

# Leveraging Machine Learning in Data Analysis and Management for Special Education: Developing low-cost Digital Diagnostic and Media Therapeutic Approaches for Children with Neurodevelopmental Disorders in Impoverished Areas

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**Abstract.** This study delves into the use of machine learning to develop cost-effective digital diagnostic and therapeutic tools for children with Neurodevelopmental Disorders (NDD) in underprivileged areas. Utilizing a predictive model, it engaged 300 students from low-income families in Nanfeng County, Jiangxi, China, evaluating their predisposition to Autism Spectrum Disorder (ASD) and Attention-Deficit/Hyperactivity Disorder (ADHD). The results underscore a heightened prevalence of these disorders in poverty-stricken settings relative to global norms. In addition the study demonstrates that digital methodologies for diagnosing and managing NDD are not only efficient and affordable but also practical for areas with limited resources. This approach crucially addresses the lack of NDD data and resources in such communities, offering vital insights into enhancing care and education for children with ADHD and ASD, as well as facilitating Epidemiological Data Collection and Management in economically challenged communities.

**Keywords:** Neurodevelopmental Disorders; Machine Learning; Digital Diagnosis; Media Therapy; Poverty; ASD; ADHD.

## 1. Introduction

The advent of the 21st century has witnessed an unparalleled evolution in the field of digital technology, revolutionizing various facets of human life, including healthcare and education. This technological renaissance holds profound implications for special education, particularly in addressing the complex needs of children with Neurodevelopmental Disorders (NDDs) such as Autism Spectrum Disorder (ASD) and Attention-Deficit/Hyperactivity Disorder (ADHD). The intersection of machine learning, data analysis, and management in this domain presents a beacon of hope, especially for those in impoverished areas, where traditional healthcare and educational resources are scarce or non-existent.

In economically disadvantaged regions, children are disproportionately affected by NDDs, often compounded by a lack of access to timely and accurate diagnosis and effective therapeutic interventions. The digital divide exacerbates these challenges, further alienating these vulnerable populations. This paper aims to bridge this gap by leveraging the potential of machine learning in developing low-cost, digital diagnostic and media therapeutic approaches tailored for children with NDDs in such areas.

Our approach centers on the innovative application of machine learning algorithms to enhance the accuracy and efficiency of diagnosing NDDs. By analyzing behavioral patterns, social interactions, and cognitive responses through digital mediums, we propose a model that not only expedites the diagnostic process but also reduces the associated costs significantly. Furthermore, this study explores the efficacy of digital media therapy (DMT) as a therapeutic intervention, utilizing a blend of interactive digital tools, educational applications, and virtual environments to cater to the unique learning and developmental needs of children with ASD and ADHD.

This introduction outlines the crucial need for such innovative approaches in special education, particularly in resource-limited settings. It sets the stage for a detailed discussion on the scarcity of



public data on NDDs in impoverished areas, the current state of digital diagnosis and treatment of ASD and ADHD, and the role of digital education and therapeutic approaches in this context. Our research methodology, data collection, and analysis techniques are designed to validate the effectiveness of these approaches, aiming to offer a new paradigm in the management and treatment of NDDs among underprivileged children.

Through this research, we aspire to make a meaningful contribution to the field of special education, offering a sustainable and accessible solution for the early detection and treatment of NDDs. The insights gained from this study have the potential to inform policy decisions and educational strategies, ultimately enhancing the quality of life for children with NDDs in impoverished areas around the globe.

## **2. Related Work**

### **2.1. Scarcity of Public Data on Neurodevelopmental Disorders (NDD) in Impoverished Areas**

Presently, there is a notable escalation in the risk of delayed physical, emotional, and socio-cognitive development among children in economically disadvantaged areas, precipitating a heightened incidence of Neurodevelopmental Disorders (NDDs) [1]. Rural areas, in comparison to their urban counterparts, demonstrate a more pronounced prevalence of NDDs, where disorders such as Autism Spectrum Disorder (ASD) and Attention-Deficit/Hyperactivity Disorder (ADHD) frequently go undetected [1]. Intriguingly, while over 80% of global births occur in low- and middle-income regions, the bulk of the epidemiological insights into NDDs predominantly originates from more affluent, developed locales. This disparity in precise epidemiological intelligence for NDDs in less affluent areas critically undermines the efficacy of public health data governance and the strategic formulation of pertinent policy interventions [2].

