Opinion-Perspective Article

Multisensory Integration and Diagnostic Accuracy in Telehealth

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ABSTRACT

Telehealth has quickly become a major component of modern healthcare systems worldwide, evolving rapidly in response to the COVID-19 pandemic. Most current research has focused on its benefits, including increased access, convenience, and efficiency. However, there is a gap in the literature regarding how telehealth changes the way clinicians perceive patients. Diagnosis begins with perception; therefore, any change in sensory input can affect clinical decision-making. This paper argues that telehealth alters the multisensory integration of visual, auditory, and somatosensory information, thereby shaping clinicians' understanding of a patient's condition. Factors such as video lag, audio distortion, and the lack of physical interaction can negatively affect these sensory cues. These differences may reduce diagnostic accuracy, particularly in cases that rely on subtle behavioral and communicative signals, such as assessments of autism or ADHD. This perspective contends that telehealth should be approached with caution, as it alters the sensory environment of healthcare delivery and carries important implications for diagnostic accuracy and clinical practice.

Keywords: Telehealth; Multisensory Integration; Diagnostic Accuracy; Perception; Neuroscience; Virtual

INTRODUCTION

When a patient's death is declared through a screen rather than by a physician at the bedside, what does that indicate about the current state of telehealth? A recent case reported by Cable News Network (CNN) described a 26-year-old patient, Conor Hylton, who was declared dead by a telehealth provider over video rather than by an in-person clinician after being admitted for abdominal pain, nausea, and vomiting (1). His care was partially managed by a remotely located physician, allowing critical decisions to be made through virtual communication rather than direct physical presence. Although this case highlights important factors, such as staffing limitations, it also raises concerns about the use of virtual care in critical medical situations. While telehealth has been widely praised for improving access for communities across the globe, cases such as this raise an unaddressed question: what happens when clinical care is removed from direct human perception?

Telehealth is a rapidly emerging technology that is transforming how healthcare is delivered by improving access, convenience, and efficiency for both patients and providers. In the United States, telemedicine use among office-based physicians increased from 16% in 2019 to 80.5% in 2021, demonstrating the rapid integration of virtual care into clinical settings (2). What began as a temporary solution during the COVID-19 pandemic has evolved into a more permanent component of

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modern healthcare systems (3). The use of virtual healthcare platforms has grown significantly because of their potential to expand access to healthcare, enabling providers to deliver care across geographical boundaries and connect with patients in underserved and remote areas. Virtual healthcare platforms include video conferencing and remote monitoring systems that enable the delivery of healthcare without requiring direct physical contact (4). Although this shift has significantly improved accessibility for many patients, it also raises important questions about how virtual environments affect the quality of clinical care.

Despite these benefits, a crucial gap remains in the literature. Most research on telehealth has focused on public health benefits, including increased patient access, reduced costs, and improved expediency within clinical settings. However, there has been limited attention to how telehealth changes the lived experience of clinical interactions in virtual healthcare environments, particularly from a sensory and perceptual perspective. In clinical settings, patient encounters are assessed—often implicitly—through the interpretation of social signals conveyed through visual and auditory channels, such as facial expressions, body language, and vocal behaviors (5). These cues are integrated by the brain to form an understanding of a patient's condition. The use of virtual platforms such as telehealth, however, can alter these sensory processes by filtering sensory inputs, potentially changing how they are perceived and interpreted (4). This raises several questions: What happens when these sensory inputs are filtered through a screen? What happens when audio is delayed, video quality is compressed, or physical touch is entirely removed? Do clinicians still perceive the same information, and if not, can diagnostic accuracy be maintained?

Understanding how sensory inputs shape the perception of patient symptoms is critical for accurate clinical decision-making. This is where the concept of multisensory integration becomes central, the idea that the combination of multiple sensory modalities is essential for forming accurate representations of the external world (6). Accordingly, this paper argues that telehealth can influence multisensory integration in ways that meaningfully affect diagnostic accuracy in virtual healthcare settings. Overlooking the role of multisensory integration poses a risk to diagnostic validity. By examining this issue through a neuroscience lens, it becomes possible to better understand how perceptual changes introduced by virtual care environments may lead to differences in diagnostic outcomes.

THE NEURAL BASIS OF CLINICAL PERCEPTION

Perception relies heavily on the brain's ability to integrate information from multiple sensory inputs. Rather than being processed in isolation, visual, auditory, and somatosensory information are combined to construct an individual's understanding of their environment (7). This process, known as multisensory integration, is critical in providers settings where clinicians must rapidly use both verbal and nonverbal cues to assess a patient's health (8). Integration of the senses is not optional; it is necessary for accurate diagnosis.

