Communication in Medical Settings

Melissa Michaud Baese-Berk, Tessa Bent, and Erica Ryherd

Introduction

Communication between health-care providers and their patients as well as among providers themselves is crucial for optimal health outcomes. Clear communication is required for providers to understand the symptoms a patient is experiencing and to determine an appropriate diagnosis. Similarly, clear communication is required for providers to hand off care to other providers in, for example, hospital settings. It is also necessary for development of a treatment plan that can be executed by the provider and/or patient. In short, quality communication is a prerequisite for quality health care.

However, speech communication in medical settings differs from the ways in which it is usually studied, which is generally in quiet laboratory-based settings. For example, hospitals are noisier than quiet sound booths. However, communication in medical settings is distinct, even, from many other "normal," nonlaboratory communication scenarios. For example, although educational settings are also typically noisy, medical settings have features that increase the challenge of communication, even compared with other everyday scenarios. For example, patients may be exposed to less familiar medical terminology during conversations. Patients may be anxious or may be speaking with a provider whose speech patterns are unfamiliar. Each of these, and many other factors, can impact the success or failure of medical communication.

In this article, we review some special considerations for communication in medical settings, focusing especially on patient-provider interactions. We include doctors, nurses, and other medical professionals as providers in this article because they face similar challenges in terms of medical communication. Our focus is on two aspects of medical communication: speech perception, or how listeners understand the words and sentences they hear, and speech production, or how these words and sounds are produced. After summarizing the special considerations of medical communication, we discuss specific challenges known to impact speech perception and speech production and how these challenges may be especially acute in medical settings. We conclude with a call for more research in this area, specifying areas that could especially benefit from additional investigation.

Special Considerations for Communication in Medical Settings

Although the functions of medical settings are similar to those in other indoor environments, they also typically have specific properties that could hinder how individuals are able to communicate in these environments. Chief among these properties are the physical contexts in which medical communication takes place and the linguistic context of communication in these settings.

Physical Contexts

Anyone who has spent even a short time in a hospital setting can tell you it is a noisy place compared with a quiet office space. Machines in the room beeping, the blaring television in a neighbor's room, a nurse's squeaking sneakers in the hallway, and pages for doctors over intercoms can all contribute to noisy environments. The sheer number and complexity of noise sources in hospitals leads to sound environments that are louder than desired overall and that fluctuate widely over short timescales. Indeed, noise levels in American hospitals frequently exceed recommendations from the World Health Organization (WHO) (e.g., Busch-Vishniac, 2019) and other advisory bodies. For example, the WHO recommends that daytime equivalent sound pressure levels (L_{eq}s) should not exceed 30 dB(A) (Berglund et al., 1999). However, overall hospital noise levels are significantly higher than this. In one study, overall hospital noise was measured at a L_{eq} of 50-60 dB(A). Similarly, operating rooms, emergency rooms, and even intensive care units (ICUs) demonstrate values far exceeding the recommendations (Ryherd et al., 2008). Furthermore, noise levels are not necessarily improving with time despite these

https://doi.org/10.1121/AT.2024.20.2.12

recommendations (Ryherd et al., 2011). The challenge of hospital noise is not restricted to the United States. A recent, systematic literature review of hospital noise articles from other countries showed that noise levels measured in nearly all locales were higher than recommended, ranging from 37 to 89 dB(A) in the daytime and 39 to 69 dB(A) at night (de Lima Andrade et al., 2021).

Indeed, the issues surrounding hospital noise have been the focus of substantial research. Mounting evidence reveals the potential impacts of poor hospital soundscapes on both patients and hospital staff. Poor soundscapes result in decreases in patient satisfaction, sleep disruption, and undesirable physiological impacts such as increased heart rate and decreased wound healing (Busch-Vishniac and Ryherd, 2023). Ryherd et al. (2012) found that the staff report that they experience annoyance, reduced concentration, disruption of tasks, alarm fatigue, and physiological stress responses due to the noisy soundscape. In short, the hospital soundscape too often falls short of the calm, relaxing environment it aspires to be (Busch-Vishniac and Ryherd, 2019).