### **2.2. Digital Diagnosis and Treatment of Autism and Attention-Deficit/Hyperactivity Disorder**

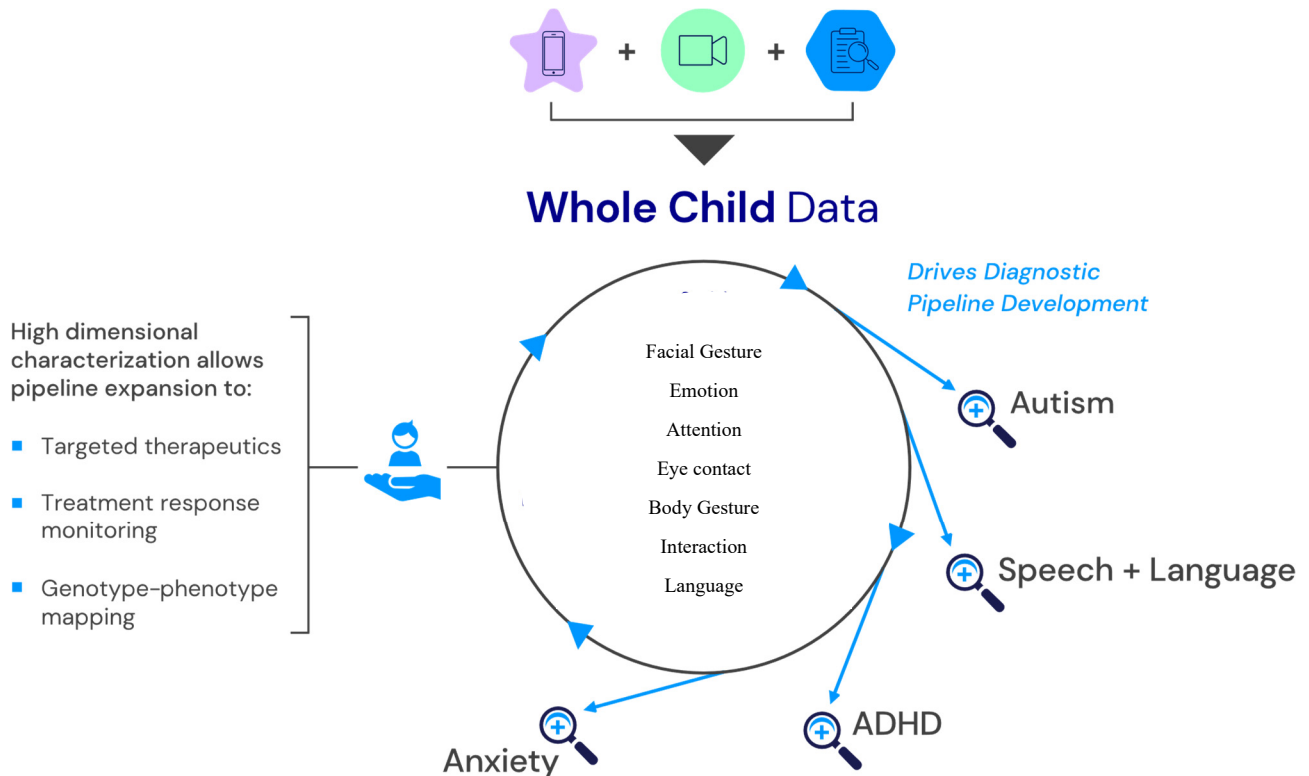
Currently, the mainstream diagnosis of ADHD follows the DSM-5 [5] criteria, which involve assessing mechanisms related to hyperactivity, attention deficit, and impulsivity. Experts combine developmental history, supplementary information, psychological measurements, behavioral observations, and impairments to make a diagnosis. This process is often challenging and time-consuming. With the advancement of machine learning and digital healthcare, digital diagnostics offer advantages such as high accuracy, shorter diagnosis times, lower costs, and remote accessibility. These advancements present opportunities for diagnosis and treatment in low-income areas.

### **2.3. Digital Education and Therapeutic Approaches for ADHD and ASD**

Digital Education and Therapeutic Approaches for ADHD and ASD encompass the utilization of technology-driven tools and strategies to support individuals with these neurodevelopmental disorders. These approaches often include interactive digital learning platforms, educational apps, virtual reality interventions, and teletherapy sessions[13]. They aim to enhance the educational experience, deliver personalized interventions, and provide remote access to therapy services. Digital education and therapy offer several advantages, such as individualized learning plans, real-time progress tracking, and increased accessibility, making them valuable resources in addressing the unique needs of individuals with ADHD and ASD[2]. Additionally, previous research has shown that this treatment approach has inherent advantages in the initial treatment of ASD patients, alleviating social anxiety in ASD patients.

