n = 1,200$) will be allocated to receive a random combination of all three Daily Growth programs. Data from Trial 1 will be used to develop the personalisation (machine learning) algorithm, to be implemented in Trial 2. The second trial will be a non-randomised trial recruiting an additional 400 parents and carers (Group 6) to receive a personalised combination of three programs allocated by the machine learning algorithm.

The Daily Growth study was supported through cultural leadership and oversight provided by the Wayapa Wuurrk team, and an Advisory Group of diverse parents, community partners, and local government members

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to test/refine outputs from pilot work and strategies for recruiting/engaging Aboriginal and under-represented parent groups. The Daily Growth study has received ethics approval from the Deakin University Human Research Ethics Committee (2024–050), and the Victorian Department of Education's Research in Schools and Early Childhood Settings (RISEC) committee (24–11–488). Any important protocol modifications will be submitted to the approving ethics committees and updated in the trial registry prior to implementation.

Participants

Parents and carers will be eligible to participate if they are a parent or carer of a child aged 2–5 years; their children are not enrolled in primary school; they are aged 18 years or older; are a resident of Victoria, Australia; and have ongoing access to a smartphone with an internet connection. All information related to the study, such as recruitment materials, app content, and surveys, will be written in English. While non-English speakers will not be excluded, it is expected that only English speakers will participate, based on their ability to comprehend the advertisements and provide informed consent. There are no restrictions on participants engaging in concomitant care or other programs during the trial.

Recruitment

Place-based recruitment

Recruitment will occur within the state of Victoria, in Australia. A combination of place-based and online recruitment methods will be employed to ensure a diverse and representative sample of parents and carers. We aim to integrate the Daily Growth program into community services that already support families, including maternal and child health services, early childhood education and care services (including long day care centres, kindergartens), community organisations, and services supporting Aboriginal and/or Torres Strait Islander and multicultural parents and carers. While recruitment will be conducted across Victoria, it will be concentrated in three key regions, Barwon South West, Wyndham City, and Whitehorse City, to leverage existing community and health partnerships and enhance demographic representativeness.

Recruitment for Trial 1 will occur in two consecutive phases to evaluate the effectiveness of 'basic' versus 'enhanced' place-based recruitment strategies. The first phase aims to recruit 25% of the sample through a combination of in-person and digital outreach. Members of the research team will seek permission from early childhood education and care centres, as well as other community organisations and family and health services, to disseminate study information to parents/carers via physical materials (e.g., posters, flyers) and digital communications (e.g., emails, centre websites, newsletters).

Recruitment materials for this phase were developed using principles from behaviour change theories, in line with emerging evidence that such approaches may enhance the uptake of parenting programs [99, 100]. Three empirically supported theories guided message development [101–103]: the Norm Activation Model [104], the Theory of Planned Behaviour [105], and Model of Goal-Directed Behaviour [106]. A multidisciplinary team with expertise in behaviour change, parenting, intervention design, and communication co-developed a series of brief statements for use in recruitment materials, e.g., "*Learn fun parenting games that the whole family can get involved in.*" Statement development followed an iterative process and was guided by three key criteria: (a) avoiding language that reinforces negative stereotypes about parenting young children, e.g., 'Terrible Twos'; (b) promoting strength-based messages, e.g., "*As parents and carers, we want our children to thrive*"; and (c) using inclusive, empowering language that avoids framing parents as deficient or in need of correction, e.g., "*Grow the connection with your child, and play to your parenting strengths.*" The final set of messages was refined based on feedback from expert researchers (external to the project team and university), the Daily Growth Advisory Group, and a 2024 online survey involving 200 parents residing in English-speaking countries recruited via Prolific.

The second phase will focus on recruiting the remaining 75% of participants through a co-designed strategy developed in collaboration with community and local government partners. The strategy will be informed by two implementation-focussed studies. First, qualitative interviews with 10–15 implementation experts to identify challenges/barriers and strategies for implementing parenting programs; and second, a Delphi study involving 10 implementation experts and 15 family service providers to reach consensus on barriers and strategies to program implementation. Examples of possible strategies include sharing parent feedback about Daily Growth with service providers, offering technical support, briefing staff on the benefits of evidence-based practices, and providing professional development resources to support reciprocal relationships with family service providers. The implementation process will be guided by the Consolidated Framework for Implementation Research (CFIR; Damschroder et al., 2022), a comprehensive framework used for identifying and addressing multilevel factors influencing implementation. Insights from these studies will guide the selection and testing of implementation strategies using the Implementation Outcomes Framework [107]. Key outcomes will include acceptability, appropriateness, implementation cost, feasibility,

representation, engagement, and organisational readiness. Findings will inform future scaling efforts and generate valuable knowledge about which strategies are most effective across different organisational contexts.

Online recruitment

To complement place-based efforts, online recruitment will be conducted via targeted social media campaigns. A range of methods will be used to target specific groups to increase the representativeness of the sample (e.g., targeting postcodes). The style and wording of advertisements is important in determining recruitment success. In line with research findings, this study will employ advertisements that [1] refer to research; include the Deakin University affiliation; refer to the compensation (as below); and are written in engaging and plain language [108]. Participants will be invited via a range of social media platforms, including Facebook and Instagram, and will be asked to contact the research team if interested in participating. Facebook advertising can be more successful at recruiting hard-to-reach populations, such as fathers, than traditional recruitment methods (Batterham, 2014; Carlini, Safioti, Rue, & Miles, 2015).

A project 'organisation' page or profile will be established on Facebook and Instagram to maintain contact with participants, affiliate organisations, and the wider public. These profiles/pages will act as a point of contact for participants and other interested individuals to find project and contact information for the study and staff. The security and privacy settings of the profiles/pages will be set up to protect participants as much as is reasonably possible, and will be monitored regularly by project staff and any content/comments deemed inappropriate or offensive will be promptly removed. A person will be blocked should they be found to be persistently posting inappropriate material. Furthermore, any participants who disclose private information or request assistance via the public forum-style page will be responded to privately by staff and their comment removed from the public page. Both paid and unpaid recruitment strategies on social media platforms will be used. Unpaid strategies will include contacting established interest groups, parenting groups, and organisations (e.g., Raising Children Network; Kids Matter), and requesting that these sites endorse our project by posting the project advertisement on their wall so that it is visible to their group members.

Participant consent process

Interested participants will download the Daily Growth app and complete registration. They will then receive a copy of the Plain Language Statement (PLS) via the Daily Growth app. After reading the PLS, participants will be asked to provide their consent. In addition, participants will be asked to consent to future research participation, however, declining this consent will not impact their participation status. Participants will be informed that they have the right to withdraw from the study at any time without consequences to their relationship with Deakin University or the researchers involved. Participants will be able to withdraw directly through the Daily Growth app or by submitting a withdrawal of consent form to the research team. Participants will be able to download the PLS at any time from the 'Settings' page of the Daily Growth app.

