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# KIP3: Robotic Companion as an External Cue to Students with ADHD

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**Abstract**

We present the design and initial evaluation of Kip3, a social robotic device for students with ADHD that provides immediate feedback for inattention or impulsivity events. We designed a research platform comprised of a tablet-based Continuous Performance Test (CPT) that is used to assess inattention and impulsivity, and a socially expressive robotic device (Kip3) as feedback. We evaluated our platform with 10 students with ADHD in a within subject user study, and report that 9 out of 10 participants felt that Kip3 helped them regain focus, but wondered if it will be effective over time and how it will identify inattention in more complex situations outside the lab.

**Author Keywords**

Assistive Technologies; Social Robots; Tangible Interfaces; ADHD; CPT; Inattentive; Impulsivity

**ACM Classification Keywords**

H.5.2 [Information Interfaces and Presentation]: User Interfaces – Prototyping, User-centered design.

**Introduction**

Attention Deficit and Hyperactivity Disorder (ADHD) is a mental health disorder manifested by a persistent pattern of inattention and/or hyperactivity-impulsivity.

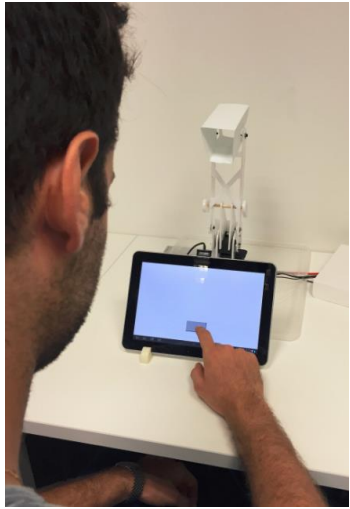


Figure 1: Participant performing the task on the tablet with Kip3 placed behind the tablet.

### **Barkley's principles**

Barkley [4] principles for an effective treatment are:

- A. Use external information and cues around the person.
- B. Keep the information within their sensory fields.
- C. Keep those cues in the natural environment as long as one needs.

ADHD interferes with the quality of social and school/work functioning [12].

Inattentive individuals fail to give close attention to details and make careless mistakes [15]. Adults with ADHD experience short-fuse temper outbursts [14], have problems keeping jobs and stable relationships [8], and display an unhealthy lifestyle [3].

Both inattention and impulsivity have shown improvement with pharmacological treatment [16] but these have limitations [13], and there is a great need for nonpharmacological complementary strategies in order to ensure a long term effective treatment. Some directions for nonpharmacological interventions include psychological treatments, neurofeedback, mindfulness and cognitive training.

We present a new assistive technology in the form of a small robotic companion called Kip3 (see Figure 1), designed as a simple external cue to help students diagnosed with ADHD regulate inattentive and impulsive tendencies.

We followed two sets of design guidelines in the design process of our assistive technology: Barkley's [4] principles (see sidebar), and the Empathy Objects guidelines [17], specifically the use of socially expressive robotic devices that provide peripheral feedback.

### **Related Work**

Classroom related studies showed that environmental factors, such as cognitive assistive technology (CAT) and external cueing systems can assist people with cognitive disabilities [10].

One example is the Attention Training System battery. This electronically generated response-cost system is placed on a student's desk and is operated by a remote control given to the teacher. It is designed to deliver feedback in order to increase levels of task related attention. This system was found to be more effective compared to a preexisting classroom management program using token reinforcement [7].

Another example is the Watchminder, a vibrating wristwatch. This self-monitoring device aims to increase the on-task behavior of elementary school children [1]. The results of this study proved effective for two out of three participants.

Socially expressive robots use gestures and other forms of nonverbal communication to express internal states and can be used to provide affective expression of digital information [5]. People tend to perceive robots as social actors and attribute to them human-like traits, including mental states [9]. This may contribute to the fact that instructions coming from physical robots are trusted more than from on-screen agents [2] and that robots can be more persuasive than on-screen agents when it comes to decisions in the physical world [14].

### **THE RESEARCH PLATFORM**

We designed a research platform to evaluate the effectiveness of a simple external cue in the form of a robot to help students diagnosed with ADHD regulate inattentive and impulsive tendencies. The research platform was implemented using two modules:

1. A tablet application we designed according to the Continuous Performance Test (CPT) [6], a computer-based test that measures a person's

## The CPT task

The Continuous Performance Test (CPT), is described in the "Standardized Assessment of Cognitive Functioning During Development and Aging using an Automated Touchscreen Battery" [6].

