COVID-19: Remote diagnostic assessment of children with suspected Autism Spectrum Disorder, a selected literature review

Liliana Carrieri, Arianna Benevenuto*, Paola Venuti*, Giulio Bertamini**, Simona De Falco**

Abstract

Diagnostic evaluations of neurodevelopmental disorders dramatically reduced and slowed down following the disruptions caused by Sars-CoV-2 pandemic. For this, it was necessary to identify solutions allowing diagnostic assessment, screening, and early patient care by implementing remote diagnostic protocols respecting the restrictions imposed by the lockdown. Centres and services specialized in Autism Spectrum Disorder (ASD) had to quickly implement innovative diagnostic protocols able to satisfy patients' needs, minimizing the chances of spreading the virus at the same time. This work collects the studies conducted so far on remote assessment of ASD both prior to and relating to the period of the SARS-CoV-2 pandemic. It also explores standard diagnostic tools that have been adapted for remote administration, in order to evaluate strengths and limitations of these methodologies.

Remote assessment methodologies were initially employed to overcome the difficulties of long-distance diagnoses and to respond to families' need for continuity of public and private services. These studies underlined the

* Department of Psychology and Cognitive Science, University of Trento (Italy).
** Department of Child and Adolescent Psychiatry – Pitié-Salpêtrière University Hospital – Sorbonne University, Paris (France).

Corresponding Author: Liliana Carrieri, Dipartimento di Psicologia e Scienze Cognitive, Università di Trento (Italy), Corso Bettini 84, 38068 Rovereto. Email: liliana.carrieri@unitn.it

validity of some remote diagnostic protocols and how telediagnosis may enable the diagnostic evaluation, making it more accessible and thus favouring timely intervention. We discussed the opportunity to integrate in person and remote approaches for diagnosing neurodevelopmental conditions, even in the post covid emergency period.

Keywords: Autism Spectrum Disorders, remote diagnosis, children, tele-diagnosis, remote assessment, ecological

Introduction

Since the World Health Organization (WHO) declared that the new SARS-CoV-2 virus (March 11, 2020) had led to the pandemic of COVID-19 disease (Punzo *et al.*, 2021), heavy consequences dramatically impacted three main domains: health, society, and economy. From the economic point of view, the effects were mainly related to a decline in employment, personal income, and an increase in absolute poverty. The scientific literature sharply highlighted the dramatic effects of health resources depletion for care providing, including, reduced access to the health care system, the presence of fear and stress, among other factors. The health effects were also closely linked to the dramatic consequences of the COVID-19 pandemic on various social systems (Peirone, 2020; Falcone & Detty, 2015). Specifically, several containment measures were taken in order to reduce the spread of the virus, including school closure and the drastic reduction of nonessential health and social services (e.g., deferral of non-emergency visits or interventions) (Wong *et al.*, 2020). From the perspective of children's psychological health, these restrictions contributed to an increase in issues related to psychological well-being in all the developmental age-groups, which were mainly expressed by anxiety, depression, and stress, particularly for those individuals suffering from previous vulnerabilities. At the same time, the pandemic led to a reduction in referrals of children with possible special needs from schools, due to a decrease in children's school attendance and the consequent reduction of in-depth psychological assessments and interventions. Professionals reported a situation-specific increase in prior psychological issues that evolved into overt psychopathological disorders. In turn,

this required significant interventions at the outpatient level or hospitalization (Cusinato *et al.*, 2020). In turn, this led to an increase in referrals to the emergency public service. Generally, specialized public services were not able to meet such an increased demand. Instead, the pandemic significantly reduced the number of accesses to behavioural health care in medical, community, and school settings (Wong *et al.*, 2020).

As a result of the aforementioned aspects, clinical assessments drastically reduced and/or slowed down. Health professionals were therefore required to find novel strategies to comply with the social distancing guidelines in order to not to suspend the processes of in-depth diagnosis, screening, and early intake altogether, which are critical in several areas of mental health, such as neurodevelopmental conditions (Grzadzinski *et al.*, 2021). Autism-related centres and services also had to rapidly implement innovative diagnostic procedures to meet patients' needs while minimizing the chances of spreading the virus. Therefore, SARS-COV2 led to an extensive revision of diagnostic modalities, introducing a telemedicine-oriented approach that allowed care delivery despite the significant constraints.

A diagnosis of ASD requires careful behavioural observation taking into consideration specific elements such as communicative-relational cues that can be particularly complicated to assess due to difficulties related to emotional reciprocity and non-verbal communication (American Psychiatric Association [APA], 2022). In addition, the autism spectrum is extremely heterogeneous and often presents comorbidities with intellectual disability and other neurodevelopmental disorders. Therefore, the assessment includes multiple sources of information: parent interviews, clinical direct observation in interaction with the child, developmental scale administration, and other psychological tests measuring cognitive and socio-relational aspects (Jang *et al.*, 2021). This type of diagnostics often requires several hours and specialized second-level services in the context of public health (Istituto Superiore di Sanità Guidelines, https://www.iss.it/ long-covid-linee-guida). The pandemic has therefore led to the urgent need for a dramatic and rapid change in assessment procedures, especially in early stages of the pandemics where home confinement was the most severe. Luckily, the literature started to show promising results related to diagnostic assessments of ASD leveraging telemedicine systems

(Jang *et al.*, 2021; Corona *et al.*, 2020; Smith *et al.*, 2017) which emerged as an appropriate strategy to respond to these changes, as well as to overcome specific limitations, e.g., limited accessibility due to geographic features.

