

Immersive and Non-immersive Virtual Reality-Based Social Cognition Assessment in Older Adults With Neurocognitive Disorders: Delphi-based Expert Consensus Study

Authors

Valeria Manera¹, Auriane Gros^{1,2}, Alessandra Dodich³, Yasmin Abo Foul⁴, Mael Addoum⁵, Gilles Allali⁶, R. Asaad Baksh⁷, Francesca Baglio⁸, Valeria Blasi⁸, Maxime Bertoux⁹, Francois Bremond¹⁰, Felice Catania¹¹, Johannes C. Michaelian¹², Marcia Cristina Nascimento Dourado¹³, Arnaud Fernandez^{1,14}, Sara Iernia⁸, Laurent Lefebvre¹⁵, Fiona Kumfor¹⁶, Michelle Kelly¹⁷, Sylvia Martin¹⁸, Sarah E. MacPherson¹⁹, Skye McDonald²⁰, Sara Palermo²¹, Louise H. Phillips²², Olivier Piguet²³, Alexandra Plonka¹, Roberto Ravera²⁴, Leonhard Schilbach²⁵, Francois Qesque²⁶, Andrea C. Samson²⁷, Suraj Samtani²⁸, Simone Shamay-Tsoory⁴, Joyce Siette²⁹, Fabio Solari³⁰, Marc Sollberger³¹, Lise Eilin Stene³², Susanne Thummler^{1,14}, Madga Tsolaki³³, Dimitra Tsovaltzi³⁴, Esther van den Berg³⁵, Jan Van den Stock³⁶, Guillaume Sacco², Philippe Robert^{1,37}, Chiara Cerami³⁸.

All authors are listed alphabetically by surname, except for the first and last three authors.

Affiliations

¹ CobTeK lab and Department of Speech Therapy (Departement d'Orthophonie, DON), Université Côte d'Azur, Nice, France

² Université Côte d'Azur, Centre Hospitalier Universitaire de Nice, Clinique Gériatrique du Cerveau et du Mouvement, Centre Mémoire Ressources et Recherche, Nice, France

³ Center for Mind/Brain Sciences - CIMEC, University of Trento, Rovereto, Italy

⁴ Department of Psychology, University of Haifa, Israel. The Integrated Brain and Behavior Research Center (IBBRC), University of Haifa, Israel

⁵ ISART DIGITAL, Paris, France

⁶ Leenaards Memory Center, Department of Clinical Neurosciences, Lausanne University Hospital and University of Lausanne, Lausanne, Switzerland.

⁷ Childlight – Global Child Safety Institute, University of Edinburgh, Moray House School of Education and Sport, St. John's Land, Holyrood, Edinburgh, UK

⁸ IRCCS, Don Carlo Gnocchi Foundation, Milan, Italy

⁹ Lille Neuroscience & Cognition, Inserm U1172, Univ Lille, CHU Lille, F-59000 Lille

¹⁰ Centre Inria d'Université Côte d'Azur

¹¹ Astir srl, Milan, Italy

¹² Brain and Mind Centre and Charles Perkins Centre, School of Psychology, Faculty of Science, The University of Sydney, Sydney, Australia

¹³ Postgraduate Program on Psychiatry and Mental Health, Institute of Psychiatry, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

¹⁴ University Department of Child and Adolescent Psychiatry, Children's Hospitals of Nice CHU-Lenval, Nice, France

¹⁵ Cognitive Psychology and Neuropsychology Department, University of Mons, Mons, Belgium

¹⁶ School of Psychology and Brain and Mind Centre, University of Sydney, Camperdown, Australia

¹⁷ School of Science, University of Newcastle, Newcastle, Australia

¹⁸ Center for Research Ethics and Bioethics, Uppsala University, Uppsala, Sweden

¹⁹ Department of Psychology, University of Edinburgh, Edinburgh, UK

²⁰ Department of Psychology, University of New South Wales, Sydney, Australia

²¹ Department of Psychology, University of Turin, Turin, Italy, & Neuroscience Institute of Turin (NIT), Turin, Italy

²² School of Psychology, University of Aberdeen, Aberdeen, Scotland, UK

²³ The University of Sydney, School of Psychology and Brain & Mind Centre, Sydney, Australia

²⁴ Department of Clinical Psychology - ASL1 Imperiese, Imperia, Italy

²⁵ Department of Psychiatry & Psychotherapy, Ludwig Maximilians Universität München, Germany, & Department of General Psychiatry 2, LVR-Klinikum Düsseldorf / Kliniken der Heinrich-Heine-Universität Düsseldorf, Germany

²⁶Laboratoire sur Les Interactions Cognition, Action, Émotion (LICAÉ), Université Paris Nanterre, 200 avenue de La République 92001, Nanterre Cedex, France, & Centre Ressource de Réhabilitation Psychosociale, CH Le Vinatier, Lyon, France

²⁷Faculty of Psychology, UniDistance Suisse, Brig, Switzerland & Department of Special Education, University of Fribourg, Fribourg, Switzerland

²⁸Centre for Healthy Brain Ageing (CHeBA), Discipline of Psychiatry and Mental Health, School of Clinical Medicine, Faculty of Medicine and Health, UNSW Sydney, Australia

²⁹The MARCS Institute for Brain, Behaviour and Development, Western Sydney University, Westmead, Australia

³⁰Department of Informatics, Bioengineering, Robotics and Systems Engineering, University of Genoa, Italy

³¹Memory Clinic, Department of Dementia Diseases, University Center for Medicine of Aging FELIX PLATTER, Basel, Switzerland

³²Norwegian Centre for Violence and Traumatic Stress Studies, NKVTS, Oslo, Norway

³³1st University Department of Neurology, School of Medicine, Aristotle University of Thessaloniki, Makedonia, Greece, Alzheimer Hellas and Laboratory of Neurodegenerative Diseases Center for Interdisciplinary Research and Innovation (CIRI—AUTH), Balkan Center, Aristotle University of Thessaloniki, Makedonia, Greece

³⁴German Research Center for Artificial Intelligence (DFKI), Cognitive Assistance Systems, Saarbrücken, Germany

³⁵Department of Neurology and Alzheimer Center Erasmus MC, Erasmus MC University Medical Center, Rotterdam, the Netherlands

³⁶Center Neuropsychiatry, Department Neurosciences, Leuven Brain Institute, KU Leuven, Leuven, Belgium

