Human Factors Considerations for SAR Intervention in Comorbid ADHD and ASD and College Students with ADHD

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Abstract

In this work, we explore prior research on clinical studies for Attention-deficit/hyperactivity disorder (ADHD) and Austim Spectrum Disorder(ASD) to identify evidence-based psychosocial interventions to inform the integration of Socially assistive Robotics (SAR) into technology-based therapeutic interventions in two subtypes of Neurodevelopmental Disorder (NDD) populations: comorbid ASD and ADHD and college students with ADHD.

1 Socially Assistive Robotics

A robot is an automated mechanical system designed to perform a limited set of tasks for specific applications by perceiving changes to its environment. Initially evolving from automation characterized by use of technology to minimize human intervention in repetitive tasks, the field of robotics encompasses not only the programmability, construction, and design of autonomous systems themselves, but also the design of interaction between humans and robotic systems in industrial, medical, agricultural, commercial, and educational domains [1]. Beyond physical considerations for interactive tasks with predefined parameters, advances in Artificial Intelligence (AI) have opened doors for **Human-Robot Interaction (HRI)** to integrate theories of human cognition in designing autonomous systems capable of engaging in social interactive tasks with humans.

Consequently, **Socially Assistive Robotics (SAR)** has emerged as a subfield of HRI to address the gap in social sophistication between humans and robots. In SAR, the robot's goal is to create close and effective interaction with a human user for the purpose of giving assistance and achieving measurable progress in a domain-specific context [2]. In this paper, we contextualize perspectives of mental healthcare applications to set a baseline for human factor considerations of SAR with regard to two domains: the emergent co-morbid ADHD and ASD population and changing therapeutic intervention considerations and the unique learning challenges faced by college students with ADHD.

Comorbid ASD and ADHD

By examining the implications of a newly established comorbidity subtype in NDD populations, we aim to compare the current trends for psychosocial intervention parameters from emerging symptom clusters against the previously established baseline of pure ASD and ADHD. Furthermore, we establish risks and opportunities from a socio-technical systems framework for mental healthcare in integrating SAR intervention.

College Students with ADHD

By examining unique challenges faced by students in Post-secondary Education (PSE), we aim to understand and analyze current systems, metrics, and solutions for this understudied population and contribute a unique outline for human-factor considerations for long-term personalization of SAR as socially assistive tutors for college students with ADHD.

1.1 Motivating SAR: Healthcare Barriers in ASD and ADHD

Due to shifting social attitudes towards NDDs and improvements in diagnostic tools, there has been a rising trend in prevalence of ASD and ADHD. In particular, the incident diagnosis rate of ASD in both children and adults in the US rose by over 175% within the last decade [3], while ADHD diagnoses rose from 6.1% to 10.2% for children and adults in the US from 1997 to 2016 [4]. While diagnosis rates trend upwards, treatment patterns lag behind. Only 30% of children in the US diagnosed with ASD received both medical and behavioral treatment, whereas 46.7% of children with ADHD received both medical and behavioral treatment [3], [5]. Adults between the ages of 16-25 with ASD experienced barriers involving perception of social stigma, lack of transitional healthcare services, and suboptimal physician awareness for ASD during transition into adulthood [6]. We outline the transitional factors for individuals with ADHD in Section 3.3. Consequently, care in adulthood suffers in quality and effectiveness. "Silos" of care for mental health co-morbidities and ASD along with financial barriers from unemployment, lead to poor treatment outcomes; for adults with ADHD, only 49.7% were reported to receive some form of treatment in the US, with diagnostic tools heavily reliant on self-reporting and lack of diagnostic confidence in adult physicians. [4], [7], [8]

2 Comorbid ADHD and ASD

ASD and ADHD are two of the most common neurodevelopmental disorders(NDD) that impact social, cognitive, and emotional functioning. Individuals with NDDs such as ASD, ADHD, communication disorders (CD), learning disorders (LD), and motor disorders(MD) require varying degrees of long-term treatment intensity; as NDDs have their origins during the early stages of child development, early intervention with social and behavioral therapies is critical to produce favorable long-term outcomes [9]. In particular for ASD, early intensive behavioral intervention therapy requires an adolescent to spend 20-40 hours a week engaging in repetitive tasks to improve communication, motor, and social-relational skills. As the reinforcement of such skills often requires consistency and step-by-step instructions, early ASD intervention has been a ripe area of application for SAR research due to robot's superior ability to isolate attention to particular responses to build up complex social abilities with consistent stimuli. The goal of SAR for ASD aims to generate clinical value by producing measurable effects on human-human interaction for the ASD population from robot-human therapeutic models[5]. As the prevalence of ADHD in people with ASD ranges from 50 to 70%, current SAR research for ASD therapy provides a natural bridge to address the similar characteristic profiles of attention, emotional, and social dysregulation [10]. Though appropriate treatment responses for individual with ASD or ADHD alone versus individuals with comorbidity of ASD and ADHD are actively being researched, current therapeutic models in SAR may be easier to adapt for variants of phenotypically similar NDDs due to overlaps in recommended treatment options [5],[3]. In the next two sections, we provide a survey of symptoms and recommended treatments for ASD, ADHD, and co-morbid ASD/ADHD presentation to establish a link to the targeted symptoms as a baseline to emulate therapeutic methods for future SAR research for ASD and ADHD. Further, we set the context for impacts of comorbidity and SAR in a sociotechnical analysis framework for mental healthcare.

