Human Factors Considerations for SAR Intervention in College Students with ADHD

ISE 570: Research Presentation

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Table of contents

Introduction

Goals of this research

- Understand current literature on ADHD[1] and ASD[2] interventions
- Understand comorbid ADHD and ASD for the **college student** demographic
- Explore integration of **SAR**[3] into existing treatment plans
- Explore human factor considerations and long-term **personalization** solutions

[1] Attention Deficit/Hyperactivity Disorder

[2] Autism Spectrum Disorder

[3] Socially Assistive Robotics

Socially Assistive Robotics (SAR)

- Robots designed to assist users through *social interaction*
- **Context**: *Integration* into current treatment plans for *mental healthcare*
- **Focus Populations**:
  - Comorbid ASD and ADHD individuals
  - College students with ADHD

Background

Motivating SAR: Healthcare Barriers

- **Rising prevalence:**
  - ASD diagnoses increased by over 175% in the last decade[4]
  - ADHD diagnoses increased from 6.1% to 10.2% (1997-2016)[5]
- **Lag in treatment:**
  - Only 30% of children with ASD receive both medical and behavioral treatment[6]
- **Treatment barriers[7]:**
  - Social stigma
  - Lack of transitional healthcare services from childhood to adulthood

[4] Grosvenor et al., "Autism Diagnosis Among US Children and Adults, 2011-2022".

[5] Fayyad et al., "Cross-National Prevalence and Correlates of Adult Attention-Deficit Hyperactivity Disorder".

[6] Xu et al., "Prevalence and Treatment Patterns of Autism Spectrum Disorder in the United States, 2016".

[7] Malik-Soni et al., "Tackling Healthcare Access Barriers for Individuals with Autism from Diagnosis to Adulthood".

Comorbid ADHD and ASD

Comorbid ADHD and ASD

- **DSM-5 changes**[8]:
  - ADHD and ASD diagnoses no longer mutually exclusive
  - Recognizes overlapping symptoms and need for a revised treatment plan
- **Comorbid presentation**:
  - Poorer independent functioning, socialization, and communication[9]

[8] Regier, Kuhl, and Kupfer, “The DSM-5: Classification and Criteria Changes”.

[9] Vaidya and Klein, “Comorbidity of Attention-Deficit Hyperactivity Disorder and Autism Spectrum Disorders: Current Status and Promising Directions”.

Behavioral Intervention Classificaiton Criteria

Symptoms Known symptom profiles of ASD, ADHD, and comorbid ASD/ADHD based on DSM-5 criteria. * are unofficial but prominent symptom domains associated with ASD or ADHD.

Intervention Recommended evidence-based psychosocial interventions for symptom profile according to National Standards Project Phase 2 for ASD and the JCCAP article by[10] for ADHD.

Common Modality Core observable mechanism in ASD participants in suggested therapy for symptom profile.

Clinical Measure Objective measures of targeted treatment effectiveness.

[10] Evans, Owens, and Bunford, "Evidence-Based Psychosocial Treatments for Children and Adolescents with Attention-Deficit/Hyperactivity Disorder".

Symptom	Intervention	Modality	Clinical Measure	Studies
ASD				
Deficits in Socio-emotional Reciprocity	DTT PRT Narrative	Appropriate Vocalizations Gesture Recognition	Self-Initiation Utterances Appropriate Interactions	[15], [16], [17], [18]
Deficits in Nonverbal Communicative Behaviors	EMT JASPER	Vocalizations Eye Gaze Gesture	Joint Attention Utterances Initiation	[19],[20]
Deficits in Social Relationships	Peer Training Video Modeling PT	Eye Contact Expressions Vocalizations	Perspective Taking Initiation Social Response	[21], [18], [22]
Stereotyped Motor Movements	ABI CBI FIP	Visual/Vocal Stimming Harmful Gestures	Stereotypy Rate Attention	[23], [24], [25]
Inflexible Adherence to Routines	DRO CBT FCT	Gesture/Vocal Rituals Expressions Harmful Gestures	Stereotypy Rate Mood Presentation	[26], [25], [24]
Restricted Fixated Interests	PRT Video Modeling Peer Training	Eye Gaze Verbal Fixation Repetitive Interaction	Joint Attention Stereotypy Rate Social Sharing	[27]
Hyper/hypo-reactivity to Sensory Input	STI SBI	Gaze Avoidance Expressive Intensity Repetitive Interaction	Stimulus Modulation Task Attention Stereotypy Rate	[28], [29]
ADHD				
Inattention	CLAS DBRC Modified Task Presentation	Eye Gaze Stimuli Response Gestures	Self-Efficacy Initiation Social Response	[30], [31], [32], [33], [14]
Hyperactivity	BPT BPI BCM	Excessive Vocalization/ Gestures	Emotional Regulation Social Compliance Conduct	[14],[31], [34], [35]

