Virtual Reality to Improve the Attention and Focus of College Students with ADHD

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Lehigh University – Health & Technology Workshop
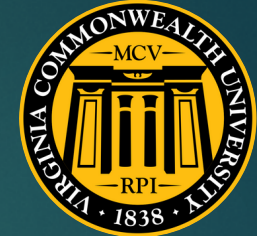September 15, 2023

Research Team

- PIs
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  - David Shepherd – Computer Science
- CO-Is
  - Jason Bennet – Arts
  - Jamie Cage – Social Work
  - Thomas Fritz – Computer Science
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  - Irene Jacobs & Caroline Lowman – Clinical psychology students
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- No disclosures or COIs

Background

- ADHD symptoms of inattention strongly predict academic performance and achievement
- Lack of attention to detail =
  - Poor reading comprehension
  - Spelling and grammar errors
  - Math computation errors in multistep problems
- Poor focus and distractibility =
  - Lower work completion efficiency
  - Frustration and failure to persist
  - Low motivation

Galera et al. (2009); Garner et al., (2013); Langberg et al., (2011); Massetti et al. (2008); Trane & Willcutt (2023); Tosto et al. (2005); Willcutt et al., 2005

Behavioral Interventions

- Behavioral interventions for ADHD are effective
  - Classroom contingency management – Provide structure and define, encourage, and reward positive behaviors
  - Provide repeated opportunities to learn and practice skills
- Requires frequent and consistent and parent/teacher monitoring and feedback
- Significant challenges with cost, feasibility, and treatment integrity
- Particularly difficult for symptoms of inattention
  - "Point-of-performance" feedback (e.g., praise)
  - Nearly impossible during actual work completion and testing

Fabiano et al. (2009); Fabiano et al. (2015); Turk et al. (2023)

Virtual Reality

- Technology to increase feasibility of behavioral interventions
- Virtual, mixed, and augmented reality
  - Anxiety treatment
  - Cognitive training
  - Assessment
  - Virtual classrooms
- Primarily educational videos and computerized tasks

Balasundaram, Ingale, & Udayan, 2020; Bashiri, Ghazisaeedi, & Shahmoradi (2017); Emmelkamp & Meyerbroker, (2021); Romero-Ayuso et al., 2021; Stokes, Rizzo, Geng, & Schweitzer (2022)

Virtual Reality and Attention

▶ Computer science/Engineering literature

▶ VR applications for open office space environments

▶ Workers randomized to a VR environment significantly outperformed a no VR condition on focus, performance, and preference

▶ FlowLight - automatically monitors worker activity levels (keyboard and mouse clicks) and wards off interruptions using a stoplight system.

  ▶ 449 adult participants

  ▶ Frequency of interruptions was reduced by 46% and majority keep using the technology consistently after the study period.

▶ Recent technology advances in screen resolution

  ▶ Personal computer screen in VR environment

Ruvimova et al., 2020; Zuger et al., 2019

Present Study

▶ Can VR be used to eliminate external audio and visual distractions while completing real world academic tasks?

▶ Do individuals with ADHD like using VR to complete homework and study?

▶ Does VR help individuals with ADHD improve focus, effort, and motivation while completing work?

▶ Can algorithms used to monitor focus and work in adults in office settings be applied to emerging adults with ADHD?

   ▶ Algorithms developed in work settings for coding tasks

▶ Do emerging adults with ADHD find getting feedback about focus and work completion helpful?

Study Design

- Open trial
- College students with ADHD (18-25)
  - Self-report (childhood and adult)
- 12 VR "sessions"
  - 50 minutes each
- VR is in open room with cubicles
- Ratings completed at baseline and every session to measure focus, effort, and motivation
- Objective tracking of focus through VR
- Feasibility/usability interviews