³⁷CreApolis, JLN Fondation, Sophia Antipolis Biot, France

³⁸IUSS Cognitive Neuroscience (ICoN) Center, Scuola Universitaria Superiore IUSS Di Pavia, Pavia, Italy & Istituti Clinici Scientifici Maugeri IRCCS, Brain e-Health Aging Laboratory, Department of Neurorehabilitation, Milan, Italy

Abstract

Background. Social cognition is increasingly recognized as a core domain affected in older adults with neurocognitive disorders (NCDs), with major implications for interpersonal functioning, autonomy, and clinical decision-making; however, its formal assessment in routine practice remains limited, partly due to the poor sensitivity, ecological validity and limited feasibility of available tools in this population. Emerging technologies such as virtual reality (VR) have been suggested to improve ecological validity, but they are still rarely used in clinical settings. **Objectives.** The present paper aimed to gather the opinions of an international group of experts in the field of social cognition assessment regarding the interest, feasibility, advantages, and barriers associated with the use of VR for assessing social cognition in NCDs. **Methods.** Expert perspectives were gathered through a Delphi-based procedure. Sixty-three experts in social cognition, neurocognitive disorders (NCDs), and digital health were initially contacted by email based on their relevant expertise and membership in the SIGNATURE network or the INTEVIDI and Mi Ricordo research projects. Forty-three experts agreed to participate, and completed two rounds of online surveys, including 10-point Likert-scale ratings and open-ended questions, followed by a hybrid consensus meeting to discuss the findings. The advantages, disadvantages, opportunities, and barriers associated with the use of immersive and non-immersive VR for assessing social cognition in NCDs, as identified by experts in the open-ended questions, were analyzed using a SWOT framework. **Results.** Expert consensus was reached (median = 9, IQR = 2; 92.1% of participants rated the statement ≥ 7) that, although VR shows promise for reproducing realistic social interactions within controlled and standardized environments, further evidence is needed regarding its usability, ecological validity, and accuracy in individuals

with NCDs before it can be implemented in clinical practice. The SWOT analysis identified key strengths of VR, including its capacity to simulate realistic social interactions and capture multimodal behavioral markers, while also highlighting challenges related to usability, integration into clinical workflows, safety, and limited psychometric validation. The consensus outlined priority areas for the development of novel, clinically viable VR-based social cognition assessment tools, including multidisciplinary collaboration to support patient-oriented interface design and improve usability, cultural adaptation, as well as large-scale psychometric validation.

Conclusions. Overall, the findings support cautious optimism about VR-based social cognition assessment in NCDs: VR offers considerable potential to bridge the gap between standardized assessment and ecologically relevant social behavior, but its clinical implementation will require further evidence on usability, validity, safety, and psychometric robustness.

Introduction

Assessing social cognition in older adults with neurocognitive disorders (NCDs) is increasingly recognized as a clinical and research priority, as testified by the emergence of large-scale international initiatives focused on the cross-cultural and transdiagnostic harmonization of socio-cognitive assessment across neuropsychiatric disorders [1–4]. Social cognition encompasses a broad range of mental processes operating across multiple levels, from rapid mechanisms (e.g., detection of socially salient cues and emotion processing) to higher-order inferential functions, including mental state attribution (mentalizing) and empathy [5,6]. Together, these processes are expressed through observable social behaviors, shaping how individuals understand observed social interactions, and how they communicate, relate to others, and navigate everyday social situations.

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5 [7]) identifies social cognition as a core domain in NCDs, consistent with contemporary dimensional frameworks such as the Research Domain Criteria (RDoC), which emphasize social processes as a central component of neuropsychiatric functioning [8]. Accordingly, impairments in social cognition processes have been documented across multiple NCDs, including Alzheimer’s disease and frontotemporal dementia [9–14], and

can also be found in prodementia stages, such as in mild NCDs [15–17] and even presymptomatic carriers at risk for neurodegeneration [18].

Alterations in social behavior and social cognition are often observed during clinical evaluation, but are infrequently formally measured using standardized tests or structured assessment tools. Barriers to formal assessment encompass the limited availability of standardized, ecologically valid measures with normative data, conceptual variability across social-cognitive domains, the absence of brief, time-efficient tools, the restricted scope of existing assessments, unclear guidelines, and inadequate clinician training, underscoring the need for enhanced clinician–researcher collaboration to support translation into routine practice [1,4,19]. Although numerous social cognition measures have been developed in experimental contexts [20], translational progress toward clinical implementation—particularly regarding psychometric validation and diagnostic applicability—remains limited [1,19]. A major barrier to clinical uptake lies in the nature of existing assessment instruments. Many commonly used tasks have been designed primarily for controlled experimental research, and rely on highly controlled, simplified, or decontextualized stimuli, such as static facial expressions, brief vignettes, or cartoon-based paradigms [6,21]. Others involve the comprehension of complex verbal narratives, which place substantial cognitive demands on non-social abilities such as attention, language, memory, and reasoning, thereby confounding the assessment of social-cognitive abilities [15]. Importantly, all these tasks typically position the participant as a passive observer rather than an active social agent [22,23]. A decade of research points to a distinction between offline social cognition—evaluations made from an observer perspective—and online social cognition, which involves real-time, reciprocal interaction and appears to rely at least partly on distinct neurocognitive

mechanisms [24,25]. Most existing social cognition tasks fail to capture the online, interactional processes increasingly recognized as central to real-world functioning. Accordingly, despite adequate performance on these tasks, people with early NCDs may still exhibit difficulties in everyday social functioning and social behavior, underscoring the limited sensitivity of these assessments to subtle, ecologically relevant impairments [26,27]. The need for ecologically valid, interactive measures and paradigms in which patients are involved as active agents has been repeatedly emphasized [27], but their development poses practical and clinical challenges. Interaction-based methods such as clinician-mediated role-plays can approximate real-life social exchanges more closely, yet require trained personnel, and standardized delivery procedures, making them difficult to implement consistently in clinical contexts [28].

