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Towards immersive teleclinics in the Metaverse: the case of neuropsychological consultation

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ABSTRACT

The Metaverse is often deemed very important for the future of medicine and healthcare, yet there exist very few real health applications making use of social VR, its core feature. Here we first present our vision of what could be a virtual clinic in the Metaverse that would allow patients and practitioners to meet in VR and carry out various activities. We then introduce Tecnis, our implementation of such a clinic for psychotherapeutic consultation and neuropsychological testing. Our system features several spaces such as a waiting room, a consultation room, and standalone activities, as well as data-based dashboards for clinicians to lead the sessions.

Keywords: Cognitive testing, Medical consultation, Metaverse, Psychotherapy, Teleclinic

1 INTRODUCTION

Immersive Virtual Reality (VR) has long been studied and used in medicine, for a large variety of use cases in care (e.g. pain relief Chan et al. (2018)), rehabilitation (e.g. low-vision rehabilitation treatment Ehrlich et al. (2017)), diagnosis (e.g. early assessment of Alzheimer's disease Howett et al. (2019)), or education (e.g. nursing education Cieslowski et al. (2023)) and training (e.g. surgical training Mao et al. (2021)). Beyond VR, the Metaverse concept can be defined as a 3D virtual space for social interactions and activities. It encompasses XR technologies, avatars, and persistent 3D worlds, offering diverse applications in education, leisure, gaming, work, or business Park and Kim (2022). It differs from VR, however, in its focus on services, its ability to be accessed with non-immersive devices, and its necessary scalability. Current Metaverse tools and practices are mostly related to social VR, with digital avatars meeting in virtual worlds, such as those offered by VRChat, RecRoom or Workrooms.

Metaverse applications in healthcare and medicine can be categorized in five main topics: medical education and training (e.g. surgical simulations, patient education for professionals); medical visualization (immersive and collaborative analysis of patient data, 3D models and AR-assistant for surgery, distant monitoring. . .); telerehabilitation (e.g. immersive technologies for mental or physical therapy at home); virtual consultation and telemedicine (e.g. meetings between practitioners and patients in virtual environments); and social support (e.g. immersive group therapy sessions). Although the metaverse in medicine is a trending topic, many of its featured applications can appear as rebranded versions of existing technologies such as autonomous VR medical applications or AR-based assisted surgery, without taking into account its fundamental social aspects. Due to the Covid pandemics, telehealth care services have gained significant attention and acceptance Wong et al. (2021), and Metaverse-based telehealth is on the agenda Sampaio et al. (2021). However if support groups between patients have used social VR technology for a long time, virtual consultations that would allow the medical meeting of patients and practitioners are still lacking, and most of the proposals have remained mere ideas, with a lack of implementation, let alone assessment. Therefore, examining how the Metaverse and social VR can contribute to teleconsultation is needed Dwivedi et al. (2022).

VR has been widely studied for the specific case of mental health applications, Freeman et al. (2017), showing promises for diagnosing and treating conditions like dementia, anxiety, and phobias through techniques like Cognitive Behavioral Therapy (CBT) and Virtual Reality Exposure Therapy (VRET) Cieřlik et al. (2020). For neuropsychological testing and training, its ability to immerse people in ecological and controlled environments for stimulating cognitive and executive functions, while measuring patient's performance and behavior, enables more precise, valid and personalized results than paper-and-pencil tests Kim et al. (2021). Medical practitioners (psychiatrists, psychologists, psychotherapists...) are increasingly incorporating VR into patient care, follow-up and monitoring during consultations, often using Head-Mounted Displays (HMDs) for their patients and dedicated commercial applications that they can control on handheld tablets. More rarely, they can lend HMD to their patients who can exercise at home. However, very few studies have focused on the use of social VR technologies for patient-practitioner meeting in the Metaverse.

In this paper, we explore the potential of social VR for immersive clinical teleconsultation. First, we detail our vision and the main principles of immersive teleclinics, where patients meet practitioners and benefit from supervised or independent assessment or remediation activities. We then present a prototype designed and implemented as part of a concrete project with psychiatrists, psychologists and researchers, aimed at providing comprehensive remote patient management, including clinical interviews and neuropsychological testing activities with therapists. We conclude with some recommendations for future works.