Sample size

Sample size for matrix factorisation or other machine learning algorithms cannot be calculated a priori as model performance depends on the strength of the signals underlying a dataset and may involve statistical interactions that are difficult to anticipate ahead of time. Instead, we demonstrate statistical power for a key comparison between in-the-moment improvement in the personalisation condition (Group 6; $n = 400$) to a control condition (e.g., Group 1; active control; estimated $n = 100$). Effective Sample Size (ESS) is used to adjust power estimates to account for clustering (ESS $= nm/[1 + [m-1]$ r; $n =$ participants, $m =$ datapoints per cluster, r $=$ within correlation). This analysis will have an ESS $= 560$ (conservative r $= 0.7$), based on 6 weeks of data collection; twice-daily surveys; an estimated 25% triggering rate for a micro-intervention (i.e., we estimate that participants will report parent/child emotion dysregulation in 25% of completed surveys); and estimating 20% attrition. Using Monte Carlo simulation (10,000 draws) in Mplus 8, this ESS provides > 80% power to detect even a very small difference between the two conditions ($d = 0.12$; $\alpha = 0.05$). This example analysis uses conditions with the smallest sample sizes, thus all of our primary analyses are powered to detect very small true effects of interest. In determining our overall sample size, we balanced two key objectives: (1) ensuring a sufficient sample for robust algorithm development, and (2) achieving adequate power for meaningful between-group comparisons. While the latter could be met with a smaller sample, the former requires a larger one. We prioritised a sample size that supports both goals, as the success of the personalisation depends on the algorithm's effectiveness.

Procedure and micro-intervention design

Across both trials, parents and carers who meet eligibility criteria and provide consent will be invited to download and register for the Daily Growth app. The app will be publicly available on the Apple App Store for iPhone devices, and Google Play for Android devices. Once registered, participants will be asked to complete a baseline

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survey via the app (15–20 min). Follow-up assessments will occur at two time-points: six weeks post survey (completed in the app) and six-month follow-up survey (via Qualtrics), both also approximately 15–20 min.

In Trial 1, after completing the baseline survey, participants will be randomly assigned to one of the five program or control groups. In both trials, parents in each of the program groups will be invited to engage with the Daily Growth app for six weeks. During this time, participants will receive twice-daily notifications on their smartphone to complete ecological momentary intervention (EMI) surveys. They will be sent two 1-min pre-EMI surveys, one in the morning (7am) and one in the evening (7 pm). Each pre-EMI survey will remain open for four hours, closing at 11am and 11 pm, respectively. If the survey is not completed within two hours, an automated reminder notification is sent (at 9am and/or 9 pm) to support program adherence. The morning and evening surveys ask participants about their own and their child's current emotions and emotion regulation, and whether they would like access to a parenting resource. If a resource is requested, participants select from a list of 30 common parenting situations and are then provided with a resource. Participants in Group 1 receive a link to the Raising Children Network (not tailored), and will not have access to any of the Daily Growth video resources. Participants in Groups 2–6 will receive a video resource specifically tailored to the parenting situation they selected. If participants have opened the link or video resource, they are then sent a notification inviting them to complete a 1-min post-EMI survey 15 min later. The post-EMI survey remains available until the next twice-daily survey notification is delivered.

Daily growth program content

Daily Growth provides in-the-moment parenting support through three distinct programs, i.e., Emotion Coaching, Active Play, and Wayapa Wuurrk. Group 2–4 parents will consistently receive only one of these programs across the six-week period. In contrast, Group 5 participants will be randomised in-the-moment to receive 1 of the 3 types of programs each time they respond in a pre-EMI survey and request a resource. Group 6 participants will also be allocated in-the-moment to receive 1 of the 3 types of programs each time they request a resource in a pre-EMI survey, but their allocation will be based on the personalisation algorithm (described below). Over the six weeks, Group 5 and 6 participants are likely to receive a combination of video resources spanning all three programs, although it is possible that they may receive videos from one, two, or all three parenting programs depending on the randomised or personalised delivery. Each program consists of 30 video resources with supportive advice

tailored to specific parenting challenges (e.g., screentime, eating challenges, not staying in bed), totalling 90 videos across the three programs. While all video resources are housed in a library within the Daily Growth app, they remain locked until accessed via the pre-EMI surveys, when a participant requests support. Each video is approximately three minutes in length, and includes both audio and subtitles.

The three Daily Growth programs emphasise core values of co-regulation, connection, creative play, nature, compassion, respect for parents' deep knowledge of their child, and community wellbeing. Each three-minute video resource combines animation, live action footage of real parents, carers and children, and expert commentary delivered via 'talking heads' with subtitles, offering practical, situation-specific guidance. Videos follow a consistent four-step structure: (1) validating parent and carer emotions, (2) explaining relevant child development concepts and milestones related to each specific parenting challenge, (3) introducing program-specific strategies, and (4) acknowledging common barriers in implementing advice and flexible options for diverse families.

Emotion Coaching

The Emotion Coaching program supports parents and carers in recognising, understanding, and responding to emotions, both their own and their child's, especially during moments of overwhelm or emotional intensity. Figure 4 illustrates the six key principles that underpin the Emotion Coaching framework. The program draws on Gottman et al.'s Meta-Emotion Theory and five essential steps of emotion coaching [49, 109], as well as concepts from the evidence-based 'Tuning in to Kids' program [67]. The five original steps include: (1) noticing and regulating their own emotions, as well as recognising their child's emotions; (2) viewing emotions as an opportunity for connection and teaching; (3) responding with empathy to their child's emotions; (4) naming and labelling of child emotions; and (5) problem-solving what may have led to the negative emotions, and limit-setting of children's behaviours. In addition to these steps, the Emotion Coaching program introduces a sixth step: reflect. This step encourages parents to pause and reflect, both individually and with their child, once everyone is calm. It supports adults to consider how they express and manage their own emotions, how they repair after conflict, and how they can model responsibility and emotional growth to their child. As described in the app, "*Kids learn to understand themselves when we talk about things later, when everyone's calm. We can problem-solve together, and role model how to share our feelings, take responsibility, and make amends for behaviour we regret.*"

Fig. 4 Screenshots of the Daily Growth Emotion Coaching Overview Diagram, Illustrating the Six Key Principles of the Program

For each of the 30 parenting situations, the Emotion Coaching video resources follow a consistent structure within the third program-specific strategies segment. Videos provide advice for parents/carers on how they might 'plan ahead' by offering concrete strategies to manage situations more smoothly. For example: "*Mealtimes look different in different families, some eat altogether, some feed kids separately. Whatever the routine, it helps to explain to kids exactly what we expect ahead of time.*" The videos also explain emotion coaching concepts in relation to child development: "*It's normal for kids to struggle at mealtimes. Young children's brains haven't developed enough to manage their emotions by themselves, so they need our support. When we show kids we notice and understand all of their emotions, it strengthens the bond between us, and shows kids that their feelings are okay.*" Each video then guides parents/carers through the six Emotion Coaching steps (outlined above), noticing their own emotions; recognising their child emotions and seeing them as opportunities for connection; responding with empathy by listening, validating, and labelling emotions; and finally, pausing to reflect together after a break.

Active Play

The Active Play program supports families to use playful movement and physical activity to strengthen parent–child connection and emotion regulation during common parenting situations. Program content was co-designed using the Design Mapping framework [96], in collaboration with a diverse group of parents and carers. Through this process, parents contributed to the development of 30 Active Play games and activities designed to help manage real-world parenting challenges while strengthening family connection and co-regulation. Each game combines movement, imaginative play, and connection, and is designed to help children to process their emotions, while offering parents/carers a simple, engaging way to co-regulate and connect with their child. As illustrated in Fig. 5, Active Play draws on twelve key principles for supporting parents and carers to use creative play, games, and physical activity with their child.