Comorbid ADHD and ASD symptoms

Symptom Cluster	Characteristics	Proposed Intervention*
Co-morbid ASD + ADHD		
Executive Functioning Deficits*	Response Inhibition Difficulties Lower Cognitive Flexibility Lower WM in Emotional Recognition	PT + PE SBI
Social Functioning*	Difficulty Initiation Conversations Lack of Personal Space [39] Inattentive and Asocial [39] Hyperactivity and Stereotypy	CBI ABA
Emotional Intelligence*	Hyperactivity and Aggression Inattention and Social Ineptness	ABA, CBT

Table 2: Summary of correlated symptom domains found in co-morbid ASD+ ADHD patients. Current Proposed Interventions: Suggestions are based on current effective treatments informed by guidelines to modify pure ASD or ADHD interventions, but comorbidity effectiveness lacks true interventional data*

Socio-technical View: Risks and Opportunities

Category	Risk	Description	Opportunities
Clinical	*Heterogeneity*	Misdiagnosis risk from broad symptomatology profile [37]	Standardize ASD phenotypes with evidence-based studies
	Rating Bias	Lack of qualitative symptom differences	Develop new ratings for co-morbidity
Scientific Validity	*Reproducibility*	Lack of consistency in clinical outcomes	Shift adherence to Research Domain Criteria framework
Systemic	*Clinician Expertise*	Over-reliance on familiar presentations	Special skills development for single domain experts
	Diagnostic Standards	Lack of specificity and sensitivity in ICD-11 [37]	Shift adherence to Research Domain Criteria framework
Technology	*Impersonalization*	Loss of interpersonal patient-provider relations	Incorporate into comprehensive care plan
	Inequities	Accessibility barriers due to privatization of treatment options	Advocate business models for community-based interventions
	Quality	Lapse in patient care quality due to intervention novelty	Gradual integration with personalized adjustments

Table 3: Socio-technical Perspective: Summarizes risks and opportunities across 3 categories in mental healthcare associated with comorbidity as a formal diagnosis (Blue). We focus on the risks for the technology dimension of SAR (Orange) as an added impact on mental healthcare

Socio-technical: SAR Influence

how does SAR influence the normative heterogeneity of existing local relationships in healthcare and countervailing power from private sector influence?[11]

[11] Silbey, “Taming Prometheus: Talk About Safety and Culture”.

Socio-technical: SAR Influence

- Integrating SAR shapes perceptions around safety culture, specifically regarding privacy and trust in information transfer of patient information between private and public entities
- Special education costs for children with ASD declined with age from $12,000 ($16,377) per year at age 6, to around $6,200 ($8,461) per year at ages 18–22[12]

[12]Ganz, “The Lifetime Distribution of the Incremental Societal Costs of Autism”.

Socio-technical: SAR Influence

Comorbidity is hypothesized to drive diagnostic rates in NDD populations[13] →

Recommendation:
Emphasizing the use of SAR in community-driven interventions

[13] Vaidya and Klein, “Comorbidity of Attention-Deficit Hyperactivity Disorder and Autism Spectrum Disorders: Current Status and Promising Directions”.

Adapting Interventions for Comorbidity

Comorbidity Adaptations to Interventions

- **Symptom Clusters:**
  - **EF[14] deficits:**
    - Difficulties inhibiting responses
    - Lower cognitive flexibility
  - **Social functioning:**
    - Difficulty initiating conversations
    - Inattentiveness and asocial behavior
- **Proposed interventions:**
  - Utilize overlapping symptoms to adapt existing treatment plans
  - Develop personalized approaches based on presentation

[14] Executive Functioning

ADHD in college students

Measuring prevalence of ADHD

- Estimates ranging from 2-8% in the U.S.[15]
- Reliance on self-reports and information from college DSOs[16].
- **Issues with measurement methodologies[17]:**
  - Small sample sizes
  - Over reporting and unverified diagnoses
  - Lack of differentiation between presentations[18]

[15] Green and Rabiner, “What Do We Really Know About ADHD in College Students?”.