The challenge of noise isn't just one of annoyance or stress for the occupants: it can impede communication. This challenge can be exacerbated if the provider (or patient) is wearing a mask, which can result in acoustic modulations to the speech and a lack of visual information from the speaker's mouth. For example, when listening to speech, we often use both visual information and acoustic information to process that speech (e.g., Rosenblum, 2008). Another issue is that masks act as a filter for speech, blocking some acoustic information that might be present without a mask (McKenna et al., 2022). Indeed, filtering of sound was made especially clear to many individuals during the Covid-19 crisis, when suddenly, without much practice, many of us were communicating exclusively through masks. Again, communication challenges in health care settings are not restricted to the United States. An article published through the International Hospital Federation states, "Regardless of the country and culture, it is clear that challenges with communication in hospital environments are shared" (Cirino et al., 2021).

Linguistic Context

In addition to the challenges of the physical environment, medical communication is rife with linguistic challenges. Specifically, most patients do not have medical training. Therefore, much of the precise medical terminology used to describe diseases or procedures is likely to be less familiar to a patient. Even words that *are* familiar (e.g., "cancer") are likely to be lower in frequency of use for most patients. In speech science, frequency is a quantitative measure of how often a word appears in some set of speech or writing and is known to impact speech processing. Below, we describe in more detail the specific challenges to two key aspects of speech communication in medical settings, speech perception and speech production, and how these challenges can impact communication.

Speech Perception Challenges

Speech in Noise

Speech perception in noisy situations has long been known to be challenging for listeners (e.g., Cherry, 1953). "Noise" in speech perception work is often divided into two categories. Energetic masking is where the signal is masked by specific spectral and temporal properties of the noise. In contrast, informational masking is where, in addition to energetic properties of the noise, listeners are also exposed to linguistic information that they must ignore to understand the speech signal. For example, construction noise is typically thought of as energetic masking, whereas conversations surrounding someone in a crowded bar is thought of as informational masking.

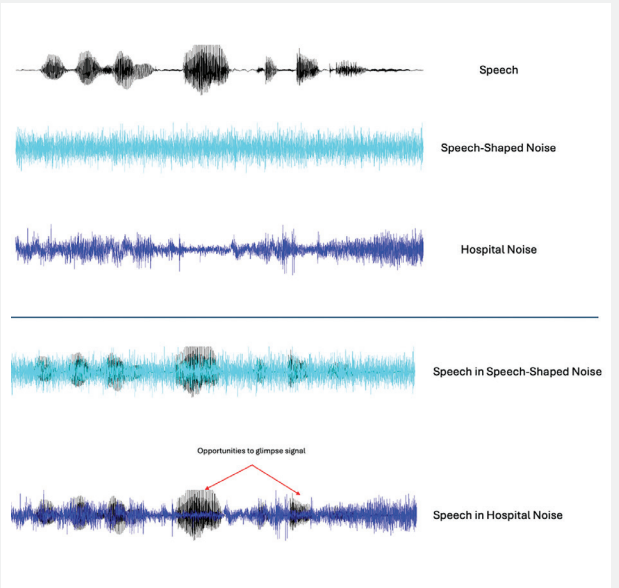
Both types of masking are known to impact speech perception, although this impact can vary as a function of specific properties of the noise (Leibold et al., 2019). Informational masking produced by a single talker is often much more challenging for listeners than a masker that includes many talkers (Van Engen and Chandrasekaran, 2012). That is, it is difficult to ignore specific words or phrases produced by a single competing talker because you can easily discern those words and phrases. However, when listening to speech in a masker that includes many talkers, the talkers' voices may blend. This creates a background sound without much distinct speech. Similarly, it is more challenging to decode speech presented in an energetic masker that shares similar spectral properties to speech than in a masker that consists primarily of frequencies much higher or much lower than those typically present in speech.

