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A Smart System Facilitating Emotional Regulation in Neurodivergent Children

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Abstract

This paper acknowledges the need for a user-centric solution that helps with emotional regulation and stress management in children with ADHD. The paper presents a unique and comprehensive solution that integrates Reinforcement Learning (RL) algorithms to enhance user experience and aid children with ADHD to regulate their emotions and behaviours through a reward-based system. Through careful analysis of existing literature, and user requirements assessment, a comprehensive framework that integrates machine learning algorithms, physical and digital solution components through a user-centric design approach has been proposed. The core objective is to design and develop a sensory regulation system specifically tailored to the requirements of children with ADHD. Through the development of an engaging and impactful sensory regulation system, children can experience social and academic aspects of school positively while also having the opportunity to expand their social circle through inclusive play environments and ultimately improving their daily experiences. This paper aims to address the imminent need for emotional regulation and stress management tools catering to children with ADHD. By incorporating Reinforcement Learning (RL) algorithms with a reward-based interaction, this paper aims to solve critical challenges faced by children with ADHD, like emotional regulation difficulties, stress management, poor social skills, and academic performance issues so that they can lead more holistic lives.

Keywords: *ADHD, children; Reinforcement learnin; fidget toy; emotional regulation; neurodivergence; reward system*

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1. Introduction

Neurodivergent disorders encompass a range of developmental disorders typically recognisable early on in childhood. One of the most frequent mental disorders affecting children is Attention-deficit/hyperactivity disorder (ADHD). Inattention, hyperactivity, and impulsivity are the most common symptoms [1]. ADHD appears to affect boys more than girls [2]. ADHD prevalence varies significantly over the world, ranging from 1% to nearly 20% [3], depending on the diagnostic criteria and evaluation procedures used [4]. ADHD prevalence was reported to be 6.34% (13/205) in a survey of 205 (117 boys and the rest female) children aged 6 to 12 years old in North India. Males were found to have a higher prevalance of ADHD (76.9%) than females (23.1%) [5]. As a result, this percentage corresponds to the global figures mentioned above, demonstrating a significant impact on the paediatric population. Furthermore, comorbid diseases and learning disabilities are usually connected with ADHD [2]. ADHD can be identified as early as preschool years and early elementary school years [5]. Thus, it can be deduced that these children have numerous challenges in school and educational settings, in terms of both social life and learning. ADHD, while being a widespread problem, went undiagnosed for a long time in India, where awareness of mental disorders and illness is poor. Previous Indian studies suggested that 11 - 12% of children with ADHD were labelled as "dullard" or "difficult" in the past [6,7,8]. As a result, many children who exhibit the typical symptoms of hyperactivity, impulsivity, and inattention [1] are frequently dismissed as misbehaving. According to research, young people with ADHD and their parents may endure stigma, stereotypical comments, and discriminatory behaviour, all of which have a negative impact on the child's self-confidence and treatment. However, coverage of these issues on social media platforms, in the newspaper, and in other news outlets has improved awareness among the Indian populace. However, mental cognizance is still very low in non-metropolitan states, and there are many misconceptions concerning the condition [9].

As previously stated, children with ADHD frequently struggle with learning [2]. Short attention spans, poor initiative, emotional and social maladjustments are among the key features presented by people with intellectual disabilities [10,11]. As a result, it represents the need for regulation, the most important of which is emotional regulation. Emotional control is important in cognitive development and relates to social, behavioural, and academic competence [12,13]. Playtime can be incredibly beneficial to children's skill development and emotional management. Children can actively participate in their world experiences through play, making decisions, attempting problem solving, and developing autonomy, creativity, and self-regulation [14]. For the sake of this study, fine-motor play is one of the five established kinds of play. Fine-motor play refers to a variety of activities that help young children develop their fine-motor hand and finger co-ordination skills. Due to their captivating nature, these pastimes are often solitary and can help children improve their attention and perseverance [15].

Tactile stimulation of various forms has been shown to improve on-task behaviour in children with attention problems [16]. Research with three fifth-grade children looked at the utility of vibrating beepers that beeped every three minutes. While wearing the beeper, the youngsters demonstrated a considerable improvement in on-task behaviour. This demonstrates the significant potential of fidget toys in educational settings if they are designed to be effective [17]. Some occupational therapists believe that a "sensory diet" is useful for children with ADHD. A sensory diet is a combination of activities designed to provide a child with numerous forms of sensory input (vestibular, proprioceptive, and tactile) at various times of the day to help with sensory system balance [18].

