

TELEPRESENCE

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October 23, 2025

RECOMMENDED CITATION

mohammad looti (2025). *TELEPRESENCE*. PSYCHOLOGICAL SCALES. Retrieved from <https://scales.arabpsychology.com/?p=53852>

TELEPRESENCE

Primary Disciplinary Field(s): Human-Computer Interaction (HCI), Robotics, Virtual Reality, Cognitive Psychology, Media Studies.

1. Core Definition and Phenomenology

Telepresence refers to the subjective experience of being physically present in a location other than one's physical body, typically facilitated by technological means that provide real-time sensory input from that remote location. While the original source content defines it simply as "the feeling of being at a remote location whenever given sensory data from that distant locale," academic literature expands this to include the cognitive and psychological merging of the physical self with the remote operating environment. This feeling is distinct from mere observation; true **telepresence** implies a sense of agency and responsiveness within the remote setting, leading to the perception that the mediated environment is the immediate reality, overriding the awareness of the user's immediate physical surroundings.

The phenomenological core of telepresence rests upon the successful mediation of sensory channels. When visual, auditory, and potentially haptic (touch) feedback loops are tightly integrated and high-fidelity, the user's sensory system is effectively 'tricked' into perceiving the remote location as the immediate environment. This phenomenon involves the suppression of the proximal environment--the user ceases to attend to their physical surroundings and focuses entirely on the distal, mediated environment. Crucially, the quality of **telepresence** is often measured by the degree to which the technological interface "disappears," allowing the user's intentionality to flow seamlessly into the remote space, thus achieving a state often described as spatial immersion or 'being there.' The success of this psychological shift is heavily dependent on reducing cognitive dissonance caused by technical artifacts.

The experience of telepresence is intrinsically linked to the concept of **perceptual fidelity**. High fidelity ensures that the sensory data received is rich, accurate, and synchronous. If there are noticeable temporal lags, visual latency, or inconsistencies between different sensory modalities (e.g., visual input lagging behind auditory input), the feeling of presence breaks down, resulting in a phenomenon known as 'cybersickness' or a realization of the mediation itself. Therefore, the successful induction of telepresence requires sophisticated engineering that minimizes technical constraints and maximizes the congruence between the user's motor commands and the corresponding feedback from the remote location, maintaining the illusion of direct, unmediated engagement and seamless extension of self.

2. Etymology and Historical Development

The term **Telepresence** was formally coined in 1980 by artificial intelligence pioneer and robotics researcher Marvin Minsky in his seminal paper of the same name. Minsky conceptualized this idea within the context of telerobotics, envisioning complex mechanical systems that would allow a human operator to perform intricate tasks remotely with the dexterity and sensory feedback usually associated with direct, physical manipulation. Minsky's vision was driven by the desire to extend human reach into hostile, dangerous, or inaccessible environments, such as deep space, underwater realms, or radioactive zones, treating the robotic proxy as an operational extension of the operator's own nervous system rather than a mere tool.

The foundational concepts, however, began to take practical form earlier, particularly in the mid-20th century, driven primarily by military and space exploration needs. Projects focusing on remotely operated vehicles (ROVs) and advanced manipulator arms for handling hazardous materials sought to bridge the spatial gap between human operator and distant machine. These early telerobotic systems established the necessity of high-resolution, real-time control, effective feedback mechanisms (especially haptics), and reliable, low-latency video streams. While these precursors were technologically primitive compared to modern systems, they solidified the engineering challenges inherent in creating a unified control and sensory loop across significant distances.

The evolution of telepresence significantly converged with the development of Virtual Reality (VR) starting in the late 1980s. While VR focuses on generating simulated, non-existent environments and achieving 'immersion,' telepresence focuses on mediating a real, existing distant environment and achieving 'presence.' Nevertheless, they share numerous hardware and software principles, such as the reliance on head-mounted displays (HMDs), motion tracking, and high-speed data rendering. More recently, the proliferation of pervasive broadband internet and high-definition video conferencing has led to consumer-grade systems where "telepresence" often refers to high-fidelity, life-sized video communication, blurring the academic requirement for embodied agency with the common requirement for sophisticated visual fidelity.