In medical settings, especially in hospitals and long-term care facilities, the noise in the environment often

contains properties of both informational and energetic masking. For example, a patient may hear the voices of other care providers at the nurse's station outside their room. Simultaneously, they may hear HVAC noises, carts squeaking, and doors slamming.

The unpredictable nature of hospital noise may also make it more challenging for listeners, and especially older listeners, to understand the signal through the noise. That is, the differences in amplitude of the noise across time may allow younger listeners to "glimpse" the target speech in periods when the noise is not as loud, allowing them to use context cues to better interpret and understand the target speech (**Figure 1**). However, older adults have a reduced ability to utilize this fluctuation in noise because they may demonstrate challenges with several temporal aspects of auditory processing (e.g., duration discrimination; Anderson et al., 2018). It is likely, then, that older adults may struggle more with other tasks that require temporal processing such as the "glimpsing" process described (see **Figure 1**). These issues are also often compounded by age-related hearing loss in older adults (Anderson and Karawani, 2020).

Figure 1. *Waveforms of speech.* ***Top:*** *speech-shaped noise (e.g., noise similar to white noise but louder in lower frequencies, similar to speech) and hospital noise.* ***Bottom:*** *waveforms of speech in both speech-shaped noise and hospital noise. Note that the "valleys" in hospital noise allow a listener to "glimpse" the speech signal, which is not possible in speech-shaped noise.*



Frequency and Familiarity of Words

It is also likely that the content of the speech patients hear in hospitals impacts their ability to understand the message being conveyed to them. Here, we describe basic findings around frequency and familiarity of words in general and then discuss how this may especially affect medical communication. Substantial previous work has demonstrated that both word frequency and word familiarity impact speech perception (e.g., Colombo et al., 2006).

Familiarity, in general, is a key driving force for improved speech perception. Parents or caregivers for small children are often able to understand these children's speech better than strangers. Similarly, experience with a family member who has a speech or language disorder may help a listener better understand their speech. However, familiarity also helps speech perception more broadly. Listeners are better able to transcribe familiar voices than unfamiliar voices, even when those voices are presented in challenging listening situations, like noisy environments (Johnsrude et al., 2013). Furthermore, listening to familiar accents improves perception of both specific speakers the listener has heard before and novel speakers who have the same accent.

Familiarity exists not only at the level of voices or accents but also in terms of the words (or lexical items) that a listener hears. Substantial previous work has demonstrated that listeners recognize familiar words more quickly and accurately than less familiar words, even in situations where they do know the words (i.e., the words are not completely unfamiliar). So, for example, a word like *head* is often rated as highly familiar as defined by the participant as both recognizing the word and knowing the meaning. A less familiar word, like *duct*, is one that the participant recognizes but is not confident they know the meaning. A word like *nave* may be rated as being even less familiar, with many participants not necessarily even recognizing the word and reporting not knowing the meaning at all. These measures of familiarity can be quantified directly, and familiarity measures are strong predictors of performance in a variety of speech perception tasks (e.g., Colombo et al., 2006). Usually, work in speech and language processing skirts this issue by only including words that are in the high familiarity category as stimuli (e.g., Bradlow and Pisoni, 1999).

Similarly, how frequently a listener encounters a word also significantly impacts perception of those words. For example, high frequent words, like *people*, are recognized more quickly and accurately than less frequent words like *hungry*; however, both words are roughly equal in their familiarity (Wilson, 1988; Brysbaert and New, 2009). That is, the frequency of use and familiarity of a word can be decoupled. This suggests that although both frequency and familiarity may impact speech perception, they are not the same construct and may impact speech perception differently.

In the case of medically related terminology, the effects of word (i.e., lexical) frequency and familiarity are quite pronounced. In one study, participants were asked to write down the words and sentences they heard in a variety of listening conditions (Bent et al., 2021). Listeners were exposed to sentences composed of medically related terminology in one of three categories. The medically related words were either high familiarity and high lexical frequency (e.g., *delivery, process*), high familiarity but low lexical frequency (e.g., *ulcer, toxic*), or low familiarity and low lexical frequency (e.g., *ectopic, tympanic*). Listeners were most accurate at writing down these sentences when listening to the high-familiarity, high-frequency words and least accurate for the low-familiarity, low-frequency words. However, this effect was even more pronounced in noisy conditions, including hospital noise. Although listeners perceive all speech less well in noise, the effect was particularly strong for less familiar words and especially for those words that are both less familiar and less frequent.