The objective of this paper is to design and develop a sensory regulation system specifically tailored to the requirements of children with ADHD. As discussed, there is a need for sensory regulation amongst these children in order to ease their experience of school and affect their learning experience in a positive way. The basis of this research is that every child, despite their limitations and differences deserves a fair and exemplary school life, both in terms of education and social life. Their formative years are so crucial in shaping the rest of their lives. Addressing the problems faced by ADHD children requires an iterative design approach that includes both a physical and digital aspect to have a comprehensive solution. Designing a system while incorporating smart inclusion of technology, gamification catering to their specific needs, can ease their symptoms and ultimately give them a chance to experience school positively and interact with their peers and form deep, meaningful connections.

This paper is divided into 6 sections. Section 2 discusses the related works in this field and highlights the research gap. Next, Section 3 describes the methodology employed for designing a smart system for emotional regulation. Section 4 conducts a qualitative and quantitative analysis with the target audience to cumulate product requirements and finalise the product. It also the discusses the design intervention in detail, and includes an in-depth user testing phase and analysis. Thereafter, stakeholder analysis, scope and limitations of the project are discussed in section 5. Finally, section 6 ultimately brings the paper to conclusion.

2. Related works

To understand and review previous studies in this field, a literature survey is conducted. The insights from prominent studies have been discussed in this section. Many different assistive technologies have been shown to increase a child's knowledge and skills when they live with challenges such as ADHD [19]. The issue in designing these devices to help children with ADHD is keeping both younger and older children or teens engaged [20]. CoolCraig [21] is a technology that is being developed to help children with ADHD engage in activities that promote emotional co-regulation and self-regulation. It is comprised of of smartwatches and a smartphone app. To assess the child's emotional state, the system applies the "Regulation Zones" technique, and the token economy strategy is used to reward goals [22]. Additionally, caretakers use the application. The smart watches have a display screen that shows the user their goals and, when necessary, recommends coping solutions. It also keeps track of the user's completed goals, regulation zones throughout the day, and awards collected. However, more testing and implementation are required to determine its efficacy in assisting with emotional control in children with ADHD [22]. A study was conducted on self-regulation in people with developmental difficulties. It included ASD (Autistic Spectrum Disorder), ADHD, and intellectual handicap, all of which were categorised together. This study investigates the use of smartwatches in the classroom. An app that allows the carer to provide notifications and social cues to the youngster in a school setting. Pictograms are used to display the carers' input to the user. This software was tested with 5 children, and it was determined that each profile needs to be personalised. This project intends to connect children with developmental disabilities with their carers in [23].

There is a wide selection of assistive technologies available to help children with illnesses such as ADHD improve their knowledge and skills. In recent years, several ongoing studies on various assistive technologies and some assistive technologies have been released, however the most of them have concentrated on Autism condition rather than ADHD [19]. People may mistake these two illnesses for having many similarities, despite the reality that they are completely distinct. As a result, technologies developed to treat ASD cannot be adopted as an assistive technology solution for ADHD right away [24]. The challenge in constructing these devices to help children with ADHD is to keep both younger and older children or teenagers entertained [20].

3. Methodology

The scope of this paper required a comprehensive literature review that assessed the different factors and problems faced by children with ADHD. Post which a survey is conducted to understand the needs of the user population. Next, a framework is developed in order to assess the different influencing factors of the three main components that formed the basis of this project. Ultimately, a solution that effectively caters to the population is developed, discussed, and tested. Each individual step has been outlined in detail in further sections as shown in figure 1. Methodologies from different papers with the same target group were studied to compare different procedures and approaches followed for the following categories. The insight summary has been presented in Table 1.

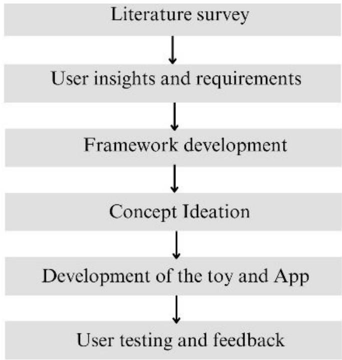

Fig. 1. Methodology adopted for this study

3.1. Interviews and surveys

To design an effective system for emotional regulation for children with ADHD, a comprehensive understanding of their unique requirements and experiences is collated through thorough quantitative and qualitative primary research. The stakeholders considered for insights are i) Children with ADHD ii) Children with undiagnosed ADHD iii) Psychologists and iv) Parents of children with ADHD. An online survey is conducted with 30 children who had diagnosed ADHD. This was done to understand their daily experiences, challenges, and the potential benefits of a fidget toy in the educative space.