Study Design

- Initial focus on mouse movement, clicks, and keyboard strokes
- Participants bring work to complete and use active studying
- First 5 sessions = no feedback
- Next 5 sessions = feedback
- Final 2 sessions = no feedback
- Algorithm
  - Take average of sessions 2 – 5 keyboard and mouse data
  - 1/4th of SD below or above average bar changes (size and color)
  - Bar on screen changes every 60 seconds
    - Green, yellow, red (more than half SD below)
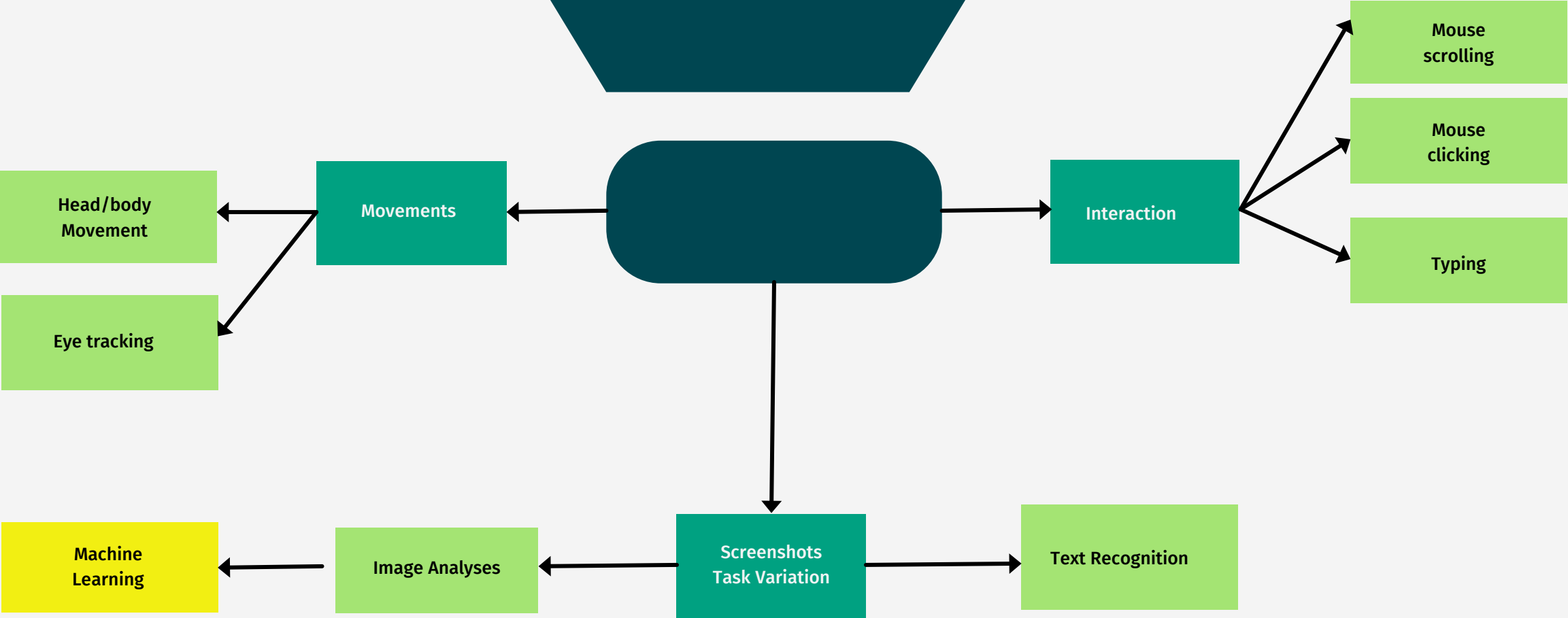
Varjo XR-3 Headset (High resolution VR headset)

https://www.canva.com/design/DAFaqkcvV-w/jzlIrG8VNmfe-ZnKpgzdAw/view?utm_content=DAFaqkcvV-w&utm_campaign=designshare&utm_medium=link&utm_source=publishsharelink

Table 1
Demographics

Student Characteristics	N = 27
Age M(SD)	21.04(1.60)

Gender N(%)	
Female	15(59.2)
Male	5(18.5)
Gender Diverse*	7(25.9)
Race	
White	14(51.8)
Black	3(11.1)
Asian	4(14.8)
Multiracial/Biracial	4(14.8)
Other	2(9.3)
Ethnicity	
Latinx	8(29.6)
Non-Latinx	19(70.3)
ADHD Characteristics	
Presentation (IA)	23(85.1)
Presentation (C)	4(14.8)
Medication Usage	17(62.9)

*Note: gender diverse refers to participants identifying as non-binary (14.8%), transgender (.07%), or those preferring to self-describe (i.e., genderfluid, .07%).