Speech Through Masks

During the Covid-19 crisis, there was a large influx of research investigating the perceptual challenges of speech perception when listening to an individual wearing a face mask. **Figure 2** shows that the number of papers published in 2020 examining speech perception and speech production with face masks was equivalent to the combined number of papers on the topic in the previous 11 years. In 2021, the number of papers on the topic tripled from the already high number in 2020.

Although masks are now much more ubiquitous than they were before the crisis, they have always been more prevalent in medical than in other settings, meaning that listeners are more likely to encounter a provider wearing a mask in these situations.

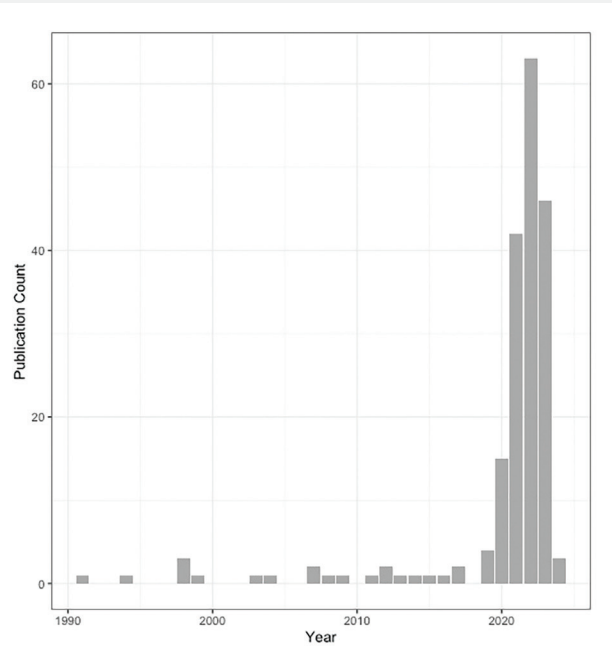


Figure 2. *Histogram of articles in speech perception and speech production through face masks from 1991 to 2024 (data from the Web of Science). Note the peak of publications in 2021, the year after the Covid-19 pandemic began.*

The challenges of speech perception through a mask have several sources. Masks can impact the acoustic properties of speech. Indeed, speech from health care providers who wear a mask shows a variety of reduced acoustic properties that may impact speech perception (McKenna et al., 2022). For example, the vowel articulation index (VAI), a measure that captures how distinct vowels are from one another in speech, is significantly reduced in speech through masks. Additionally, high-frequency (i.e., >4-kHz) information in the signal is also reduced. Interestingly, it is possible that these two effects are driven by different aspects of mask wearing. The reduction in high-frequency information may be due to filtering the effects of masks. However, the reduction in VAI is thought to be due to restrictions in jaw and lip movement when wearing a mask. Thus, it is possible that the mask not only creates a filter effect that impacts acoustic information but also that the act of wearing a mask can impact the articulation of speech and thus the acoustic characteristics of that speech.

Furthermore, listeners lose an additional channel of information during speech perception in the form of the visual information provided by a speaker's mouth movements. Although speech perception is often thought of as an auditory experience, it is, in fact, usually a multimodal one. That is, listeners incorporate visual information with auditory information when listening to speech (Rosenblum, 2008). Visual information is especially important in challenging listening situations such as noisy environments or listening to unfamiliar accents. It is also important for listeners, including older adults, who may have some hearing loss.