### 3. Methods

#### 3.1. Digital Diagnostic of ADHD and ASD in Impoverished Areas



**Figure 1.** The Structure of Data collection and Prediction

##### 3.1.1. Participants

We conducted a recruitment of 300 students from three elementary schools situated in the economically challenged regions of Nanfeng County, Jiangxi Province, China. These students hail from families that align with the poverty line criteria established by the World Bank[4]. The cohort comprises 39% female and 61% male students, with an average age positioned at 8 years and 5 months. The age range extends from the youngest participant at 7 years and 2 months to the oldest at 12 years and 7 months. Notably, none of these students have been previously diagnosed with any Neurodevelopmental Disorders, providing a unique demographic for our study.

##### 3.1.2. Data Collection

In our study, we meticulously gathered data encompassing classroom behavior, social gaming interactions, and structured questionnaires tailored for ASD and ADHD diagnostic purposes. To capture nuanced physical and facial dynamics, we deployed cameras, complemented by the use of Mediapipe[14] for precise movement tracking. The classroom behavior analysis entailed a predictive model of interactions among participants, educators, peers, and their immediate educational environment, with a specific focus on capturing physical and facial expressions via classroom cameras. Additionally, interaction analysis was conducted through a close examination of participants' engagement with a designated social gaming application for children, within a predefined temporal scope, meticulously recording their head, facial, and ocular movements. To align with global diagnostic standards, we incorporated the DSM-5 [5] criteria for ADHD and ASD in our questionnaire frameworks.

##### 3.1.3. Prediction Model

We utilized the predictive model advanced by Shashank et al. [3] for prognosticating the propensity of participants towards Autism and ADHD. This sophisticated model employs a trifecta of diagnostic techniques: facial expression analysis, gaze tracking, and RGBD head movement analysis, to

intricately evaluate user behavior. This approach is instrumental in facilitating the diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD). Empirical evidence from prior experiments showcases its efficacy, with the model achieving a remarkable 96% accuracy in differentiating between control and condition-specific groups (ADHD/ASD), and a commendable 94% precision in discerning between comorbid (ADHD+ASD) and exclusively ASD cohorts[3]. Such statistical robustness underscores the model's capability in rendering highly accurate diagnostic forecasts, thereby empowering clinicians with enhanced efficacy in the definitive diagnosis or exclusion of ASD and ADHD.

### 3.1.4. Data Analysis

In concordance with contemporary scholarly insights regarding the diagnosis of ADHD and ASD[15][16], we have meticulously calibrated the allocation of weights within our tripartite predictive analysis framework. The component of classroom behavioral analysis ( $x_1$ ) is assigned a weight of 0.3, reflecting its proportional contribution to the overall assessment. In a similar vein, the analysis pertaining to social gaming interactions ( $x_2$ ) is also allocated a weight of 0.3. The diagnostic questionnaire, perceived to bear marginally greater significance in the holistic evaluation ( $x_3$ ), is accorded a weight of 0.4. This allocation schema is indicative of the intricate interplay among various assessment modalities, particularly in the context of neurodevelopmental disorder diagnosis. The specific analysis of ADHD and ASD subtypes is further grounded in and guided by the nuanced application of targeted assessment scales.

$$f(x) = 0.3x_1 + 0.3x_2 + 0.4x_3 \quad (1)$$

## 3.2. Digital Media Therapy

### 3.2.1. Participates

There were a total of 12 participants, with 7 males and 5 females, averaging 8 years and 5 months in age. The oldest participant was 9 years and 4 months old, while the youngest was 7 years and 5 months old. All participants exhibited strong tendencies toward ADHD or ASD in the Digital Diagnostic, with scores out of 10. The average tendency score was 8.77, with the highest being 9.45 and the lowest being 7.81.

### 3.2.2. NeuroCare Application

We have developed a digital psychological therapy application utilizing a generative AI API with contextual understanding and the ability to analyze real-time user interactions. In this application, an intelligent digital persona is integrated with ADHD and ASD therapies. Through natural language conversations, user feedback and states are collected, and psychological therapy content tailored to user needs is incorporated into multimedia productions involving images, sounds, and other modalities. This approach enables cost-effective and efficient psychological therapy for users.