The principles underpinning Active Play are informed by research linking executive function and neurophysiological processes to effective emotion regulation [110–112]. They encourage parents to consider how different types and intensities of physical activity and movement can be purposefully used to meet the demands of
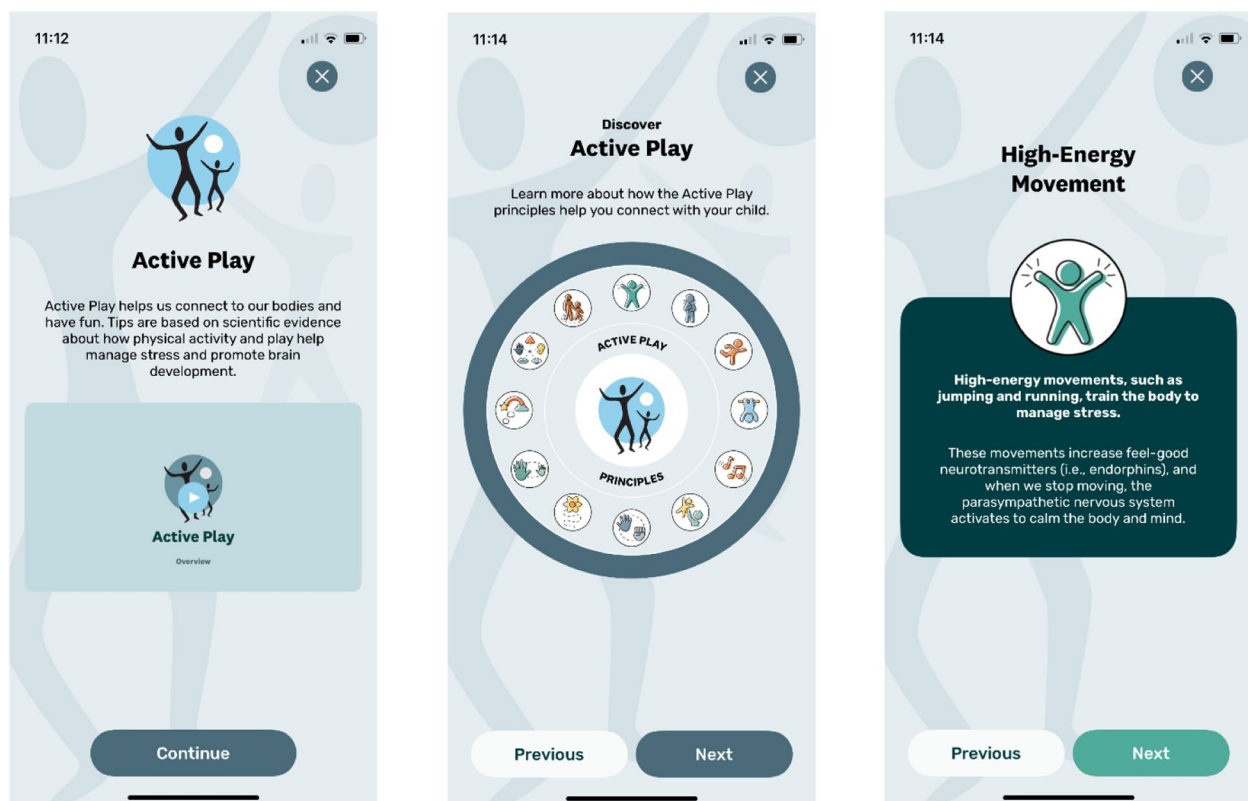
Fig. 5 Screenshots of the Daily Growth Active Play Overview Diagram, Illustrating the Twelve Key Principles of the Program

different parenting situations. For example, slow, deliberate movements combined with deep breathing can activate the parasympathetic nervous system to promote calmness, whereas high-energy activities like jumping and running can help the body practice managing arousal and stress. Reflecting this, the goals of Active Play games differ depending on the context: some are designed to help parents respond when their child is mildly dysregulated, others aim to prevent dysregulation occurring, and others focus on building skills and brain functioning that support effective emotion regulation development through repeated use.

All Active Play videos follow a consistent structure within the third program-specific strategies segment. Each video begins with a brief explanation of why movement-based play may be helpful in relation to a specific parenting situation. For example: "*It is possible to plan a relaxing game at bedtime to help manage feelings of worry or sadness at being separated, and to help kids stay in bed. The aim of Active Play here is to do a relaxing body scan with your child in bed, focusing on each part of the body and consciously relaxing it. Relaxation exercises can help us get our body and mind ready for bed, by helping us feel relaxed, and reducing symptoms of stress and anxiety.*" Next, the video introduces the specific activity

that parents/carers can try with their child: "*We can pretend our child is a caterpillar going into its cocoon, ready to wake up as a beautiful butterfly in the morning. This game uses imagination, but if you'd feel more comfortable guiding your child through a body scan without the rest of the game, that's great too. As your child gets into bed, you might introduce the game by saying… 'Come on little caterpillar, let's put you into your cocoon.'*"

The videos provide suggestions for adapting the activity to suit the child's age, interests, and developmental needs. Common barriers are acknowledged, and practical solutions are offered to ensure flexibility and reduce pressure on parents. In every video, parents/carers are reminded to consider the timing of the activity, i.e., whether it is an appropriate time to play, and when another approach might be more appropriate, such as staying close and using gentle touch when a child is very upset: "*If your child is emotional, use your judgement to decide if it's the right time to play. If they are very upset, you might need to pause and come back to play when they are feeling calmer.*" Finally, the overview video reminds parents and carers that Active Play is not intended for constant use. Parents are encouraged to prioritise their own wellbeing, and to support their child's independent play, which is also important for healthy brain development. Resources
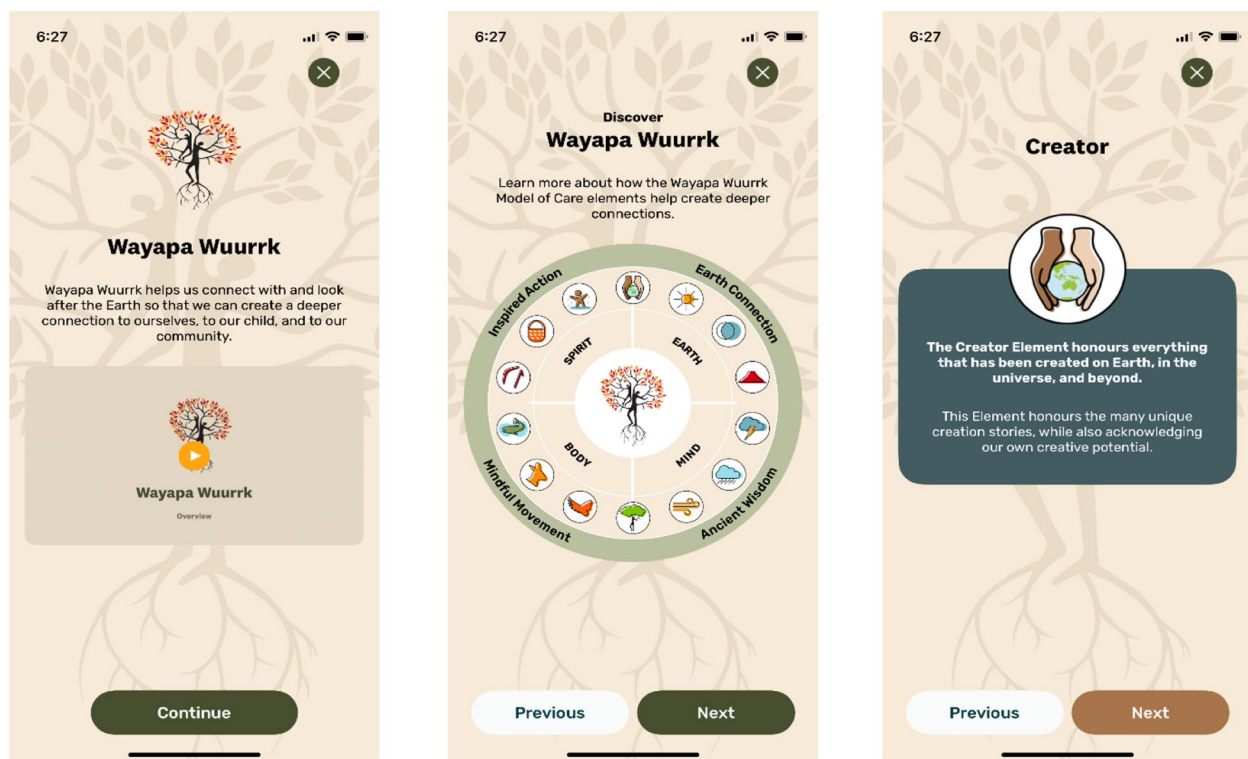
Fig. 6 Screenshots of the Daily Growth Wayapa Wuurrk Overview Diagram, Illustrating the Fourteen Elements of the Program

include supplementary information and strategies relating to child development and parenting that aim to enhance the efficacy and engagement of the games. These strategies include, but are not limited to, encouraging outdoor, creative, and child-led play; using scaffolding to help children learn by building upon existing knowledge; and adapting play-based physical activity to a child's individual routines, interests, preferences, and developmental level [61, 113–115].