The test consists of a sequence of four possible shapes (circle, square, triangle and diamond) that are displayed every 2.5 seconds. All shapes are black, and are placed in the middle of the screen for a duration of 200ms. After that duration the shape disappears, and no shape is presented for 2.5 seconds, until the next shape appears. The total duration (2.7 seconds) between shapes showing up is called a period.

When a displayed shape is identical to the previous shape it is considered a 'target period', otherwise, it is considered a 'non-target' period.

sustained and selective attention, commonly used as an ADHD assessment tool.

2. A small social robotic companion, Kip3, that can be triggered to present a small set of pre-designed gestures. The triggers for the gestures were participants' performance errors in the CPT test (i.e., errors associated with inattention and impulsivity).

### *The tablet-based CPT task*

We designed a simple tablet game following the principles of the CPT, see sidebar for more details.

Participants were instructed to click a large grey button immediately when they identify repeating shapes. If the participant clicks the button during a "target period", the participant's response was recorded as a hit, otherwise, it was recorded as a false alarm. If a "target period" has passed without a button press, a miss was recorded. These three events were detected by the CPT application and logged to a CSV file. The false alarm and miss events were sent to the robot which in turn delivered an immediate appropriate feedback gesture. The tablet communicated with the robot using WiFi. The sequence of shapes was generated using a custom sequence generator, designed to generate a random sequence of shapes, uniformly distributed along a defined time frame. The settings we used were a task length of 11 minutes and 15 seconds, which produces 250 stimuli in which 40 are targets.

### *The Social Robotic Companion*

Kip3 is based on the Kip1 empathy object [11, 17], a robotic conversation companion intended to increase conversants' awareness to their voice level during a conversation. The mechanical design and physical

appearance are similar, but Kip3 has a new set of behavioral triggers and physical gestures.

Building on Kip1, we designed four gestures that differed from each other in multiple dimensions, including vibration, duration and rate of movement. Two researchers discussed the perceived emotion of each gesture and classified the gestures to two types: "criticizing" and "compassionate".

Kip3's goal is to serve as a reminder during inattention or impulsivity events. During the user study we allowed each user to choose the gesture that Kip3 would deliver as feedback.

## Pilot Study

We conducted a small user study aimed at gauging participants' reaction to the tablet-based CPT and to the gestures of the Kip3 prototype.

### *Participants*

10 undergraduate students were recruited to the study, all diagnosed with ADHD, aged 20-35 (M=26.3, SD=3.43), 4 males and 6 females. They were recruited using the services of the Accessibility and Study Skills Center at the university, and through personal connections. 80% of the participants are treated with medications and were instructed not to take them before performing the CPT task. All participants signed an informed consent form according to the institute IRB protocol.

### *Procedure*

We followed a within subjects design, so participants performed two blocks of CPT in the lab, one with Kip3

### **Pilot study: 8 out of the 12 Interview questions**

1. Did you notice a difference in your performance between the two tasks?
2. Do you think your performance was different or similar between the two tasks and why?
3. What do you think about Kip?
4. Did his presence helped you or bothered you?
5. What did you think about the gesture you have chosen, helpful or disturbing?
6. What did you like/dislike about the gesture?
7. Would you like to take Kip home to try him with other tasks?
8. Do you use any external feedback while performing a continuous/focus demanding task?

and one without Kip3, counterbalanced for order. A research assistant was present during all sessions.

All participants received a description of the CPT task. The "Kip-1st" group's introduction included physically showing Kip3, presenting its name, and explaining that it is designed to "help you finish the task in the best way possible". To increase autonomy and feeling of control, participants were asked to choose one of four possible gestures from Kip3's repertoire, and guided to choose one gesture that would be most likely to help them regain attention when distracted and/or regulate impulsivity. Participants were unaware of the researchers' classification of the gestures (i.e., "criticizing" vs. "compassionate").

Participants were then shown how Kip3 is triggered by the CPT software when they err on the CPT task. To increase autonomy and feeling of control participants were guided to position Kip3 according to their convenience. Participants performed one practice trial to verify that they understood the CPT instructions. They then were instructed to err on a second trial, to observe Kip's feedback.

The procedure for the control group was identical except for the following differences. Kip3 was presented on the table only after the first CPT block. After this presentation, participants completed the practice trial with KIP.