### 3.2.3. Data Collection

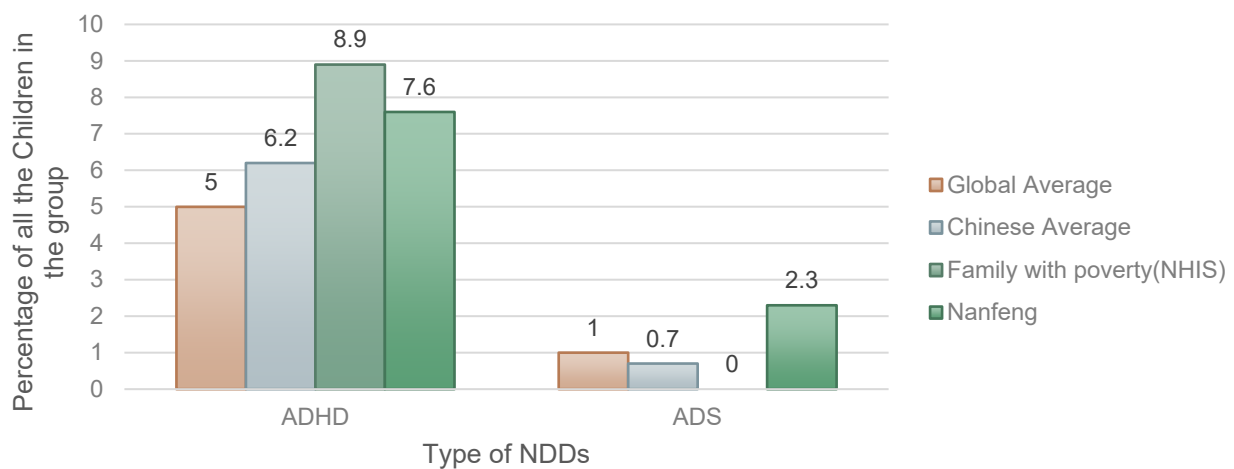
The experiment duration is thirty days, and participants are required to use the NeuroCare application for two hours daily, with their usage being monitored. Participants will undergo ADHD or ASD assessments every five days. These assessments will be used to monitor treatment progress and evaluate its effectiveness.

## 4. Result and Discussion

### 4.1. The Tendencies of Children Towards ADHD and ASD

Based on our data analysis, participants showing tendencies towards ADHD accounted for 7.6% of the total number of participants, surpassing the global average of 5% for children[6] and the Chinese average of 6.2%[8]. It approached the ADHD prevalence of 8.9% among children from families with incomes below the poverty line as reported by the National Health Interview Survey (NHIS) in the United States[7]. Notably, the predominance was in the inattentive subtype of ADHD, with the combined subtype being the least prevalent.

**Table 1.** Comparison of the Prevalence of ADHD and ASD in Nanfeng Children with Children in Different Types of Areas.



Participants exhibiting tendencies towards ASD constituted 2.0% of the total participants, exceeding the global average of 1% for children[9] and the Chinese average of 0.7%[10]. Due to the lack of epidemiological data in impoverished areas, comparisons with other impoverished regions are unavailable. Among ASD subtypes, the highest prevalence was observed in the absence of Autistic Disorder.

These findings underscore the importance of considering socioeconomic factors in the diagnosis and management of ADHD in children, particularly those from low-income families. Additionally, there is an urgent need for comprehensive data collection, epidemiological research, and detailed health data recording for ASD in impoverished areas.