3.2. Framework Development

A framework is proposed to assess the requirements for emotional regulation of children with ADHD. This framework comprises three components, namely, 'ADHD,' 'Children,' and 'Regulation methods. This framework is employed to generate a prototype systemic solution utilising the reinforcement learning model.

3.3 Reinforcement learning Model

Reinforcement learning (RL) [25] explores how natural and artificial systems may learn to predict and optimise their behaviour in situations where actions lead them from one state or situation to the next, as well as to rewards and penalties. Such environments can be found in a variety of disciplines, including ethology, economics, psychology, and control theory [26]. RL may provide more than merely a computational, 'approximate ideal learner' theory for affective decision-making. RL algorithms, like as the temporal difference (TD) learning rule [27], appear to be directly instantiated in brain mechanisms, such as the phasic firing of dopamine neurons [28]. Because RL appears to be so transparently embedded, it has become possible to use it in a much more rapid way to form hypotheses about, and retrodictive and predictive interpretations of, a wealth of behavioural and neurological data collected across a wide range of paradigms and systems [29,30,31,32, 33]. Children with ADHD have been observed to be unable to alter their conduct following errors, as seen by decreased post-error response time decreasing [34]. Furthermore, children with ADHD have poor feedback monitoring, as evidenced by lower heart rate responses to performance feedback [35]. Reinforcement is important in the learning process because contingencies such as reward and penalties that follow behavioural responses increase or decrease the likelihood of that behaviour being repeated [36]. Hence this model proves to be very beneficial for implementation in the app.

3.4 Development of smart fidget toy

The fidget toy is developed using user-centric approach to design by sticking to the norms of ergonomics and anthropometry appropriate for children and adolescents. Additionally, biomimicry is used to develop the shape, aesthetics and the haptic vibratory feedback which mimics the buzzing of the bee. A wrist band that has a heart BPM sensor is designed to be worn by the children. It is made of silicon material for comfort and has a system through which the fidget toy can be securely attached to the wrist belt, allowing easy and convenient access anytime it is required. Iterating the prototypes allowed for improving user interaction and comfort.

3.5 Application Development

To access all the information collated by the sensors, an app is created. The app also has additional features like meditation sessions, positive reinforcement quotes and a feature that allows the user to learn skills to focus and calm their minds and be motivated to do so through a reward system. Another feature of the app is that it allows the user to make existing games more ADHD friendly by introducing simpler rules and adding visual cues by allowing the user to access all the popular games via the app's database. The easy-to-use app layout is designed to enable ADHD children as well as parents, caregivers, and doctors to easily access their heart rate and stress level readings, allowing them to get a better knowledge of their physiological state. The software also provides personalised insights and practical advice for efficiently managing their well-being, suited to each user's specific needs. The RL model is integrated into the app in order to facilitate emotional regulation in the user.

3.6 User testing

A group of 5 children with diagnosed ADHD took part in the user testing phase to determine the usability and effectiveness of the design intervention. They were allowed to use the app and fidget toy as when they needed for a period of 4 hours. They were advised to use the app and fidget toy under circumstances of stress and emotional dysregulation. Post the allotted time, numerical data was collated to determine the usability of the design intervention.

4. Results

The two-pronged solution, Buzz and CalmCove, the fidget toy and app respectively, have been developed in order to tackle the specific and unique requirements of children with ADHD. In addition, it strongly addresses the research gap identified in the literature review. With a user-centric approach, the design encapsulates relevant features have been incorporated through concepts of machine learning, emotional regulation strategies, anxiety-culling tactile design with respect to the fidget toy. The users' need for more focus in classrooms, strategies to manage inattention, calming down and impulsivity have been prioritised in the solution. The fidget toy involves haptic vibratory feedback and a sliding mechanism. This section begins with a synopsis on the survey and interviews conducted. Next, the framework developed for the solution is discussed in detail. Integration of the RL model into the app has ben discussed in the section after. The next two sub-sections deal with the design of the smart fidget toy and app in detail. The final sub-section describes the user testing phase and the subsequent insights collated.