At the neural level, multisensory integration occurs through coordinated activity across multiple brain regions, including the superior temporal sulcus, the posterior parietal cortex, and subcortical structures such as the superior colliculus. These regions are involved in integrating audiovisual and sensorimotor signals and in combining information from multiple senses to generate perceptual experiences (9). In particular, the superior temporal sulcus plays a key role in processing socially and environmentally relevant stimuli, such as speech dynamics and facial expressions, making it especially important in clinical contexts.

A major challenge in multisensory integration is the binding problem, or how the brain determines which sensory signals belong together (9). For example, when a clinician observes a patient speaking, the brain must decide whether the visual movement of the lips and the auditory speech signals originate from the same source. This problem is typically resolved through temporal synchrony, whereby sensory inputs that occur close together in time are more likely to be integrated, while inputs that are temporally misaligned are perceived as separate signals (7). Accurate interpretation therefore requires coordination among what the patient says, facial expressions, and vocal tone.

One factor that influences whether information from multiple senses is successfully combined is the timing of sensory signals. This coordination is governed by the temporal binding window, which defines the range of time within which sensory inputs are most likely to be perceived as a unified event. If an audio or visual delay exceeds this window, proper integration can fail, leading to errors in perception. Importantly, the temporal binding window is not fixed across individuals or contexts and often operates within fractions of a second. In certain conditions, such as ADHD and autism, differences in multisensory processing have been observed (7).

Individuals with these conditions demonstrate altered temporal binding windows, which affect social communication. These findings indicate that perception within clinical populations is already variable and may be further complicated in environments where sensory input is altered or degraded. This has important implications for telehealth, where audiovisual delays may affect how patient behaviors and symptoms are perceived.

Beyond the timing of sensory information, the brain must also determine which sensory cues are most reliable. Current neuroscience models demonstrate that the brain does not treat all sensory inputs equally; instead, it assigns greater weight to cues perceived as more reliable while downregulating less reliable inputs (10). Accordingly, when one sensory modality becomes less reliable, the brain relies more heavily on other available inputs. For example, in noisy environments where speech is difficult to hear, individuals naturally depend more on visual cues such as lip movements and facial expressions to understand spoken language. This process is often modeled using Bayesian inference, in which the brain combines prior expectations with sensory evidence to construct perception. As a result, degradation of one sensory input, such as poor video quality or delayed audio, can alter how information is interpreted by encouraging clinicians to rely more heavily on remaining cues or prior expectations. While this adaptation can be beneficial, sensory reweighting may introduce perceptual bias, reducing diagnostic reliability and contributing to clinical error.

Not all changes in sensory input necessarily impair perception. One potential counterargument is the principle of inverse effectiveness, which suggests that multisensory integration may become more effective when individual sensory inputs are weak or degraded (11). Under this framework, combining multiple imperfect cues can sometimes yield greater perceptual benefit than relying on a single strong signal. In telehealth settings, clinicians may partially compensate for degraded audio or visual input by drawing more heavily on available contextual cues. However, this capacity for compensation is limited, as inverse effectiveness assumes that multiple sensory modalities remain available, even if degraded. When sensory degradation becomes too severe, or when entire sensory modalities are removed altogether, clinicians may no longer be able to compensate effectively, resulting in diminished perceptual accuracy. Therefore, compensation may help in some telehealth encounters, but it is unlikely to eliminate the perceptual challenges introduced by virtual care environments.

THE EFFECT OF TELEHEALTH ON THE SENSORY ENVIRONMENT

Telehealth creates a fundamentally different sensory environment compared to traditional in-person clinical encounters. In virtual visits, constraints on sensory input and timing, combined with indirect observation of the patient, have important implications for how patient information is interpreted and how diagnoses are made.

One of the most significant challenges in telehealth is the complete loss of olfactory and somatosensory input, particularly in primary care settings. During in-person clinical visits, olfactory cues provide important information about a patient's hygiene practices. Clinicians rely on physical sensory information obtained through techniques such as palpation, reflex testing, and other tactile cues to gather diagnostic information (12). In virtual visits, however, these sensory modalities are entirely absent, forcing clinicians to depend more heavily on visual and auditory information. These remaining modalities alone are not always sufficient to provide the level of detail required for accurate diagnostic assessment. This imbalance in sensory input may increase diagnostic uncertainty and introduce perceptual bias.

Even the sensory modalities that remain available may be degraded. Visual information can be affected by poor resolution, inadequate lighting, or a limited field of view, making it more difficult to detect subtle physical or behavioral cues (13). Similarly, auditory information may be compromised by background noise, compression, or lag. These disruptions can further impair temporal synchrony between sensory inputs, thereby degrading multisensory integration. For example, a delay between a patient's speech and corresponding lip movements that exceeds the temporal binding window may lead to misperception.

