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Focus-G: Intelligent Toy Gun for Enhancing Children's Attention Skills

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Abstract. This study introduces Focus-G, an innovative toy model for cultivating children's attention using novel physical training, real-time feedback, and data analysis. Two main training modes, Accumulation Shooting, and Rapid Response, are conducted in a gamified format. Preliminary user experiences indicate positive effects on children's attention, with high satisfaction levels. Limitations were identified, suggesting future improvements such as diverse casing designs, long-term tracking, and in-depth qualitative analysis. The innovation lies in the comprehensive application of physical training, real-time feedback, and data analysis, offering a holistic and personalized tool for children's attention cultivation.

Keywords. Children's development, Focus and attention Training, Intelligent Toys, Real-time feedback

1. Introduction

Concentration plays a crucial role in the psychological and cognitive development of children. Good concentration helps them better understand educational content, fostering self-control and patience to cope with life and learning challenges. Enhanced concentration improves efficiency, enabling children to complete tasks more effectively, enjoy moments of learning and life, and boost overall happiness. Therefore, educators and parents should collaborate to create a conducive learning and living environment for children, nurturing their concentration and facilitating comprehensive development to face future challenges.

Many specially designed toys can help children enhance concentration and attention. These toys integrate children's interests and cognitive development, encouraging focused activities. These toys not only provide engaging learning experiences to capture children's attention but also assist in controlling game time and content, reducing the risk of addiction to computer games. Compared to electronic

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games, these toys offer opportunities away from screens, minimizing electronic device use and contributing to the improvement of children's attention issues.

In this paper, we introduced Focus-G, a toy gun for cultivating children's concentration based on sensor technology combined with a mobile application, as Figure 1, comprising a toy gun, a target, and an application. Using Focus-G, hitting the target triggers audio-visual signals to stimulate children during training. Meanwhile, parents can analyze their child's training progress through the mobile application to assist in understanding the child's concentration.

To develop Focus-G, we engaged with experts in educational exploration and created a prototype. Preliminary user research was conducted to assess parental opinions on Focus-G. The results indicated that parents are willing for children to use Focus-G in concentration training, finding the carefully designed toy gun visually appealing to children and effective in practical exercises. The feedback from parents' surveys suggests practical effectiveness, and parents anticipate further extensions of Focus-G.

Our primary contributions include: (1) designing a sensor-based toy combination to train children's concentration, including a toy gun, a target, and an application; (2) proposing educational toys that provide better control over children's game time and content, reducing the risk of game addiction; (3) deriving methods to improve children's concentration through prototype interviews and semi-structured interviews. The innovation lies in the integration of sensor technology and a mobile application, providing a comprehensive tool for personalized children's concentration training.

Figure 1. A Children Is Using Focus-G.

2. Related Work

2.1. Children's attention learning

Children's attention is crucial for mental and cognitive development, impacting understanding in teaching, self-control, social skills, and life efficiency [1]. Attention Deficit Hyperactivity Disorder (ADHD) is a common cause of attention deficits in children, and in severe cases, it may lead to antisocial behavior and declining academic

performance [1]. Research suggests that the structure of children's attention is unstable at 7-8 years old but can be categorized into perceptual attention and executive attention factors from the age of 9, including attention types distinct from adults [2]. Attention plays a critical role in development, especially in the control of alert states in infancy, the development of orienting networks in childhood, and the rapid improvement of executive networks [3].

2.2. Concentration Training Models

Concentration can be improved through network training and state training, where video games and computer exercises serve as effective network training methods, while mindfulness meditation is a state training method that enhances executive attention and reduces stress [3]. Studies indicate that game-based digital therapy programs significantly impact attention and cognitive functions in ADHD children, serving as a complementary approach to medication, enhancing children's quality of life, and strengthening attention [4]. Improving early focused attention in children, especially in those with ADHD, can ameliorate symptoms of attention deficits through educational games [5]. However, excessive screen time is associated with negative impacts on child development, particularly detrimental effects on language development. It is recommended to control children's daily screen time to minimize adverse effects [6]. Research shows that specific training activities, such as focus training, can significantly enhance attention abilities in school-age children, including sustained attention and selective attention, thereby improving academic performance and daily life [7].