Based on this research evidence, the aim of this review was to show discuss and compere different telemedicine approaches in the contest of ASD before and after COVID-19, in order to highlight strength and limits that characterize online assessments.

Telemedicine and ASD before COVID-19

In response to COVID-19, telemedicine in ASD clinical settings increased. However, the first studies on telemedicine date back to the pre-pandemic period. These tools were designed both to facilitate consulting and to decrease difficulties in making diagnoses due to geographic distances (Regina Molinini-Avejonas *et al.*, 2015). Further, the aim also included to generally increase access to diagnostic services, which are essential to identify children at risk of ASD at an early stage in order to promptly and timely initiate habilitation and rehabilitation (Grzadzinski *et al.*, 2021; Juárez *et al.*, 2018; Smith, C. *et al.*, 2017).

As early as 2016, research highlighted that telemedicine could indeed represent an opportunity to speed up the diagnostic process. For example, the study by Smith *et al.* (2017) compared the Naturalistic Observation Diagnostic Assessment (NODA), an innovative telemedicine diagnostic approach exploiting home videos recorded under clinical guidance, with an In-Person Assessment (IPA) using gold standard instruments. IPA results were not provided to families until NODA procedures were completed. The participant age ranged from 18 months to 6 years and 11 months.

The IPA phase involved the administration of diagnostic tests. Specifically, the Autism Diagnostic Interview-Revised (ADI-R; Rutter *et al.*, 2003) is a parent interview measuring: reciprocity in social interaction, communication and language, restricted, repetitive, stereotyped patterns of behaviour. The Autism Diagnostic Observation Schedule-Second Edition (ADOS-2; Lord *et al.*, 2013) is a semi-structured diagnostic test, administered by a trained clinician that assesses

the 2 clusters of symptomatology, i.e., social affect and the area of restricted repetitive patterns of behaviours and interests (APA, 2022). The Vineland Adaptive Scales second edition (VABS-2; Sparrow *et al.*, 2016) is a parent interview measuring adaptive behaviour in different life-contexts and domains. The Mullen Scales of Early Learning (MSEL; Mullen, 1995) consists of an evaluation of early intellectual development and school readiness up to 68 months of age. Finally, the Kaufman Brief Intelligence Test – second edition (KBIT-2; Kaufman, 2004) is an evaluation of verbal and non-verbal intelligence suitable to children from 69 months of age. The Naturalistic Observation Diagnostic Assessment (NODA), based on both the developmental history and the collection of video data. Results showed diagnostic concordance between the two methods. Given the high level of agreement with the IPA, this study showed that NODA has the potential to improve the efficiency of the diagnostic process for ASD while meeting the criteria for diagnostic validity. The authors reported that NODA provided useful initial information relevant for an ASD diagnosis, and significantly accelerated the onset of the rehabilitation pathway. Therefore, this evidence suggests that the information gathered through the NODA can be comparable to the one provided IPA assessment.

The NODA was also designed to be integrated with an IPA assessment in more complex general situations. For example, in some cases clinicians may have the need to observe the child's behaviour in the home setting. Further, the procedure was designed to generate a detailed report describing specific behaviours, which can be targeted and analysed from the videos.

Despite supporting the accuracy of a new telemedicine approach, these results came with some limitations. The diagnostic assessment always involved the IPA first and the NODA afterwards, and this may have influenced the parents' behaviour while recording the videos. In addition, the sample size was too small to obtain reliable and reproducible results, and the study results should be interpreted as preliminary evidence, despite promising. As highlighted by the authors, in order to determine the reliability and validity of a new diagnostic method for ASD, numerous studies including social validity, and larger representative samples are needed.

In 2018, the study by Juarez *et al.* compared tele-diagnostic accuracy with gold standard double-masked evaluations. This first tele-assessment of young children (aged 20-34 months) correctly identified 78.9 % (15 children out of 19) of children who were eventually diagnosed with ASD (true positives), indicating a fair sensitivity of the tool. Further, no children were misidentified as ASD (false positives), as the only non-ASD child in the sample was correctly undiagnosed by the remote procedure. However, in this type of diagnostic study it is also important to focus attention on false negatives (which accounted for 5%). These patients are at risk of being excluded from subsequent assessments and may receive a delayed diagnosis. The delay in accessing appropriate care in conditions requiring early intervention actually represent a critical aspect. These findings suggest that within a population characterized by delayed developmental milestones, remote assessment still allows for a reliable and potentially accurate diagnosis of ASD. The telemedicine assessment outlined in this work involved the Screening tool for Autism in Toddlers and Young Children (STAT), an interview based on the DSM-5 (APA, 2013). The psychologists also completed the clinical best estimate assessment, classifications from an expert multidisciplinary team. Furthermore, in terms of feasibility and social validity it was found that these tools were successful in breaking down geographic and time barriers to traditional access to hospital-based ASD assessment. They indeed provided timely diagnosis, access to treatment, and follow-up monitoring to a large number of children and families.