3. Technological Modalities and Enablers

Telepresence systems are broadly categorized based on the mechanism of presence they facilitate. The primary distinction is between systems that offer **embodied telepresence** and those offering **perceptual telepresence**. Embodied systems, typically categorized under Telerobotics, integrate sensors (cameras, microphones, pressure sensors) onto a mobile, physical platform--an avatar. The operator controls the movement of this platform using human interfaces, and the avatar's sensors feed corresponding data back to the operator, often through sophisticated interfaces like exoskeleton controllers or specialized gloves, ensuring high motor correlation and feedback. The success of this modality depends on maintaining the illusion that the robotic proxy is the user's actual body in the remote space.

Perceptual systems, sometimes referred to as immersive video or holographic telepresence, use advanced display technologies, such as large video walls, 3D displays, or volumetric capture techniques, to create the illusion that the distant environment or participants are physically present in the local room. These systems prioritize high spatial and temporal resolution, along with sophisticated audio spatialization, to minimize visual and auditory cues that betray the mediation. High-end corporate telepresence suites, for instance, utilize precise calibration of cameras, display size, and lighting to achieve 'eye contact' and life-sized projection, maximizing the perception of shared physical space for remote collaboration.

A critical enabler across all modalities is the capacity for **bidirectional interactivity**, which demands extremely low latency and high bandwidth communication infrastructure. Telepresence is fundamentally about closed-loop control: the user acts upon the remote environment (feed-forward) and receives appropriate, immediate feedback (feed-back). Any significant delay (latency) degrades the sense of presence and compromises operational efficiency, especially in tasks requiring fine motor control like telesurgery. Advances in high-speed networking technologies, such as 5G and fiber-optic backbones, are essential for reducing this critical delay and making highly responsive telepresence systems viable across global distances.

4. Key Characteristics of Presence

The subjective experience of telepresence is often decomposed into several key measurable characteristics used by researchers to quantify the effectiveness of a system. These include immersion, fidelity, interactivity, and social presence. **Immersion** refers to the objective quality of the technological system--specifically, the extent to which the technology surrounds the user and delivers continuous, comprehensive sensory information. A system with a high degree of immersion, such as a full-field-of-view Head-Mounted Display (HMD) with localized haptics, provides the essential foundation necessary for the psychological feeling of presence to manifest fully.

Interactivity is defined by the speed, mapping, and range of actions the user can perform in the remote environment. Seamless interactivity means that the user's cognitive and motor commands (e.g., reaching for an object, scanning a room) translate intuitively and instantaneously into actions by the remote avatar or camera. Conversely, systems with poor interactivity--characterized by significant control lag or unintuitive interfaces--are major inhibitors of telepresence, as they constantly remind the user that they are operating a mediated tool rather than acting directly within the environment. Interactivity must also account for feedback, ensuring that consequential actions in the remote space result in expected sensory returns.

In collaborative and communicative contexts, **Social Presence** becomes paramount. Social presence is the perception that one is truly interacting with another conscious, co-located entity in

the remote space, and that the interaction is mutual and intentional. Effective social telepresence requires the accurate transmission of subtle social cues, including non-verbal communication, posture, eye gaze, and micro-expressions. If a system fails to convey these nuanced signals, the collaboration can feel unnatural or distant, even if the basic video and audio fidelity are high. Thus, achieving successful social telepresence often necessitates technology that prioritizes the conveyance of emotional and intentional signals over sheer pixel count.

5. Applications Across Diverse Fields

The utility of telepresence extends across a multitude of high-stakes sectors, demonstrating its importance in overcoming geographic barriers and mitigating risk. In scientific fields, particularly deep-sea and space exploration, telepresence allows highly trained personnel to operate complex, delicate instruments or perform critical repairs in environments fundamentally hostile to human life. For example, planetary rovers and deep-sea remotely operated vehicles rely entirely on telepresence to relay sensory data and execute commands, extending human cognitive ability to extreme, distant operational zones without endangering human explorers.