Wayapa Wuurrk

Meaning 'connect to the Earth' in the languages of the Peek Whurrong People and Gunaikurnai People, respectively, Wayapa Wuurrk was co-founded by Jamie Marloo Thomas and Sara Jones in 2014 as an Indigenous Australian social enterprise and wellness practice for the world. Grounded in Earth connection and human-nature reciprocity [84], it provides a framework for wholistic wellbeing through storytelling, movement, and Earth-mindfulness. The Daily Growth Wayapa Wuurrk videos were co-designed by a working group with input from a larger 'Wayapa Wisdom Circle' of Wayapa practitioners, including First Nations practitioners [84]. Central to Wayapa Wuurrk is the belief that individual and collective health are interwoven with the health of Country. Fourteen elements are used to communicate

foundational concepts through metaphor and narrative storytelling [116, 117], supported through visual iconography arranged in a circular framework (Fig. 6). Drawing on Wayapa principles, the videos encourage parents and children to reconnect with the natural world, using environmental metaphors to reflect different phases of child development—mirroring Indigenous research methodologies that emphasise learning from Country [118].

Within the program-specific strategies segment, Wayapa Wuurrk videos draw on a flexible set of components, with each video incorporating a tailored combination based on the parenting situation. The Wayapa videos validate the emotional complexity of parenting without blame, offering nature-based wisdom and strength-based support that recognises parents are doing their best. Wayapa offers unique language and practices that promote parent–child harmony, encouraging compassion and emotional reconnection through Earth mindfulness, tailored to the diverse realities of family life. Videos also include wisdom statements that connect the parenting situation to one of the 14 Wayapa elements (e.g., "*The Wayapa Air Element reminds us to view our child's behaviour from a different perspective, a birds eye view.*") Many videos also encourage the use of storytelling to engage children and support transitions, such as: "*When we look*

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outside, we see that the stars and the moon are in the sky. The sun is going to bed and so should we."

App platform

A smartphone app for iOS and Android will be used to provide parents with access to the Daily Growth parenting program. The app has been built by Deakin University's Applied Artificial Intelligence Initiative using their existing research platform (Conductor) software development kit. Study data will be collected and managed using the Conductor platform, hosted on the Google Cloud platform (data centre located in NSW, Australia). Conductor is a secure, web-based application designed to orchestrate and support data capture for digital research studies. Conductor provides benefits for the longitudinal collection of data by providing a well-designed platform for distributing surveys and interventions, and data management. Participants can self-register through the app after completing the consent and eligibility criteria screening, which verifies their location is within Victoria, Australia, and that they are a carer of a 2–5-year-old child who is not yet in primary school education. Participants are sent a Time-based One-Time Password (TOTP) to sign-in to the app. Participants interact with the app by completing surveys, and watching and favouriting video resources (non-control group). All associated data, including survey responses and app interaction events, are stored on the platform.

Randomisation methods

Participant allocation to trial groups will be implemented via the Conductor platform using a computer-generated randomised block algorithm, independent of researcher involvement. The allocation sequence will be embedded within the platform and remain inaccessible to the research team. Members of the research team will be blinded to group assignment. Trial 1 Groups 1–5 will be allocated across two recruitment phases. Allocation will occur only after baseline survey completion. In Phase 1 (25% of the sample), participants will be randomised within 30 blocks of 17, each with the following allocation: 3× Group 1; 1× Group 2; 1× Group 3; 1× Group 4; 11 ×Group 5. In Phase 2 (remaining 75%), participants will be randomised within 90 blocks of 15, with the same proportional allocation. Blocks in both phases will be filled sequentially. Once all allocations in a block are filled, participants will be randomly allocated to a group in the next block until the sample is recruited in each phase. To enable comparison of recruitment strategies, 50 additional Group 1 participants will be recruited in Phase 1 to achieve an equal sample size between Group 1 participants in Phase 1 and Phase 2.

Group 5 participants will also be randomised each time they request a video resource via a pre-EMI survey. At each request, they will be allocated one of the three parenting programs (Emotion Coaching, Active Play, or Wayapa Wuurrk). Repetition is possible, meaning participants may receive the same program or video in succession.

Daily Growth app user experience flow

On downloading the Daily Growth app, participants are presented with a welcome screen and a short video introducing them to the Daily Growth study and what they can expect from their participation (see Fig. 7), followed by a consent screen outlining what their participation entails, with a link to the Plain Language Statement (PLS). Once participants have read the PLS and provided consent, they are asked to provide one-time access to location data on their smartphone to confirm they are living in Victoria, Australia.

To finalise registration, participants create a profile using their name and email address, enter an emailed one-time 6-digit code, and are asked to allow push notifications on their smartphone. The Daily Growth app provides participants with a 'Daily Tasks' tile on their home screen to remind them of any tasks that are yet to be completed (Fig. 7). For example, participants can see if there is any of the baseline survey they still need to complete, whether there are any daily surveys available to them, or if they are due to complete the post or follow-up surveys. Participants in Groups 2–6 have access to a library with videos unlocked via their completed pre-EMI surveys (Fig. 8). Participants also have ongoing access to 'Support' and 'Settings' sections (Fig. 8). The Support section will link participants to external support services, as well as provide answers to a set of Frequently Asked Questions. The Settings section allows participants to view their details, contact the research team, and view information related to the study, such as the PLS or consent form.