2.1 Therapeutic Intervention Comparison

Formally, ADHD is defined by impaired functioning in the areas of attention, hyperactivity, and impulsivity [11]. ASD is defined by social dysfunction, communicative impairment, and restricted/repetitive behaviors [11]. Prior to 2013, ASD and ADHD were mutually exclusive

diagnoses until the DSM-5 updated the diagnostic criteria to allow for co-occurrence of conditions, leading to recognition of co-morbidity of ASD and ADHD [12]. Much research is being done to formally understand the underlying psychological, genetic, and neurobiological factors, but one thing is clear from current studies—comorbidity leads to poorer adaptive outcomes in independent functioning, socialization, and communication [13]. Though the following table is derived from clinical research studies for symptom profiles based on the DSM-5 classification on pure ADHD and ASD, recommended therapeutic interventions will likely be adjusted to accommodate evidence-based (EB) findings both for pharmacological and non-pharmacological treatments as clinical studies adapt to include the ADHD and ASD comorbidity presentation. Table 1 establishes a baseline classification of psychosocial interventions for pure ASD and ADHD presentations from clinical studies that considered the following 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 [14] for ADHD.

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

Clinical Measure Objective measures of targeted treatment effectiveness.

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]

Table 1: This table summarizes the DSM-5 pure ASD and ADHD symptoms, suggested therapeutic intervention, the underlying modalities targeted in the therapeutic models, and associated measures of success as the clinical endpoint. Note: All summarized clinical studies utilized adolescent and youth participants up to age 21 based on the NSP2 EB studies as there exists only one established intervention for adults (age 22+) presently [36].

These criteria from Table 1 establish the parameters of primary EB intervention models differentiated by the primary modality of delivery for measuring improvement across each symptom dimension. For instance, Consequence-Based Intervention (CBI) may involve targeting a specific stereotypy such as vocal stimming with a consistent response interruption mechanism such as "no" upon occurrence of the symptom to block the individual from engaging in the behavior and establish a decreased stereotypy rate over time [25]. These baseline intervention characteristics provide a blueprint to guide the implementation process as new instruments of modality measurement, such as perceptual capabilities from HRI intervention models, or diagnostic changes, such as the introduction of comorbidity in ASD and ADHD, inform the specification of the interaction to maintain consistency in clinical endpoints or serve as an EB reference for endpoint modifications as new patient outcome goals are established.

2.1.1 COMORBIDITY ADAPTATIONS TO INTERVENTION METHODS

From recent studies exploring perspectives from genetic etiology, biological pathways, and neuroimaging, it is established that 50–72% of the contributing genetic factors overlap between ASD and ADHD. Thus, the DSM-5 criteria have shifted to accommodate the previously defined "subtypes" into "presentations" guided by the genetic profiling of ASD and ADHD as a family of related disorders with varying scales of severity and overlapping phenotypic presentations [37]. On the psychological side, studies have begun to explore direct and indirect associations of symptomatology profiles guided by genetic and environmental factors. Three distinct pathways have been identified between impulsivity to social ineptness, hyperactivity to stereotyped behavior, and verbal IQ which suggest beneficial effects on the related clinical endpoints for direct pathways. Using the Child Behavior Checklist (CBCL) and SNAP-IV Rating Scale, one study found that the comorbidity phenotype shared more adaptive behavior impairments with ASD but shared more externalizing behavioral problems with ADHD [38]. The former studies necessitate iterations of current EB therapies to integrate findings on symptom dependencies; in its current state, individual symptoms from Table 1 can be clustered by skill impairments according to the following domains:

Executive Functioning Mental control processes needed to carry out goal-directed behaviors such as planning, executing ideas, and organizing utilizing working memory and cognitive flexibility [39].