This information is disrupted with most face masks. One typical task used in speech perception work measures "intelligibility," or an individual's ability to write down the words or sentences they hear. This task can be done with video files that combine auditory and visual information or files with only auditory information. Recent work has demonstrated that intelligibility in an audiovisual task suffers a significant drop when the speaker is wearing a mask (see tinyurl.com/3wmcn484 for a discussion). This is true even when the mask is transparent and a listener could see some portions of a speaker's mouth (Brown et al., 2021). Interestingly, when listening to masked speech in an "audio-only" listening condition, this detriment to speech perception still exists. This finding suggests that some challenges in speech perception of masked speech are related to the filtering properties of the masks in addition to the challenges of lost visual information (Mendel et al., 2022). Moreover, challenges of listening to speech produced through face masks are greater in noisy situations (Toscano and Toscano, 2021) and when listening to nonnative speech (Smiljanic et al., 2021). Previous research has demonstrated that speech is easier to understand when speakers are explicitly asked to speak clearly compared with when they are speaking in a more conversational fashion (Bradlow, 2002). Speech produced through a face mask is even more challenging to understand when it is also produced conversationally compared with speech with intentional clarity (Smiljanic et al., 2021).

Cognitive Load and Listening Effort

Another aspect of medical interactions is that they can result in high levels of stress and anxiety. This issue is well-documented in cases of the "white coat effect" or "white coat hypertension," where anxiety about being in a medical situation results in physical symptoms, like increased blood pressure.

Similarly, anxiety impacts speech perception. Individuals who are acutely anxious perform poorly on speech perception tasks. In fact, this performance decrement is like participants completing other complex tasks that reduce performance. For example, a divided attention task where participants are asked to simultaneously do a speech perception task and another task such as a visual search. In such situations, participants do poorer in speech perception than when they do that task alone. When participants complete speech perception tasks during conditions designed to induce acute anxiety, a similar decrease in performance is seen even though there is no such competing task (Mattys et al., 2013). For example, when participants are placed in a situation where they are breathing in air enriched with 7.5% CO_2, a well-established mechanism to induce anxiety (Bailey et al., 2005), they perform poorly on a speech perception task compared with when they breathe normal air.

Stressful situations can also increase the listening effort required to understand speech. The listening effort is measured both subjectively and objectively using behavioral and physiological measures and has been shown to increase in a variety of challenging communication settings such as speech in noise or listening to an unfamiliar accent. Although an increased listening effort can result in improved understanding of individual words, an increased listening effort is also associated with costs later in processing. For example, a listener may suffer reduced comprehension and/or memory for content.

Listeners also demonstrate an increased listening effort (both subjective and objective) when listening to speech produced with masks. An increased listening effort can result in challenges not only with speech perception but also with poorer performance on secondary tasks and poorer memory for the speech the listener hears (Peelle, 2018). Indeed, memory suffers when listening to masked speech (Truong and Weber, 2021).

Listener and Talker Demographics

The issues described in **Speech Perception Challenges** exist regardless of the language background of the provider or the patient or the age of the patient. However, listener and talker demographics impact the efficacy of

medical communication. As individuals age, they are more likely to interact with medical providers. Simultaneously, they are also more likely to face challenges in terms of both hearing loss and cognitive decline. Significant previous work has demonstrated that older adults have more difficulty than younger adults in a variety of challenging listening situations (Peelle and Wingfield, 2022). This difficulty correlates with both hearing impairments and cognitive impairments that occur as an individual ages.

Additionally, challenges in speech perception can be exacerbated when conversation partners do not share a language background. Graduates of international medical schools make up 40% of general medicine providers in the United States (Mick et al., 2000), suggesting that many medical providers have a first language other than American English and may speak English with an accent that may not be familiar to their patients. This could result in increased challenges for communication because listeners who have English as their first language often have more difficulty understanding speakers who learned English as adults than they do in understanding other individuals who share their first language. Furthermore, communicative efficiency between individuals who do not share a language background is reduced compared with those who do (Van Engen et al., 2010).