Participant reimbursement

To further support adherence, participants will be provided with supermarket gift vouchers as reimbursement for their time at the two-week ($25), six-week ($40 or $75), and six months post survey ($15) timepoints. To receive the $25 voucher, participants must have completed the baseline survey, and at least 11 out of 28 pre-EMI surveys sent in the first two weeks of the study. To receive the $40 voucher, participants must have completed the baseline survey, the post survey, and 21–41 pre-EMI surveys sent during the six-week study period, out of 84 pre-EMI surveys in total. To receive the $75 voucher, participants must have completed the baseline
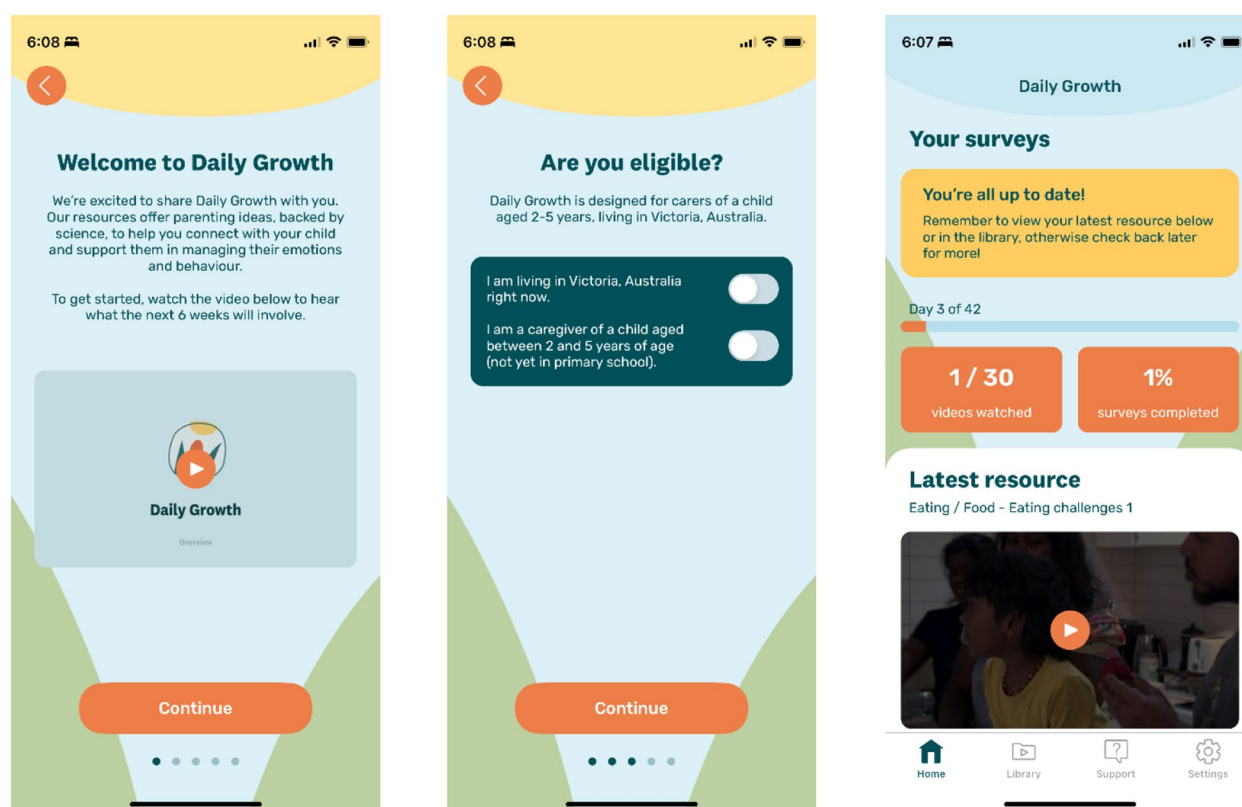
Fig. 7 Screenshots of the Daily Growth App Showing the 'Welcome' Screen, 'Eligibility' Screen, and 'Home' Screen

survey, the post survey, and 42 or more pre-EMI surveys sent during the six-week study period, out of 84 pre-EMI surveys in total. To receive the $15 voucher, participants must have completed the baseline and follow-up surveys. Participants will therefore receive vouchers totalling up to $115 should they fulfill the criteria for all timepoints. Participants are reminded to complete the surveys via push notifications to their device, infrequent emails, and SMS messages if they provided their mobile number during registration. Recruitment documents (advertisements and PLS) will inform participants of the compensation for all recruitment avenues in the trial, with one exception. Where recruiting through early childhood centres (kindergartens, childcare centres etc), separate recruitment materials (advertisements and PLS) will be used that do not mention compensation, in accordance with requirements of the Victorian Department of Education ethics body. However, participants recruited through these centres will remain eligible to receive the same compensation as all other participants.

Measures
Baseline, post, and follow-up surveys
Participants will be asked to complete a 20-minute baseline survey at the beginning of their participation.

At the completion of the six-week period, they will be asked to complete a 20-minute post survey, and then a 20-minute follow-up survey six months after program completion. Primary and secondary outcomes for the baseline, post, and follow-up surveys are described in detail in Table 1. The baseline, post, and follow-up surveys will assess parent and child emotion regulation as the primary outcome via the Early Emotion Regulation Behaviour Questionnaire (child emotion regulation, 18 items) and the Difficulties in Emotion Regulation Scale (parent emotion regulation, 8 items). The baseline, post, and follow-up surveys will assess a range of secondary outcomes, including child behaviour problems, child mental health and positive/negative affect, parent stress and mental health, emotion-related parenting and beliefs, mindful parenting, parenting using child-led play, physical activity, and connection to nature, family functioning, inter-parental conflict, shared book reading, social support, and parental reflective functioning.

Implementation outcomes
Implementation success will be evaluated using four key outcomes from the Implementation Outcomes Framework (IOF; [107]): including acceptability, appropriateness, cost, and feasibility. Additionally, organisational
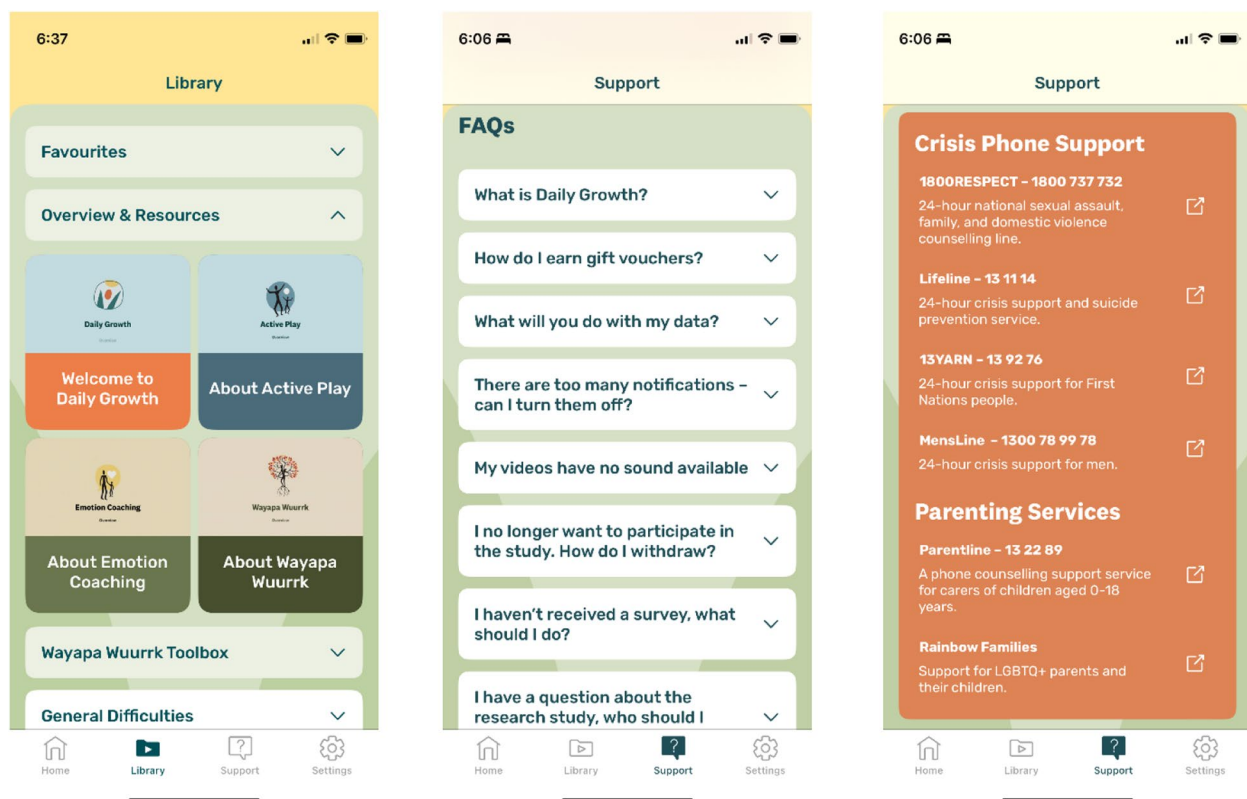
Fig. 8 Screenshots of the Daily Growth App Showing 'Library' and 'Support' Screens