[16] Disability Service Office

[17] DuPaul et al., “College Students with ADHD: Current Status and Future Directions”.

[18] Canu and Carlson, “Differences in Heterosocial Behavior and Outcomes of ADHD-symptomatic Subtypes in a College Sample”.

Unique challenges in the Post-Secondary Education context

- Children: Financial support, structured environment from parents and teachers
- Adults: Freedom and control over schedule and deadlines
- PSE[19] students:
  - Lack benefits of either group[20]
  - Necessitates strong coping mechanisms for academic success

[19] Post-Secondary Education

[20] Kwon, Kim, and Kwak, “Difficulties Faced by University Students with Self-Reported Symptoms of Attention-Deficit Hyperactivity Disorder: A Qualitative Study”.

Impact on college students

- **Academic impact[21]:**
  - Struggle to keep up with workload and peers
  - Poor EF; difficulty with task initiation
  - Time management and keeping deadlines
- **Social impact:**
  - Emotional dysregulation
  - Difficulty building and maintaining relationships

[21] Kwon, Kim, and Kwak.

Applications and Conclusions

Current Tools and Solutions

- **Digital interventions**[22]: Internet-based training systems based on CBT[23]
- **Effectiveness**:
  - Reduction in overall ADHD symptoms.
  - Need for long-term studies to assess sustained impact
- **Limitations**:
  - Minimal studies on the college student population
  - Unclear long term impact

[22] Liu et al., “The Effect of Digital Interventions on Attention Deficit Hyperactivity Disorder (ADHD): A Meta-Analysis of Randomized Controlled Trials”.

[23] Cognitive Behavioral Therapy

Applications of SAR

- Act as a study companion or “body double”
- Help maintain focus and staying motivated
- **Limitations:**
  - Hard-coded movement intervals
  - Lack of personalization

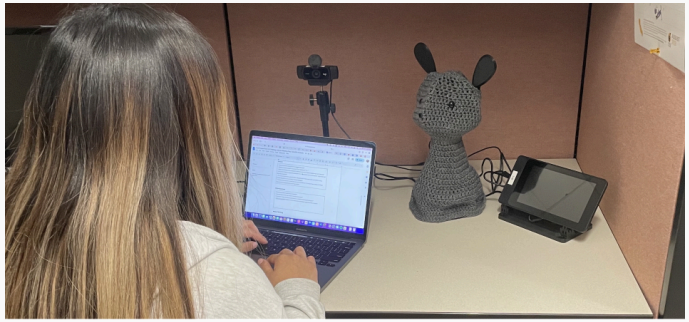

Figure 4: The Blossom study companion[24]

[24] O'Connell et al., “Design and Evaluation of a Socially Assistive Robot Schoolwork Companion for College Students with ADHD”.

Conclusion

- **Summary**:
  - SAR has potential to address treatment gaps for comorbid ASD and ADHD
  - College students with ADHD can benefit from personalized SAR interventions
- **Future work**:
  - Conduct long-term, longitudinal studies for college student with ADHD
  - Adapt SAR for comorbid ASD and ADHD

Bibliography

Canu, Will H., and Garyn L. Carlson. “Differences in Heterosocial Behavior and Outcomes of ADHD-symptomatic Subtypes in a College Sample.” *Journal of Attention Disorders* 6, no. 3 (April 2003): 123–33. https://doi.org/10.1177/108705470300600304

DuPaul, George J., Lisa L. Weyandt, Sean M. O'Dell, and Michael Varejao. “College Students with ADHD: Current Status and Future Directions.” *Journal of Attention Disorders* 13, no. 3 (November 2009): 234–50. https://doi.org/10.1177/1087054709340650

References

Evans, Steven W, Julie Owens, and Miss Nora Bunford. “Evidence-Based Psychosocial Treatments for Children and Adolescents with Attention-Deficit/Hyperactivity Disorder.” *Journal of Clinical Child and Adolescent Psychology : the Official Journal for the Society of Clinical Child and Adolescent Psychology, American Psychological Association, Division 53* 43, no. 4 (2014): 527–51. https://doi.org/10.1080/15374416.2013.850700