It is possible that international physicians are serving patients who are also second-language English speakers, which may reduce these challenges (see, e.g., Bent and Bradlow, 2003). However, this possibility seems unlikely as physicians from international backgrounds are most likely to practice in rural and underserved areas where patients are more likely to be first-language English speakers (Ranasinghe, 2015). One could imagine that similar challenges could emerge even for providers and patients who come from the same language background but are from different regions with different accents.

This linguistic challenge is representative of broader cross-cultural communication issues that may arise. Consensus in the medical field in the United States suggests that cross-cultural communication challenges not only exist (e.g., Powell Sears, 2012) but also can result in patient dissatisfaction and poorer health outcomes (Flores, 2000). Although the role of language, specifically, has been understudied, a 2021 meta-analysis suggests that matching language backgrounds with providers and patients correlate with increased compliance, patient satisfaction with their care, and improved clinical outcomes (Hsueh et al., 2021).

Other Challenges

Vocal Health and Vocal Strain

In most situations, medical providers must communicate verbally with their patients. Because individuals who are typically required to use their voices to conduct their jobs, medical providers are at higher risk for vocal problems than those who do not need to communicate verbally to conduct their jobs. For example, medical providers are more likely to face vocal strain and physiological challenges associated with this strain than individuals who are not required to communicate verbally in their job. Challenges of vocal problems may be exacerbated because the providers are often communicating in noisy situations, resulting in the Lombard effect (Lombard, 1911), a well-studied, involuntary response where a speaker speaks more loudly when in a noisy environment. This involuntary response would result in increased vocal effort in louder environments.

Issues of increased vocal effort are even more extreme when a health care provider is wearing a mask to communicate because individuals wearing face masks typically produce greater vocal effort than without a mask (Shekaraiah and Suresh, 2021). Effort can be measured both subjectively by asking a participant to rate how much effort they expended and objectively by measuring voice acoustics before and after speaking. Indeed, a study that investigated effort before and after the providers' workday demonstrated both increased effort and increased symptoms of vocal strain after a workday compared with before the workday began (McKenna et al., 2023). Symptoms of vocal strain may include hoarseness, loss of voice, and pain (Sandage et al., 2022). The potential implications on the vocal health of the provider and their well-being are concerning, given that vocal communication is a crucial piece of the work for many medical care providers, and increased vocal strain may be correlated with declines in the general well-being for providers.

Provider-Provider Interactions

The bulk of the work reviewed here has focused on medical provider-patient interactions because these are a core component of medical care and positive

health care outcomes. However, it should be said that the issues raised in **Speech Perception Challenges** are likely to also hold for other types of interactions, including interactions between providers. Indeed, interactions between providers are paramount to patient safety and the essential function of health care settings. For example, during shift changes at a hospital, the doctor who is concluding their shift must convey information about their patients to the doctor who is beginning their shift. This might include information about dosage of medicine, state of symptoms, or new diagnoses. Although the patient's chart may contain some of this information, it is common practice for doctors to provide information to one another verbally during this "handoff."

Understanding the factors that impact communication between providers is quite important. A substantial body of work has demonstrated that individuals frequently and systematically overestimate the understanding of their interlocutors. That is, when asked to estimate how well a listener understood them, speakers believe that the listener understood more than they did (Keysar and Henly, 2002). Furthermore, this overestimation happens even when a speaker knows that the listener has a very limited ability to understand them. For example, when Mandarin Chinese speakers explained something in Mandarin to English-speaking Americans, they overestimated how much the listeners understood, even when explicitly informed that the listener did not speak Chinese (Lau et al., 2022). Crucially, such illusions exist in the medical field. When investigating the hand-off between two providers, providers systematically overestimated the effectiveness of their communication. That is, they believed that the hand-off was successful, even when they failed to communicate or understand the most critical information about a patient 40% of the time (Chang et al., 2010).

Calls for More Research

Despite the clear challenges facing many individuals listening to or producing speech in medical settings, this area of research is quite understudied. Although we understand many issues that may impact speech, most of the work in these areas is not done in situ using naturalistic noise or situations and most does not use realistic communication scenarios. Therefore, we call for more research in medical communication broadly speaking as well as in speech perception and production in these settings. It is our hope that through an influx of research in this area, we can provide recommendations to providers and patients to improve communication and overall health outcomes.