4.1 Insights from surveys and interviews

A group of 6 children aged 12-14 with diagnosed ADHD were interviewed to obtain qualitative data. These interviews highlighted the day-to-day experiences of children with ADHD and how they deal with their symptoms. The analysis of the interviews highlighted the need for tailormade solutions to aid them in their academic performance, to inculcate self-regulatory practices and improve their overall well-being.

4.2 Framework development

The illustrated Fig. 2. Shows the three major factors which influence the final solution outcome of this project. A comprehensive solution must allow for the integration of the causative factor or ADHD, the effective execution on the target population or children with ADHD and finally, the means through which the affected population can be helped, or regulation methods which can be implemented.

Table 1. Comparing methodologies

Category	Methodology proposed in this paper	[37]	[38]	[39]	[40]
Primary research	Online survey and detailed interviews with wide range of stakeholders	Qualitative feedback was collected through the form of interviews with ADHD students and their teachers	Has a thorough secondary research but lacks primary research component	Interviewed Children aged 3-6 years at a development centre	Questionnaires and observations were used for primary research
Framework development	solution is based on a three-pronged approach. It offers a more systemic approach	Focused on designing a physical product addressing only the tactile needs of the children	Does not specify a framework	No clear framework but, AR technology is used for interactive construction blocks.	Frameworks of other related works were analysed
Design solution	Developed an app and fidget toy that addresses emotional regulation from all angles	Designed a multifunctional fidget toy a focus on ergonomics and only tactile stimulation	Primary focus is AR interactive interfaces and visual overlays	AR interactive incentives and graphics are the focus.	Focuses on AR Tabletop games and tangible toys
Physical prototype Development	Prototype had tactile and haptic feedback, biomimicry, and heart bpm sensor	Promotes the use of ecofriendly material, is ergonomically designed, and solely addresses the physical aspect	Describes AR games but does not include a physical component	Creates prototypes of AR-based building blocks.	AR tabletop games are designed
User testing	Consisted of 5 children with diagnosed ADHD to evaluate tactile stimulation of the toy, and test the app and bpm sensor	User testing was conducted using 6 participants,1 with ADHD and the others without. The focus was on reducing anxiety through tactile stimulation	Empirical evaluation or user testing has been included	Due to the age of the kids, data is collected using questionnaires with support.	The table top games are tested with ADHD children

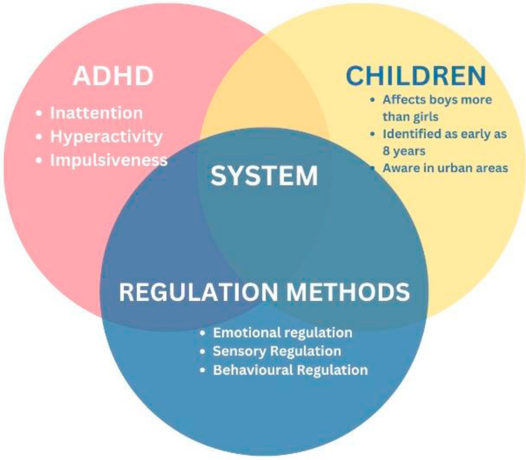

Fig. 2. Framework development

The interplay between these three factors is bidirectional. On the one hand, ADHD can affect with varying degrees of severity, a child's regulation abilities, making it difficult for them to manage their emotions and behaviour in various environments like school or home [2]. On the other hand, ineffective regulation methods can exacerbate ADHD symptoms, such as attention management, impulsivity and hyper activity may lead to increased disruptive behaviour and emotional dysregulation [41,42].

Therefore, this project aims to target regulation management in children with ADHD by addressing this interplay of factors. By providing psychoeducation, simplifying tasks, and activities, and teaching adaptive strategies to them, it can enhance their daily life experiences [12,13]. This intervention aims to work in tandem with the users' individual characteristics, needs and considerations and most importantly, understanding their unique behavioural and cognitive profiles.