In a study by Valentine *et al.* (2021) a systematic literature review analysed major databases of scientific publications in the biomedical, psychological, and health fields during the period from 2018 through December 2019. A review of research quality was performed in accordance with the Oxford Center for Evidence-Based Medicine Levels of Evidence. The extracted data included the type of technology employed and its purpose (evaluation, treatment, and monitoring). The aim of this systematic review was to highlight how telemedicine was employed prior to the COVID-19 pandemic, with clinical samples in the field of neurodevelopment including patients with Neurodevelopmental Disorders (NDDs), their families, and health care professionals. Telemedicine services were shown to be clinically effective for the diagnosis and monitoring of NDDs. In addition, some evidence of

positive economic impact also emerged, including increased efficiency in service delivery (e.g.: increased treatment availability and reduced waiting times) (Valentine *et al.*, 2021).

Methods

Our aim was to explore research literature and experience about telediagnosis for autism and neurodevelopmental conditions, especially with respect to changes introduced by the pandemics. Therefore, we conducted a searched the PudMed database starting from the following search string:

"(TELEMEDICINE OR TELEHEALTH OR REMOTE OR INNOVATIVE) AND (ASD OR AUTISM OR NEURODEVELOPMENT) AND (EVALUATION OR DIAGNOSTIC OR DIAGNOSIS) AND (COVID-19 OR PANDEMIC)".

The query produced N=104 articles.

The first and last authors analyzed the abstracts of the results and excluded articles that did not specifically relate to the design and implementation of remote procedures to address the diagnosis of neurodevelopmental conditions. Exclusion criteria included articles related to treatment, parent/providers perspectives, and works that did not detail and evaluate telemedicine diagnostic approaches with respect to in-person clinical outcomes. Reviews were excluded but analyzed for relevant articles.

The screening resulted in selecting N=3 articles, i.e., Jang *et al.* (2021), Wagner *et al.* (2022), and Narzisi *et al.* (2020), that evaluated telemedicine approaches to autism diagnosis.

Given that remote diagnostics could be employed also independently from the pandemic emergency, we also inspected the bibliography from these articles, identifying N=4 additional articles that presented similar approaches employed for different reasons, e.g., underserved populations. Hence, we included research works from Corona *et al.* (2020, 2021), Juarez *et al.* (2018), and Smiths *et al.* (2017).

In this review, we discuss and compare the different approaches implemented to achieve and evaluate remote diagnosis for autism.

ASD: remote diagnosis during the pandemic

The COVID-19 pandemic caused unprecedented disruptions to health care, including direct impacts on service delivery related to ASD. Thus, caregiver-mediated tele-assessment presented an opportunity to provide continuity of services within social distancing guidelines.

Among the most relevant and recent studies related to the tele-assessment of ASD children are Wagner *et al.* (2020) and Narzisi *et al.* (2020). Both research groups structured an online assessment process by repurposing or introducing specific instruments designed to assess behaviours present in children with ASD.

Specifically, the study by. Wagner *et al.* (2020) described a tele-assessment model, introducing the TELE-ASD-PEDS (Corona *et al.*, 2020). Clinicians collected structured behavioural information by scaffolding a standardized child-caregiver dyadic play interaction, guided by the clinician. The methodology also involved the administration of a clinical interview to caregivers during multiple appointments. This assessment included anamnestic questions investigating the child's developmental history, adaptive and spontaneous behaviours, current home skills, and the presence of ASD-related behaviours. Clinicians subsequently combined the TELE-ASD-PEDS behavioural observations with other information from the interviews to formulate a diagnostic impression (ASD vs. no ASD). The TELE-ASD-PEDS is described in detail in the Appendix section. At the end of the assessment, online feedback was conducted with families centered on both diagnostic impressions and practical recommendations. Most clinicians (67%) reported that an average visit took between 60 and 120 minutes. The remaining 33% reported longer visits lasting between 120 and 180 minutes. Finally, the protocol included additional assessments and resources (e.g., videos and handouts on ASD and interventions) to be sent to families via multimedia channels ensuring privacy. Because of the importance of not committing false negatives in the diagnostic evaluation, this type of initiative aligned with current research developments, which increasingly highlight the importance and usefulness of initiating intervention pathways even before the onset of a clear symptomatic manifestation (Grzadzinski *et al.*, 2021). However, it is also important to consider the inherent limitations of

public assistance, which require increasing rationalization of resources. In this perspective, telematic and caregiver-driven methodologies may represent important approaches to improve diagnostic and screening procedures while maintaining adequate sustainability in terms of costs and resources. However, in some cases distractions within the home environment made it difficult to understand the child's actual level of functioning. Finally, the highest TELE-ASD-PEDS scores corresponded to the group of children who subsequently received a diagnosis of autism, suggesting that this approach may be useful for identifying children with clear symptoms, but raising the issue of false negative detection. However, further research is still needed in order to be able to perform proper tele-assessment of autism even for the most complex and heterogeneous situations, and to facilitate remote assessment for families with difficulties or inability to access or use technological tools.

The study by Narzisi *et al.* (2020) included a tele-assessment structured in two phases: Pre-Specialty Counseling (PSC) and Specialist Assessment (SA), involving a fully remote assessment.