Social Functioning Skills related to interactivity involving social and emotional reciprocation, conversational skills, and maintaining relationships

Emotional Intelligence Skills related to self and external emotional regulation, recognition, and social cognition and perception

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*

2.2 SOCIOTECHNICAL SYSTEMS: COMORBIDITY INCLUSION AND SAR

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

Comorbidity Risks

The acceptability of a co-morbid ASD+ADHD presentation presents both challenges and opportunities for defining a new conceptualization of diagnostic considerations and therapeutic interventions for ASD and ADHD outlined in Table 3. Prior to the DSM-5 changes, children with overlapping symptoms were often excluded or poorly accounted for. Due to the novelty of comorbidity, trials have failed to yield consistent results due to lack of standards in empirical studies, and previous studies require re-evaluation with adjusted population criteria to include co-morbid populations [39]. Furthermore, the heterogeneity of the ASD and ADHD symptomatology profile is in contention with precise diagnostic markers, leading to lapses in quality of individualized care as well as hypothesized over-diagnoses of the comorbidity in ASD and ADHD [37]. To challenge the heterogeneity and lack of effective standards of assessment for evidence-based interventions in the comorbid population, the Research Domain Criteria (RDoC) was created as an alternative to disease-based symptom presentation. Under RDoC, ASD and ADHD comorbidity clinical studies would develop metrics around 4 dimensions of environment, development/lifespan, units of analysis (genetic factors, neural pathways, etc.), and neurobehavioral domains to present a comprehensive approach to mental disorders. One study to utilize RDoC for comorbidity found that 92% of children in the ASD + ADHD group were in the impaired executive functioning (EF) class using latent profile analysis on BRIEF, a parent-report on executive functioning targets across 10 dimensions and encourages future research to find the biological markers of these behavioral markers for EF. Furthermore, the lack of scientific validity still poses questions around the legitimacy of a comorbidity diagnosis. One study counterposes that severity of the attentional trait in ASD is mistaken for comorbidity in ASD and ADHD, and further RDoC-based studies on neurocognitive functions and biological factors would provide formal cause-effect etiological perspectives [40]

SAR Risks

Another perspective of heterogeneity is through the view of sociotechnical systems theory with heterogeneous systems and actors in public-private partnerships for mental healthcare. Implementation of SAR necessitates research beyond the patient interaction model by psychologists, clinicians, researchers, and engineers and to the complex sociotechnical system of mental healthcare as a whole. SAR can be classified as a subtype of digitalization in mental health technologies, where digital mental health is characterized as any technology implemented for mental health assessment, support, prevention, and treatment [41].

Specifically, we ask: *how does SAR influence the normative heterogeneity of existing local relationships in healthcare and countervailing power from private sector influence?*

Normative heterogeneity refers to the network of individuals and their shared culture, values of existing local relationships in healthcare and countervailing power from private sector influence. Integrating SAR shapes perceptions around safety culture, specifically regarding privacy and trust in information transfer of patient information between private and public entities and internal values on data stewardship. A recent study further corroborates perceived threats from emerging perceptions on digitalized mental health. As public or private healthcare institutions onboard private stakeholders into the integration plan for SAR as an intervention for comorbid ASD and ADHD, careful consideration must be made towards the influence on interpersonal relations of current intervention methods to maintain the same standards of patient care.

According to a cross-population study on adolescents under 18 in the US by Benevides, children with ASD had a significantly greater likelihood of having an unmet therapy need compared with children with ADHD, and found that "lack of school resources" was a major barrier for therapy access [42]. Adjusting for inflation in 2018 for a study by Rogge surveying economic costs across lifetime distribution of ASD, 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 [43]. As comorbidity is hypothesized to drive diagnostic rates in NDD populations, specialized interventions to target broader symptomatic domains for both ADHD and ASD will drive cost barriers to healthcare access of which the effects will be exacerbated by the influence of private stakeholder relations with SAR technology. Thus, it is vital to promote equitable standards by emphasizing the use of SAR in community-driven interventions, such as school, group, and classroom interventions, to bridge cost barriers in order to equalize accessibility for children with comorbid ASD and ADHD.

3   ADHD in college students

Estimates of ADHD in college students range from 2-8% in the U.S. [44] depending on the methodology used for measurement.

The PSE context introduces unique challenges compared to children and adults due to the need for time-management, organization, and self-regulation in a less structured environment [45]. Children are often supported by parents financially and are provided structure and rigor, whereas adults often have more freedom and control over their schedules and deadlines. PSE students often do not have benefits of either group, necessitating strong coping mechanisms to succeed academically. Even then, issues in other aspects—social, psychological, and neuropsychological—may go unnoticed, leading to further problems in adulthood [45].