2 PRINCIPLES FOR IMMERSIVE TELECONSULTATION

We propose our vision for teleconsultation in the Metaverse, which is based on a few principles (Fig. 1):

1. Immersive remote consultations between medical practitioners and patients should take place in *immersive teleclinics* run by socio-economic players, such as public or private hospitals or clinics, telemedicine operators, who make social VR consultation rooms available to their staff, or lend them to independent practitioners.
2. An immersive teleclinic is a set of *spaces*, e.g. welcoming spaces, social rooms, waiting rooms, consultation rooms, collective or individual exercise rooms, etc. It also provides web access for

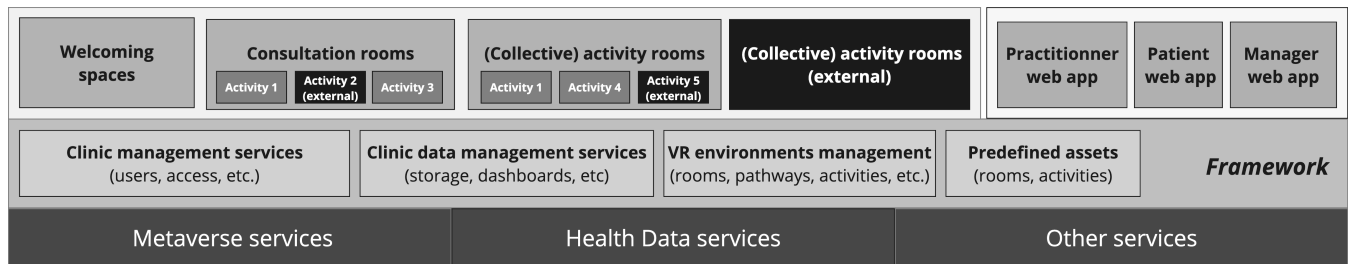


Figure 1. An immersive teleclinic as a set of social VR spaces and rooms where activities can take place, associated to web applications. The clinic makes use of external activity modules. It is built upon a framework featuring several services and predefined assets, based on various lower-level services (metaverse, web, health data, etc).

functionalities that do not need immersion, such as users and appointments management, offline access to data and dashboards, etc.

3. Depending on available technology, patients and practitioners in VR can perform various *activities* in the clinic, ranging from simple social interaction in consultation via avatars to remote examination with specific sensors, as well as a variety of exercises, either dedicated to assessment or remediation. Activities can be carried out alone (e.g. cognitive training) or collectively (e.g. elbow rehabilitation), and be accompanied or not by practitioners. Activities can take place in *consultation rooms* or dedicated *activity rooms*.
4. Activities can be already offered by the teleclinic software, but it is important that third party vendors can propose external modules that can be plugged into the clinic using an Activity API.
5. An immersive teleclinic is built on a *framework* offered by specific socio-economic players such as software companies, metaverse providers, etc. It can run on premise or in the cloud, and be connected to clinical information systems, secured health data management systems, etc. The framework is composed of a set of predefined modules for clinic and data management, as well as predefined rooms, activities, etc. that can be tailored.
6. The use of an immersive teleclinic and immersive teleconsultation should be *integrated within patients' healthcare paths* in a coherent way. The paths would be composed of real and virtual teleconsultations, depending on the activities that would be carried out. For instance, a first encounter, followed by distant testing, then a consultation associated to a prescription with distant monitoring related to performances in assessment exercises that would be carried out every week.
7. Patients at home can either possess their own HMD and be autonomous, or necessitate that a handover assistant be present, who would bring the HMD, set up the access, and accompany the patient during the session. Such profession needs to be considered in relation to existing paramedical professions, and integrated into the range of healthcare services.

This principles and the associated architecture described in Figure 1 are by no means definitive, but should give the main insights of our proposal.