4.2.1 Application of Reinforcement Learning (RL) Model

The design intervention has a tactile fidget toy and an app that aids with emotional regulation in children with ADHD. The two-pronged solution incorporated a comprehensive approach, integrating a tactile sliding action in the fidget toy, built-in heart rate monitor in the wrist belt and Reinforcement Learning (RL) algorithms within the app. This unique integration attempts to improve ADHD children's focus, emotional regulation, and stress management.

The RL algorithm used in the app adheres to a Q-Learning framework, with the Q-Value update equation [43] being:

$$Q(s, a) = (1 - \alpha) * Q(s, a) + \alpha * (r + \gamma * \max(Q(s', a'))) \quad (1)$$

where Q(s, a) represents the Q-value for state-action pair (s, a), r is the reward gained post taking action a in state s, α represents the learning rate, γ represents the discount factor, and max(Q(s', a')) represents the maximum Q-value for the next state s' and all plausible actions a'.

The app's RL agent will learn and adapt through multiple iterative trials and interactions with the user. It will also investigate various activities and assess their implications using Q-values. A reward system is used to offer positive reinforcement. This happens to be the basis of the app, and the Q-values will continue to update correspondingly using the Q-Learning update equation.

The software uses heart rate data collated by the wrist band's heart beat monitor to analyse the child's stress levels and predict their mood states. The program analyses heart rate patterns using statistical approaches such as standard deviation, mean, and heart rate variability (HRV). HRV can be estimated using the root mean square of successive differences (RMSSD) [44] formula:

$$HRV = \sqrt{((\sum ((RR(i+1) - RR(i))^2)) / (n - 1))} \quad (2)$$

RR(i) is the time interval between two consecutive heartbeats, and the number of intervals is n. The heart rate data and metrics obtained are then sent into the RL system as additional decision-making and adaption elements. The RL agent learns to connect distinct heart rate patterns with different stress levels and mood states, driving the interaction dynamics of the fidget toy, wrist belt and the app's reaction methods.

Additionally, the app includes feedback mechanisms based on the child's heart bpm data and performance through the wrist band. To explain this with an example, if the child's heart rate exceeds a predefined threshold, signalling an increase in stress or the beginning of a panic attack, the app sends visual or audio cues depending on what the user picks. These cues advise the user to participate in deep breathing exercises, watch calming nature patterns and so on. Due to the iterative nature of the RL, as well as the heart rate monitoring and adaptive response mechanisms, the app will be able to optimise its engagement and soothing tactics with the user. The q-values will change in response to the user's replies, heart rate patterns and define rewards, ensuring continual optimisation and improved user experience.

This design intervention establishes a dynamic and personalised system that actively involves children with ADHD in their emotional-regulation process by using RL algorithms alongside the tactile sliding motion of the fidget toy and heart rate monitoring capabilities of the wrist band. The combination of mathematics and data-driven methodologies equips the app to show stress levels and mood states accurately, allowing it to provide timely and effective support for the child's well-being and emotional-regulation not just in classrooms, but anytime they require its assistance.

4.3 Designing the smart fidget toy

The design for the fidget toy is inspired the shape of the bee, its wing mechanism, and its buzzing noise. These inputs make for a very intreguing fidget toy that can potentially interest children of varying ages. Keeping in mind the ergonomics, the dimensions of the toy are as follows, 5cm x1.7cmx 1.5cm. The initial prototype testing is shown in the figure 3 below. Fig. 4 shows the final prototype along with 3D model designed using Fusion360.

To integrate all the smart features and sensors, an Arduino nano is used. To incorporate the buzzing feature, a micro vibration motor is used. The motor is small and quiet and is not loud enough to disturb the users' peers in a classroom. The result is a calming vibration feedback which calms the user down as they fidget. The vibration motor gets activated when the user puts force on the push button, this sends feedback to the vibration motor which then provides vibration feedback to the user. The vibration motor is activated with the help of a force sensor which detects the pressure input of the user. The system and software requirements for the design solution have been shown in the Table 2. below. The circuit diagram and connections made on the breadboard along with code snippets are shown in the fig. 5 and 6 respectively.