3.1   Difficulties in measuring prevalence

Measuring the prevalence of ADHD, particularly in college students, is challenging as primary methods rely on student self-reports or statistics collected from the college Disability Service Offices (DSOs).

Self-reported surveys: Tools like the Adult ADHD Self-Report Scale (ASRS) [46], GRIT [47], and Barkley Deficits in Executive Functioning Scale (BDEFS) [48]. However, current studies within the PSE population lack consistency and rigor in the metrics used to sample

and measure the prevalence of ADHD. These metrics might also overestimate prevalence due to overreporting for the misuse of prescription stimulants.

Administrative data: Information collected from college DSOs are another primary source of data. However, this information could underestimate the prevalence because of underreporting of diagnoses to schools due to the stigma of disclosing the diagnosis, difficulty of registration due to additional documents requiring evidence of impairments in academic settings, or other factors.

3.2 Issues with current studies

Some of the key issues with current studies in the measurement of ADHD among college students include [49]:

- Overreporting caused by unverified diagnoses and self-reported surveys which rely on students to answer the questionnaires truthfully
- Lack of differentiation between subtypes: There are limited studies that take into account the subtypes of ADHD—inattentive, hyperactive, and combined. Studies have noted differences in the areas of impact by subtype [50].
- Small sample sizes: Studies assessing this population of students have limited sample sizes, limiting the generalizability of study results
- Lack of double-blind studies: Numerous placebo-controlled double-blind studies exist for ADHD in children but not for the PSE demographic

3.3 Unique challenges faced by the PSE demographic

Procrastination and time-management: Students find it difficult to initiate tasks, especially those requiring multiple sub-steps, planning, and prioritization, due to poor executive function (EF) [51]

Academic Impact: Poor performance at the PSE level can have a significantly bigger impact than earlier schooling, causing a great deal of stress and difficulty keeping up with other students. Even though the students with ADHD often report average GPAs, further surveys have found difficulty staying concentrated, meeting deadlines, and keeping other aspects of their life in balance, often having to work much harder to stay on the same level as their peers [52]

Social and emotional impact: Students report significant difficulties socializing, and with emotion regulation needed to build and maintain stable relationships [45]

Having and disclosing an ADHD diagnosis can be stigmatizing even in the scientific research community [53]. It can be seen as an "undesirable" [54] and "unhealthy" [55] trait from a neurotypical standpoint. Such negative perceptions can make it challenging to fit in and socialize with peers and groups in the PSE context.

Transitioning from childhood ADHD services can be challenging due to poor communication of key information to children and their caregivers [56], making it difficult to utilize and seek the right resources independently when entering PSE.

3.3.1 Current tools and solutions to help college students with ADHD

Current technologies and tools to help with ADHD treatment plans have been studied. [57] analyzes 25 randomized controlled trials (RCTs) to assess the effectiveness of digital interventions. Due to varying scales used in each study, the scores were combined using Standardized Mean Difference (SMD). The study found that overall ADHD symptoms, inattention symptoms, and hyperactivity symptoms all reduced using digital interventions (SMD = $-0.33, -0.31, -0.15$).

They noted heterogeneity in the effectiveness based on the kind of intervention used, which included neurofeedback, CBT, chatbots, Internet-based training systems among many others. They found that Internet-based training was more effective than neurofeedback and computerized cognitive training for overall ADHD symptoms. These Internet-based training systems include self-help interventions based on Cognitive Behavioral Therapy (CBT).

These Internet-based systems were more effective in improving inattention and hyperactivity symptoms in the long term (>10 weeks). However, they observed that there were no improvements in *sustaining* the reduction of symptoms in the long term and concluded that more long-term studies on the effectiveness of digital interventions are necessary.

3.4 Application of SAR to college students with ADHD

College students with ADHD face difficulties keeping up with peers in the PSE setting, often missing deadlines and struggle with procrastination and time-management [45]. The use of SAR in college dorms as a study companion can help students stay on-task, acting as "body double" to complete homeworks on time [58]. O'Connell study the effectiveness of a desk robot with physical reaction capabilities (gaze shift, posture sway, sigh) and a Pomodoro timer [59] in keeping focused and staying motivated during study sessions. The tested robot uses hard-coded movements randomized intervals and is unable to respond to visual or auditory stimulus. A common criticism from students was that the movements were "distracting, jerky and random". Integrating face recognition or eye-tracking [60] to assess students' attention and responding to facial cues from changes in emotional state [61] or changes in gaze could provide a more personalized and human-like interaction.

