陽明交通大學 百川學士學位學程

專題探索(三)專題期末書面報告

救貓貓—製作測量及改善專注力之電腦遊戲

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Abstract

This project presents a 2D game, Save the Kittens (STK), designed to assess and improve attention and impulsivity levels. Inspired by established attention assessment tools like the Conners Continuous Performance Test (CPT 3), the game is a single-player experience where players rescue cats from drowning. Developed using Unity and C#, the game incorporates dynamic targets and distractions to evaluate reaction times and focus. Thorough research into existing assessment games informed the design to ensure efficacy in targeting attention deficits. Upon completion, the game was tested with participants, demonstrating its potential as an engaging and practical tool for attention assessment.

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1. Motivation and Background

Attention Deficit Hyperactivity Disorder (ADHD) is a widespread neurodevelopmental condition affecting a significant portion of the pediatric population worldwide [1]. It is characterized by persistent inattention, hyperactivity, and impulsivity patterns, significantly impacting daily social, academic, and occupational functioning.

The motivation behind this project stems from the need for accessible, engaging, and practical tools to assess and improve attention-deficit levels. Traditional tests like the Continuous Performance Test (CPT) and the Continuous Attention Task Assessment (CATA) are often considered tedious, which may make it challenging to distinguish genuine attention deficits from disengagement due to boredom, thereby makes it difficult to accurately evaluate symptoms, especially in children [2].

Additionally, traditional testing methods can be expensive and inaccessible to the general public. By creating a game-based assessment tool, we aim to offer a more affordable and widely available solution that can be used in the comfort of one's home. This approach not only broadens accessibility but also provides a more user-friendly experience.

Gamification plays a crucial role in this project, allowing for a more engaging and realistic assessment of attention. Unlike conventional tests, a game environment is more reflective of real-life situations, making it easier for participants to stay focused. The playful nature of the game also helps reduce anxiety, enabling participants to perform in a way that better represents their true attentional capabilities. Ultimately, this project aims to create a tool that is both effective in assessment and enjoyable for the user, making it a practical alternative to traditional methods [3].

2. Literature review

The market offers several game-based tools designed to assess and improve symptoms of attention deficit hyperactivity disorder (ADHD). One prominent example is EndeavorRX, the first FDA-authorized video game treatment for children with ADHD. EndeavorRX engages players in tasks that require sustained attention and cognitive control, such as navigating dynamic environments, collecting targets, and avoiding obstacles. The game's adaptive difficulty ensures gradual improvement without overwhelming players, while multitasking challenges encourage rapid task-switching. A built-in reward system keeps players motivated and enhances therapeutic engagement. The game is prescribed for 25 minutes per day, five days a week, ensuring a structured and consistent approach to treatment [4].

Traditional attention assessment tools, such as the Continuous Performance Test (CPT) and the Conners Continuous Auditory Test of Attention (CATA), also provide valuable insights into ADHD symptoms. The CPT evaluates sustained attention and cognitive control by presenting target stimuli (e.g., letters) and requiring participants to inhibit responses to non-targets (e.g., the letter 'X'). Key metrics such as reaction time, omissions, commissions, and response time variability are used to analyze attentional performance. The CATA, on the other hand, assesses auditory attention by requiring participants to respond to specific auditory cues while ignoring non-target stimuli. These methods, while effective, often lack engagement and accessibility, making them less ideal for young or inattentive participants [5].

Building on the principles of these established tools, Save the Kittens (STK) was designed to offer a more engaging, gamified approach to attention assessment. Similar to the CPT, STK uses distinct targets (e.g., kittens) and non-targets (e.g., ducks and bushes) to test selective attention and response inhibition. Players must identify and interact with targets

while ignoring distractions, allowing the game to measure reaction times, accuracy, omissions, and commissions. These metrics provide insights into attentional control and impulse regulation.

The game also incorporates elements from the CPT, including the assessment of sustained and divided attention, processing speed, and error monitoring. Additionally, the inclusion of immediate feedback and dynamic difficulty adjustments ensures that players remain engaged and challenged, catering to users of various age groups and cognitive abilities.