Emerging technologies such as virtual reality (VR) and mixed reality (MR) offer a promising avenue for addressing limitations of traditional social cognition tests. These approaches have already been adopted in other areas of neuropsychological assessment (e.g., [29]) and enable the simulation of more realistic and dynamic social scenarios while maintaining experimental control over stimulus delivery. Integrating machine learning and model-based engines, they also bear the potential to engage patients in non-stereotyped online interaction that goes beyond role-play [30]. By exploiting the built-in sensors and software libraries provided by the VR systems, these technologies may also allow precise quantitative measurement of behavioral markers, including response times, gaze patterns, movement dynamics, and interpersonal distance, which may represent a new class of ecologically valid markers of social functioning complementing traditional assessment [31,32]. The interest of using VR for social cognition assessment has been already demonstrated in psychiatric conditions,

such as schizophrenia and psychosis [33–35]. Early studies in aging and dementia populations indicate that VR-based tasks are feasible and safe when designed to ensure emotional safety—by avoiding distressing or overstimulating content—and usability, through intuitive interfaces, simple task demands, and minimal cognitive and motor load, thereby reducing anxiety, confusion, and task disengagement [36,37]. Immersive technologies may help identify social cognitive impairments that remain undetected by traditional assessments, reflecting the enhanced ecological validity and sensitivity of VR-based paradigms [20]. Immersive and semi-immersive environments have also shown promise in enhancing engagement, emotional resonance, and learning transfer, especially when scenarios mirror real-world social situations [31].

However, challenges remain regarding feasibility in routine clinical setting, and overall acceptability in older clinical populations [38]. Furthermore, although VR- and MR-based tools show promise, few have undergone psychometric validation, comparison with existing social cognition tests, normative standardization, or large-scale clinical testing, which are essential steps before such instruments can be integrated into routine diagnostic workflows [39].

Despite growing interest in VR for social cognition assessment, the available evidence remains limited and fragmented, and several methodological and practical issues are still under debate [40]. Therefore, the aim of the present study was to gather and synthesize expert perspectives on the use of VR for social cognition assessment in older adults with NCDs through a Delphi-based process, to establish a consensus-based framework for future research and clinical practice. The resulting expert consensus is presented within a SWOT (Strengths, Weaknesses, Opportunities, and Threats)

framework, providing a structured overview that facilitates interpretation of the current evidence base and helps identify priorities for future research and implementation.

Methods

A group of six facilitators (VM, AG, GS, PR, CC, and AD) launched a call for experts through the INTEVIDI (<https://intevidi.my.canva.site/>), Mi Ricordo (<https://anr.fr/Projet-ANR-24-THCS-0001>), and the SIGNATURE initiative (<https://sites.google.com/unitn.it/signature-initiative/home?authuser=0>) networks in April 2025, with the aim to cover a diverse group of professional stakeholders in the domain of social cognition. 63 experts were initially contacted by email based on their relevant expertise and membership in the SIGNATURE networks or INTEVIDI and Mi Ricordo research projects. Forty-three experts, who are listed as co-authors in the manuscript, accepted the invitation and participated in a Delphi-based process designed to ensure anonymity and structured iteration. The method consisted of two rounds of online surveys conducted between June and November 2025, followed by a hybrid consensus meeting in Nice (France) on December 1st, 2025. Throughout the process, group discussions and consensus-building were driven by controlled and statistical feedback. The expert panel consisted of international specialists in social cognition, including psychologists/neuropsychologists (n=22), neurologists (n=7), psychiatrists (n=6), computer scientists (n=5), speech and language therapists (n=2), and one geriatrician (n=1). Participants were based in 13 countries: Australia (n=7), Belgium (n=2), Brazil (n=1), France (n=11), Germany (n=2), Greece (n=1), Israel (n=2), Italy (n=8), Norway (n=1), Sweden (n=1), Switzerland (n=3), the Netherlands (n=1), and the United Kingdom (n=3). The fields of expertise included social cognition in NCDs (n=31), social cognition

across other clinical conditions (e.g., schizophrenia, autism, post-traumatic stress disorders, psychiatric disorders, acquired brain injury, n=12), and new technologies for health (n=13). Twenty-eight experts (65%) were involved in clinical practice, while nine (21%) were directly engaged in digital health R&D activities. Regarding professional experience, most experts (49%, n=21) had between 10 and 20 years of experience, followed by experts with 20–30 years (25%, n=11), with more than 30 years (12%, n=5), with 5–10 years (9%, n=4), and with less than 5 years (5%, n=2).

Ethical considerations

Participation was voluntary and based on participants' availability, and informed consent was obtained electronically prior to participation. Experts did not receive any compensation. The study was approved by the Scuola Universitaria Superiore IUSS Pavia Ethical Committee (IUSS–University of Pavia; Protocol 104/22) and was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki and its subsequent amendments.

Survey Content and Delphi-based Procedure

The surveys distributed within the consortia networks addressed three topics related to social cognition assessment in patients with NCDs: (a) the development of a brief social cognition assessment; (b) the characteristics of a comprehensive social cognition assessment battery; and (c) the development of digital approaches to social cognition assessment including perceived advantages and disadvantages of using immersive and non-immersive VR systems. The present paper focuses on this third topic, specifically on expert perspectives regarding the use of VR for assessing social cognition in individuals with NCDs. Participants rated a series of statements using 10-point Likert

scales and provided qualitative responses to open-ended questions and comment fields (see Table 1).

The Delphi-based procedure included two rounds. Following the first round, the facilitators provided participants with a written summary of the anonymized results. For the rating questions, consensus was predefined according to published methodological guidance. Specifically, an item was considered to have reached consensus if it simultaneously met the following three criteria: a median rating ≥ 7 , an interquartile range (IQR) ≤ 3 , and at least 70% of experts rated it within the 7–10 range. This definition combines measures of central tendency, dispersion, and percentage agreement, in line with previous recommendations [41]. Reporting all three metrics is also recommended in the CREDES guidance for Delphi studies [42] to enhance transparency and reproducibility. Statements that did not reach consensus in Round 1 were revised based on participants' comments and responses to the open-ended questions and were subsequently resubmitted in Round 2. Items that failed to reach consensus after Round 2 were discussed during the hybrid online meeting and were not included in the final recommendations.

Based on the first Round of Delphi responses, the facilitators developed a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis that was shared with the expert panel for comments and additional suggestions during the second Delphi Round to reach the consensus agreement. Upon completion of the two Delphi rounds, the experts participated in a hybrid consensus meeting, during which the findings were reviewed and final recommendations were discussed.