4 Conclusion

In this work, we explored the potential integration of SAR into treatment plans for individuals with co-morbid ASD and ADHD, and college students with ADHD. Current literature focuses on studying ADHD prevalence and treatments in children and adults but few focus on the college student demographic who face unique challenges. Long-term, longitudinal studies for this demographic are necessary to understand and develop effective treatment plans.

Current SAR research primarily study the effectiveness in individuals with ASD. We believe that the development of SARs particularly for college students with ADHD can benefit from the overlap of existing research studying the co-morbidity of ASD and ADHD, and the effectiveness of SAR for the ASD population.

References

[1] A.-N. Sharkawy, "Human-Robot Interaction: Applications." Accessed: Nov. 25, 2024. [Online]. Available: http://arxiv.org/abs/2102.00928

[2] D. Feil-Seifer and M. Matarić, "Defining Socially Assistive Robotics," in *Proceedings of the IEEE 9th International Conference on Rehabilitation Robotics*, Jul. 2005, pp. 465–468. doi: 10.1109/ICORR.2005.1501143.

[3] L. P. Grosvenor *et al.*, "Autism Diagnosis Among US Children and Adults, 2011-2022," *JAMA Network Open*, vol. 7, no. 10, p. e2442218, Oct. 2024, doi: 10.1001/jamanetworkopen.2024.42218.

[4] J. Fayyad *et al.*, "Cross-National Prevalence and Correlates of Adult Attention-Deficit Hyperactivity Disorder," *The British Journal of Psychiatry*, vol. 190, no. 5, pp. 402–409, May 2007, doi: 10.1192/bjp.bp.106.034389.

[5]   G. Xu *et al.*, "Prevalence and Treatment Patterns of Autism Spectrum Disorder in the United States, 2016," *JAMA Pediatrics*, vol. 173, no. 2, pp. 153–159, Feb. 2019, doi: 10.1001/jamapediatrics.2018.4208.

[6]   N. Malik-Soni *et al.*, "Tackling Healthcare Access Barriers for Individuals with Autism from Diagnosis to Adulthood," *Pediatric Research*, vol. 91, no. 5, pp. 1028–1035, Apr. 2022, doi: 10.1038/s41390-021-01465-y.

[7]   B. B. Maddox and V. L. Gaus, "Community Mental Health Services for Autistic Adults: Good News and Bad News," *Autism in Adulthood*, vol. 1, no. 1, pp. 15–19, Mar. 2019, doi: 10.1089/aut.2018.0006.

[8]   J. J. McGough, "Treatment Controversies in Adult ADHD," *American Journal of Psychiatry*, vol. 173, no. 10, pp. 960–966, Oct. 2016, doi: 10.1176/appi.ajp.2016.15091207.

[9]   L. Francés *et al.*, "Current State of Knowledge on the Prevalence of Neurodevelopmental Disorders in Childhood According to the DSM-5: A Systematic Review in Accordance with the PRISMA Criteria," *Child and Adolescent Psychiatry and Mental Health*, vol. 16, no. 1, p. 27, Mar. 2022, doi: 10.1186/s13034-022-00462-1.

[10] L. Bakola and A. Drigas, *Technological Development Process of Emotional Intelligence as a Therapeutic Recovery Implement in Children with ADHD and ASD Comorbidity.* International Association of Online Engineering, 2020, pp. 75–85. Accessed: Nov. 25, 2024. [Online]. Available: https://www.learntechlib.org/p/217998/

[11] N. O. Davis and S. H. Kollins, "Treatment for Co-Occurring Attention Deficit/Hyperactivity Disorder and Autism Spectrum Disorder," *Neurotherapeutics*, vol. 9, no. 3, pp. 518–530, Jul. 2012, doi: 10.1007/s13311-012-0126-9.

[12] D. A. Regier, E. A. Kuhl, and D. J. Kupfer, "The DSM-5: Classification and Criteria Changes," *World Psychiatry*, vol. 12, no. 2, pp. 92–98, Jun. 2013, doi: 10.1002/wps.20050.

[13] C. J. Vaidya and C. Klein, "Comorbidity of Attention-Deficit Hyperactivity Disorder and Autism Spectrum Disorders: Current Status and Promising Directions," *New Discoveries in the Behavioral Neuroscience of Attention-Deficit Hyperactivity Disorder.* Springer International Publishing, Cham, pp. 159–177, 2022. doi: 10.1007/7854_2022_334.

[14] S. W. Evans, J. Owens, and M. N. 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*, vol. 43, no. 4, pp. 527–551, 2014, doi: 10.1080/15374416.2013.850700.