The PSC phase began with a call to the specialists. Afterwards, 10 self-report questionnaires were sent to the families, divided between parental and child aspects. Specifically for parents, the Parenting Stress Index – 4 (PSI-4) is a self-report questionnaire used to explore parental stress levels and as a screening measure to evaluate the parenting system (Abidin, 2012). For child aspects, the Behavior Rating Inventory of Executive Function (BRIEF) is a standardized questionnaire that measures executive functioning in preschoolers, children and adolescents in home and school settings (Gioia *et al.*, 2003; Gioia *et al.*, 2015); the Child Behavior Checklist (CBCL), is a questionnaire to analyse children's behavioural emotional problems and competencies (Achenbach *et al.*, 1991); the MacArthur Communicative Development Inventory (Bates *et al.*, 2004) is a parent report instrument which capture important information about children's developing abilities in early language, including vocabulary comprehension, production, gestures, and grammar; the Childhood Autism Rating Scale™, Second Edition – Parent/Caregiver Questionnaire (CARS2-QPC) is a rating scale to identify children with autism and to determine symptom severity through quantifiable ratings based on direct observation (Schopler *et al.*, 2010); the Repetitive Behavior Scale-Revised (RBS-

R) is a self-report questionnaire used to measure the breadth of repetitive behaviour in children, adolescents, and adults with Autism Spectrum Disorder (Lam *et al.*, 2007), the Social Communication Questionnaire (SCQ) is a parent questionnaire that evaluate communication, social and relational skills of children who may be autistic (Rutter, 2003); the Sensory Profile (SP) is a structured observational grid used by parents to assesses the child's sensory processing patterns within the settings of home, school, and community-based activities. (Dunn, 1999); the Social Responsiveness Scale (SRS) is a parent-report interview for evaluating reciprocal social behaviour, communication and repetitive and stereotyped behaviours (Constantino *et al.*, 2005).

Child cognitive profile was directly investigated through the administration of the Leiter–R parent social–emotional rating scales (Roid & Miller, 1997), the parent's perception of the child's cognitive/social functioning and emotion regulation (Narzisi, 2020). Further, an online interview with a psychologist specialized in ASD diagnosis was scheduled.

In the PSC phase, during the remote meeting the psychologist explained to the parents how to develop some short, structured videos of the child in the home environment. Afterwards, a booklet summarizing all the procedures for making the videos was sent to the family.

The PSC phase is age-specific and adapted to childrens' developmental level. With respect to preschool children, the videos were 15-20 minutes length and structured as follows:

a) The child playing with a parent (setting inspired by the ADOS-BOSCC), 15 minutes. The Brief Observation of Social Communication Change (BOSCC) (Grzadzinski *et al.*, 2016) is an observational rating scale, described in detail in the Appendix section.
b) The child playing alone (setting inspired by ADOS-2 free play), 15 minutes.
c) The child playing with a sibling (if any), 15 minutes.
d) Family meal, 15 minutes.
e) Any behavior that concerns parents, 15 minutes.
   The SA was spread over four days.

During the first day, parents were required to make a 3 hour commitment (preferably in the morning). During this period, the psychologist collected anamnestic information (1 h) and performed the

administration of the ADI-R (1 h) and the Vineland/VABS (1 h). Thereafter, a team meeting was scheduled (1 h) in order to update with respect to the gathered information. Each expert independently observed the 5 videos produced by the parents and coded the provided questionnaires. In the team, there was always a clinician trained and certified for the administering of the ADOS-2 for both clinical and research purposes.

a) During the second day, the family was asked to have three remote sessions lasting 25 minutes each with the three clinicians (psychologist, speech therapist, and psychomotor therapist). During the sessions, the clinicians interacted with both the child and one parent. If the child was preschool, the parent was asked to set up an environment inspired by ADOS-BOSCC. If the child was older or non-autonomous, the parent was asked to scaffold the interaction in a LEGO therapy inspired environment. If the child showed good cognitive abilities, clinicians may request to interact only with the child in order to propose some items directly from the ADOS-2 Module 3. In this case, the three sessions lasted 45 minutes each.

b) On the third day, a 3-hour group meeting involving the clinicians were scheduled in order to discuss the child's functional profile. During this meeting the videos and the questionnaires were analysed in detail. The final preliminary diagnosis (ASD or non-ASD) was based on clinical judgment supported by the diagnostic criteria of the DSM-5, and all the source of information collected during the two assessment phases.

c) During the fourth day, the team leader, together with the clinicians, ran a remote meeting with parents to provide them with feedback about their child's functional profile and the possible preliminary diagnosis. Individualized psychoeducational counselling was provided to parents during the meeting.

A total of about 13 hours were planned for the completion of the SA phase (9 h for the evaluations and 4 h for the meetings).

The authors proposed this approach as a first step for tele-assessment; however, they also highlighted that it may not be suitable for all families, especially if unfamiliar with technology. For this reason, they believe that although it is a valid tool to get the most complete and ecological overall clinical picture by observing the child in the family context, there are still irreplaceable key elements that need in-person

assessment. For this reason, some of the families assessed online during the lockdown were invited to an in-person appointment scheduled as soon as the emergency crisis was over. Among the most positive elements highlighted by this preliminary study are the high flexibility of application and the ability to observe specific behaviours that, in an artificial environment (e.g., clinical center or laboratory), may not always be clear or elicitable. Finally, it is promising that many parents found this model easy and accessible, even though they had generally good technological skills.