Acknowledgments

This work is supported by an Opportunity Award from the James S. McDonnell Foundation (see doi.org/10.37717/2021-3028).

Like this article? Here's more from this author:

LISTEN

We Don't All Talk the Same: Teaching Linguistic Diversity

bit.ly/AA-linguistic-diversity

On *Across Acoustics*, we interview Melissa Michaud Baese-Berk (one of the authors of this article!) and Paul Reed about how implementing more diversity in the speech science classroom can result in better outcomes for students.

References

Anderson, S., and Karawani, H. (2020). Objective evidence of temporal processing deficits in older adults. *Hearing Research* 397, 108053.

Anderson, S., Gordon-Salant, S., and Dubno, J. R. (2018). Hearing and aging effects on speech understanding: Challenges and solutions. *Acoustics Today*, 14(4), 10-18.

Bailey, J. E., Argyropoulos, S. V., Kendrick, A. H., and Nutt, D. J. (2005). Behavioral and cardiovascular effects of 7.5% CO_2 in human volunteers. *Depression and Anxiety* 21(1), 18-25.

Bent, T., and Bradlow, A. R. (2003). The interlanguage speech intelligibility benefit. The *Journal of the Acoustical Society of America* 114, 1600-1610.

Bent, T., Baese-Berk, M. M., Ryherd, E. E., and Perry, S. (2021). How hospital noise impacts intelligibility of medically related sentences. *The Journal of the Acoustical Society of America* 150, A273-A274.

Berglund, B., Lindvall, T., and Schewela, D. (Eds.). (1999). *Guidelines for Community Noise*. Technical Report, World Health Organization, Geneva, Switzerland.

Bradlow, A. R. (2002). Confluent talker-and listener-oriented forces in clear speech production. *Laboratory Phonology* 7, 241-273.

Bradlow, A. R., and Pisoni, D. B. (1999). Recognition of spoken words by native and non-native listeners: Talker-, listener-, and item-related factors. *The Journal of the Acoustical Society of America* 106, 2074-2085.

Brown, V. A., Van Engen, K. J., and Peelle, J. E. (2021). Face mask type affects audiovisual speech intelligibility and subjective listening effort in young and older adults. *Cognitive Research: Principles and Implications* 6(1), 49.

Brysbaert, M., and New, B. (2009). Moving beyond Kučera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavior Research Methods* 41(4), 977-990.

Busch-Vishniac, I. (2019). *Next Steps in Hospital Noise Research*. University Library (UB) of RWTH Aachen, Aachen, Germany.

Busch-Vishniac, I., and Ryherd, E. (2019). Hospital soundscapes: Characterization, impacts, and interventions. *Acoustics Today* 15(3), 11-18. https://doi.org/10.1121/AT.2019.15.3.11.

Busch-Vishniac, I., and Ryherd, E. (2023). Hospital soundscapes. In Schulte-Fortkamp, B., Fiebig, A., Sisneros, J. A., Popper, A. N., and Fay, R. R. (Eds.), *Soundscapes: Humans and Their Acoustic Environment.* Springer Cham, Cham, Switzerland, pp. 277-311.

Chang, V. Y., Arora, V. M., Lev-Ari, S., D'Arcy, M., and Keysar, B. (2010). Interns overestimate the effectiveness of their hand-off communication. *Pediatrics* 125(3), 491-496.

Cherry, E. C. (1953). Some experiments on the recognition of speech, with one and with two ears. *The Journal of the Acoustical Society of America* 25, 975-979.

Cirino, J. A., Johansen, T., Luis, L., and Kueven, J. (2021). *Communication Challenges in Hospitals Around the World*. International Hospital Federation, Geneva, Switzerland. Available at https://tinyurl.com/285t6exm.