[15] M. J. Weiss, J. Hilton, and S. Russo, "Discrete Trial Teaching and Social Skill Training: Don't Throw the Baby Out with the Bathwater," *Handbook of Social Skills and Autism Spectrum Disorder : Assessment, Curricula, and Intervention.* Springer International Publishing, Cham, pp. 155–169, 2017. doi: 10.1007/978-3-319-62995-7_10.

[16] K. B. L. CCC-A M. S., "Evidence-Based Practices for Effective Communication and Social Intervention: Articles: Indiana Resource Center for Autism: Indiana University Bloomington." Accessed: Dec. 02, 2024. [Online]. Available: https://iidc.indiana.edu/irca/articles/evidence-based-practices-for-effective-communication-and-social-intervention.html

[17] F. Sansosti, K. Powell-Smith, and D. Kincaid, "A Research Synthesis of Social Story Interventions for Children With Autism Spectrum Disorders," *Focus on Autism and Other Developmental Disabilities*, vol. 19, pp. 194–204, Nov. 2004, doi: 10.1177/10883576040190040101.

[18] J. H. Franco, B. L. Davis, and J. L. Davis, "Increasing Social Interaction Using Prelinguistic Milieu Teaching With Nonverbal School-Age Children With Autism," *American Journal of Speech-Language Pathology*, vol. 22, no. 3, pp. 489–502, Aug. 2013, doi: 10.1044/1058-0360(2012/10-0103).

[19] K. Lynn Kern, B. Katherine M, S. Pumpki, V. Mohini, and C. Stephen, "Intervention for Non-verbal and Minimally-Verbal Individuals with Autism: A Systematic Review," *International Journal of Pediatric Research*, vol. 5, no. 2, Sep. 2019, doi: 10.23937/2469-5769/1510056.

[20] E. Pellicano, "Individual Differences in Executive Function and Central Coherence Predict Developmental Changes in Theory of Mind in Autism," *Developmental Psychology*, vol. 46, no. 2, pp. 530–544, 2010, doi: 10.1037/a0018287.

[21] "Social Skills Interventions for Individuals with Autism: Evaluation for Evidence-Based Practices within a Best Evidence Synthesis Framework | Journal of Autism and Developmental Disorders." Accessed: Dec. 02, 2024. [Online]. Available: https://link-springer-com.libproxy1.usc.edu/article/10.1007/s10803-009-0842-0

[22] J. Bahri *et al.*, "Toward an Integrative Socio-Cognitive Approach in Autism Spectrum Disorder: NEAR Method Adaptation—Study Protocol," *Frontiers in Psychiatry*, vol. 14, May 2023, doi: 10.3389/fpsyt.2023.940066.

[23] J. P. Stichter, J. K. Randolph, D. Kay, and N. Gage, "The Use of Structural Analysis to Develop Antecedent-based Interventions for Students with Autism," *Journal of Autism and Developmental Disorders*, vol. 39, no. 6, pp. 883–896, Jun. 2009, doi: 10.1007/s10803-009-0693-8.

[24] J. T. Rapp and T. R. Vollmer, "Stereotypy I: A Review of Behavioral Assessment and Treatment," *Research in Developmental Disabilities*, vol. 26, no. 6, pp. 527–547, Nov. 2005, doi: 10.1016/j.ridd.2004.11.005.

[25] B. A. Boyd, S. G. McDonough, and J. W. Bodfish, "Evidence-Based Behavioral Interventions for Repetitive Behaviors in Autism," *Journal of Autism and Developmental Disorders*, vol. 42, no. 6, pp. 1236–1248, Jun. 2012, doi: 10.1007/s10803-011-1284-z.

[26] "Differential Reinforcement of Other Behaviors to Treat Challenging Behaviors Among Children With Autism: A Systematic and Quality Review." Accessed: Nov. 30, 2024. [Online]. Available: https://journals.sagepub.com/doi/epub/10.1177/0145445517743487

[27] C. Harrop, J. Amsbary, S. Towner-Wright, B. Reichow, and B. A. Boyd, "That's What I like: The Use of Circumscribed Interests within Interventions for Individuals with Autism Spectrum Disorder. A Systematic Review," *Research in Autism Spectrum Disorders*, vol. 57, pp. 63–86, Jan. 2019, doi: 10.1016/j.rasd.2018.09.008.

[28] A. Posar and P. Visconti, "Sensory Abnormalities in Children with Autism Spectrum Disorder," *Jornal de Pediatria*, vol. 94, no. 4, pp. 342–350, Jul. 2018, doi: 10.1016/j.jped.2017.08.008.

[29] "A Systematic Review of Sensory Processing Interventions for Children with Autism Spectrum Disorders." Accessed: Dec. 01, 2024. [Online]. Available: https://journals.sagepub.com/doi/epub/10.1177/1362361313517762

[30] J. Bergen, "Managing Inattentive ADHD."