Unlike traditional tools, the gamified nature of STK reflects real-life scenarios more closely, as players must balance tasks and distractions in a dynamic environment. The primary target audience includes individuals with attention deficits or impulsivity symptoms, offering a tool that is accessible to psychologists, educators, parents, and even general users interested in understanding their cognitive performance. The flexibility of STK allows it to be used in both clinical and home settings, broadening its potential impact as a supplementary assessment tool or training aid for attention improvement.

3. Materials and Methods

3.1. Development Framework

The game was developed using the Unity Engine, a cross-platform tool ideal for creating interactive experiences with complex mechanics. Unity's flexibility enabled the seamless integration of visual assets and game logic. C# was used to implement the game’s logic, defining how it responds to player actions, tracks performance metrics, and processes results. The language’s robustness allowed for the efficient execution of real-time data collection and gameplay interactions.

3.2. Game Mechanics

The game revolves around rescuing kittens, which serve as moving target stimuli while avoiding ducks and bushes, which act as non-target stimuli. Among them, kittens and ducks are moving targets and non-targets, which moves along a straight path in set length and random direction. Bushes on the other hand remain static on the screen as static non-targets. The screen can display one kitten (target), up to two ducks (moving non-targets), and a random number of static bushes (non-targets) at any time. The player's objective is to collect kittens while avoiding interactions with non-targets.

Players control a boat that moves forward at a constant velocity and can steer left or right using the A/D or left/right arrow keys. Interaction with objects is achieved by clicking on them with the mouse or bumping into them with the boat, introducing versatility and an added layer of challenge. This combination of movement and interaction creates a dynamic and engaging gameplay experience, testing the player's focus, impulse control, and reaction time.

Stimuli are generated at intervals of 1, 2, or 4 seconds, with the sequence being a permutation of these intervals, mirroring the timing structure of the Continuous Performance Test (CPT), maintaining player engagement and testing reaction times across varying levels of difficulty. The game session concludes when the total number of stimuli generated (targets and non-targets combined) reaches 360, taking roughly 8 minutes, ensuring the gameplay duration aligns with CPT standards for attention assessment while maintaining player engagement.

3.3. Stimulus Movement

The movement of stimuli is designed to create a challenging but fair gameplay experience. Kittens and ducks move in straight lines at constant velocities, with their paths determined by random directions and fixed lengths. Before a stimulus appears, a splash animation is displayed at the spawn location, giving players advance notice and time to

prepare. This mechanism enhances fairness while testing the player's ability to react to dynamic visual cues (Figure 1).

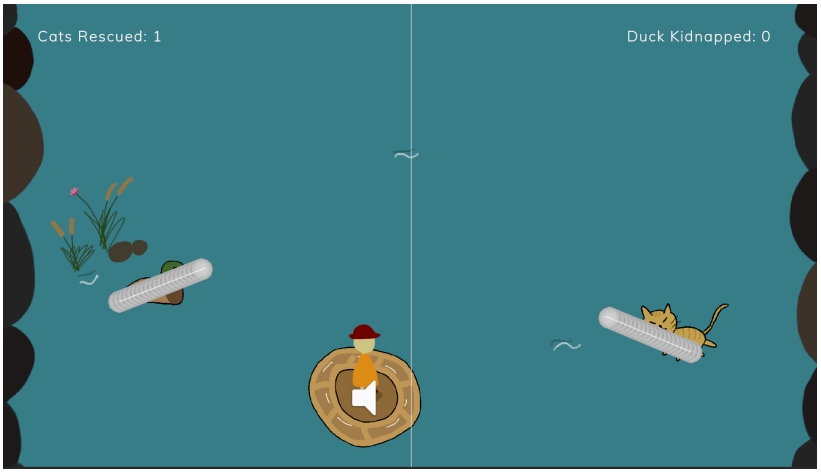

Figure 1. Stimuli initialization and movements

3.4. Game Performance Metrics

The game tracks and outputs detailed performance metrics to evaluate attentional control, response behavior, and consistency. These include:

- Collected Objects:
    - Kittens: The total number of target kittens successfully collected.
    - Ducks: The total number of non-target ducks interacted with.
    - Bushes: The total number of non-target bushes interacted with.
- Average Reaction Time:
    - Measures the time from the spawn of a target (kitten) to the moment the player interacts with it. This data is used to calculate:
        - Hit Reaction Time (HRT): The average reaction time for successfully collecting target kittens.
        - Commissions: Interactions with non-target stimuli (ducks or bushes).
        - Ommissions: Failure to interact with a target.