Discussion: Strengths, weaknesses and future directions

In the present critical review, three main studies investigating the feasibility of televaluations for ASD diagnosis were taken into consideration in order to elaborate an evaluation of the potentialities and limitations of remote settings. The first one presented the NODA method (Smith *et al.*, 2017), a naturalistic observation diagnostic assessment tool integrating data of the developmental history through anamnestic interviews with direct observation of the child in home videos uploaded by the parents. Notably, the time required for data collection was about 40 minutes for parents to upload interaction videos, and more than one hour for clinicians to tag relevant behaviours.

The second method outlined the development of the TELE-ASD-PEDS (Wagner *et al.*, 2022), which also integrates different sources of information. This remote protocol has an administration time of 2-3 hours total and requires parents to scaffold structured play interaction with their child, remotely guided by the clinician.

The last study (Narzisi, 2020) involved a two-stage structure: pre-specialist consultation and specialist assessment. Also in this case, a direct observation of the child in different contexts is performed, with structured information gathered by careful video analysis performed by expert examiners. Even in this case, additional information was provided by parent self-report instruments. This protocol has a total administration time of about 13 hours. The video collection phase had a total duration of about 75 minutes, and 3 hours were scheduled by the group to complete the pre-specialist consultation.

In general, research showed how conducting tele-diagnosis reduced assessment time and enhanced access to diagnostic services for autistic children. In addition, tele-diagnosis reduced issues related to distance by facilitating access where geographic or logistic barriers to early initial assessment was encountered. Practitioners also reported the usefulness of the ecological observation of children and families in their home environments while interacting with familiar people and materials (Corona *et al.*, 2020). Subsequent studies further showed that most parents actually found the tele-assessment comfortable (Corona *et al.*, 2021).

Furthermore, the study by Corona *et al.* (2021) found that the majority of parents reported that they felt comfortable during the tele-screening, finding the vocal instructions easy to follow. They also felt that the screening lasted for the right amount of time.

Focusing on limitations, there was a minority of parents (12%) who indicated that the screening activities did not elicit the behaviours in children that they were concerned about. In turn, this may increase the risk of false negatives. Further, from a broader perspective tele-diagnosis may not be feasible for all families, especially those who struggle to use technological devices or those who do not have an internet connection, as pointed out in the study by Narzisi *et al.* (2020). Moreover, psychometric properties are not yet available. The NODA validation study provided correlations between the online procedure and the in-person assessment, whereas for the TELE-ASD-PEDS data collection for psychometric properties is still ongoing, limiting the ability to adequately assess their validity and reliability with respect to gold-standard diagnostic tools. Finally, Wagner *et al.* (2022) pointed out that little is known about the experiences of practitioners attempting home-directed tele-assessments in uncontrolled and unstructured situations within research and evaluation protocols. Therefore, future research should include these aspects in order to develop adapted evaluation protocols for at-home assessments.

As well, future research is necessary to design and validate procedures that are flexible and less structured than those of standard diagnostic assessments while remaining easy enough to be implemented by parents. It will also be important to put special emphasis on observational aspects, reproducibility, and data collection methods that can be employed online while maintaining privacy. In future studies, it is essential to carry on focusing on child-caregiver dyadic aspects,

favouring the development of a "caregiver-mediated" diagnosis under expert guidance. The clinician will therefore play a more "external" role, in which they must be able to structure and guide the interaction not only with the child but, indeed, between children and their caregivers. Emphasizing the caregivers' role also means developing new ways of interacting with them, guiding them to enact, structure, and mediate the kind of interactions that are generally employed by clinicians in assessment processes. Such procedures could, on one hand, greatly increase the complexity of tele-assessment and, on the other hand, greatly reduce the waiting time to make an early diagnosis. Moreover, clinicians will probably face more challenges during this particular type of assessment, given that they will need to take into account both the elements of the dyad at the same time, while not being able to directly intervene to mediate the exchange as it generally happens during in-person evaluations. Finally, as pointed out by Corona *et al.* (2021), it will be crucial to understand for whom and under what circumstances telemedicine is the most appropriate and effective, in relation to the precision and individualization of care.

Conclusion

The possibility of observing children and families in their home environments can increase the external validity of the diagnostic process due to the possibility to collect information with high ecological value involving different contexts of the child's life. This kind of information represents key aspects already included not only in diagnostic criteria but also for the differential diagnosis stage (DSM-5 TR; APA, 2022). As evidenced in the study by Corona *et al.* (2021), some parents indicated that the planned activities did not elicit the target behaviours they were concerned about. This result represents an important point of critical reflection for designing and developing interactive protocols and structuring specific assessment routines able to elicit key behaviours relevant for the diagnosis (e.g., dysfunctional behaviours or presence of stereotypies). This would greatly expand the external validity of diagnostic procedures. The home environment generally facilitates children with neurodevelopmental conditions. Therefore, it is arguable that, at least in some cases, the compensations provided by known contexts and

people, along with the presence of previously established routines may mask the presence of maladaptive aspects, simply because the situation is unable to sufficiently activate the child. As an example, dysfunctional profiles generally emerge only in contexts of high social and/or emotional loads, high unpredictability, with unfamiliar people, or in the face of a significant increase in the required tolerance to frustration.