readiness, representation, and engagement will be assessed to allow for a more nuanced evaluation of implementation success. Acceptability is defined as the perceived satisfaction with the app and will be measured via the Acceptability of Intervention Measure (AIM; [119]). Appropriateness is defined as the perceived compatibility of the program with a given organisation and will be assessed via the Intervention Appropriateness Measure (IAM; [119]). Cost is defined as the costs associated with implementation and applied strategies, tracked via expense records. Feasibility is defined as the extent to which the Daily Growth app can be successfully implemented within a given organisation and will be assessed via the Feasibility of Intervention Measure (FIM; 119). Organisational readiness is defined as the extent to which an organisation is both willing and able to implement a program and will be measured using the Organisational Readiness for Implementing Change (ORIC) measure [120]. Representation includes the extent to which participants reflect the diversity of the Australian population (e.g. socioeconomic status, ethnicity, gender, geographical location) and can be evaluated through comparing participant demographic characteristics (as assessed via the baseline survey) with population data.

User engagement and uptake outcomes

Participant app usage data will be collected, including app usage time, pre to post change on the 1-min pre-EMI and post-EMI surveys associated with each program resource, survey completion and video playback metadata, and the number of times each video micro-intervention is marked as a favourite.

1-min Pre-EMI and Post-EMI surveys

Across the six weeks, participants will be prompted to complete a 1-min pre-EMI survey twice a day and will also be prompted to complete a 1-min post-EMI survey if they choose to receive a parenting resource. Items for both of these surveys are presented in Table 2. The pre-EMI survey consists of:

- One item asking about in-the-moment participant emotion regulation;
- One item asking about participant emotion regulation in the previous hour (conditional on the response to the previous item);
- One item asking about the participant's difficulty in managing their child in the moment;

Table 1 Summary of Assessment Domains for the Baseline, Post, and Follow-Up Surveys

Domain/Construct	Measure (*N* Total Items) (measure citation)	Timepoint	Subscale/s (*n* Items)	Example Item	Scale/Response Options
Parent/family/child demographic characteristics	Designed by research team (32) (NA)	Baseline survey; Post surveys (6 weeks/6 months)	NA	What is your age?	Open textbox Yes; No Categorical response options
Child emotion regulation	Early Emotion Regulation Behaviour Questionnaire (18) [127]	Baseline survey; Post surveys (6 weeks/6 months)	Emotional reactivity (6); Verbal help-seeking (2); Physical venting (3); Mindfulness (3); Verbal venting (3); Physical help-seeking (1)	My child has strong emotional reactions If my child is angry because they want to continue screen time (e.g., TV, tablet, phone), but it is time to turn it off, they would: *Say how frustrated or angry they are currently feeling*	1 (Strongly disagree) – 7 (Strongly agree) [Emotional reactivity items] 1 (Very unlikely)—7 (Very likely)
Parent emotion regulation	Difficulties in Emotion Regulation Scale-16 (8) [128]	Baseline survey; Post surveys (6 weeks/6 months)	Difficulties Engaging in Goal-Directed Behavior (3); Impulse Control Difficulties (5);	When I am upset, I have difficulty focusing on other things	1 (Almost never)—5 (Almost always
Child behaviour problems	Multidimensional Assessment of Pre-school Disruptive Behaviour (10) [129]	Baseline survey; Post surveys (6 weeks/6 months)	Temper loss (3); Noncompliance (4); Aggression (3)	How often over the past month did your child… *Hit, shove, or kick you or another parent/adult?*	0 (Never in the past month)—5 (Many times each day)
Child depression	Short Mood and Feelings Questionnaire – Parent Report Version (1) [130]	Baseline survey; Post surveys (6 weeks/6 months)	NA	Please indicate how your child has been feeling or acting in the past two weeks: *Your child cried a lot*	0 (Not true)—2 (True)
Child negative affect	Shortened Positive and Negative Affect Schedule for Children-Parent Version (2) [131]	Baseline survey; Post surveys (6 weeks/6 months)	Negative Affect (2)	Thinking about your child and how they normally feel, to what extent does your child generally feel: *Sad*	1 (Very slightly or not at all)—5 Extremely)
Parent psychological distress	Kessler-6 (6) [132]	Baseline survey; Post surveys (6 weeks/6 months)	Psychological distress (6)	Thinking about yourself in the past four weeks, about how often did you feel… *Nervous?*	0 (None of the time)—4 (All of the time)
Parent stress	Depression Anxiety Stress Scales-21 (7) [133]	Baseline survey; Post surveys (6 weeks/6 months)	Stress (7)	I found it hard to wind down	0 (Did not apply to me at all)—3 (Applied to me very much, or most of the time)
Mindful parenting	Interpersonal Mindfulness in Parenting scale (3) [134]	Baseline survey; Post surveys (6 weeks/6 months)	NA	When I'm upset with my child, I notice how I am feeling	1 (Almost never)—5 (Almost always
Emotion-related parenting practices	Emotion-focused parenting items (3) [135]	Baseline survey; Post surveys (6 weeks/6 months)	NA	I connect with my child and provide comfort and support	1 (Almost never)—5 (Almost always)

Table 1 (continued)

Domain/ Construct	Measure (*N* Total Items) (measure citation)	Timepoint	Subscale/s (*n* Items)	Example Item	Scale/Response Options
Emotion-related parenting practices	Modified version of the Short-Form Coping with Toddlers' Negative Emotions Scale (18) (King et al., 2025)	Baseline survey; Post surveys (6 weeks/6 months)	Empathy (3); Emotion Labelling (3); Problem-Focused Responses (3); Distress Reactions (3); Minimization Reactions (3); Punitive Reactions (3);	If my child becomes angry because they are not allowed to have a snack (i.e., candy, ice cream) when they want it, I would: Acknowledge that they want the snack	1 (Very unlikely)—7 (Very likely)
Inter-parental conflict	Inter-Parental Conflict (4) [136]	Baseline survey; Post surveys (6 weeks/6 months)	Verbal inter-parental conflict (4)	How often do you and your partner disagree about child-rearing issues?	0 (Never)—4 (Always)
Parent reflective functioning	Parental Reflective Functioning Questionnaire (9) [137]	Baseline survey; Post surveys (6 weeks/6 months)	Interest and Curiosity in Mental States (4); Pre-Mentalising Modes (5)	I try to see situations through the eyes of my child	1 (Strongly disagree)—7 (Strongly agree)
Parent beliefs about child emotions	Parents' Beliefs about Children's Emotions questionnaire (15) [138]	Baseline survey; Post surveys (6 weeks/6 months)	Value of Anger (3); Manipulation (3); Control (3); Autonomy (3); Stability (3)	It's usually best to let a child work through their negative feelings on their own	1 (Strongly disagree)—6 (Strongly agree)
Social support	Social support (1) [139]	Baseline survey; Post surveys (6 weeks/6 months)	NA	Overall, how do you feel about the amount of support or help you get from family or friends living elsewhere?	1 (I get enough help/I don't need any help)—3 (I don't get any help at all)
Home learning environment	Shared book reading (1) [140]	Baseline survey; Post surveys (6 weeks/6 months)	NA	In a typical week, how often do you read books to your child?	0 (Not at all)—3 (Every day)
Active Play parenting	Adapted/designed by research team (6) (NA)	Baseline survey; Post surveys (6 weeks/6 months)	NA	How often do you use the following to prevent or manage your child's difficult emotions? *Rough and tumble play*	1 (Almost never)—5 (Almost always
Wayapa Wuurrk parenting	Adapted/designed by research team (6) (NA)	Baseline survey; Post surveys (6 weeks/6 months)	NA	I take notice of the natural world around me wherever I am	1 (Strongly disagree)—7 (Strongly agree)
Connection to nature	Adapted/designed by research team (2) (NA)	Baseline survey; Post surveys (6 weeks/6 months)	NA	How much does nature overlap with your sense of self?	1 (Self and nature are separate)—5 (Self and nature are one)
User Satisfaction/Program Engagement	Adapted/designed by research team (22) (NA)	Post surveys (6 weeks)	NA	The Daily Growth app was easy to use	1 (Strongly disagree)—7 (Strongly agree) Categorical response options Open textbox
Parent emotion regulation	Adapted/designed by research team (3) (NA)	Daily EMA items (pre items)	NA	How upset do you feel right now?	0 (Not at all)—5 (Extremely)
Parenting resource	Adapted/designed by research team (1) (NA)	Daily EMA items (pre items)	NA	Would you like a resource?	Yes—for a parenting challenge right now; Yes—for future parenting challenges; No—not needed; No—too busy