2.3. Conclusion

The innovative application of concentration training models, such as Focus-G, which monitors children's concentration through sensor technology and an application, providing real-time feedback, offers diverse and innovative approaches in this field. This research and innovation pave the way for the development of more similar toys and therapeutic methods aimed at enhancing children's concentration. The utilization of sensor technology and applications in toys, as demonstrated by Focus-G, represents a promising avenue for further research and development in improving children's attention and concentration.

3. Design Process

To design and create Focus-G, we initiated a design exploration meeting with experts, outlining the design process and resulting design objectives.

3.1. Design Exploration with Experts

We conducted preliminary research with three early childhood education experts from Guangzhou, China, including a child behavior therapist and two child psychologists, each with over three years of experience in child education. Each design exploration experience meeting lasted approximately 60 minutes, involving the introduction of our initial ideas, discussions, and exchanges with the experts. They shared their previous

educational experiences and provided semi-structured interviews about their perspectives on our prototype. They agreed with our starting point of "training children's concentration through a specially designed toy gun" and offered the following suggestions:

- Advise designing the children's toy gun to be child-friendly, reducing sharp edges and sizing it for safety and easy handling by children.
- Recommend avoiding setting targets for feedback to prevent children from developing a rebellious mindset.
- Suggest sensory toys, such as tactile, auditory, and visual stimuli, to help children focus their attention. Through sensory experiences, such as touch, vision, and hearing, children's concentration is exercised.

3.2. Design Objectives

Based on the design exploration meetings with experts and relevant preliminary work, we synthesized key objectives to form an interactive model supporting children's concentration training:

- Design the product with a rounded appearance.
- Consider the actual age and uncontrollable behavior of children; design the product with simple functions and easy operation.
- Craft the target in a cartoonish shape, equipped with lights and amplifiers to attract children's attention.

4. System Description

Based on the design exploration with experts, we developed the prototype Focus-G, consisting of both hardware and software components as Figure 2. There are two hardware components: a toy gun with laser emission capability and a target simulator with light-sensitive, audio-visual feedback features. The software is an instructional and data analysis application that connects wirelessly to the hardware.

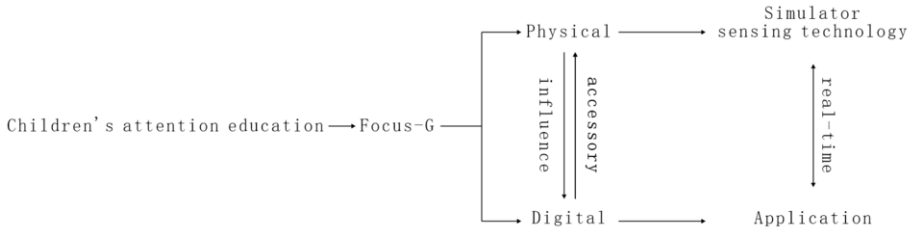

Figure 2: Focus-G Concept Framework.

4.1. Application

We provide a mobile application, as Figure 3, through which parents can monitor and understand real-time data from the simulator. This application not only aggregates and analyzes data but also sends timely reminders to parents. Additionally, through the guidance of the application, children can better familiarize themselves with the operation of the simulator. Parents can gain insights into their child's performance on the simulator, supporting and guiding their psychological development in collaboration with psychologists to facilitate their growth.

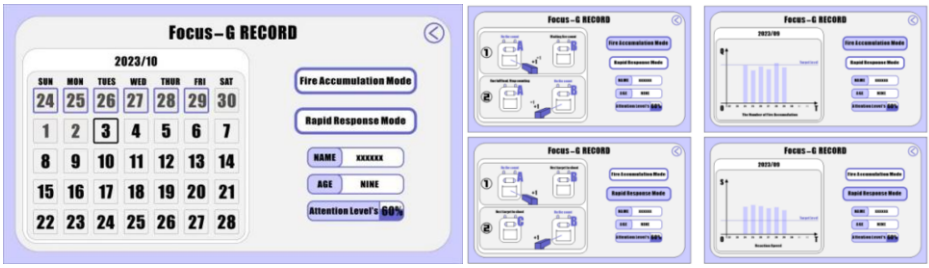

Figure 3: Focus-G Software Interface.

4.2. Simulator

The Focus-G simulator consists of two parts: the toy gun simulator and the target simulator, integrating various sensors and actuators to simulate multiple functionalities as Figure 4. We utilized Arduino development boards to collect and transmit sensor data, sending digital signals to the backend server via a Bluetooth module. The backend processes the received data signals, and both actuators and the application start working.