Lupton and Maslen (2017) describe this transformation as a shift toward "sensing sensors," wherein providers interpret digital representations rather than directly engaging with a patient's physical presence (4). This perspective suggests that telehealth does not merely transmit information but can fundamentally alter the nature of the information being conveyed. Because sensory input must be mediated through technological systems, telehealth modifies both the quality and timing of perceptual data. In this context, telehealth can be understood as a form of sensory degradation, in which the inputs necessary for accurate perception are reduced in fidelity. During in-person appointments, clinicians are able to assess patients directly through multiple sensory mechanisms. In contrast, telehealth requires sensory information to pass through cameras, microphones, display screens, and video compression software, each of which can distort or delay the transmitted signal. Even subtle reductions in audiovisual quality can influence how providers interpret patient behaviors and symptoms.

An additional factor influencing multisensory integration in telehealth is the design of the telehealth platform itself. For instance, teledermatology—a form of telehealth in which clinicians evaluate skin conditions using patient-submitted images or live video rather than in-person consultations—illustrates how perception can shift in virtual care environments (14). The effectiveness of teledermatology depends on the quality and clarity of the images submitted by the patients, as limitations of the remote physical examination may require clinicians to rely on photographs and detailed patient descriptions to inform diagnostic decisions. To address such limitations, clinicians often need additional information, image quality verification, or follow-up evaluations when visual data are insufficient. In these situations, clinicians must rely more heavily on descriptions reported by the patients and contextual information to compensate for incomplete visual input. From a multisensory integration perspective, this shift alters the balance of sensory information that is available during clinical assessment, thus influencing how symptoms are perceived and interpreted.

The influence of telehealth on perception extends beyond the clinical encounter itself and may also be shaped by the design of the technology being used. Given the wide availability of telehealth platforms worldwide, differences in video compression, buffering, latency reduction, and image processing are common. One platform may prioritize smoother video playback by buffering frames, whereas another may minimize lag by sacrificing image resolution. Although these differences may appear minimal, they can potentially alter the timing and quality of information presented to clinicians. These platform-related delays can directly affect the temporal binding window. If delays between a patient's lip movements and speech exceed the temporal window within which audiovisual stimuli are typically integrated, clinicians may perceive these cues as less synchronized or coherent (7). This disruption can reduce a provider's ability to accurately interpret subtle behavioral and communicative signals, potentially affecting diagnostic accuracy.

DIAGNOSTIC CONSEQUENCES

The neuroscience principles discussed have important implications for clinical decision-making. Before clinicians can interpret patient symptoms and apply their clinical knowledge, they must first accurately perceive the information presented to them. Because of this, any changes in sensory input—whether in quality or timing—can directly affect diagnostic accuracy. The diagnostic utility of telehealth visits depends on clear audio and high-quality visual information, both of which may be impaired by unstable internet connections, device limitations, poor lighting, or background noise, potentially contributing to diagnostic error (15). When sensory input is degraded, clinicians experience increased uncertainty, which in turn influences their interpretation of patient data. Unfortunately, in telehealth settings, clinicians often work with degraded or incomplete sensory information, introducing additional uncertainty into clinical diagnoses.

Although telehealth improves accessibility and convenience, it can limit clinicians' ability to observe key patient behaviors. This is particularly apparent in clinical conditions that rely on subtle behavioral, social, and multisensory cues for accurate diagnosis. In these situations, disruptions in sensory perception may disproportionately affect diagnostic accuracy and may not impact all patient populations equally. Individuals with neurodevelopmental conditions, such as autism and ADHD, often exhibit differences in sensory processing, including altered temporal integration, and may therefore be more vulnerable to the sensory constraints of telehealth environments (7).

Clinicians conducting virtual autism assessments often struggle to detect subtle but diagnostically important cues, such as eye contact, affective expression, social reciprocity, and fine motor behaviors. These cues are especially difficult to perceive in more complex cases, where behavioral patterns are nuanced rather than overt, and diagnosis depends heavily on the interpretation of such patterns over time. A recent systematic review found that although telehealth-based autism assessments improved convenience and access to care, clinicians frequently reported difficulty observing key behaviors virtually and expressed concerns about diagnostic accuracy in more complex cases (13).

Patients with ADHD may face similar challenges, as research suggests they can exhibit broader temporal binding windows, meaning that sensory timing cues are processed less precisely (7). In telehealth settings, where audiovisual signals may already be delayed or poorly synchronized, these disruptions can further impair the interpretation of behavioral cues. These findings demonstrate how alterations in sensory information conveyed through telehealth, such as eye movements, facial expressions, and vocal nuances, can meaningfully influence provider interpretation and clinical judgment.