Data analysis

For the quantitative analyses of the Delphi rating items, results were summarized using the median, interquartile range (IQR), and percentage of responses rated ≥ 7 . The qualitative analysis, which focused on the responses to the open-ended questions concerning the perceived advantages and disadvantages of immersive and non-immersive VR, were organized within a SWOT framework comprising Strengths, Weaknesses, Opportunities, and Threats. The facilitators reviewed the first Delphi round responses, identified recurrent concepts, and organized them. Strengths and weaknesses referred primarily to perceived internal characteristics of VR-based assessment, whereas opportunities and threats captured broader factors that could facilitate or hinder its future development, validation, and clinical implementation. The preliminary SWOT framework was circulated to the expert panel during Round 2, allowing participants to comment on its content, suggest additional elements, and clarify or refine the interpretation of the identified themes. The framework was subsequently revised by the facilitators and reviewed during the final hybrid consensus meeting.

Results

Quantitative Delphi results

The results of the two Delphi rating items addressing the use of VR for the assessment of social cognition in people living with NCDs are summarized in Table 1.

[Insert Table 1 here]

In Delphi Round 1, experts overall agreed that immersive VR is a suitable technology for assessing social cognition in patients with NCDs (median = 7, IQR = 3). However, substantial variability was observed in the responses, with only 51.2% of participants assigning a rating of 7 or higher (range = 1–10). Thus, consensus on this

statement was not reached. Based on the ratings and qualitative comments collected during Round 1, the statement was reformulated to better reflect the conditions considered necessary for the clinical application of VR-based assessment. In Delphi Round 2, experts evaluated the revised statement acknowledging both the potential of VR to reproduce realistic social interactions within controlled and standardized environments and the need for further evidence regarding usability, ecological validity, and assessment accuracy before clinical implementation. The revised statement reached consensus with a median rating of 9, IQR of 2, and 92.1% of participants assigning a score ≥ 7 (range = 5–10). These findings indicate strong agreement that VR represents a promising approach to social cognition assessment, while also emphasizing that its introduction into routine clinical practice should be supported by additional validation and feasibility evidence.

Qualitative findings: SWOT Analysis

Responses to the open-ended questions were organized into a SWOT framework comprising Strengths, Weaknesses, Opportunities, and Threats. The preliminary framework developed from Delphi Round 1 responses was reviewed by facilitators and refined through participant feedback during Delphi Round 2 and the final consensus meeting. Figure 1 summarizes the resulting analysis reporting main technological, clinical, methodological, and implementation-related considerations identified by the expert panel.

[Insert Figure 1 here]

Strengths: Ecological Validity, Standardization, and Multimodal Assessment

According to expert opinions, VR is perceived as a promising tool for supporting the assessment of individuals with NCDs. Experts highlight its potential to simulate real-life interactions in controlled settings, increasing ecological validity and bridging the gap with everyday functioning. VR is seen as enabling complex scenarios that are difficult to recreate in conventional clinical contexts, while providing standardized and reproducible conditions. Experts also suggest that VR could help detect subtle social cognition deficits and allow collection of multimodal data, such as eye gaze and physiological metrics. Personalized and engaging environments, including collaborative or multi-person interactions, are viewed as opportunities for closer observation of social functioning. In summary, the most prominent strengths highlighted by experts were VR's capacity to provide ecologically valid, standardized, and multimodal assessment of social cognition.

Weaknesses: Usability, Safety, and Clinical Implementation

Experts underline several current challenges that may limit the use of VR in older people with NCDs and still need to be addressed by technology-based assessments. Usability issues could arise due to cognitive, sensory, or motor deficits, and patients might experience confusion, irritation, or difficulty following instructions. Physical side effects such as cybersickness (e.g., nausea, dizziness, eyestrain), or falls need also to be considered. From a clinical perspective, lengthy setup time, workflow burden, and technical complexity may prevent effective implementation, highlighting the need for automated scoring and reporting. Experts further point out that standardization across sites could be challenging, multiple confounding factors may affect interpretation, and some patients may perceive VR as “a game” reducing realism. In this context, user-

friendly interfaces, including large fonts and simple navigation, are crucial aspects. Finally, to date, very few VR- or MR-based applications for the assessment of social cognition are available, and they are mostly designed as experimental tools within research settings, with rare adoption in clinical settings [43,44]. Finally, the experts note that although some of these limitations are specific to VR solutions (e.g., cybersickness), the large majority are common with other digital solutions. In summary, the most prominent challenges highlighted by experts were usability and safety concerns, barriers to clinical implementation, and the limited availability of clinically validated VR assessment tools.

Opportunities: Accessibility, Scalability, and Integration into Clinical Practice

Experts identify several potential opportunities for VR. Hybrid immersive and non-immersive modalities are thought to be crucial to enhance the engagement of more vulnerable populations, thereby broadening the pool of potential end users and improving the accessibility of VR-based tools. Simpler or non-immersive VR solutions, such as 360° videos, may also reduce barriers to use in the oldest populations, as well as early exposure to VR may potentially improve patient acceptance. Multi-platform, scalable, or browser-based approaches, as well as smartphone-based monitoring, are seen as ways to support more frequent or remote assessments. Integration with clinical workflows, modular task selection, networked or multiplayer interactions, and use as a complement to classical assessments are additional promising strategies. In the view of the experts, VR adaptation for rural populations or culturally diverse groups, as well as potential applications of augmented reality, are other crucial aspects to consider for future research studies. In summary, the most prominent opportunities highlighted by

experts were improved accessibility, greater scalability, and integration of VR-based assessment into routine clinical practice.

Threats: Costs, Digital Inequalities, Technological Obsolescence, and Governance

Experts also report potential threats that may hinder VR adoption. High hardware and implementation costs, limited resources in clinical settings, and digital inequalities (e.g., access to equipment, internet connectivity, digital literacy) have been identified as major constraints to scalability, equitable access and integration of VR-based tools in clinical settings. Another threat of VR adoption is its rapid technological evolution, which accelerates obsolescence and may discourage investment in systems that are still costly but risk becoming outdated relatively quickly. A potential solution may be to rely on clinically validated paradigms while using off-the-shelf devices and standard frameworks, enabling cost-effective software portability to newer technologies and improving accessibility without requiring custom hardware. Data privacy, ethical concerns, and regulatory requirements (e.g., GDPR/HIPAA) are also noted as critical factors influencing the development, deployment and clinical adoption. Concerns about low adherence among older users, safety risks such as falls or nausea, limited robust validation evidence, and possible technological confounds have also been reported. VR may also be perceived as artificial or ethically questionable for some patients. In summary, the most prominent threats highlighted by experts were high costs, digital inequalities, rapid technological obsolescence, and governance challenges related to privacy, ethics, and regulation.