In the toy gun simulator, we used an infrared laser sensor as the emission end. It simulates a real mechanical trigger command, triggering the sensor with a light signal in a point-touch manner when a child pulls the trigger. The signal can only be triggered again when the hand leaves the trigger and pulls it again.

In the target simulator, we arranged a matrix of 25 infrared laser sensors for light signal detection. These sensors are placed at the center of the target, and covered with an acrylic shell at the front to prevent dust and accidental touches while avoiding signal blockage. To enhance the user feedback experience, three bicolor LED flashlights are integrated into the target simulator to convey the hit effect. The blue signal light remains on, and the red signal light lights up when hit. At the back of the target, a speaker component is placed. When hit, the amplifier module sends a signal, and the speaker plays a specified sound effect.

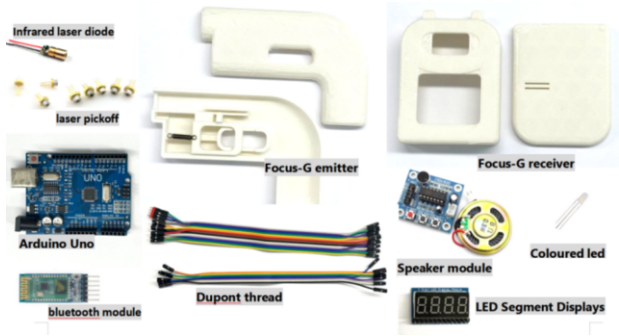

Figure 4: Focus-G Simulator.

4.3. Interaction and Principles

Building upon basic concentration training, we developed two modes on top of the early prototype: Accumulated Shooting and Rapid Response.

4.3.1. Accumulated Shooting Mode

In the Accumulated Shooting Mode, children engage in fundamental repetitive training as Figure 5. Due to variations in children's levels of concentration and attention spans, the app determines the training duration based on pre-inputted age and attention levels measured by the "Conners Scale." For younger children, short and frequent concentration training may be more effective. Multiple brief training sessions make it easier to maintain a child's interest and focus than a single prolonged session. In this training mode, children continuously shoot at the target, with targets A, B, and C lighting up sequentially as prompts for shooting. The child's scores for hitting the target accumulate, displayed on the numeric display, and recorded in the background application. A single target needs to accumulate the corresponding score before extinguishing, signaling the child to aim and shoot at the next target.

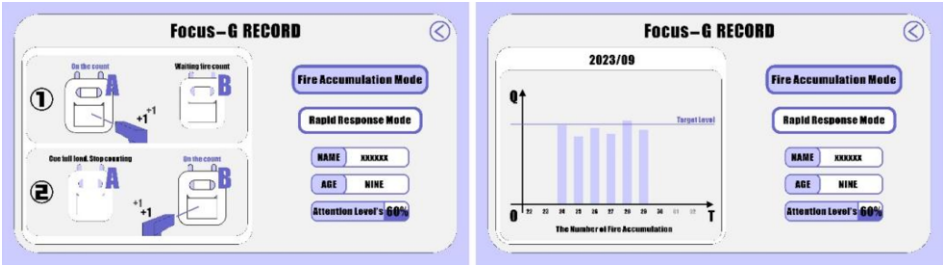

Figure 5: Accumulated Shooting Mode.

4.3.2. Rapid Response Mode

Rapid Response Mode aims to enhance children's reaction speed, hand-eye coordination, and focused attention through a game-like training activity as Figure 6. During aiming and shooting, children are required to concentrate, maintain focus, and improve attention endurance. Reaction training typically requires children to remain alert for a specified duration, helping cultivate their attention endurance for sustained focus over longer periods. In this mode, children are required to focus their attention on specific targets. Through this training, children learn to allocate attention, process multiple stimuli, and enhance their attention allocation ability. This flexible training contributes to adaptive focus, enabling them to maintain concentration in different environments. Improved concentration often accompanies increased reaction speed. As children's focus is exercised, they become more adept at quickly perceiving and responding. In the Rapid Response Mode, randomly illuminated targets prompt the child to hit the lit target to turn off the light. The training duration is determined based on the child's pre-inputted age and attention level.