At the end of each session, these metrics are summarized in a final performance report, providing a breakdown of the player's actions and attentional abilities. This report includes the total number of kittens, ducks, and bushes collected and the calculated average reaction time and error statistics.

3.5. Visual and Audio Design

The game's visuals and animations were hand-drawn using an iPad and Procreate, creating detailed assets like the player's boat, kittens, ducks, bushes, and splash effects. These personalized designs enhance gameplay clarity and provide an immersive, visually appealing experience. The audio combines royalty-free sound effects, custom recordings, and music composed using Bosca Ceoil, a simple tool for creating loopable tracks. The sound effects and music complement the game's playful tone, while the custom recordings add a unique, personal touch. Together, the visuals and audio create an engaging, interactive experience that supports the game's attention-assessment goals.

3.6. Game Results and Output

After each session, the game generates a comprehensive report summarizing the player's performance. This report includes:

- The number of kittens, ducks, and bushes collected by the player.
- Average Reaction Time (HRT) for successfully collecting kittens.
- Error statistics, including commissions and ommissions.

The report also provides insights into attentional performance, enabling players or researchers to evaluate the player's focus, response consistency, and impulse control. The output metrics highlight both strengths and areas for improvement, offering a valuable tool for informal attention assessments and training (Figure 2).

Figure 2. Game result page

4. Results and Discussion

To evaluate the effectiveness of STK as an attention-assessment tool, its results were compared with the traditional CPT, a widely used method for measuring sustained and selective attention. A total of 11 participants, aged 19 to 32, completed both STK and CPT in random order. The comparison focused on three key metrics: omission rate, commission rate, and reaction time.

- Omission Rate Comparison (Figure 3): The omission rate comparison revealed a weak negative correlation of -0.22. This suggests that while both STK and CPT assess attentional lapses, STK may evaluate this metric differently due to its interactive and dynamic game environment. The weaker correlation indicates the potential for STK to provide complementary insights beyond those captured by the CPT.
- Commission Rate Comparison (Figure 4): The commission rates from STK and CPT showed a moderate positive correlation of 0.43. This suggests that the game aligns reasonably well with the CPT in assessing impulse control, as both tools track the frequency of incorrect responses to non-target stimuli.

- Reaction Time Comparison (Figure 5): The average reaction times recorded in the STK game were highly correlated with those measured in the CPT, with a strong positive correlation of 0.70. This high correlation highlights the game's reliability in capturing reaction times, a critical aspect of attentional performance.

These findings validate the game's potential as a viable tool for assessing attention deficits. The moderate to strong correlations with established CPT metrics, particularly in reaction time and commission rates, suggest that the game effectively mirrors traditional assessment methods while providing a more engaging and interactive experience. Moreover, including dynamic visual and auditory stimuli in STK introduces additional challenges that may provide deeper insights into real-world attentional demands.

The results underscore the utility of the STK game as both an assessment tool and a training aid, with its metrics offering actionable insights into a user's cognitive performance. Future iterations of the game could further refine the metrics and expand its applicability across different populations.