Discussion

The growing attention devoted to social cognition assessment in older adults with NCDs reflects a broader shift toward more ecologically valid and clinically meaningful approaches to characterizing socio-cognitive deficits, as illustrated by the emergence of large-scale international initiatives aimed at harmonizing social cognition assessment across cultures and diagnostic categories [1–4]. In this context, immersive technologies such as VR and MR have attracted increasing interest because of their potential to overcome some of the limitations of conventional social cognition measures by providing standardized yet ecologically valid social environments [36]. However, despite this growing interest, some relevant concerns threaten feasibility, validity, clinical utility, and implementation in the context of NCDs diagnosis and care [38].

The present study is aimed to establish a preliminary expert consensus on the use of VR for social cognition assessment in individuals with NCDs. Overall, the findings revealed a position of cautious optimism. Experts acknowledged that, despite more than a decade of evidence demonstrating the clinical relevance of social cognition deficits in mild and major NCDs, their routine assessment remains constrained by the limited availability of tools that are simultaneously sensitive, ecologically valid, and clinically feasible, as previously acknowledged [1]. The panel reinforced the view that traditional observer-based measures capture only part of the complexity of everyday social functioning and that more interactive, dynamic, and context-sensitive approaches are needed. Within this framework, VR—both immersive and non-immersive—and MR can be powerful tools and promising technologies capable of simulating realistic social interactions while preserving the standardization and experimental control required for clinical assessment. Experts highlighted the potential of these technologies to improve ecological validity, detect subtle socio-cognitive impairments, and generate rich

behavioral data. At the same time, they emphasized several important barriers to implementation, including usability challenges for older adults, technical and logistical demands on clinicians, safety and ethical considerations, and the current lack of robust evidence regarding their psychometric properties and clinical utility. Consistent with this nuanced perspective, the SWOT analysis identified both substantial opportunities for innovation and important methodological and practical challenges that must be addressed before VR-based social cognition assessment can be routinely implemented in clinical practice.

Beyond methodological and practical considerations, the experts also highlighted issues related to digital equity, which have important implications for the implementation of VR-based assessment. Access to appropriate equipment, reliable internet connectivity, technical support, and sufficient digital literacy may vary considerably across healthcare systems, clinical settings, and patient populations. As a result, the feasibility of VR-based social cognition assessment is likely to differ according to available resources, potentially limiting implementation in under-resourced settings or among individuals with less familiarity with digital technologies. These considerations suggest that, while VR offers promising opportunities to enhance ecological validity and assessment sensitivity, its adoption should not be viewed as universally achievable in the short term. Future development and validation efforts should therefore consider not only psychometric performance but also accessibility, affordability, and implementation strategies that promote equitable access across diverse clinical contexts.

A major important strength of the present study lies in the composition of the international panel of experts, which brought together professionals from different

countries and disciplinary backgrounds, from experts in social cognition across NCDs and other clinical conditions, to specialists in emerging digital technologies with expertise in social interaction. This multidisciplinary and international representation enhances the breadth of viewpoints considered and supports the relevance of the conclusions presented in this paper. However, some limitations should be acknowledged. First, the inclusion of individuals living with NCDs or informal caregivers in the panel composition would have provided additional insights into acceptability, usability, accessibility, comfort and perceived relevance in everyday life. Future work should incorporate patients and caregivers through participatory and co-design approaches to ensure that the development and implementation of VR-based assessment tools remain aligned with the priorities, needs and preferences of the intended end users. Another limitation of the study is that the Delphi process covered several distinct topics, and only two rating questions focused specifically on VR. This relatively limited number of rating items reflects the facilitators' initial expectation that the potential role of VR would generate a relatively straightforward consensus. In contrast, the heterogeneity of the ratings, together with the richness of the open-ended responses and the subsequent consensus discussion, revealed that the topic involves substantially greater methodological, clinical, and ethical complexity than originally anticipated. Consequently, although the qualitative findings provide a detailed account of expert perspectives, the quantitative consensus results should be interpreted in light of the restricted number of VR-specific items. Future works should examine this topic more systematically through a broader set of statements addressing specific issues as psychometric validity, usability, safety, accessibility, clinical utility, implementation requirements, or ethical and regulatory considerations.

Moving forward, several key avenues for research and development are critical. First, systematic psychometric validation—including reliability, construct validity, sensitivity to disease stage, and diagnostic utility (including establishing normative data for older adults) — must be prioritized before VR tools can be incorporated into routine clinical workflows [45]. Large, multisite studies with well-characterized samples, ideally coordinated through international networks such as the SIGNATURE initiative, will be essential. Second, the development of culturally sensitive tests should be a priority. Because culture modulates fundamental aspects of social cognition, including gaze behaviour, interpersonal distance, social attention, and social norms, these parameters must be incorporated into experimental paradigms to ensure ecological validity [46,47]. Third, usability and accessibility must be optimized through age-appropriate interface design, simplified interaction requirements, and adaptive task difficulty; non-immersive or hybrid solutions (e.g., 360° video, augmented-reality overlays) may offer valuable compromises for individuals with functional difficulties and movement disorders [48,49]. Fourth, VR assessments should increasingly integrate subtle multi-modal behavioral markers (e.g., gaze behavior, movement patterns, interpersonal distance, vocal prosody) to provide a richer and more mechanistic understanding of social-cognitive deficits [50]. Fifth, the integration of VR within clinical ecosystems (e.g., automated scoring, remote deployment through lightweight platforms, cost-effective solutions) will be crucial for scalability. Finally, ethical, regulatory, and data-privacy considerations—including patient comfort, informed consent, and secure data handling—must be addressed proactively to ensure responsible implementation in vulnerable populations. Evidence on usability constraints in particular populations (e.g., patients with severe NCDs) should

be carefully collected to inform decisions about when VR-based assessment tools are appropriate—and when they should be avoided.

Conclusions

In conclusion, VR-based approaches represent a promising avenue for advancing the assessment of social cognition in NCDs, offering the potential to bridge the gap between *offline* social cognition, in which participants passively observe social stimuli, and *online* social cognition, in which they actively engage within dynamic social contexts [22,23]. Realizing this potential will require coordinated, interdisciplinary efforts across cognitive neuroscience, neurology, gerontology, clinical neuropsychology, computer science, and health-technology regulation to co-design effective sociotechnical solutions. With continued investment in validation, usability, interoperability, and ethical governance, supported by governmental and private funding, VR has the potential to transform social cognition assessment from passive, static measurement to an interactive, dynamic, and clinically meaningful evaluation of social behavior in aging and dementia. The future clinical impact of VR solutions will depend on addressing challenges related to validation, usability, clinician training, and equitable implementation. Ensuring that these technologies are accessible across a range of healthcare settings, rather than only in well-resourced environments, will be critical for maximizing their broader applicability and clinical value. The expert consensus provides a first foundation for guiding these future developments and supporting the integration of VR-based social cognition assessment into clinical practice.