### 4.2. The Objective Factors Influencing Support for Children with ADHD and ASD

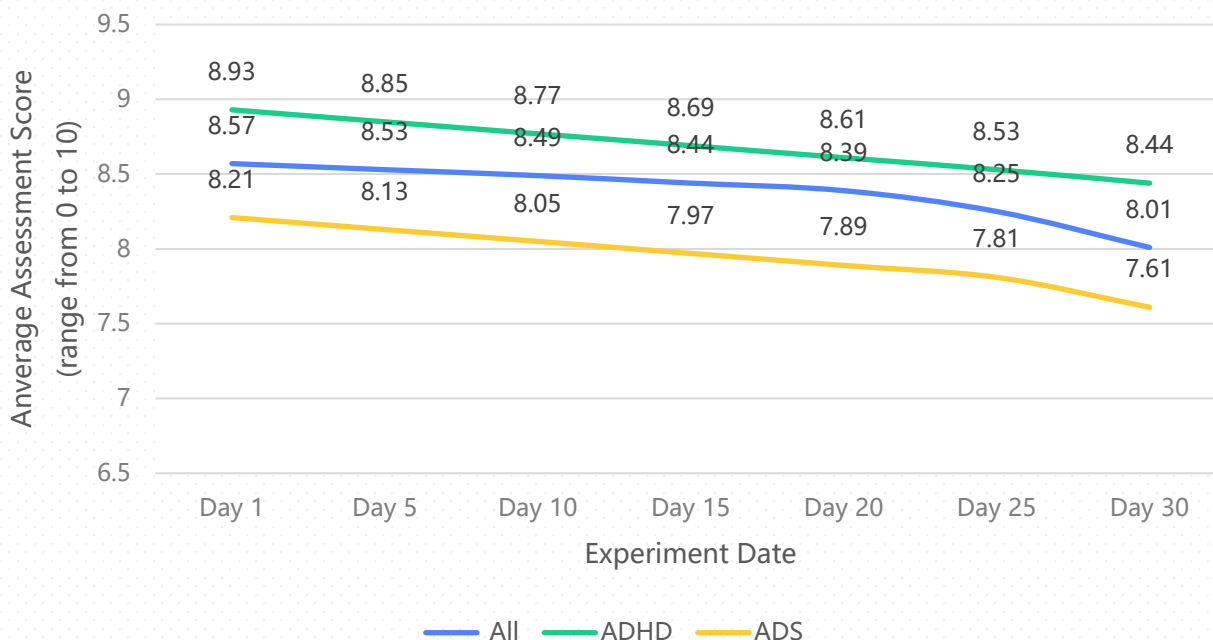
Based on our analysis, it is evident that teachers and guardians in impoverished areas exhibit a diverse range of attitudes towards ADHD (Attention-Deficit/Hyperactivity Disorder) and ASD (Autism Spectrum Disorder). Alarming, the rate of insufficient understanding of these disorders stands at 68%, with a prevalence of misconceptions and biases reaching 82%. This highlights the significant challenges faced by children with ADHD and ASD in low-income environments, necessitating the urgent development of relevant intervention measures and educational policies to enhance their well-being.

In terms of economic and temporal aspects, the average cost and duration of diagnosis for ADHD and ASD are 3 months and \$2,000, respectively, while psychologist therapy costs over \$1,000 annually. In contrast, our data-driven digital diagnostics require only 3 days, costing \$100, with digital therapist annual expenses ranging from \$100 to \$150 per individual. These cost-effective digital diagnostic and therapeutic methods are well-suited for impoverished areas, given their affordability, remote

accessibility, speedy diagnosis, and improved patient data management. These advantages help alleviate the burden of limited healthcare resources, particularly in remote regions, promoting early intervention and treatment and enhancing treatment outcomes.

### 4.3. Digital Media Therapy(DMT)

**Table 2.** Average Assessment Scores of ADHD and ASD in the 30-day experiment



After two months of treatment, 11 out of 12 participants showed a noticeable decrease in their ADHD or ASD assessment scores, with an average reduction of 0.56 points and a maximum decrease of 1.2 points. The ADHD group had an average decrease of 0.49 points, while the ASD group had an average decrease of 0.60 points. This suggests that the latest generative AI-based multimodal digital media therapy has a significant impact on the treatment of ADHD and ASD.

## 5. Conclusion and Future Work

This research highlights the critical role of machine learning and digital media in special education for Neurodevelopmental Disorders (NDDs) in impoverished areas. The digital diagnostic and therapeutic methods proposed are cost-effective, addressing the resource scarcity in these areas and facilitating inclusive healthcare and education. Additionally, the study shows the effectiveness of digital media therapy (DMT) for ADHD and ASD, with significant post-treatment improvements. This supports the integration of technology in managing neurodevelopmental disorders, aligning with the global trend towards digital healthcare.

Future research should expand to more diverse populations and conduct longitudinal studies on the long-term effects of digital interventions for NDDs. Integrating these tools into mainstream systems, especially in low-resource areas, is vital. This study urges policymakers and professionals to address the challenges in NDD care in impoverished regions, aiming to improve policies and practices for these children's betterment.

In summary, using machine learning in special education in resource-limited settings shows promise for enhancing NDD care and education, contributing significantly to the field and advocating for equitable and accessible education and healthcare for all children.