[31] E. B. Owens, S. P. Hinshaw, K. McBurnett, and L. Pfiffner, "Predictors of Response to Behavioral Treatments Among Children With ADHD-Inattentive Type," *Journal of Clinical Child & Adolescent Psychology*, vol. 47, no. sup1, pp. S219–S232, Dec. 2018, doi: 10.1080/15374416.2016.1228461.

[32] J. M. Swanson, "Snap-IV 26-item teacher and parent rating scale James ...." [Online]. Available: https://www.shared-care.ca/files/Scoring_for_SNAP_IV_Guide_26-item.pdf

[33] C. Reynolds, *S A M P L EBehavior Assessment System for Children, Third Edition (BASCTM-3)*. 2015. [Online]. Available: https://www.pearson assessments.com/content/dam/school/global/clinical/us/assets/basc-3/basc-3-rating-scales-report-with-intervention-recommendations-sample.pdf

[34] S. W. Evans, J. S. Owens, B. T. Wymbs, and A. R. Ray, "Evidence-Based Psychosocial Treatments for Children and Adolescents With Attention Deficit/Hyperactivity Disorder," *Journal of Clinical Child & Adolescent Psychology*, vol. 47, no. 2, pp. 157–198, Mar. 2018, doi: 10.1080/15374416.2017.1390757.

[35] L. J. Pfiffner and L. M. Haack, "Behavior Management for School Aged Children with ADHD," *Child and adolescent psychiatric clinics of North America*, vol. 23, no. 4, pp. 731–746, Oct. 2014, doi: 10.1016/j.chc.2014.05.014.

[36] N. A. Center, "Findings and Conclusions: National Standards Project, Phase 2," *Randolph, MA*, 2015.

[37] I. Kamp-Becker, "Autism Spectrum Disorder in ICD-11—a Critical Reflection of Its Possible Impact on Clinical Practice and Research," *Molecular Psychiatry*, vol. 29, no. 3, pp. 633–638, Mar. 2024, doi: 10.1038/s41380-023-02354-y.

[38] F. Craig, A. L. Lamanna, F. Margari, E. Matera, M. Simone, and L. Margari, "Overlap Between Autism Spectrum Disorders and Attention Deficit Hyperactivity Disorder: Searching for Distinctive/Common Clinical Features," *Autism Research*, vol. 8, no. 3, pp. 328–337, Jun. 2015, doi: 10.1002/aur.1449.

[39] S. Martinez, K. Stoyanov, and L. Carcache, "Unraveling the Spectrum: Overlap, Distinctions, and Nuances of ADHD and ASD in Children," *Frontiers in Psychiatry*, vol. 15, p. 1387179, 2024.

[40] C. Hours, C. Recasens, and J.-M. Baleyte, "ASD and ADHD Comorbidity: What Are We Talking About?," *Frontiers in psychiatry*, vol. 13, p. 837424, 2022.

[41] B. Wies, C. Landers, and M. Ienca, "Digital Mental Health for Young People: A Scoping Review of Ethical Promises and Challenges," *Frontiers in Digital Health*, vol. 3, Sep. 2021, doi: 10.3389/fdgth.2021.697072.

[42] T. W. Benevides, H. J. Carretta, C. K. Ivey, and S. J. Lane, "Therapy Access among Children with Autism Spectrum Disorder, Cerebral Palsy, and Attention-deficit–Hyperactivity Disorder: A Population-based Study," *Developmental Medicine & Child Neurology*, vol. 59, no. 12, pp. 1291–1298, Dec. 2017, doi: 10.1111/dmcn.13560.

[43] M. L. Ganz, "The Lifetime Distribution of the Incremental Societal Costs of Autism," *Archives of Pediatrics & Adolescent Medicine*, vol. 161, no. 4, pp. 343–349, Apr. 2007, doi: 10.1001/archpedi.161.4.343.

[44] A. L. Green and D. L. Rabiner, "What Do We Really Know about ADHD in College Students?," *Neurotherapeutics*, vol. 9, no. 3, pp. 559–568, Jul. 2012, doi: 10.1007/s13311-012-0127-8.

[45] S. J. Kwon, Y. Kim, and Y. 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*, vol. 12, no. 1, p. 12, Feb. 2018, doi: 10.1186/s13034-018-0218-3.

[46] R. C. Kessler *et al.*, "The World Health Organization Adult ADHD Self-Report Scale (ASRS): A Short Screening Scale for Use in the General Population," *Psychological Medicine*, vol. 35, no. 2, pp. 245–256, Feb. 2005, doi: 10.1017/S0033291704002892.