Attention/Focus

		Not at all	Sometimes	Often	Very Often
1	I couldn't focus.	0	1	2	3
2	I stared off into space.	0	1	2	3
3	I daydreamed.	0	1	2	3
4	I lost my train of thought.	0	1	2	3
5	I got lost in my own thoughts.	0	1	2	3
6	I wasn't paying attention	0	1	2	3
7	I zoned out or spaced out.	0	1	2	3

Homework Effort/Efficiency

		Not True	Somewhat True	Pretty Much True	Definitely True
1	I consistently worked hard	1	2	3	4
2	I gave my best effort	1	2	3	4
3	I completed the work I planned to	1	2	3	4
4	I made the most of my time	1	2	3	4
5	I worked efficiently	1	2	3	4
6	I met my work completion goals	1	2	3	4
7	I kept working even when I didn't want to	1	2	3	4

Homework Motivation

		Not True	Somewhat True	Pretty Much True	Definitely True
1	I felt motivated to complete my work	1	2	3	4
2	I feel like the work I accomplished will help me succeed academically	1	2	3	4
3	I felt driven to give my best effort	1	2	3	4
4	Doing well was important to me	1	2	3	4
5	I wanted to produce quality work	1	2	3	4
6	I was motivated to make the most of the time	1	2	3	4
7	I was driven to meet my work completion goals	1	2	3	4

Attention/Focus Results

Baseline M ± SD	Sessions 1 - 5 M ± SD	Sessions 6 - 10 M ± SD	Sessions 11 - 12 M ± SD
15.40 ± 5.27	3.90 ± 2.96	3.90 ± 3.92	3.21 ± 2.72
Cohen's *d* - Baseline vs. Sessions 1 - 5 = 3.24			
Cohen's *d* - Baseline vs. Sessions 6 - 10 = 2.65			
Cohen's *d* - Baseline vs. Sessions 11 - 12 = 2.76			

Effort/Efficiency Results

Baseline M ± SD	Sessions 1 - 5 M ± SD	Sessions 6 - 10 M ± SD	Sessions 11 - 12 M ± SD
15.44 ± 4.52	22.18 ± 4.42	22.62 ± 5.09	22.37 ± 4.41
Cohen's *d* - Baseline vs. Sessions 1 - 5 = 1.51			
Cohen's *d* - Baseline vs. Sessions 6 - 10 = 1.45			
Cohen's *d* - Baseline vs. Sessions 11 - 12 = 1.55			