The studies presented so far highlighted promising preliminary evidence supporting the clinical utility and feasibility of tele-diagnosis, while raising key concerns to design new approaches. While there are some complications related to the standardization of instruments, remote approaches make it possible to greatly reduce the waiting time, thus favouring early diagnosis and timely initiation of intervention, especially for children with autism spectrum disorders. The various studies, both before and during the pandemic, highlighted the possibility to capture some important elements for proper assessment, despite the fact that not all behaviours are observable using short videos made in familiar settings. For this reason, an integration between the two methodologies could be explored in research design that could be successfully integrated in clinical screenings and assessments.

References

Abidin, R. R. (2012). *Parenting Stress Index–Fourth Edition (PSI-4).* Lutz, FL: Psychological Assessment Resources.

Achenbach, T. M., & Edelbrock, C. (1991). *Child behavior checklist.* Burlington (Vt), 7, 371-392.

Achenbach, T. M., & Rescorla, L. A. (2000). *Manual for the ASEBA preschool forms and profiles* (Vol. 30). Burlington, VT: University of Vermont, Research center for children, youth, & families.

American Psychiatric Association, DSM-5 Task Force (2013). *Diagnostic and statistical manual of mental disorders: DSM-5™* (5th ed.). American Psychiatric Publishing, Inc.

American Psychiatric Association (2022). *Diagnostic and statistical manual of mental disorders, fifth edition, text revision*. Washington, DC: American Psychiatric Association.

Bates, E., Dale, P. S., Fenson, L., Hartung, J. P., Pethick, S., Reilly, J. S., ... & Thal, D. (2004). *MacArthur Communicative Development Inventory.* DOI: 10.1016/S0163-6383(98)91617-4

Corona, L., Hine, J., Nicholson, A., Stone, C., Swanson, A., Wade, J., ... & Warren, Z. (2020). TELE-ASD-PEDS: A telemedicine-based ASD evaluation tool for toddlers and young children. *Vanderbilt University Medical Center.*

Corona, L. L., Weitlauf, A. S., Hine, J., Berman, A., Miceli, A., Nicholson, A., ... & Warren, Z. (2021). Parent perceptions of caregiver-mediated telemedicine tools for assessing autism risk in toddlers. *Journal of Autism and Developmental Disorders*, *51*, 476-486. DOI: 10.1007/s10803-020-04554-9

Constantino, J. N., & Gruber, C. P. (2005). *Social Responsiveness Scale (SRS)*. Los Angeles, CA: Western Psychological Services

Cusinato, M., Iannattone, S., Spoto, A., Poli, M., Moretti, C., Gatta, M., & Miscioscia, M. (2020). Stress, resilience, and well-being in Italian children and their parents during the COVID-19 pandemic. *International journal of environmental research and public health*, *17*(22), 8297. DOI: 10.3390/ijerph17228297

Dunn, W. (1999). *The Sensory Profile.* San Antonio, TX: The Psychological Corporation.

Falcone, R. E., & Detty, A. (2015). The Next Pandemic: Hospital Management. *Emergency Medicine Reports*, *36*(26).

Fenson, L., Pethick, S., Renda, C., Cox, J. L., Dale, P. S., & Reznick, J. S. (2000). Short-form versions of the MacArthur communicative development inventories. *Applied psycholinguistics*, 21(1), 95-115. DOI: 10.1017/S0142716400001053.

Frost, K. M., Brian, J., Gengoux, G. W., Hardan, A., Rieth, S. R., Stahmer, A., & Ingersoll, B. (2020). Identifying and measuring the common elements of naturalistic developmental behavioral interventions for autism spectrum disorder: Development of the NDBI-Fi. *Autism*, *24*(8), 2285-2297. DOI: 10.1177/1362361320944011

Frost, M., & Duan, S. X. (2020). Rethinking the role of technology in virtual teams in light of COVID-19. *arXiv preprint arXiv:2011.07303*. DOI: 10.48550/arXiv.2011.07303

Gioia, G. A., Espy, K. A., & Isquith, P. K. (2003). *Behavior Rating Inventory of Executive Function, Preschool Version (BRIEF-P)*. Odessa, FL: Psychological Assessment Resources.

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2015). *BRIEF-2: Behavior rating inventory of executive function*. Lutz, FL: Psychological Assessment Resources.

Grzadzinski, R., Carr, T., Colombi, C., McGuire, K., Dufek, S., Pickles, A., & Lord, C. (2016). Measuring changes in social communication behaviors: preliminary development of the Brief Observation of Social

Communication Change (BOSCC). *Journal of autism and developmental disorders*, *46*, 2464-2479. DOI: 10.1007/s10803-016-2782-9

Grzadzinski, R., Amso, D., Landa, R., Watson, L., Guralnick, M., Zwaigen-baum, L., ... & Piven, J. (2021). Pre-symptomatic intervention for autism spectrum disorder (ASD): defining a research agenda. *Journal of neurodevelopmental disorders*, *13*(1), 1-23. DOI: 10.1186/s11689-021-09393-y.