Table 1 (continued)

Domain/ Construct	Measure (*N* Total Items) (measure citation)	Timepoint	Subscale/s (*n* Items)	Example Item	Scale/Response Options
Parenting situation	Adapted/designed by research team (1) (NA)	Daily EMA items (pre items)	NA	Select a recent parenting challenge, or one you're interested in learning about	Eating/Food; Morning/Evening Routine; Siblings/Peers; Car/Road/Safety; Clingy/Resistant; Screen Time; Dressing
Parent emotion regulation	Adapted/designed by research team (1) (NA)	Daily EMA items (post items)	NA	How upset do you feel right now?	0 (Not at all)—5 (Extremely)
Parent co-regulation of children's emotions	Adapted/designed by research team (1) (NA)	Daily EMA items (post items)	NA	Is it difficult managing your child's emotions and behaviour right now?	0 (Not at all)—5 (Extremely)
Parenting resource	Adapted/designed by research team (1) (NA)	Daily EMA items (post items)	NA	Did you find this resource useful?	0 (Not at all)—5 (Extremely)
Program Engagement	Adapted/designed by research team (3) (NA)	Weekly EMA items (pre items)	NA	How helpful were the ideas?	0 (Not at all)—5 (Extremely) Yes; No Categorical response options

NA Not applicable

Table 2 Summary of Items in the 1-min Pre-EMI and Post-EMI Surveys

Domain/Construct (*N* items)	Item/Example Item	Scale/Response Options
Pre-EMI Survey		
Parent Emotion Regulation (3)	How upset do you feel right now?	0 (Not at all)—5 (Extremely)
Parenting Situation (3)	Select a recent parenting challenge, or one you're interested in learning about	Six categories (if selected, a further drop-down menu is shown offering a further 2-5 specific situations): Eating/Food; Morning/Evening Routine; Siblings/Peers; Car/Road/Safety; Clingy/Resistant; Screen Time; Dressing
Weekly Items		
Program Engagement (2)	Have you tried using ideas from the resources this week?	Yes; No
Post-EMI Survey[1]		
User Satisfaction (1)	Did you find this resource useful?	0 (Not at all)—5 (Extremely)

[1] The post-EMI survey was completed by participants who requested a parenting resource

- One item asking whether the participant would like to receive a parenting resource;
- One item asking about a recent parenting challenge (conditional on requesting a parenting resource); and
- Two items asking whether the participant had implemented any of the resources over the previous week (asked weekly).

The post-EMI survey consists of:

- One item asking about the usefulness of the parenting resource
- One item asking about in-the-moment participant emotion regulation
- One item asking about the participant's difficulty in managing their child in the moment

Developing a personalisation algorithm for daily growth

The Daily Growth personalisation algorithm will be developed using data from Trial 1, including parent demographics and baseline parenting skills; parent app behaviour (e.g., ratings and completion times); contextual factors (e.g., time of day, stage, and type of program); and 'priors' informed by literature and pilot data. The data collected will enable the algorithm to learn patterns and make personalised recommendations. For the personalised version of Daily Growth (Trial 2), the timing and combination of micro-interventions received by each participant over six weeks will vary depending on the algorithm. The goal of the personalisation is to enhance the benefits of Daily Growth, by ensuring the micro-interventions received by each participant are relevant and meaningful to them.

The first step of analysis will be examining and cleaning Trial 1, Group 5 data to check for outliers and missing data. The analysis will prioritise critical data points, particularly the baseline and final data collected after the six-week program given that these data points are essential for evaluating the outcomes of the study. The extent of data completeness will be assessed by evaluating the number of participants who have completed data collection across the six-week program period. The handling of missing data will involve reviewing several methodologies to identify the most suitable approach for the project. If only a small number of participants and observations have missing data (< 5%), we may not impute. Depending on the extent of missing data, we will consider a range of imputation techniques, from statistical methods such as moving averages to machine learning approaches such as Random Forest. Sensitivity analyses will be used to evaluate robustness of results to assumptions about reasons for missing, conducted through pattern mixture modelling. With multiple imputation, we will use all available variables and fully conditional specification for multiple imputation. Inclusion of all available variables increases chances that imputation requirement for missing at random is satisfied.

To further explore the data, univariate and multivariate analyses will be performed. We will analyse the distribution of the variables (e.g., using qq plots) and analyse differences among the groups (e.g., using ANOVA or its non-parametric equivalent). We will perform multivariate analyses using clustering and subsequently develop the recommender system using the following steps: (1) training, (2) optimisation and validation, and (3) testing. We will use different subsamples for each step with a relative proportion of 50/20/30 or 60/10/30, depending on total sample size. The selection of an appropriate machine learning based recommendation algorithm will be guided by empirical evidence from the literature, including studies applying machine learning algorithms in mental health with non-parenting samples [121–125], and the specific context needs of the project. The right algorithm is a context-dependent matter, and cannot be ascertained pre-data collection. Accordingly, once a set of potential algorithms relevant to the present context is identified and adapted to the current problem, further analysis will be conducted to assess the effectiveness and feasibility of these algorithms within the constraints of the project.

As the project progresses, further refinements and adaptations may be necessary based on the data collected and the performance of the algorithms in real-world testing. In cases where multiple algorithms show similar performance, the selection will also consider the relative simplicity of the algorithms. If performance is comparable, preference will be given to the simpler algorithm, as this can facilitate easier deployment and better explainability. Baseline and post-treatment data will then be analysed via a series of mixed effects regression models with the time (baseline, post-treatment) by program type (Emotion Coaching; Wayapa Wuurrk; Active Play) interaction, and adjusting for clustering of observations within parents over time.

Testing the implementation of the personalisation algorithm in Daily Growth

Once patterns within the data have been learned, predictions from the trained algorithm will be evaluated in a 'hold-out' dataset from the Trial 1, Group 5. We will then implement the algorithm in Trial 2, Group 6 (*n* =400). The response data for parents who receive the personalised version of Daily Growth will be compared to the response data for parents in Group 5 who received the non-personalised version of Daily Growth. This will involve a newly recruited sample of 400 parents in Trial 2, Group 6. All aspects of the trial will be identical to Trial 1, but instead of participants being randomised in-the-moment to one of three types of tailored parenting support programs, the personalisation algorithm will allocate participants each time they request a parenting micro-intervention. It is expected that there will be variation in the combination of parenting support received by each parent over the six-week period, with some parents receiving a mix of all three types, while others may receive combinations of one or two types.