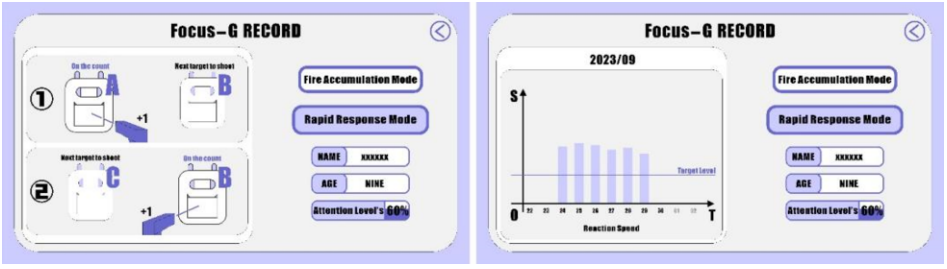

Figure 6: Rapid Response Mode.

5. Preliminary User Experience

To assess the effectiveness of Focus-G in enhancing children's attention and gathering parental opinions, we conducted an initial user study. We recruited 12 families from the local community, each consisting of a parent and a child with an average age of 10. All participants had a basic understanding of children's attention through the internet or courses and were familiar with the "Conners Scale." The scale was used to quantify the attention levels of 12 children and their parents under standardized conditions.

5.1. Procedure

Initially, we prepared props and introduced the prototype and its usage to 12 groups of families. Before the experiment, we used the "Conners Scale" to quantify the attention levels of 12 children. Participants were then given 1 hour for independent training and learning using Focus-G, during which we observed them. After completion, parents were encouraged to take Focus-G home and continue usage for a week, with daily sessions. Following the usage period, we recorded the "Conners Scale" for parents and children again, observed data changes, and conducted semi-structured interviews to

explore participant perspectives. The interviews focused on three main themes: (1) their relationship with Focus-G, (2) their opinions on the future development of Focus-G, and (3) behavioral differences observed in children after using Focus-G.

5.2. Results

Based on the "Conners Scale" score data as Figure 7, observations of children's attention issues revealed some trends. Overall, scores for behavior, learning, and physical and mental health were relatively low, but anxiety scores were also relatively low, possibly indicating psychological issues in students. Differences in ADHD indices suggest individual variances in attention and hyperactivity, warranting further assessment. Personalized support plans for learning issues are recommended, emphasizing the importance of practical assessment and professional intervention for a comprehensive understanding and management of children's attention issues.

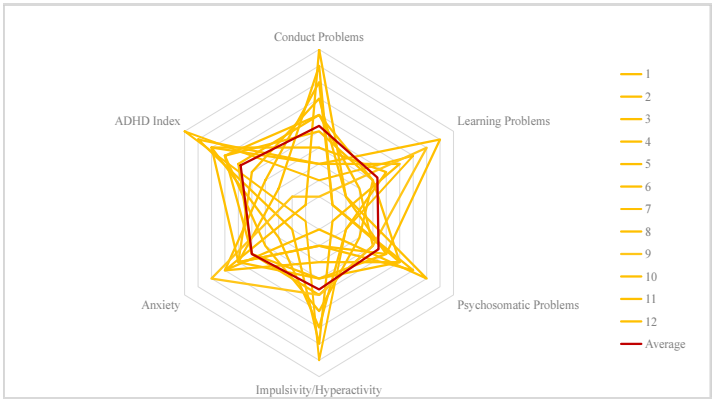

Figure 7: "Conners Parent Rating Scales" Scoring Model Translation.

As shown in Table 1, all participants expressed a high willingness to use Focus-G. According to the parental satisfaction survey results, overall evaluations of the user experience with the Conners Child Behavior Questionnaire and product functionality were generally positive. With an average rating of 4.6, parents were highly satisfied with the product overall. Specifically, users expressed high satisfaction with the product's usability and user interface design, with ratings ranging from 4.4 to 4.6, indicating a comprehensive approval of the product by users. Parents' evaluations of problem-solving and support services were relatively stable, with an average score of 4.5. Additionally, the product's problem-solving ability and overall impression received positive responses. Parents' average recommendation score for the product was 4.5, indicating a tendency to recommend the product to other parents. Overall, the survey results reflect a positive response to the Conners Child Behavior Questionnaire in the user community, with high satisfaction among parents regarding its functionality, performance, and support services. These positive evaluations provide valuable insights for further product improvement and user experience enhancement.

Table 1: Parental Satisfaction Survey (Results Participants will rate each question on a scale of 1 to 5, where 1 indicates the lowest satisfaction and 5 indicates the highest satisfaction.)