3 THE CASE OF NEUROPSYCHOLOGICAL CONSULTATION: TECNIS PROJECT

The Tecnis (*Téléclinique Immersive*) project is a joint program between Nantes University and the University Hospital of Nantes. Its aim is to investigate how to take immersive cognitive testing to the next level, by integrating them into current practices. The interdisciplinary team is composed of one

neuro-psychologist, one psychiatrist, and several clinical psychologists, XR/UX/HCI scientists, a UX researcher and a development engineer.

The methodology we followed is classical user-centered design. We first carried out several interviews and focus groups with various stakeholders outside of the team (neuro-psychologists, psychiatrists, neurologists, geriatrician, general practitioner), so as to describe what psychiatric patients' journey are, from detection to long-term follow-up or remission, and identify where and when immersive technologies could be useful. We also developed our general vision (section 2), and wrote numerous scenarios related to the various possibilities, both in VR and AR, before settling on the topic we would be focusing on, namely neuropsychological teleconsultation, for carrying out tests remotely. We made this choice because such testing is a time-consuming activity in a overloaded healthcare sector, that do not rely solely on dialog, that can be instrumented with data, and that can re-occur for longitudinal follow-up. We then held 8 interdisciplinary co-design workshops that helped us make our key design decisions, define our spaces, the types of activities that would be carried out, as well as the interactions. We also underwent used immersive prototyping, and had our prototypes tested and commented upon by a "partner patient", several nurses and hospital patients.

Our main design decisions were as follows.

- We should allow patients and clinicians to meet in VR during full clinical sessions composed of discussions, neuropsychological testing, and debriefings, as in conventional practice. The meeting would take place on a virtual desk, while each user would seat in front of a table/desk in reality.
- We should provide a waiting room for patients to wait for the practitioner, who could be late, as in real life, first because it acts as a transition space before a medical meeting, and second because waiting time is specifically important in psychotherapy, to help patients focus.
- Apart from psychotherapeutic interview, activities in immersive psychotherapy are mainly related to *cognitive performance testing and/or cognitive remediation or training*. Those activities can be carried out either on the practitioner's desk, or in "standalone" independent VR environments. They can be performed alone or accompanied by the practitioner.
- As in a real psychoterapeutic consultation, the practitioner should be able to lead the session and decide of the activities beforehand, or during the session with a control panel. He should be provided with data-based tools for lived enriched observation during interviews and activities, as well as dashboards for post-activity or post-session debriefing.
- In both desk-based and standalone activities, behavioral data is to be automatically collected so as to produce indicators for the practitioner to access to in dedicated real-time, post-session or longitudinal dashboards.

The patient / practitioner workflow is described on Fig. 2. First both users are welcomed in their home space, where they can consult their agenda, specify their avatar, follow tutorials, etc. From there, patients teleport in the waiting room, where several waiting activities are proposed, to spend between 5 and 20 minutes, while practitioners teleport in the consultation room where they can prepare the upcoming session. When they are ready, practitioners teleport into the waiting room so as to welcome patients, engage in discussion, and invite them to join the consultation room. Once there, practitioners can lead the consultation, propose desk test activities, and discuss the results. At some point, they can invite patients to stand up and head towards the standalone activity space, where standalone testing can take place, before going back at the desk for other activities or data-based debriefing.

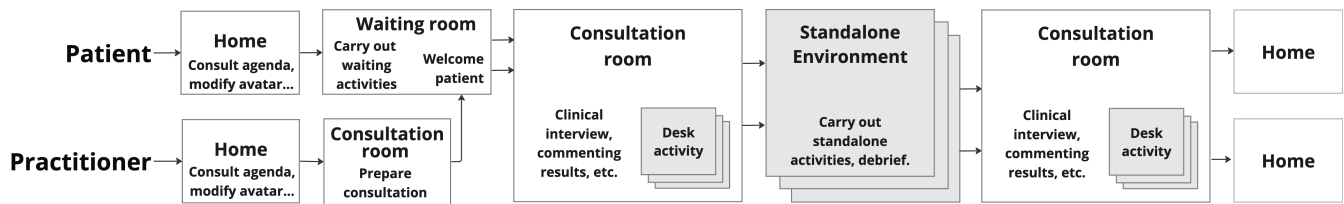


Figure 2. Simplified workflow for a consultation in Tecnis. The practitioner welcomes the patient in the waiting room before proceeding to the consultation room where a mix of discussions and activities can occur. Elements provided by the clinic are in white, activity modules plugged into the clinic in gray.