One of the most transformative applications is in **Telesurgery**, a field where high-fidelity telepresence is critical for safety and precision. Highly skilled surgeons can operate robotic instruments on patients located in remote hospitals, using systems that provide stereoscopic vision, motion scaling, and accurate haptic feedback. This capability not only reduces the risk associated with transporting critically ill patients but also democratizes access to specialized medical expertise, allowing surgeons to operate in underserved areas globally, provided the network infrastructure can guarantee the ultra-low latency necessary for the precise, milliseconds-critical manipulations required in surgical procedures.

Commercially and educationally, mobile telepresence robots are increasingly utilized to bridge the gap for remote workers, students, or patients with mobility issues. These systems, often comprising a wheeled base with a camera and screen, allow remote individuals to physically navigate an office, attend classroom lectures, or participate in informal hallway conversations. By giving the remote user a dynamic, physical avatar in the distant location, these systems mitigate the feelings of isolation associated with purely screen-based remote communication, fostering a stronger sense of inclusion and organizational belonging.

6. Psychological and Cognitive Impact

Extended use of highly effective telepresence systems induces significant psychological and cognitive phenomena. The most profound effect is the **recalibration of the body schema**. When telepresence is seamless, users experience a genuine perceptual shift where they begin to define the boundaries of their physical self not by their actual skin, but by the periphery of their remote

avatar or the extent of their operational control. This phenomenon is analogous to tool incorporation, where instruments, such as surgical tools or robotic arms, are neurologically treated as extensions of the operator's own limbs, enhancing dexterity and precision.

However, this immersion comes with a considerable cognitive cost. The user must continuously dedicate cognitive resources to monitoring the system for inconsistencies, adapting to control mappings, and compensating for minute latencies--a phenomenon often referred to as increased **cognitive load**. High cognitive load can rapidly lead to fatigue, reduced situational awareness, and an increased likelihood of operational errors. Moreover, the sensory conflicts inherent in some systems (e.g., visual movement without corresponding signals from the inner ear) can trigger 'cybersickness,' manifesting as nausea, dizziness, and disorientation, severely limiting the duration and usability of the telepresence experience.

The emotional and ethical consequences are also vital to consider. In contexts where telepresence facilitates remote interaction with other humans (e.g., tele-therapy or remote management), the feeling of shared presence can foster crucial emotional trust and rapport. Conversely, in highly detached scenarios, such as the remote operation of military drones, the extreme spatial and psychological separation between the operator and the outcome of their actions can lead to a form of emotional blunting or 'moral injury.' The physical absence of the operator from the consequence zone fundamentally alters the human experience of causality and responsibility.

7. Challenges, Debates, and Ethical Considerations

Despite significant technological progress, several substantial technical challenges persist in achieving universal, flawless telepresence. The foundational impediment remains **latency and bandwidth**. While networks are faster, achieving the instantaneous, sub-10-millisecond response time required for highly coupled tasks like high-speed vehicle control or microsurgery is still difficult to guarantee across long geographical distances using current public internet infrastructure. Furthermore, the faithful capture and transmission of complex sensory data, particularly realistic haptic feedback (touch, texture, and force), remains an active and expensive area of research, limiting the ability of operators to truly 'feel' the remote environment.

Ethical and legal challenges are also rapidly emerging. Privacy is a major concern, as sophisticated telepresence systems require pervasive, high-resolution sensor networks to function effectively. Questions arise regarding the security and control of the data collected by the remote avatar, particularly concerning the potential for unauthorized surveillance or the hacking and hijacking of the remote body. A compromised telepresence robot not only poses security risks to the physical environment it occupies but also undermines the operator's simulated presence and potentially compromises their identity.

Finally, debates concerning **agency and accountability** are critical as robotic components gain

more autonomy. As telepresence systems increasingly incorporate local artificial intelligence to handle micro-adjustments or avoid immediate obstacles, the line between human intent and machine execution blurs. Defining the legal and ethical locus of control--who is responsible for errors when the human operator feels fully present but the machine executes commands autonomously--requires robust philosophical and legal frameworks that adequately address the shared agency inherent in advanced telepresence interaction.

Further Reading

[Wikipedia - Telepresence](#)

[Wikipedia - Marvin Minsky](#)

[Wikipedia - Telerobotics](#)

[Wikipedia - Virtual Reality](#)

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