#### *Measures*

The qualitative measures were based on a post-session semi-structured interview. Participants were asked 12 questions; see sidebar for a selection of the questions.

Interviews were transcribed by a research assistant, and then analyzed by two of the researchers. Disagreements were settled through discussion.

The quantitative measures included the response time to hit and the number of false alarms and misses. We do not analyze these measures in this work-in-progress.

#### *Results and discussion*

All participants chose to place Kip3 behind the tablet device, in front of them. Interview analyses suggest that 9 out of the 10 participants felt that Kip3 helped them regain focus, mainly because of the technology as a real-time feedback to their performance: "his presence helped me. He told me if I am doing everything well or not, and if not, I should concentrate more" (#10, Female, 22). See sidebar on the next page for additional supportive quotes.

For one participant, the real-time feedback was not a positive experience: "it even created a little bit of frustration. I really tried to focus and succeed. And he was the one that told me I am wrong, so I was asking myself 'what? How come I was wrong?' and I was frustrated, but I didn't have a chance to fix it" (#1, Female, 26).

The following excerpts suggest that participants' perceived Kip3's feedback as conveying criticism, indifference, or compassion:

"for me it was like a game element, competition, I didn't want him to catch me in the act... I didn't want him to respond" (#2, Male, 29)

**9 out of the 10 participants felt that Kip helped them regain focus:**

"with the robot it woke me up, I felt more focused, when I missed one and I didn't notice, it woke me up. But with the second test, without Kip, I was more focused because I knew I do not have Kip there to remind me" (#3, Female, 27)

"knowing I have feedback as soon as I do a mistake, that kept me more focused...the immediate feedback that tells me if I'm right or wrong, helped me" (#4, Female, 25)

"after he moved for the first time I told myself, ok, wake up, so I changed my body posture and opened my eyes even more" (#5, Female, 22)

"he is cute, he helps, like in bowling, the rails on the sides so the ball will not fall" (#3, Female, 27)

Interestingly, although participants were unaware of the researchers' classification of the gestures, their choices of gestures were evenly split between the two categories. In the post-session interviews, two participants who chose a "compassionate" gesture thought that a "criticizing" gesture might have been more effective.

Interview analyses show how important it was for participants to choose a gesture that's appropriate for them. "I deliberately chose the more noisy gesture, I react better to a 'reset' sound that will put me in place... I looked for a swift movement... I wanted a small vibration and that's it" (#9, Male, 26)

"I chose the slower gesture because the vibration gesture is scary, but maybe it would have helped me more because it's faster" (#6, Female, 34)

"I chose that one because there is something in that one that says 'no...try to think about it again'. All the other gestures stressed me out." (#1, Female, 26)

Overall, participants thought that Kip3 can help them regain attention in various situations, but wondered if it will be effective over time, how it will identify inattention in more complex situations outside the lab, and how others around them will react to it.

"It's a little embarrassing, I would not walk with a robot and place him near me. But at home I will, when I am alone, yes... but I would stop him at some point, because no one is capable of being focused for a really

long time" (#3, Female, 27). See sidebar on the next page for more supportive quotes.

**Conclusion and future work**

Affecting behavior is not a simple task, especially with populations that have a learning, behavior, or cognitive disability. Our work-in-progress shows that providing ADHD students with a social robotic device that serves as immediate feedback for inattention or impulsivity events is a promising yet complex direction that should be further explored.

The majority of study participants said the social robot's immediate feedback helped them regain focus during the lab based CPT test, but many were skeptical about its ability to help outside the lab.

Further work should focus on understanding the relationship between the gesture's design, the emotion it evokes, and the resulting effect on the user's performance.

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**Participants felt that an external feedback device can help them regain attention:**

"I would like to take him, because I need something that will bring me back to focus" (#5, Female, 22)

"I do not think it would have helped me over time. It's good for a few minutes, not for the long term" (#2, Male, 29)

"Yes, but I need it to talk to me. Right now it's a little distracting, it's only one motion. I wonder in what task it can help me, I'm studying psychology, I'm not sure" (#4, Female, 25)

"yes, of course I will take it with me. If he can identify when I am loosing attention, sure, why not" (#7, Male, 26)

"it would be nice when I am seating at home and someone will hint me (tapping his fingers), and will remind me to study, but not a parent!" (#9, Male, 26)

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