LIMITATIONS AND FUTURE DIRECTIONS

Limited evidence directly links multisensory integration to diagnostic accuracy in virtual clinical settings. One reason for this shortcoming is that much of the argument relies on applying well-established principles from neuroscience and psychology to telehealth environments rather than drawing from direct empirical evidence. Although existing research strongly supports the role of multisensory integration in perception, relatively few studies have directly examined how these processes change in real-world telehealth settings or how such changes affect diagnostic outcomes. As a result, the framework presented here should be viewed as a conceptual model only. This gap highlights the need for further research examining how specific changes in sensory input—such as audio and visual lag, reduced visual resolution, and the complete absence of olfactory and somatosensory information—relate to clinician perception and diagnostic accuracy.

Another important direction for future research is determining whether clinicians can adapt to altered perceptual information over time. In many contexts, the brain can adjust its temporal binding window to accommodate consistent delays following repeated exposure to altered sensory timing (7). However, it remains unclear whether clinicians develop similar adaptations in telehealth environments and whether such adjustments improve diagnostic accuracy or introduce new perceptual biases that reduce reliability.

Additionally, not all telehealth environments are equivalent. Differences in platform design, video compression algorithms, and hardware quality may subtly influence multisensory integration. Future studies should investigate whether certain telehealth platforms better support perceptual accuracy across diverse patient populations and whether greater standardization could reduce variability in diagnostic outcomes.

The framework presented in this paper may also have practical implications for telehealth implementation and policy. If multisensory integration plays an important role in diagnostic perception, future telehealth guidelines may need to play a greater emphasis on the quality, timing and synchronization of sensory information during virtual encounters. For example, platform evaluation standards could incorporate measures of audiovisual latency, image fidelity and signal reliability in addition to traditional metrics such as accessibility and usability. Emerging healthcare technologies that integrate multisensory information fusion techniques have been proposed as a means of improving the quality of information available to clinicians and supporting more accurate decision making (16). Such approaches may inform future telehealth platform design, clinical workflows, and diagnostic protocols aimed at reducing perceptual uncertainty in virtual care environments.

This paper does not address broader public health considerations, such as healthcare access, disparities, policy implementation, or socioeconomic barriers to telehealth use. While these factors are critically important, the focus of this perspective is the neuroscience of perception in telehealth and its implications for diagnostic accuracy in clinical practice. Nonetheless, these systemic factors likely interact with perceptual processes.

CONCLUSION

This paper argues that telehealth may alter multisensory integration by changing the quality, timing, and availability of sensory information during clinical encounters. Because clinicians rely on the integration of visual, auditory, and somatosensory cues to perceive and interpret patient symptoms, these changes may influence diagnostic perception and, in some cases, diagnostic accuracy. Telehealth is often evaluated based on its ability to enhance healthcare delivery through increased convenience or efficiency. However, there has been less attention to what may be changed or lost in the process. Accordingly, telehealth should be viewed not only as a tool for delivering care, but also as a technology that reshapes the conditions in which sensory information is perceived, integrated, and interpreted. This paper argues that telehealth does not merely deliver healthcare but also alters the conditions under which patients are perceived. A pressing issue, therefore, is whether current evaluations of telehealth adequately address how clinical care is experienced when perception is mediated by technology.

The broader implications of this argument extend beyond individual clinician–patient encounters. For example, these considerations may be relevant in mental health settings, where effective care depends on the rapport, trust and nuanced communication between patients and providers (17). Differences within the sensory environment in telehealth settings can influence not just the diagnostic accuracy, but the quality of these interpersonal interactions. Thus, patient disclosure and overall engagement with care can be harmed. This concern leads to a broader question: are clinicians truly seeing the patient, or are they seeing a technologically mediated version of the patient shaped by digital systems? This issue becomes more tangible when revisiting the case of Conor Hylton, whose family is now suing the hospital for negligence (1). Although this case may appear to be an outlier, it highlights a significant concern—that clinical decisions in virtual settings may have dire consequences, for both patient and providers.

Thus, moving forward, several steps should be taken—including improvements in clinical training and changes in telehealth design—to better account for perceptual limitations and support effective clinical decision-making. Clinical training should incorporate greater awareness of the perceptual constraints inherent in virtual care, enabling clinicians to better identify and respond to misleading or incomplete sensory data. In addition, telehealth platforms should be evaluated on their ability to maintain audiovisual synchrony and preserve the quality and timing of sensory information—factors that are essential for accurate clinical perception. Overall, it is important to recognize that telehealth cannot be used in a truly unbiased manner without explicitly accounting for the perceptual changes introduced by the virtual environment.

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