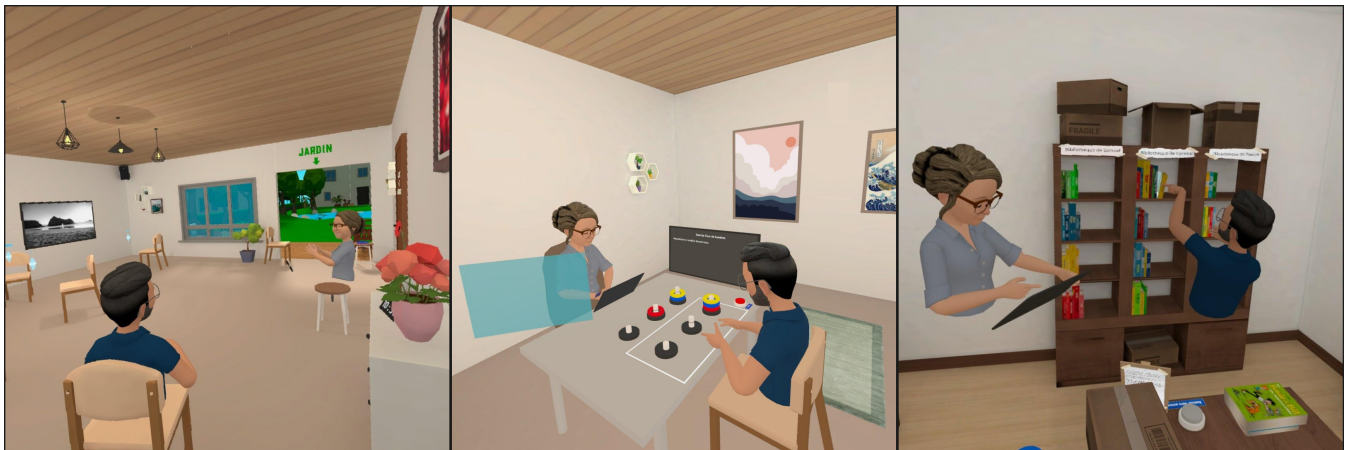


Figure 3. The clinic is composed of various environments. From left to right: Waiting room with different chairs and waiting activities, the female practitioner welcomes the patient; Consultation room with a desk-based activity (here a version of the *Tower of London* test); Both users in a standalone activity environment (here *Shelves* that we developed for executive function testing, see Ribeiro et al. (2024)).

We can now rapidly describe the various environments we have developed (Fig. 3). The *waiting room* is an environment that allows the user to teleport from chair to chair (or bench when outside in the garden) and carry out waiting activities. Amongst the ones we have designed with the medical members of our team, we implemented the following: an activity for controlling one's respiration; another for consulting medical information and newspapers on a table; a contemplation activity with large scale images accompanied with sound; and a gardening stand where patients can select and plant flowers creatively. The *consultation room* features a desk, where the practitioner has access to a control panel and several screens, one of them for sharing information with the patient. The control panel allows to launch tests, control their unfolding and access the resulting data. In our prototype we have implemented a fully functional version of the "Tower of London" test. Lastly, both the patient (by standing and moving) and the practitioner (staying in the chair) can go into *standalone tests environments*, where the patient carries out the activity while the practitioner controls and observes the task, getting information on the control tablet.

4 CONCLUSION

Beyond this, teleconsultation and teleclinics in the Metaverse should be studied for others domains than psychotherapy, and a lot of topics are waiting for careful studies: effects of avatars, integration of remote sensors technologies, experiential aspects of teleconsultation and visits to clinic in the Metaverse, business models, integration of immersive teleclinics into health systems, etc.

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