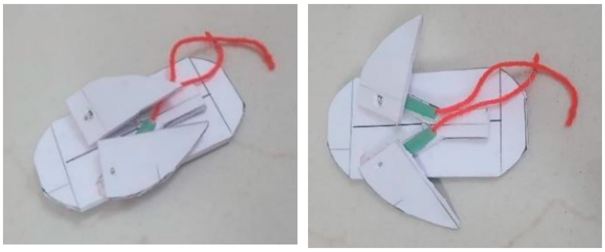

Fig. 3. Initial protype

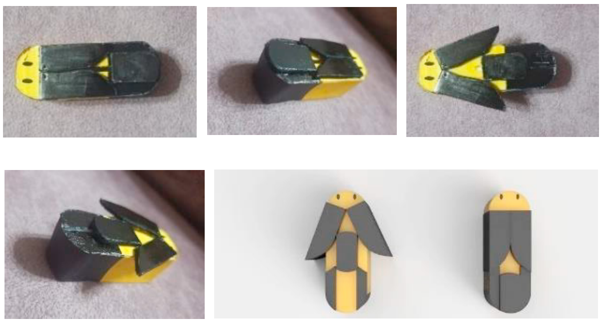

Fig. 4. Final prototype and 3D model

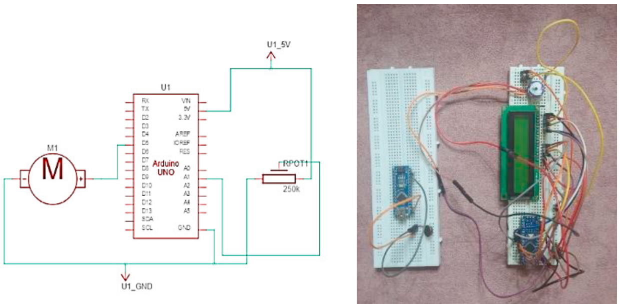

Fig. 5. Circuit connection and diagram

```
// C++ code
//
int mvm =5;
int vresistor = A1;
int data = 0;

void setup()
{
  pinMode(mvm, OUTPUT)
  ;pinMode(vresistor, INPUT);
}

void loop()
{
  data = analogRead(vresistor);
  data = map(data,0,1023,0,255);
  analogWrite(mvm,data);

}
```

```
192 lines (156 sloc) | 4.6 KB
#include<LiquidCrystal.h>



LiquidCrystal lcd(2,3,4,5,6,7);
int pulsePin = A0;
int blinkPin = 13;

volatile int BPM;
volatile int Signal;
volatile int IBI = 600;
volatile boolean Pulse = false;
volatile boolean QS = false;

static boolean serialVisual = true;

volatile int rate[10];
volatile unsigned long sampleCounter = 0;
volatile unsigned long lastBeatTime = 0;
volatile int P = 512;
volatile int T = 512;
volatile int thresh = 525;
volatile int amp = 100;
volatile boolean firstBeat = true;
volatile boolean secondBeat = false;

```

Fig. 6. Code snippets for fidget toy

Table 2. System and software requirements for fidget toy

Category	Requirements
Haptic feedback	Micro vibration motor
Hardware development board	Arduino Nano
Pressure detection and interaction	Force sensor
Connectivity	WiFi
App platform	Compatible with Android and iOS
Stress assessment (software)	Via Heart BPM data integration
Stress assessment (hardware)	Heart BPM sensor
Data synchronisation	Real time synchronisation between fidget toy and app
Machine learning model	RL model

4.4 Smartphone App

The app is designed to allow users to access all of the data collected by the sensors and a connection is established between through Wi-Fi. The features also includes meditation sessions, positive reinforcement quotes, and a function that allows users to learn how to focus and relax their brains while being motivated to do so through a reward system, powered by the RL model. Another benefit of the software is that it allows the user to make current games more ADHD friendly by introducing simpler rules, adding visual signals, and accessing all of the popular games via the programme's database. The simple app structure is intended to allow ADHD children to easily access their heart rate and stress level measurements, giving them a better understanding of their physiological state. The high-fidelity screens for the app were designed using Figma as shown in Fig. 7.