Data Availability

The datasets generated or analyzed during this study are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Author Contributions

VM, CC, AD, AG, GS et PR contributed to the conceptualization and methodology of the study. All authors contributed to the investigation and data collection. VM and CC contributed to the formal analysis. VM, CC, AD, AG, GS and PR drafted the initial version of the manuscript. All authors contributed to the interpretation of the findings, critically reviewed and revised the manuscript through multiple rounds of revision, and approved the final version for publication.

Funding statement

This work was supported by the Interreg-Alcotra project INTEVIDI (Grant agreement No. 20178) and by the French government, through the UCA-JEDI Investments in the Future project managed by the National Research Agency (ANR) with the reference number ANR-15-IDEX-01. This research was also partially supported by the Joint Program for Neurodegenerative Disease 2025 Call for “Health and Social Care Research with a Focus on the Moderate and Late Stages of Neurodegenerative Diseases” (Project Name: DISCeRN, n. ANR-25-JPW2-0002-01).

Generative IA Disclosure

Generative artificial intelligence (ChatGPT) was used solely to correct and improve the English language of the manuscript. The authors reviewed and edited all AI-assisted text and take full responsibility for the content of the manuscript.

References

1. Cerami C, Boccardi M, Meli C, Panzavolta A, Funghi G, Festari C, Cappa SF, Chatzikostopoulos T, Chicherio C, Clarens F. Understanding barriers and optimizing socio-cognitive assessment in the diagnosis of neurocognitive disorders. *J Neuropsychol*. 2025;19(3):603–618. doi:10.1111/jnp.12431
2. Dodich A, Panzavolta A, Funghi G, Meli C, Festari C, Chatzikostopoulos T, Chicherio C, Clarens F, De Oliveira FF, Filardi M. International consensus for the assessment of social cognition in neurocognitive disorders: framework definition and clinical recommendations of the SIGNATURE initiative. *Alzheimers Res. Ther*. 2026;18(1):6. doi:10.1186/s13195-025-01908-2
3. Pinkham AE, Hajdúk M, Ziermans T. Harmonizing cross-cultural and transdiagnostic assessment of social cognition by expert panel consensus. *Schizophrenia*. 2025;11(1):25. doi:10.1038/s41537-024-00540-7
4. Van den Stock J, Bertoux M, Diehl-Schmid J, Piguet O, Rankin KP, Pasquier F, Ducharme S, Pijnenburg Y, Kumfor F. Current potential for clinical optimization of social cognition assessment for frontotemporal dementia and primary psychiatric disorders. *Neuropsychol Rev*. 2023 June;33(2):544–550. doi:10.1007/s11065-022-09554-3
5. Eikelboom WS, van den Berg E, Beauchamp MH, Bray KO, Kumfor F, MacPherson SE, McDonald S, Spikman JM, Kessels RP. Providing a taxonomy for social cognition: How to bridge the gap between expert opinion, empirical data, and theoretical models. *J Psychiatr Neurosci*. 2025;50(3):E157–E161. doi:10.1503/jpn.240156
6. Qesque F, Apperly I, Baillargeon R, Baron-Cohen S, Becchio C, Bekkering H, Bernstein D, Bertoux M, Bird G, Bukowski H. Defining key concepts for mental state attribution. *Commun Psychol*. 2024;2(1):29. doi:10.1038/s44271-024-00077-6
7. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. *Am Psychiatric Assoc* 2013;21(21):591–643. doi:10.1176/appi.books.9780890425787

8. Insel T, Cuthbert B, Garvey M, Heinssen R, Pine DS, Quinn K, Sanislow C, Wang P. Research Domain Criteria (RDoC): Toward a New Classification Framework for Research on Mental Disorders. *Am J Psychiatr*. 2010;167:748–751. doi:10.1176/appi.ajp.2010.09091379
9. Belfort T, Nogueira ML, Gaigher J, Rangel R, de Souza N, Dourado MCN. Comparing patterns of impairment in social cognition between young-onset and late-onset Alzheimer's disease. *Journal of Alzheimer's Disease* SAGE Publications; 2025 Apr 1;104(4):1053–1063. doi: 10.1177/13872877251323046
10. Bora E, Walterfang M, Velakoulis D. Theory of mind in behavioural-variant frontotemporal dementia and Alzheimer's disease: A meta-analysis. *J Neurol, Neurosur Ps*. 2015;86(7):714–719. doi:10.1136/jnnp-2014-309445
11. Demichelis OP, Coundouris SP, Grainger SA, Henry JD. Empathy and theory of mind in Alzheimer's disease: A meta-analysis. *J Int Neuropsych Soc*. 2020;26(10):963–977. doi:10.1017/S1355617720000478
12. Henry JD, Phillips LH, Von Hippel C. A meta-analytic review of theory of mind difficulties in behavioural-variant frontotemporal dementia. *Neuropsychologia*. 2014;56:53–62. doi:10.1016/j.neuropsychologia.2013.12.024
13. Shi P, Chapman H, Liu L, Rodgers F, Shaw J, Livingston G, Rankin KP, Warren JD, Sommerlad A. Social cognition in mild cognitive impairment and dementia: a systematic review and meta-analysis. *Alzheimers Dementi*. 2025;21(3):e70076. doi:10.1002/alz.70076
14. Stam D, Rosseel S, De Winter F-L, Van den Bossche MJA, Vandenbulcke M, Van den Stock J. Facial expression recognition deficits in frontotemporal dementia and Alzheimer's disease: a meta-analytic investigation of effects of phenotypic variant, task modality, geographical region and symptomatic specificity. *J Neurol*. 2023 Dec;270(12):5731–5755. doi:10.1007/s00415-023-11927-4
15. Bora E, Yener GG. Meta-Analysis of Social Cognition in Mild Cognitive Impairment. *J Geriatr Psychiatry Neurol*. 2017 July 1;30(4):206–213. doi: 10.1177/0891988717710337
16. Chander RJ, Numbers K, Grainger SA, Cleary R, Mather KA, Kochan NA, Brodaty H, Henry JD, Sachdev PS. Differential social cognitive performance in older adults with Mild Cognitive Impairment and dementia. *American J Geriatr Psychiatr*. 2025 Mar 1;33(3):248–259. doi:10.1016/j.jagp.2024.08.008
17. Quaranta D, Di Tella S, Cassano V, L'Abbate F, Bruno M, Gaudino S, Panfili M, Silveri MC, Marra C. Neural correlates of empathy in mild cognitive impairment. *Cogn Affect Behav Ne*. 2024;24(1):171–183. doi:10.3758/s13415-023-01146-9
18. Russell LL, Greaves CV, Bocchetta M, Nicholas J, Convery RS, Moore K, Cash DM, van Swieten J, Jiskoot L, Moreno F, Sanchez-Valle R, Borroni B, Laforce RJ, Masellis M, Tartaglia MC, Graff C, Rotondo E, Galimberti D, Rowe JB, Finger E, Synofzik M,