Jang, J., White, S. P., Esler, A. N., Kim, S. H., Klaiman, C., Megerian, J. T., ... & Kanne, S. M. (2021). Diagnostic evaluations of autism spectrum disorder during the COVID-19 pandemic. *Journal of Autism and Developmental Disorders*, 1-12. DOI: 10.1007/s10803-021-04960-7

Juárez, A. P., Weitlauf, A. S., Nicholson, A., Pasternak, A., Broderick, N., Hine, J., ... & Warren, Z. (2018). Early identification of ASD through telemedicine: Potential value for underserved populations. *Journal of autism and developmental disorders*, *48*, 2601-2610. DOI: 10.1007/s10803-018-3524-y

Kaufman, A. S. (2004). *Kaufman brief intelligence test–second edition (KBIT-2).* Circle Pines, MN: American Guidance Service.

Lam, K. S., & Aman, M. G. (2007). The Repetitive Behavior Scale-Revised: independent validation in individuals with autism spectrum disorders. *Journal of autism and developmental disorders*, *37*, 855-866. DOI: 10.1007/s10803-006-0213-z

Lord, C., Rutter, M., DiLavore, P., C., Risi, S., Luyster, R., J., Gotham, K., Bishop, S., L., & Guthrie, W. (2013). *Autism Diagnostic Observation Schedule-Second Edition.* Italian Adaptation.

Mullen, E. M. (1995). *Mullen Scales of Early Learning,* Edited by: AGS. Circle Pines, MN: American Guidance Service Inc.

Narzisi, A. (2020). Phase 2 and later of COVID-19 lockdown: Is it possible to perform remote diagnosis and intervention for autism spectrum disorder? An online-mediated approach. *Journal of clinical medicine*, *9*(6), 1850. DOI: 10.3390/jcm9061850

Nazneen, N., Rozga, A., Smith, C. J., Oberleitner, R., Abowd, G. D., & Arriaga, R. I. (2015). A novel system for supporting autism diagnosis using home videos: Iterative development and evaluation of system design. *JMIR mHealth and uHealth*, *3*(2), e4393. DOI: 10.2196/mhealth.4393

Peckett, H., MacCallum, F., & Knibbs, J. (2016). Maternal experience of Lego Therapy in families with children with autism spectrum conditions: What is the impact on family relationships?. *Autism*, *20*(7), 879-887. DOI: 10.1177/1362361315621054

Peirone, L. (2020). Nuovo coronavirus e resilienza. *Strategie contro un nemico invisibile.* Torino: Anthropos.

Punzo, O., Bella, A., Riccardo F., Pezzotti, P., D'Ancona, F. (2021). Dipartimento Malattie Infettive, ISS. Text available at: https://www. epicentro.iss.it/coronavirus/sars-cov-2#:~:text=Il%2031%20dicembre %202019%2C%20le,South%20China%20Seafood%20City%20market

Regina Molini-Avejonas, D., Rondon-Melo, S., de La Higuera Amato, C. A., & Samelli, A. G. (2015). A systematic review of the use of telehealth in speech, language and hearing sciences. *Journal of telemedicine and telecare*, *21*(7), 367-376. DOI: 10.1177/1357633X15583215

Roid, G. H., & Miller, L. J. (1997). *Leiter international performance scale-revised (Leiter-R).* Wood Dale, IL: Stoelting, 10.

Rutter, M., Le Couteur, A., & Lord, C. (2003). *Autism diagnostic interview-revised.* Los Angeles, CA: Western Psychological Services, 29, 30.

Rutter, M. (2003). *Social communication questionnaire.* Manual. Western Psychological Services, Los Angeles.

Schopler, E., Van Bourgondien, M. E., Wellman, G. J., & Love, S. R. (2010). *Childhood Autism Rating Scale–Second Edition (CARS-2).* Los Angeles, CA: Western Psychological Services.

Sherman, E. M., & Brooks, B. L. (2010). Behavior rating inventory of executive function–preschool version (BRIEF-P): Test review and clinical guidelines for use. *Child Neuropsychology*, *16*(5), 503-519. DOI: 10.1080/09297041003679344

Smith, C. J., Rozga, A., Matthews, N., Oberleitner, R., Nazneen, N., & Abowd, G. (2017). Investigating the accuracy of a novel telehealth diagnostic approach for autism spectrum disorder. *Psychological assessment*, *29*(3), 245. DOI: 10.1037/pas0000317

Sparrow, S., S., Cicchetti, D., V., & Balla, D., A. (2016). *Vineland Adaptive Behavior Scales-II* – Second Edition – Survey Interview Form. Italian Adaptation.