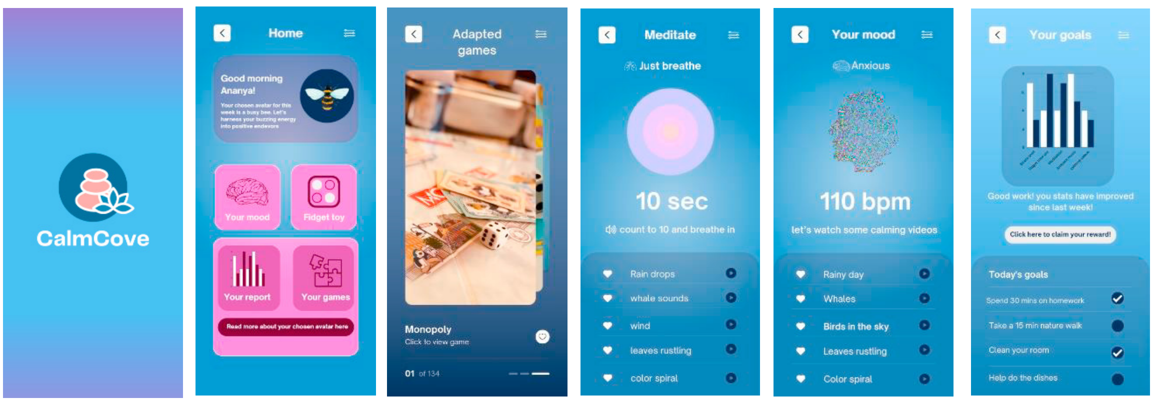

Fig. 7. App screens for CalmCove app

4.5 User testing

A comprehensive assessment of the proposed solution was conducted with a group of 5 children with ADHD. The aim was to evaluate the effectiveness of the app and fidget toy across various parameters. The following analysis presented in Table 3 and 4 respectively, will present the results obtained from these feedbacks and tests, shedding light on the solution's performance. The children were given prototypes of the app and fidget toys to interact with for a period of 4 hrs. The tests were all conducted in homes and play spaces. In that time period, the children were asked to use the app and fidget toy to re-focus while doing homework, manage their stress whenever required. Post the trial period, the children were asked to rate their overall experience for each parameter on a scale of 1 to 10. The parameters are all judged on a scale of 1 to 10 where 1 indicates little to no improvement and 10 indicates high degree of improvement. Once they filled the forms, they were asked to explain their rating and discuss what they liked about it and where there was room for improvement. Their insights were collated and have been summarised in the insights Table. 5.

Table 3. User feedback for fidget toy and app

Participant no.	Focus Improvement (Scale 1-10)	Stress Reduction (Scale 1-10)	Emotional Regulation (Scale 1-10)	No. of times used in 4hrs	App screen time (In mins)	User satisfaction
1	7	6	8	6	60	8
2	5	8	7	9	50	7
3	7	7	6	6	40	7
4	8	7	7	10	45	9
5	6	8	7	11	57	7

Another round of testing was conducted to assess if the app could help calm the child every time the heart rate monitor detected a sudden rise. The children were made to follow some stress management techniques like deep breathing and listening to calming auditory tones assisted by the app. Post which, their heart rate data was collected and compared to the previous set to see if there was an improvement. They rated their experience on a scale of 1 to 10 after the testing process. It must be considered that the range for resting heartrate for 12+ year olds is 60 – 100. Anything above the 100th mark has been considered to be an indicator of stress/panic here.

Table 4. User testing for fidget toy and app

Participant no.	Initial heart rate (bpm)	Stress management duration (minutes)	Final heart rate (bpm)
1	115	15	80
2	110	15	84
3	105	15	78
4	107	15	83
5	101	15	85

The insights gathered from the testing phase are shown in the table as presented in Table 5.

5. Discussion

The proposed solution consisting the fidget toy and the app, integrated with RL algorithm holds an immense potential in the way the needs of individuals with ADHD are addressed. The app is equipped to provide personal support, stress management, mood prediction, enabling emotional regulation and improving focus in the daily lives of children with ADHD. This has the potential to extend to individuals of all age groups with this disorder. The fidget toy complements the app both technically and by providing tactile feedback thereby ensuring an all-rounded and engaging user experience. Together, they offer a clear and comprehensive solution to improve the well-being and cognitive functioning of children with ADHD.

The implementation of the RL algorithm in the app enables constant and continuous learning and adaption to the users' needs, thus ensuring optimal and cohesive personal interventions. With each interaction, the app has the ability to learn from user behaviour, stress levels, heart rate to suggest user specific strategies and activities that promote emotional regulation and increase focus. This adaptive approach enhances the functioning and effectiveness of the app. Additionally, the scope of the design intervention extends beyond just ADHD management in children. The key integration of heart rate monitoring and stress prediction opens many possibilities for wider applications in emotional wellbeing and stress management. The app's ability to assess moods and provide appropriate strategies for calming can benefit people with anxiety issues and other emotional regulation deficits.