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## References

- [1] F. Amato, M. Di Gregorio, C. Monaco, M. Sebillio, G. Tortora and G. Vitiello, "Socially Assistive Robotics combined with Artificial Intelligence for ADHD," 2021 IEEE 18th Annual Consumer Communications & Networking Conference (CCNC), Las Vegas, NV, USA, 2021, pp. 1-6, doi: 10.1109/CCNC49032.2021.9369633.
- [2] Bitta M, Kariuki SM, Abubakar A, Newton CRJC. Burden of neurodevelopmental disorders in low and middle-income countries: A systematic review and meta-analysis. *Wellcome Open Res.* 2017 Dec 29;2: 121. doi: 10.12688/wellcomeopenres.13540.3. PMID: 29881784; PMCID: PMC5964629.
- [3] S. Jaiswal, M. F. Valstar, A. Gillott and D. Daley, "Automatic Detection of ADHD and ASD from Expressive Behaviour in RGBD Data," 2017 12th IEEE International Conference on Automatic Face & Gesture Recognition (FG 2017), Washington, DC, USA, 2017, pp. 762-769, doi: 10.1109/FG.2017.95.
- [4] Information on: <https://blogs.worldbank.org/voices/adjustment-global-poverty-lines>.
- [5] Dsm. diagnostic and statistical manual of mental disorders (dsm-5), [online] Available: <http://www.dsm5.org/>.
- [6] Cortese, S., Song, M., Farhat, L.C. et al. Incidence, prevalence, and global burden of ADHD from 1990 to 2019 across 204 countries: data, with critical re-analysis, from the Global Burden of Disease study. *Mol Psychiatry* (2023). <https://doi.org/10.1038/s41380-023-02228-3>.
- [7] <https://www.cdc.gov/nchs/products/databriefs/db70.htm>.
- [8] Liu, A., Xu, Y., Yan, Q. et al. The Prevalence of Attention Deficit/Hyperactivity Disorder among Chinese Children and Adolescents. *Sci Rep* 8, 11169 (2018). <https://doi.org/10.1038/s41598-018-29488-2>.
- [9] Zeidan J, Fombonne E, Scora J, Ibrahim A, Durkin MS, Saxena S, Yusuf A, Shih A, Elsabbagh M. Global prevalence of autism: A systematic review update. *Autism Res.* 2022 May;15(5):778-790. doi: 10.1002/aur.2696. Epub 2022 Mar 3. PMID: 35238171; PMCID: PMC9310578.
- [10] Zhou H, Xu X, Yan W, Zou X, Wu L, Luo X, Li T, Huang Y, Guan H, Chen X, Mao M, Xia K, Zhang L, Li E, Ge X, Zhang L, Li C, Zhang X, Zhou Y, Ding D, Shih A, Fombonne E, Zheng Y, Han J, Sun Z, Jiang YH, Wang Y; LATENT-NHC Study Team. Prevalence of Autism Spectrum Disorder in China: A Nationwide Multi-center Population-based Study Among Children Aged 6 to 12 Years. *Neurosci Bull.* 2020 Sep;36(9):961-971. doi: 10.1007/s12264-020-00530-6. Epub 2020 Jun 30. PMID: 32607739; PMCID: PMC7475160.
- [11] Faraone, S. V., Banaschewski, T., Coghill, D, Zheng, Y, & Wang, Y. (2021). The world federation of adhd international consensus statement: 208 evidence-based conclusions about the disorder. *Neuroscience & Biobehavioral Reviews* (January 2002).
- [12] Information on: <https://cognoa.com/clinical-research/>.
- [13] Goharinejad, S., Goharinejad, S., Hajesmaeel-Gohari, S. et al. The usefulness of virtual, augmented, and mixed reality technologies in the diagnosis and treatment of attention deficit hyperactivity disorder in children: an overview of relevant studies. *BMC Psychiatry* 22, 4 (2022). <https://doi.org/10.1186/s12888-021-03632-1>.
- [14] Information on: <https://developers.google.com/mediapipe>.
- [15] Lim L, Marquand A, Cubillo AA, Smith AB, Chantiluke K, Simmons A, Mehta M, Rubia K. Disorder-specific predictive classification of adolescents with attention deficit hyperactivity disorder (ADHD) relative to autism using structural magnetic resonance imaging. *PLoS One.* 2013 May 16;8(5): e63660. doi: 10.1371/journal.pone.0063660. PMID: 23696841; PMCID: PMC3656087.
- [16] Lebeña, A., Faresjö, Å., Faresjö, T. et al. Clinical implications of ADHD, ASD, and their co-occurrence in early adulthood--the prospective ABIS-study. *BMC Psychiatry* 23, 851 (2023). <https://doi.org/10.1186/s12888-023-05298-3>.