[47] A. L. Duckworth, C. Peterson, M. D. Matthews, and D. R. Kelly, "Grit: Perseverance and Passion for Long-Term Goals," *Journal of Personality and Social Psychology*, vol. 92, no. 6, pp. 1087–1101, 2007, doi: 10.1037/0022-3514.92.6.1087.

[48] J. M. Kamradt *et al.*, "Barkley Deficits in Executive Functioning Scale (BDEFS): Validation in a Large Multisite College Sample," *Assessment*, vol. 28, no. 3, pp. 964–976, Apr. 2021, doi: 10.1177/1073191119869823.

[49] G. J. DuPaul, L. L. Weyandt, S. M. O'Dell, and M. Varejao, "College Students with ADHD: Current Status and Future Directions," *Journal of Attention Disorders*, vol. 13, no. 3, pp. 234–250, Nov. 2009, doi: 10.1177/1087054709340650.

[50] W. H. Canu and G. L. Carlson, "Differences in Heterosocial Behavior and Outcomes of ADHD-symptomatic Subtypes in a College Sample," *Journal of Attention Disorders*, vol. 6, no. 3, pp. 123–133, Apr. 2003, doi: 10.1177/108705470300600304.

[51] H. C. Niermann and A. Scheres, "The Relation between Procrastination and Symptoms of Attention-deficit Hyperactivity Disorder (ADHD) in Undergraduate Students," *International Journal of Methods in Psychiatric Research*, vol. 23, no. 4, pp. 411–421, Jul. 2014, doi: 10.1002/mpr.1440.

[52] S. Gray, P. Fettes, S. Woltering, K. Mawjee, and R. Tannock, "Symptom Manifestation and Impairments in College Students With ADHD," *Journal of learning disabilities*, vol. 49, Mar. 2015, doi: 10.1177/0022219415576523.

[53] K. Spiel, E. Hornecker, R. M. Williams, and J. Good, "ADHD and Technology Research – Investigated by Neurodivergent Readers," in *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, in CHI '22. New York, NY, USA: Association for Computing Machinery, Apr. 2022, pp. 1–21. doi: 10.1145/3491102.3517592.

[54] J. Wang, N. Yan, H. Liu, M. Liu, and C. Tai, "Brain-Computer Interfaces Based on Attention and Complex Mental Tasks," *Digital Human Modeling*, vol. 4561. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 467–473, 2007. doi: 10.1007/978-3-540-73321-8_54.

[55] T. Eslami and F. Saeed, "Similarity Based Classification of ADHD Using Singular Value Decomposition," in *Proceedings of the 15th ACM International Conference on Computing Frontiers*, Ischia Italy: ACM, May 2018, pp. 19–25. doi: 10.1145/3203217.3203239.

[56] A. Price *et al.*, "In Transition with ADHD: The Role of Information, in Facilitating or Impeding Young People's Transition into Adult Services," *BMC Psychiatry*, vol. 19, no. 1, p. 404, Dec. 2019, doi: 10.1186/s12888-019-2284-3.

[57] X. Liu *et al.*, "The Effect of Digital Interventions on Attention Deficit Hyperactivity Disorder (ADHD): A Meta-Analysis of Randomized Controlled Trials," *Journal of Affective Disorders*, vol. 365, pp. 563–577, Nov. 2024, doi: 10.1016/j.jad.2024.08.156.

[58] A. O'Connell *et al.*, "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*, in HRI '24. New York, NY, USA: Association for Computing Machinery, Mar. 2024, pp. 533–541. doi: 10.1145/3610977.3634929.

[59] F. Cirillo, *The Pomodoro Technique: The Acclaimed Time-Management System That Has Transformed How We Work*. Crown, 2018.

[60] F. Amato, M. Di Gregorio, C. Monaco, M. Sebillo, G. Tortora, and G. Vitiello, "Socially Assistive Robotics Combined with Artificial Intelligence for ADHD," in *2021 IEEE 18th Annual Consumer Communications & Networking Conference (CCNC)*, Jan. 2021, pp. 1–6. doi: 10.1109/CCNC49032.2021.9369633.

[61] R. Subramanian, J. Wache, M. K. Abadi, R. L. Vieriu, S. Winkler, and N. Sebe, "ASCERTAIN: Emotion and Personality Recognition Using Commercial Sensors," *IEEE Transactions on Affective Computing*, vol. 9, no. 2, pp. 147–160, Apr. 2018, doi: 10.1109/TAFFC.2016.2625250.

A APPENDIX

You may include other additional sections here.