Table 5. Insights from user testing

Category	Insight
Heart Rate Data	Heart rate significantly reduced post use of stress management techniques through the app thus proving very useful to the user group
Optimisation and Personalisation	App successfully personalised emotional regulation techniques for each user thus proving useful whenever the techniques are employed by the users, however user no. 5 suggested that they had some difficulty in learning and adapting to the app, suggesting that better personalisation options need to be provided
Frequency of App Usage	High usage of the app indicates a need to for the tools provided and thus proving their need and efficacy
Session Duration	Longer session durations suggest higher user engagement, suggesting that the toy and app pique the interest of the user and hold on to their attention for a long time.
Overall User Experience	The overall user response suggests that they are satisfied with the product and see its potential.

5.1 Business Model

The app will be pushed through Google Playstore for android devices and app store for iOS devices. A dedicated website, and collaborations with ADHD support groups and educational associations will also help in marketing the solution. Revenue streams will be generated through in-app purchases, subscription models, fidget toy sales, and strategic partnerships with hardware manufacturers. Key activities involve continuous research and development, user-centric design, collaborations with hardware manufacturers, user support, and impactful marketing strategies. In terms of costing, the business model includes major factors such as maintenance and development of app, manufacturing of the fidget toy and its production, customer support, marketing, and advertising expenses as well as ongoing research and improvement to the app and fidget toy. The costing portion of the business model incorporates several critical variables, which are listed as follows. They are, app maintenance and development, material acquisition, fidget toy manufacture, production and distribution, marketing and advertising costs, and ongoing research and development. By incorporating all these variables into the costing, a long-term and financially feasible solution that adds value to the lives of users can be achieved, as well as long-term growth and success in this endeavor.

5.2 Stakeholder Analysis

The main stakeholders identified are children with ADHD, parents and caregivers, teachers, toy and hardware manufactures, health care professionals, ADHD support groups, designers and researchers. There is a collaborative communication cycle within the stakeholder circle. Together they form a dynamic system of communication that is key to the implementation of the solution. It can be understood as follows. Parents, caregivers, and teachers initially assess apparent symptoms of ADHD among children. The product is introduced to the children and then used. The parents and children then provide feedback with respect to the app and fidget toy and suggest improvements to the designers and researches. Hardware manufactures are then made aware of the changes in the product and a new and improved version is released into the market. Support groups bring much needed awareness to both ADHD and the available solutions.

5.3 Limitations and future scope

This study introduces a novel method for children with ADHD that combines Reinforcement Learning algorithms, a tactile fidget toy, and a smartphone app to aid with emotional regulation and stress management. The limitations of the study include a small sample size for testing and limited age group representation, a short testing duration, a regional focus with an urban Indian population, and the absence of comparative analysis. Future research can investigate a broader age range, long-term effectiveness, scalability, cost-efficiency, adaptability to different settings, and potential extension to other neurodevelopmental problems. Despite these constraints, the project's tremendous potential for addressing the special requirements of children with ADHD highlights its importance.

6. Conclusion

In conclusion, this paper epitomises the significance to recognise and address the need for a user-centred approach to help ADHD children with emotional regulation and stress management. The proposed solution consisting the fidget toy and the app, integrated with RL algorithm holds an immense potential with the way the needs of individuals with ADHD are addressed. Through a series of targeted assessments, numerical data was gathered to evaluate the impact of the solutions on aspects like, focus improvement, stress reduction, emotional regulation, and user engagement. In this testing phase, the outcomes were quantitatively measured, thus offering valuable insights that help judge the effectiveness of the designed solution. Moreover, the efficacy of all the stress management techniques have been proven and have been useful to the user base. Also, there is high user engagement thus suggesting that there is a need for such a design system which caters to the needs of children with ADHD in diverse contexts. The app is equipped to provide personal support, stress management, mood prediction, enabling emotional regulation and improving focus in the daily lives of children with ADHD. By prioritising user needs and a user centric design approach, this solution has the potential to help people with different kinds of emotional dysregulation. Future implementation and improvement of the proposed system can open a plethora of possibilities of inclusive classrooms and play spaces for children thus assuring a regulated and inclusive environment for them to thrive socially and academically.

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