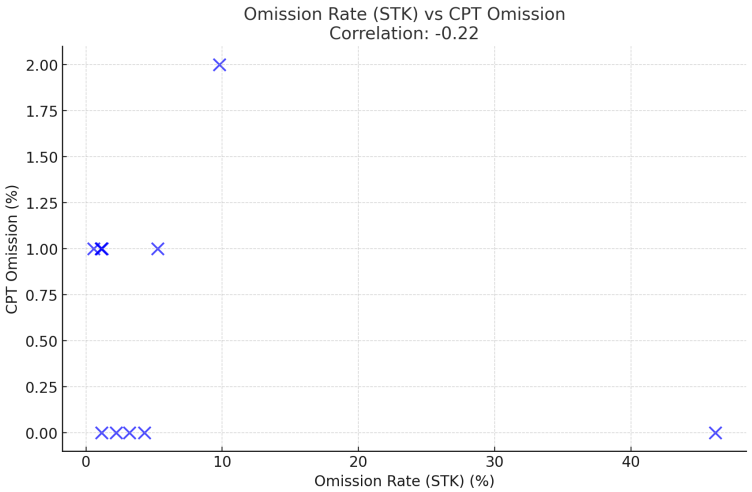

Figure 3. Ommission rate comparison of STK and CPT

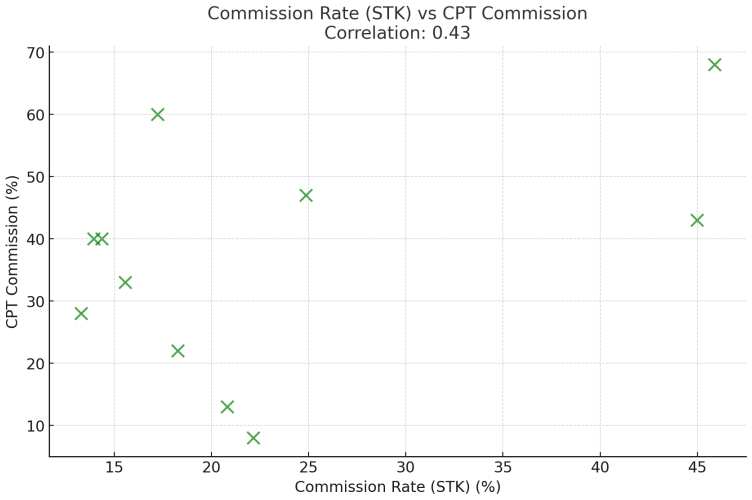

Figure 4. Commission rate comparison of STK and CPT

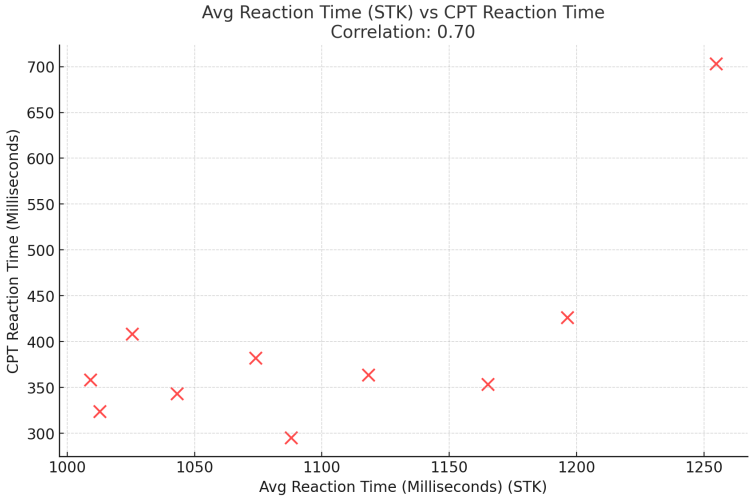

Figure 5. Average reaction time comparison of STK and CPT

5. Conclusion

This project successfully developed STK, a 2D game designed to assess and improve attention control through an engaging and interactive platform. Inspired by the principles of the CPT, the game incorporates dynamic visual and auditory stimuli to evaluate key metrics such as omission rate, commission rate, and reaction time.

The results of the study, conducted with 11 volunteers aged 19 to 32, demonstrate the game's potential as a reliable attention assessment tool. Comparisons between STK and CPT

showed a strong correlation in reaction time (0.70) and a moderate correlation in commission rates (0.43), validating the game's effectiveness in capturing critical aspects of attentional performance. Although the omission rate correlation was weaker (-0.22), this highlights the game's unique way of evaluating attentional lapses under different task conditions.

Overall, this project demonstrates the feasibility of using gamified approaches for cognitive assessments. With further development, STK could be a valuable tool in clinical, educational, and personal settings, offering accessible and enjoyable ways to assess and improve attention. Future work could involve refining metrics, expanding participant demographics, and incorporating additional gameplay elements to enhance the assessment experience. This project demonstrates how innovative and engaging tools can transform traditional assessment methods, paving the way for further exploration in the intersection of gaming and cognitive science.

6. References

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