Motivation

Baseline M ± SD	Sessions 1 - 5 M ± SD	Sessions 6 - 10 M ± SD	Sessions 11 - 12 M ± SD
19.00 ± 3.84	23.71 ± 3.81	23.49 ± 4.80	22.63 ± 4.23
Cohen's *d* - Baseline vs. Sessions 1 - 5 = 1.23			
Cohen's *d* - Baseline vs. Sessions 6 - 10 = 0.99			
Cohen's *d* - Baseline vs. Sessions 11 - 12 = 0.91			
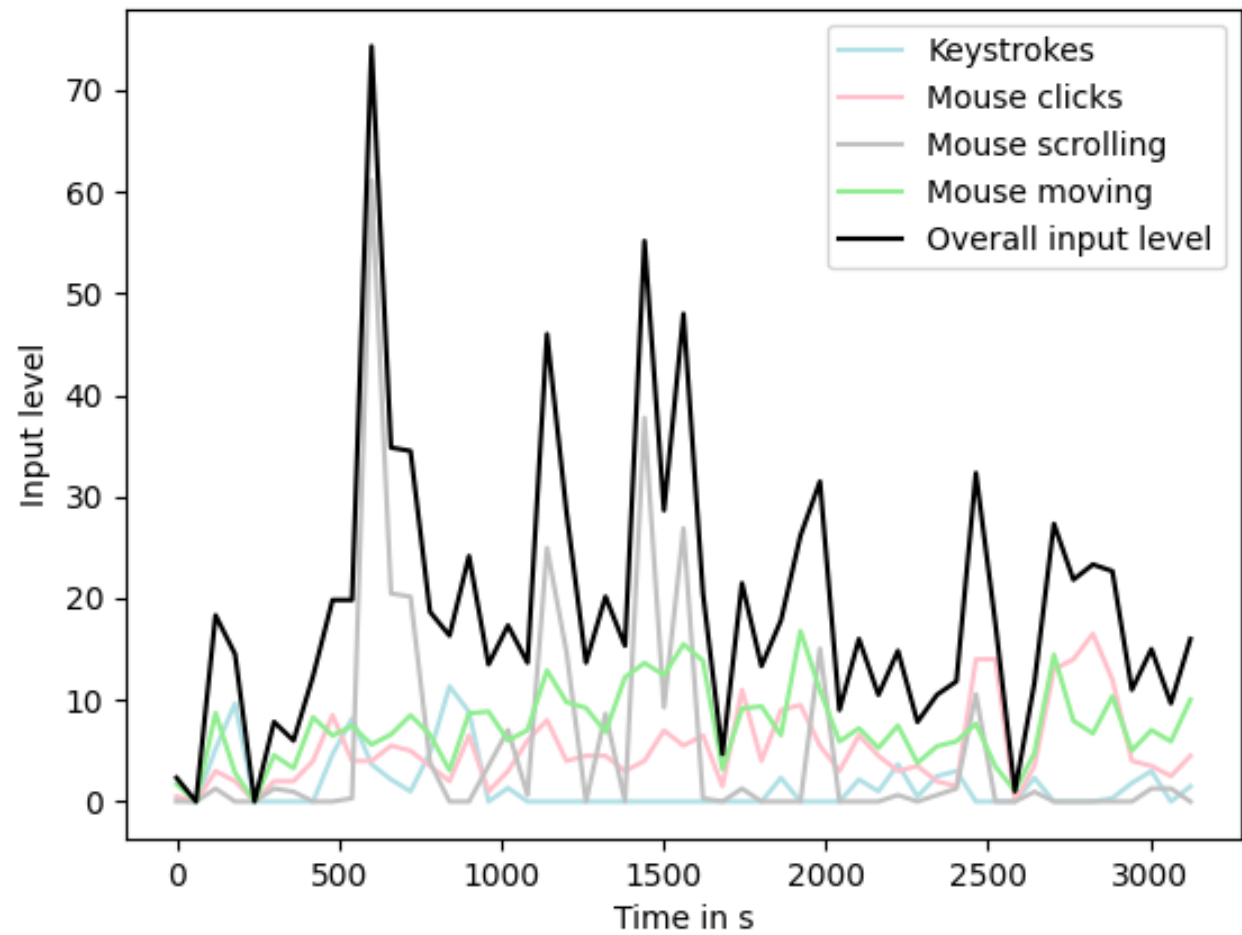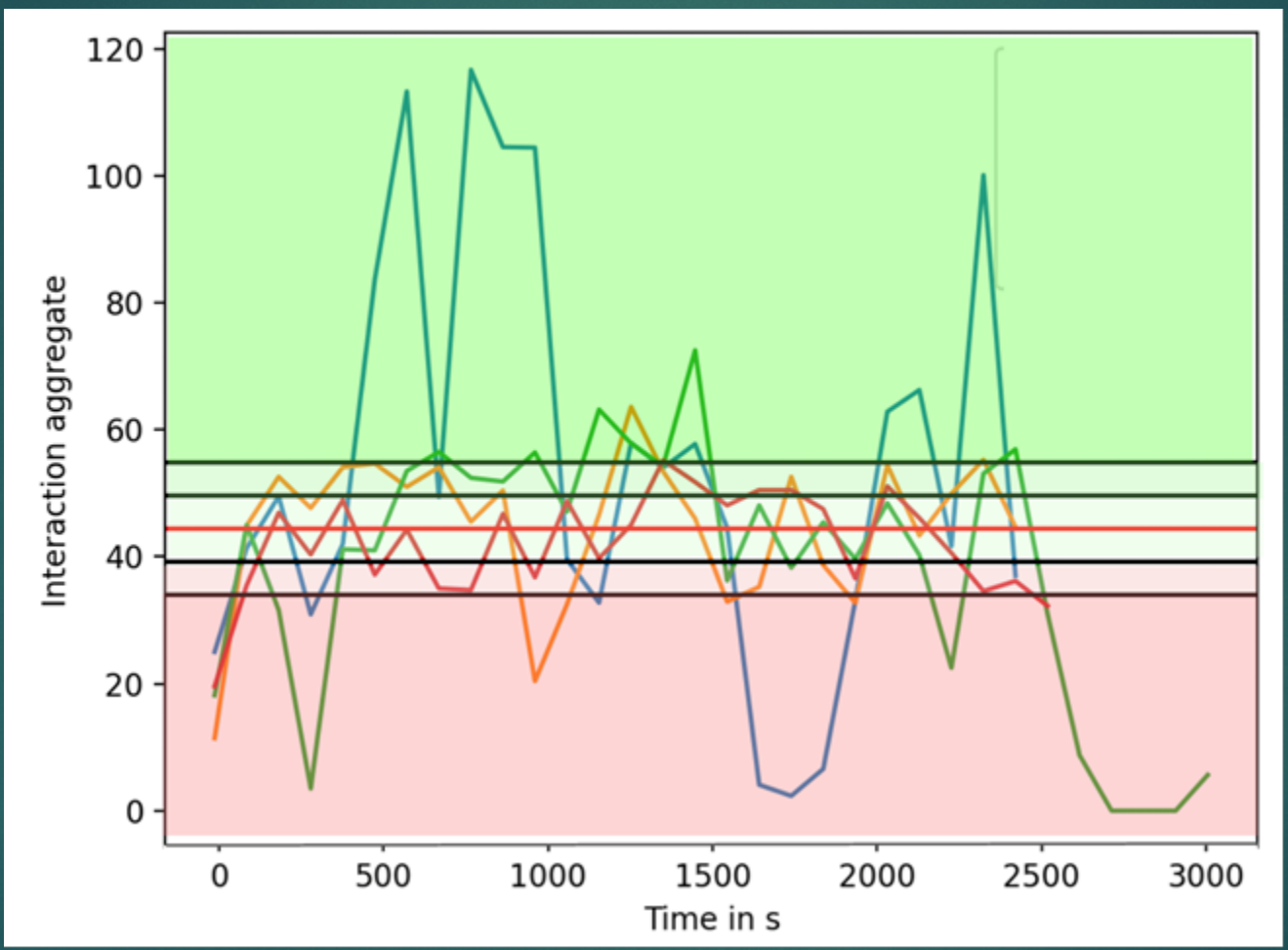
Qualitative

- If a friend/family member asked you about using VR to complete their work/assignments, would you recommend that they try it?

  - 100% of participants responded "yes"

- If VR was available at the library, would you use it?

  - 100% of participants responded "yes"

- If VR was available at home, would you use it?

  - 73% of participants responded "yes"

- If you completed homework and studied in VR for the majority of the time during the semester, do you believe that you would be more efficient with your time and perform better academically?

  - 100% of participants responded "yes"

Future Directions

- **Refine on-task tracking**
  - Impact of task type
- **Refine ways of providing feedback about on-task**
  - At what threshold and how
- **Gamifying homework/studying**
  - Different environments
  - Points systems
- **Extend to younger children**

Future Directions

- ▶ **Three arm study including passthrough VR control**
  - ▶ Passthrough v. VR only v. VR + monitoring and feedback
- ▶ **Consideration of how many sessions and length**
  - ▶ What is needed to improve functioning, GPA, etc.
- ▶ **Evaluate impact on testing**
  - ▶ E.g., math problem completion and accuracy

Challenges and Limitations

- Use of VR to study outside of a research study
- Cost of VR
- Screen time
- Accommodation versus intervention
  - Generalization?
  - Depends on goal
  - Perform up to full potential, motivation, self-efficacy

Questions