Valentine, A. Z., Hall, S. S., Young, E., Brown, B. J., Groom, M. J., Hollis, C., & Hall, C. L. (2021). Implementation of telehealth services to assess, monitor, and treat neurodevelopmental disorders: Systematic review. *Journal of Medical Internet Research*, *23*(1), e22619. DOI: 10.2196/22619

Vivanti, G., Kasari, C., Green, J., Mandell, D., Maye, M., & Hudry, K. (2018). Implementing and evaluating early intervention for children with autism: Where are the gaps and what should we do? *Autism research*, *11*(1), 16-23. DOI: 10.1002/aur.1900

Wagner, L., Corona, L. L., Weitlauf, A. S., Marsh, K. L., Berman, A. F., Broderick, N. A., ... & Warren, Z. (2021). Use of the TELE-ASD-PEDS for autism evaluations in response to COVID-19: Preliminary outcomes

and clinician acceptability. *Journal of autism and developmental disorders*, *51*, 3063-3072. DOI: 10.1007/s10803-020-04767-y

Wagner, L., Weitlauf, A. S., Hine, J., Corona, L. L., Berman, A. F., Nicholson, A., ... & Warren, Z. (2022). Transitioning to telemedicine during COVID-19: Impact on perceptions and use of telemedicine procedures for the diagnosis of autism in toddlers. *Journal of Autism and Developmental Disorders*, 1-11. DOI: 10.1007/s10803-021-05112-7

Wechsler, D. (1999). *Wechsler Abbreviated Scale of Intelligence (WASI)* [Database record]. APA PsycTests.

Wong, C. A., Ming, D., Maslow, G., & Gifford, E. J. (2020). Mitigating the impacts of the COVID-19 pandemic response on at-risk children. *Pediatrics*, *146*(1). DOI: 10.1542/peds.2020-0973

Appendix

Diagnostic tools for remote assessment of ASD

As of 2016, researchers have tested and validated several diagnostic tools for remote assessment of individuals with autism spectrum disorder. Among the most important and easily applicable are the following:

Brief Observation of Social Communication Change (BOSCC) (Grzadzinski *et al.*, 2016).

The BOSCC is a rating scale coded by videotaping a play session between the child and a caregiver, or with a professional. The BOSCC was developed from the ADOS-2, modifying and expanding its items to discriminate small changes over short periods of time; the items are organized into three areas, including Social Communication (SC) and Restricted Repetitive Behaviors and interests (RRB). The videotaped session lasts 15 minutes and can take place either in the child's home or in a clinical setting, but it is essential that the context remains the same in subsequent administrations. During the session, the child should be free to move around and should have a variety of materials available, all of which are accessible. Play material differ according to the child's age and level of language development. Only the middle 10 minutes of the session are used for coding, and they are further divided into two 5-minute segments. Each segment is coded separately after being viewed twice, and the final scores are obtained by averaging the scores of the two segments. Scoring of each item is done with the use of a specific decision tree.

ASD PEDS Canvas (Wagner et al., 2020; Corona et al., 2020)

The TELE-ASD-PEDS is a tool developed specifically for telemedicine with the purpose of being used by practitioners and families for the assessment of ASD. It is based on the ASD-PEDS, an assessment procedure developed through the use of machine learning techniques on a large clinical database consisting of assessments conducted through gold standards in children with ASD. This tool, designed for clinicians experienced in the early diagnosis of ASD, allows to assess the symptoms of children at risk for autism spectrum disorder less than 36 months of age, through the remote observation of play interactions within the dyad. This tool involves a structured

interaction situation using toys and materials readily available in most families' homes (e.g. bubbles). Using the TELE-ASD-PEDS, a practitioner guides a parent through several basic tasks with their child. These tasks allow the operator to check for the presence of autism symptoms. The administration takes approximately 10-20 minutes. In contrast, the entire tele-assessment procedure lasts longer. Data collection and analysis of psychometric properties are still ongoing (clinicaltrials.gov, NCT03847337). Subsequently, the clinicians analyzed the child's behaviors either using a dichotomous (yes/no) or Likert scale (from 1 = absence of ASD behaviors to 3 = ASD behaviors clearly present). The behaviors analyzed were: (1) Socially directed speech and sounds, (2) Frequent and flexible eye contact; (3) Unusual vocalizations; (4) Unusual or repetitive play; (5) Unusual or repetitive body movements; (6) Combines gestures, eye contact, and speech/vocalization; (7) Unusual sensory exploration or reaction.

The nature observation diagnostic assessment (NODA) (Smith et al., 2017)

The NODA is an innovative diagnostic approach used for tele-assessment that uses home videos under clinical guidance. At first, parents are asked to complete a short interview about their child's development and history. These responses are stored in the family's online account. The NODA app is installed on a mobile device and guides parents to record their child in four structured scenarios with a 10-minute duration: (1) family meal, (2) play time with others, (3) play time alone, and (4) parental concerns. The first three scenarios allow both social-communicative and play aspects to be observed. The application includes instructions for introducing specific social presses (e.g., interact with your child in a playful manner, call your child by name, ask your child where something is in the room, point to something to direct his or her gaze), with the goal of promoting the initiation of specific social routines or target behaviors considered diagnostically important (Smith *et al.*, 2017). The pilot study showed how these instructions improved the clinical utility of the videos (Nazneen *et al.*, 2015). The evaluators analyzed the videos, identifying each behavior using indicators taken from the DSM 5 (e.g. no social response). Based on clinical judgment, raters then determined whether there was sufficient evidence from developmental history and labeled behaviors to meet each DSM-5 criterion for ASD and, ultimately, whether to assign a diagnosis.