Fayyad, John, Ron De Graaf, Ronald Kessler, Jordi Alonso, Matthias Angermeyer, Koen Demyttenaere, Giovanni De Girolamo, et al. “Cross-National Prevalence and Correlates of Adult Attention-Deficit Hyperactivity Disorder.” *The British Journal of Psychiatry* 190, no. 5 (May 2007): 402–9. https://doi.org/10.1192/bjp.bp.106.034389

References

Ganz, Michael L. “The Lifetime Distribution of the Incremental Societal Costs of Autism.” *Archives of Pediatrics & Adolescent Medicine* 161, no. 4 (April 1, 2007): 343–49. https://doi.org/10.1001/archpedi.161.4.343

Green, Andrea L., and David L. Rabiner. “What Do We Really Know About ADHD in College Students?.” *Neurotherapeutics* 9, no. 3 (July 2012): 559–68. https://doi.org/10.1007/s13311-012-0127-8

Grosvenor, Luke P., Lisa A. Croen, Frances L. Lynch, Ben J. Marafino, Melissa Maye, Robert B. Penfold, Gregory E. Simon, and Jennifer L. Ames. “Autism Diagnosis Among US Children and Adults, 2011-2022.” *JAMA Network Open* 7, no. 10

References

(October 30, 2024): e2442218. https://doi.org/10.1001/jamanetworkopen.2024.42218

Kwon, Soo Jin, Yoonjung Kim, and Yeunhee Kwak. “Difficulties Faced by University Students with Self-Reported Symptoms of Attention-Deficit Hyperactivity Disorder: A Qualitative Study.” *Child and Adolescent Psychiatry and Mental Health* 12, no. 1 (February 1, 2018): 12–13. https://doi.org/10.1186/s13034-018-0218-3

Liu, Xin, Yawen Yang, Zhiyu Ye, Fang Wang, Kuan Zeng, Ye Sun, Ying Huang, and Lisha Dai. “The Effect of Digital Interventions on Attention Deficit Hyperactivity Disorder (ADHD): A Meta-Analysis of Randomized Controlled Trials.” *Journal of Affective Disorders* 365 (November 15, 2024): 563–77. https://doi.org/10.1016/j.jad.2024.08.156

References

Malik-Soni, Natasha, Andrew Shaker, Helen Luck, Anne E. Mullin, Ryan E. Wiley, M. E. Suzanne Lewis, Joaquin Fuentes, and Thomas W. Frazier. “Tackling Healthcare Access Barriers for Individuals with Autism from Diagnosis to Adulthood.” *Pediatric Research* 91, no. 5 (April 2022): 1028–35. https://doi.org/10.1038/s41390-021-01465-y

O'Connell, Amy, Ashveen Banga, Jennifer Ayissi, Nikki Yaminrafie, Ellen Ko, Andrew Le, Bailey Cislowski, and Maja Mataric. “Design and Evaluation of a Socially Assistive Robot Schoolwork Companion for College Students with ADHD.” In *Proceedings of the 2024 ACM/IEEE International Conference on Human-Robot Interaction*,

References

533–41. HRI '24. New York, NY, USA: Association for Computing Machinery, 2024. https://doi.org/10.1145/3610977.3634929

Regier, Darrel A, Emily A Kuhl, and David J Kupfer. “The DSM-5: Classification and Criteria Changes.” *World Psychiatry* 12, no. 2 (June 2013): 92–98. https://doi.org/10.1002/wps.20050

Silbey, Susan S. “Taming Prometheus: Talk About Safety and Culture.” *Annual Review of Sociology* 35, no. 1 (2009): 341–69

Vaidya, Chandan J., and Christoph Klein. “Comorbidity of Attention-Deficit Hyperactivity Disorder and Autism Spectrum Disorders: Current Status and Promising Directions.” Edited by S. Clare Stanford and Emma Sciberras. *New Discoveries in the*

References

Behavioral Neuroscience of Attention-Deficit Hyperactivity Disorder. Cham: Springer International Publishing, 2022. https://doi.org/10.1007/7854_2022_334

Xu, Guifeng, Lane Strathearn, Buyun Liu, Matthew O'Brien, Todd G. Kopelman, Jing Zhu, Linda G. Snetselaar, and Wei Bao. "Prevalence and Treatment Patterns of Autism Spectrum Disorder in the United States, 2016." *JAMA Pediatrics* 173, no. 2 (February 1, 2019): 153–59. https://doi.org/10.1001/jamapediatrics.2018.4208