- Vandenberghe R, de Mendonça A, Tagliavini F, Santana I, Ducharme S, Butler C, Gerhard A, Levin J, Danek A, Otto M, Warren JD, Rohrer JD. Social cognition impairment in genetic frontotemporal dementia within the GENFI cohort. *Cortex*. 2020;133:384–398. doi:10.1016/j.cortex.2020.08.023
19. Quesque F, Nivet M, Etchepare A, Wauquiez G, Prouteau A, Desgranges B, Bertoux M. Social cognition in neuropsychology: A nationwide survey revealing current representations and practices. *Appl Neuropsych Adul*. 2024;31(4):689–702. doi:10.1080/23279095.2022.2061859
 20. Msika E-F, Verny M, Dieudonné B, Ehrlé N, Gaston-Bellegarde A, Orriols E, Piolino P, Narme P. Multidimensional assessment of social cognition using non-immersive virtual reality in dementia with Lewy bodies and Alzheimer’s disease: an exploratory study. *J Clin Exp Neuropsychol*. 2024;46(5):488–503. doi:10.1080/13803395.2024.2357362
 21. Rossetto F, Castelli I, Baglio F, Massaro D, Alberoni M, Nemni R, Shamay-Tsoory S, Marchetti A. Cognitive and affective theory of mind in mild cognitive impairment and Parkinson’s disease: Preliminary evidence from the Italian version of the Yoni task. *Dev neuropsychol*. 2018;43(8):764–780. doi:10.1080/87565641.2018.1529175
 22. Schilbach L. Towards a second-person neuropsychiatry. *Philos T Roy Soc B*. 2016;371(1686). doi:10.1098/rstb.2015.0081
 23. Schilbach L, Timmermans B, Reddy V, Costall A, Bente G, Schlicht T, Vogeley K. Toward a second-person neuroscience1. *Behav Brain Sci*. 2013;36(4):393–414. doi:10.1017/S0140525X12000660
 24. Schilbach L. On the relationship of online and offline social cognition. *Front Hum Neurosci*. 2014;8:278. doi:10.3389/fnhum.2014.00278
 25. Schilbach L, Redcay E. Synchrony across brains. *Annu Rev Psychol*. 2025;76(1):883–911. doi:10.1146/annurev-psych-080123-101149
 26. Setién-Suero E, Murillo-García N, Sevilla-Ramos M, Abreu-Fernández G, Pozueta A, Ayesa-Arriola R. Exploring the relationship between deficits in social cognition and neurodegenerative dementia: A systematic review. *Front Aging Neurosci*. 2022;14:778093. doi:10.3389/fnagi.2022.778093
 27. Shim Y, Na S, Yang S-J, Ryu HJ, Yoon B, Rhee HY, Jang J-W, Jung YH, Chin J. Social cognition in Neurodegenerative Disorders. *Dement Neurocogn Disord*. 2025 July;24(3):147–161. doi:10.12779/dnd.2025.24.3.147
 28. Benito-Ruiz G, Luzón-Collado C, Arrillaga-González J, Lahera G. Development of an ecologically valid assessment for social cognition based on real interaction: Preliminary results. *Behav Sci*. 2022;12(2):54. doi:10.3390/bs12020054

29. Kourtesis P, MacPherson SE. An ecologically valid examination of event-based and time-based prospective memory using immersive virtual reality: The influence of attention, memory, and executive function processes on real-world prospective memory. *Neuropsychol Rehabil.* 2023;33(2):255–280. doi:10.1080/09602011.2021.2008983
30. Manera V, Abrahams S, Agüera-Ortiz L, Bremond F, David R, Fairchild K, Gros A, Hanon C, Husain M, König A. Recommendations for the nonpharmacological treatment of apathy in brain disorders. *Am J Geriatr Psychiatry.* 2020;28(4):410–420. doi:10.1016/j.jagp.2019.07.014
31. Appel L, Appel E, Bogler O, Wiseman M, Cohen L, Ein N, Abrams HB, Campos JL. Older adults with cognitive and/or physical impairments can benefit from immersive virtual reality experiences: a feasibility study. *Front Med.* 2020;6:329. doi:10.3389/fmed.2019.00329
32. Riva G, Serino S. Virtual reality in the assessment, understanding and treatment of mental health disorders. *J Clin Med.* 2020;9(11):3434. doi:10.3390/jcm9113434
33. Adery LH, Ichinose M, Torregrossa LJ, Wade J, Nichols H, Bekele E, Bian D, Gizdic A, Granholm E, Sarkar N. The acceptability and feasibility of a novel virtual reality based social skills training game for schizophrenia: Preliminary findings. *Psychiat Res.* 2018;270:496–502. doi:10.1016/j.psychres.2018.10.014
34. Oker A, Prigent E, Courgeon M, Eyharabide V, Urbach M, Bazin N, Amorim M-A, Passerieux C, Martin J-C, Brunet-Gouet E. How and why affective and reactive virtual agents will bring new insights on social cognitive disorders in schizophrenia? An illustration with a virtual card game paradigm. *Front Hum Neurosci.* 2015;9:133. doi:10.3389/fnhum.2015.00133
35. Rus-Calafell M, Garety P, Sason E, Craig TJ, Valmaggia LR. Virtual reality in the assessment and treatment of psychosis: A systematic review of its utility, acceptability and effectiveness. *Psychol Med.* 2018;48(3):362–391. doi:10.1017/S0033291717001945
36. Moreno A, Wall KJ, Thangavelu K, Craven L, Ward E, Dissanayaka NN. A systematic review of the use of virtual reality and its effects on cognition in individuals with neurocognitive disorders. *Alzheimers Dement.* 2019;5:834–850. doi:10.1016/j.trci.2019.09.016
37. Zygouris S, Segkouli S, Triantafyllidis A, Giakoumis D, Tsolaki M, Votis K, Tzovaras D. Usability of the Virtual Supermarket Test for older adults with and without cognitive impairment. *J Alzheimers Dis.* 2022;6(1):229–234. doi:10.3233/ADR-210064
38. Ajeet Gokani H, Sommerlad A, Jawharieh H, Ang CS, Huntley J. Carers and professionals' views on using virtual reality in dementia care: A qualitative study. *Dementia.* 2025;24(1):71–90. doi:10.1177/14713012241272786