The study will evaluate the implementation process by comparing participants who received randomised support to participants receiving personalisation support, in terms of: (1) parent and child outcomes in-the-moment after receiving the micro-intervention; (2) parent and child outcomes at 6-weeks post and 6-months follow-up

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assessments; and (3) parent satisfaction at 6-weeks post and 6-months follow-up assessments; and (4) process data comparing engagement and usage (i.e., data on user interaction, completion rates, and feedback, such as the use of 'favourites') over the 6-week program period. Baseline and post-treatment data will be analysed using linear mixed effects regression models with the time (baseline, post-treatment) by group (Group A and B) interaction and adjusting for clustering of observations within parents over time.

Statistical analysis

Analyses will be conducted in Stata using an intention-to-treat approach. For Trial 1, we will run a series of models comparing outcomes in the active control group (Group 1) with each of the other groups: Group 2 (Emotion Coaching), Group 3 (Active Play), Group 4 (Wayapa Wuurrk) and Group 5 (non-personalised random combination). For Trial 2, we will compare outcomes in the fully personalised app (Group 6) with each of the other groups from Trial 1 (Groups 1–5) separately.

To assess longer-term outcomes, we will use multilevel mixed-effects linear regression with post-intervention scores (6-week and 6-month) as dependent variables. Primary outcome variables will include parent emotion regulation and emotion-focussed parenting, and secondary outcomes will include child emotion regulation, parent and child mental health, and family functioning. Separate models will be run for each outcome. Fixed effects will include group (Groups 1–6), time (6-week and 6-month), and a group × time interaction. Random intercepts for participants will account for repeated measures. This modelling approach will enable us to test whether changes in outcomes over time differ by group. For Trial 1, comparisons will focus on the active control group (Group 1) relative to each of the other conditions (Groups 2–5). For Trial 2, comparisons will focus on the personalised group (Group 6) relative to each of the other conditions (Groups 1–5). Results will be reported with effect sizes and 95% confidence intervals. Sensitivity analyses will be conducted using multiple imputation under missing at random assumptions and reference-based imputation to assess robustness to different missing data mechanisms [126].

To assess immediate in-the-moment effects (EMI outcomes), we will use multilevel mixed-effects linear regression to account for repeated observations nested within participants. Separate models will be run for each outcome, with post-EMI emotion (*How upset do you feel right now*) and regulation (*Is it difficult managing your child's emotions and behaviour right now*) scores as the dependent variables. Fixed effects will be condition (Groups 1–6), timepoint (pre vs post), and the condition x timepoint interaction. Random intercepts and random slopes for time will be included to account for individual variation in both baseline levels and change over time. The interaction term will be used to test whether changes from pre- to post-EMI differ across conditions. Covariates, such as continuous time (i.e., day in the trial) and non-prompted app usage, will be added in a second step to evaluate their influence on estimates.

Data management

Study data will be collected and managed using the Conductor platform, hosted on the Google Cloud platform (data centre located in NSW, Australia). Data will be downloaded from the Conductor platform on a monthly basis and stored on Deakin University's servers in a password-protected folder. As part of the consent process, participants will be consenting to their information from the current study being stored indefinitely for the purposes of data sharing, i.e., archival in a public data repository, such as the Open Science Framework and the Australian Data Archive (to promote open science/transparency of the research project). Data that are shared will be de-identified. Separately, participants will be invited to provide optional consent to be contacted for future research, such as further follow up beyond 6 months should additional studies be developed. The PLS will inform participants that they will be sent details about any future research they are invited to participate in, with no obligation on their part. Any new studies will be subject to a new ethics application.

At the conclusion of the research study, recruitment materials, the project landing page, and online survey materials used in the study will be deactivated or removed. All data will remain securely stored on Deakin University servers. Information collected as part of this research project involves children who are under 18 years old. In line with Deakin University's research data management procedure for data from research involving minors, participant data will be kept for 15 years after a child reaches adulthood (18 years of age), i.e., until the youngest reference child reaches the age of 33 years. At any time during or after data collection, participants are able to request to be withdrawn from the study. They can request to be withdrawn from the app only, which retains participant data on Conductor; or they can request withdrawal by completing the Plain Language Statement withdrawal section in which participants can request that all their data to be removed.

Data monitoring

A formal Data Monitoring Committee has not been convened for this trial due to the scale of the study, resource constraints, and the low-risk nature of the Daily Growth

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intervention, meaning adverse events are not anticipated to be severe or frequent. To ensure appropriate oversight, the trial will instead be monitored by a Trial Management Group, comprising senior investigators and relevant stakeholders. This group will meet monthly to review study progress, monitor data integrity, and make decisions regarding any necessary protocol amendments.

Dissemination of outcomes

A number of methods of dissemination will be undertaken including academic and popular media outlets. Two main papers are planned: (1) describing the machine learning architecture that fuels our innovative approach; and (2) primary outcome paper. In addition, the results from this study will be published in peer-reviewed journals, The Conversation, online data visualisations, and presented at academic conferences. A plain language summary of results from the study will be made available to participants upon request. Participants are advised of the process to request a plain language summary of the results in the Plain Language Statement.

Access to data

The data custodian of the trial will be Principal Investigator of Daily Growth (Elizabeth Westrupp).

Ancillary and post-trial care

No adverse events are anticipated due to the non-invasive nature of the support offered, thus the provision of compensation will not be required. However, contact information for mental health support services has been included in the Daily Growth app to provide assistance should participants experience any distress during the study.

Data collection progress

Data collection for Trial commenced in December 2024. At the time of submission, 109 participants have completed the app registration, of which 65 have completed the baseline surveys and been allocated to a group. Place-based recruitment began in December 2024 and is ongoing. Online recruitment is scheduled to launch in July 2025. Recruitment for Trial 1 is expected to be completed by December 2026, with Trial 2 recruitment anticipated to conclude by July 2027.

Discussion

Children's emotion regulation is a critical protective factor for child development and long-term mental health outcomes [2, 14–17]. Parents play a central role in supporting the development of these skills [3, 141], yet access to effective, early universal parenting support remains limited, particularly among underserved communities [4, 52]. Access to parenting support via smartphone devices provides researchers and clinicians a unique opportunity to deliver population-level support in a format that is accessible to a large number of parents and carers in the community [41].This protocol outlines two sequential trials evaluating the Daily Growth app, which contains three co-designed innovative parenting programs, delivered as brief, in-the-moment support through ecological momentary interventions (EMIs). Daily Growth integrates programs theorised to impact child emotion regulation through teaching parents skills in Emotion Coaching, using Active Play, and Wayapa Wuurrk earth -based Indigenous mindfulness and wellbeing activities. The first trial will assess the effectiveness of Daily Growth compared to an active control or single-program support, while the second will test a machine learning system for personalising program delivery based on real-time and baseline data. By embedding personalisation and flexibility into a universally accessible platform, Daily Growth aims to address major barriers to engagement and inclusivity in early parenting support. This study will contribute valuable insights into the feasibility, acceptability, and impact of delivering personalised, real-time parenting programs at scale, and inform future directions for early mental health prevention efforts.

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Declarations

Ethics approval and consent to participate
The Daily Growth project has received ethics approval from the Deakin University Human Research Ethics Committee (2024–050), and the Victorian Department of Education's ethics committee (24–11-488).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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