Number	Questions	1	2	3	4	5	6	7	8	9	10	11	12	Average
1	Overall satisfaction with the product	4	4	5	5	5	4	4	5	5	4	5	5	4.6
2	Rate the usability and user interface design	5	4	5	5	5	4	4	5	5	4	5	5	4.7
3	Satisfaction with the functionality provided	4	4	5	5	5	4	5	4	4	5	5	4	4.6
4	Performance and responsiveness of the product	5	4	4	4	5	5	5	4	4	5	5	5	4.6
5	Satisfaction with the design and appearance	4	4	4	5	4	5	4	4	5	5	4	5	4.4
6	Evaluation of issue resolution	5	5	5	4	4	4	5	5	5	4	4	4	4.5

7	capability Satisfaction with the support services	5	5	5	4	5	4	4	4	5	5	4	5	4.6
8	Likelihood to recommend the product to others	4	5	5	5	5	4	4	4	5	4	4	5	4.5
9	General feedback and overall impressions	5	5	4	5	5	4	4	4	5	5	5	5	4.7

6. Limitations and Future Work

In our research, we identified several limitations. Firstly, we only designed one product shell, and in the future, it may be beneficial to consider designing more shells and modularizing internal components. Such improvements could potentially enhance children's enthusiasm for the toy, thereby better-achieving training goals. Secondly, the duration of the experiment was limited, which may restrict our comprehensive understanding of the system's development under parental feedback. For a more in-depth understanding of the product's performance over the long term, future research may require longer tracking and observation periods. This would help gather more information about user experiences, potential issues, and areas for product improvement. Additionally, our survey results were primarily based on quantitative data, and future studies could incorporate more in-depth qualitative analysis, such as in-depth interviews and content analysis of user feedback, to better understand user needs and experiences. Overall, through more design improvements and in-depth research methods, we hope to further optimize the product, enhance user satisfaction, and better serve the goal of cultivating children's attention.

7. Conclusion

In this paper, we provided a detailed overview of Focus-G, an innovative toy model designed to assist children in developing concentration. Through real-time feedback and correction, Focus-G provides valuable information to parents based on children's training data, allowing them to adjust parenting methods and approaches in real-time. Our user study results indicate that Focus-G plays a positive role in the process of children's attention learning. The use of simulators enables parents to learn about children's attention and promote their development through attention exercises.

Compared to past research, our prototype integrates physical training, real-time feedback, and data analysis, providing parents with a more comprehensive and personalized tool for cultivating children's attention. However, we also acknowledge some limitations. Firstly, our study only involved one product shell, and in the future, considering the design of more shells could increase the system's flexibility and applicability. Secondly, the duration of the experiment was relatively short, and future research may consider longer-term tracking to gain a more comprehensive understanding of Focus-G's performance and effects over extended use.

Overall, we believe that Focus-G has the potential not only in cultivating children's attention but also in a broader spectrum of children's learning activities. Through ongoing improvements and in-depth research, we aim to refine the system, providing better support for parents and helping children achieve better learning outcomes.

Acknowledgments

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References

[1] Hazem, Alawadly. (2022). "Attention Functions and Deficits in Children." Aswan University Medical Journal, 2(2):221-232.

[2] Ting, Tao., Ligang, Wang., Chunlei, Fan., Wenbin, Gao., Jiannong, Shi. (2017). "Latent Factors in Attention Emerge from 9 Years of Age among Elementary School Children." Frontiers in Psychology, 8(8):1725-1725.

[3] Michael, I., Posner., Mary, K., Rothbart., Yi-Yuan, Tang. (2015). "Enhancing attention through training." Current opinion in behavioral sciences, 4:1-5.

[4] Seon-Chil, Kim., Gaeun, Kim., Jeong-Heon, Song. (2022). "Adjuvant Therapy for Attention in Children with ADHD Using Game-Type Digital Therapy." International Journal of Environmental Research and Public Health, 19(22):14982-14982.

[5] Qaulan, Raniyah., Amir, Syamsudin. (2019). Centerred Concentration for ADHD Children via Educational Game. 422-426.
[6] Angel, Belle, C., Dy. (2023). Measuring effects of screen time on the development of children in the Philippines: a cross-sectional study. BMC Public Health, 23(1).
[7] Yi-Jung, Lai., Kang-Ming, Chang., Kang-Ming, Chang. (2020). Improvement of Attention in Elementary School Students through Fixation Focus Training Activity.. International Journal of Environmental Research and Public Health, 17(13):4780-.