39. Pieri L, Tosi G, Romano D. Virtual reality technology in neuropsychological testing: A systematic review. *J Neuropsychol.* 2023;17(2):382–399. doi:10.1111/jnp.12304
40. Neveu E, Huynh L-K, Roy I, Salles J, Lavertu G, Zarglayoun H, Dodin P, Beauchamp MH. Social cognition assessment using virtual reality: A systematic review. *Tech Mind Behav.* 2025;6(3):225. doi:10.1037/tmb0000159
41. Diamond IR, Grant RC, Feldman BM, Pencharz PB, Ling SC, Moore AM, Wales PW. Defining consensus: A systematic review recommends methodologic criteria for reporting of Delphi studies. *J Clin Epidemiol.* 2014;67(4):401–409. doi:10.1016/j.jclinepi.2013.12.002
42. Jünger S, Payne SA, Brine J, Radbruch L, Brearley SG. Guidance on Conducting and REporting DELphi Studies (CREDES) in palliative care: Recommendations based on a methodological systematic review. *Palliative Med.* 2017;31(8):684–706. doi:10.1177/0269216317690685
43. Bassano C, Chessa M, Solari F. Visualization and interaction technologies in serious and exergames for cognitive assessment and training: A survey on available solutions and their validation. *IEEE;* 2022;10:104295–104312. doi:10.1109/ACCESS.2022.3210562
44. Ventura J, Welikson T, Ered A, Subotnik KL, Keefe RSE, Hellemann GS, Nuechterlein KH. Virtual reality assessment of functional capacity in the early course of schizophrenia: Associations with cognitive performance and daily functioning. *Early Interv Psychiatry.* 2020 Feb;14(1):106–114. doi:10.1111/eip.12831
45. Tan NC, Lim JE, Allen JC, Wong WT, Quah JHM, Muthulakshmi P, Teh TA, Lim SH, Malhotra R. Age-related performance in using a fully immersive and automated Virtual Reality system to assess cognitive function. *Front Psychol.* 2022;13-847590. doi:10.3389/fpsyg.2022.847590
46. Markus HR, Kitayama S. Culture and the self: Implications for cognition, emotion, and motivation. *College student development and academic life Routledge;* 2014. p. 264–293.
47. Sicorello M, Stevanov J, Ashida H, Hecht H. Effect of Gaze on Personal Space: A Japanese–German Cross-Cultural Study. *J Cross-Cult Psychol.* 2019;50(1):8–21. doi: 10.1177/0022022118798513
48. Großekathöfer JD, Seis C, Gamer M. Reality in a sphere: A direct comparison of social attention in the laboratory and the real world. *Behav Res Methods.* 2022;54(5):2286–2301. doi:10.3758/s13428-021-01724-0
49. Presti P, Galasso GM, Ruzzon D, Avanzini P, Caruana F, Rizzolatti G, Vecchiato G. Architectural experience influences the processing of others' body expressions. *Proc Nat Acad Sci USA.* 2023;120(41):e2302215120. doi:10.1073/pnas.2302215120

50. Davis R. The feasibility of using virtual reality and eye tracking in research with older adults with and without Alzheimer's disease. *Front Aging Neurosci.* 2021;13:607219. doi:10.3389/fnagi.2021.607219

Table 1. Results of the Delphi rating questions on the use of VR for the assessment of social cognition in people living with NCDs

Delphi round	Delphi item	Median	IQR	% of ratings ≥ 7
1	Immersive VR is a suitable technology for assessing social cognition in patients with NCDs.	7	3	51,2%
2	Although VR shows promise in reproducing realistic social interactions within controlled and standardized environments, further evidence is required regarding its usability, ecological validity, and accuracy in individuals with NCDs before it can be implemented in clinical practice.	9	2	92,1%

Results in bold indicate items reaching a consensus

Figure 1. SWOT Analysis: Experts' opinions on the use of VR in older adults with Neurocognitive Disorders

✓ Strengths • Simulates real-life interactions in controlled settings. • High ecological validity; bridges gap with real-world functioning. • Allows creation of complex scenarios not feasible with traditional tools. • Standardized, reproducible conditions. • Detects subtle social cognition deficits. • Supports multimodal data (eye gaze, physiological metrics) collection. • Personalized, engaging environments. • Enables collaborative/multi-person interactions. • Early use may improve acceptance. • Closer observation of social functioning in real time.	⚠ Weaknesses • Usability challenges due to cognitive, sensory, or motor deficits. • Irritation, confusion, or difficulty understanding instructions. • Nausea, dizziness, risk of falls. • Lengthy setup time and high workflow burden for clinicians. • Requires automated scoring/reporting to avoid inefficiency. • High technical complexity; difficult to standardize across sites. • Many confounding variables affect results' interpretation. • Patients may view VR as "a game", reducing realism. • Interface demands (font size, navigation complexity). • Few available VR- or MR-based solutions
💡 Opportunities • Use of simpler or non-immersive VR (e.g., 360° videos). • Multi-platform and scalable solutions; browser-based access. • Integration with clinical workflows and modular task selection. • Smartphone-based monitoring for daily use. • Networked/multiplayer interactions for social cognition tasks. • VR as a complement to classical assessments. • Adaptation for rural or culturally diverse groups. • Potential use of hybrid modalities or augmented reality	✗ Threats • High hardware and implementation costs. • Rapid technological evolution, which accelerates obsolescence • Limited resources in many hospitals/services. • Digital inequality: equipment availability, digital literacy, internet. • Data privacy, GDPR/HIPAA, and ethical issues. • Low adherence among older users. • Lack of robust validation evidence. • Technological confounds may bias results. • VR may feel artificial or ethically problematic for some patients.