Colombo, L., Pasini, M., and Balota, D. A. (2006). Dissociating the influence of familiarity and meaningfulness from word frequency in naming and lexical decision performance. *Memory and Cognition* 34(6), 1312-1324. https://doi.org/10.3758/BF03193274.

de Lima Andrade, E., da Cunha e Silva, D. C., de Lima, E. A., de Oliveira, R. A., Zannin, P. H. T., and Martins, A. C. G. (2021). Environmental noise in hospitals: A systematic review. *Environmental Science and Pollution Research* 28, 19629-19642.

Flores, G. (2000). Culture and the patient-physician relationship: Achieving cultural competency in health care. *The Journal of Pediatrics* 136(1), 14-23.

Hsueh, L., Hirsh, A. T., Maupomé, G., and Stewart, J. C. (2021). Patient-provider language concordance and health outcomes: A systematic review, evidence map, and research agenda. *Medical Care Research and Review* 78(1), 3-23.

Johnsrude, I. S., Mackey, A., Hakyemez, H., Alexander, E., Trang, H. P., and Carlyon, R. P. (2013). Swinging at a cocktail party: Voice familiarity aids speech perception in the presence of a competing voice. *Psychological Science* 24(10), 1995-2004.

Keysar, B., and Henly, A. S. (2002). Speakers' overestimation of their effectiveness. *Psychological Science* 13(3), 207-212.

Lau, B. K. Y., Geipel, J., Wu, Y., and Keysar, B. (2022). The extreme illusion of understanding. Journal of Experimental *Psychology: General* 151(11), 2957-2962.

Leibold, L. J., Buss, E., and Calandruccio, L. (2019). Too young for the cocktail party. *Acoustics Today* 15(1), 37-43.

Lombard, E. (1911). Le signe de l'élévation de la voix. *Annales des Maladies de l'Oreille et du Larynx* XXXVII(2), 101-109.

Mattys, S. L., Seymour, F., Attwood, A. S., and Munafò, M. R. (2013). Effects of acute anxiety induction on speech perception: Are anxious listeners distracted listeners? *Psychological Science 2*4(8), 1606-1608.

McKenna, V. S., Kendall, C. L., Patel, T. H., Howell, R. J., and Gustin, R. L. (2022). Impact of face masks on speech acoustics and vocal effort in healthcare professionals. *The Laryngoscope* 132(2), 391-397.

McKenna, V. S., Patel, T. H., Kendall, C. L., Howell, R. J., and Gustin, R. L. (2023). Voice acoustics and vocal effort in mask-wearing healthcare professionals: A comparison pre-and post-workday. *Journal of Voice* 37(5), 802.e15-802.e23.

Mendel, L. L., Pousson, M. A., Shukla, B., Sander, K., and Larson, B. (2022). Listening effort and speech perception performance using different facemasks. *Journal of Speech, Language, and Hearing Research* 65(11), 4354-4368.

Mick, S. S., Lee, S.-Y. D., and Wodchis, W. P. (2000). Variations in geographical distribution of foreign and domestically trained physicians in the United States: 'Safety nets' or 'surplus exacerbation'? *Social Science and Medicine* 50(2), 185-202.

Peelle, J. E. (2018). Listening effort: How the cognitive consequences of acoustic challenge are reflected in brain and behavior. *Ear and Hearing* 39(2), 204-214.

Peelle, J., and Wingfield, A. (2022). How our brains make sense of noisy speech. *Acoustics Today* 18(3), 40-48. https://doi.org/10.1121/AT.2022.18.3.40.

Powell Sears, K. (2012). Improving cultural competence education: The utility of an intersectional framework. *Medical Education* 46(6), 545-551.

Ranasinghe, P. D. (2015). International medical graduates in the United States physician workforce. *Journal of Osteopathic Medicine* 115(4), 236-241.

Rosenblum, L. D. (2008). Speech perception as a multimodal phenomenon. *Current Directions in Psychological Science* 17(6), 405-409.

Ryherd, E. E., Okcu, S., Ackerman, J., Zimring, C., and Waye, K. P. (2012). Noise pollution in hospitals: Impacts on staff. *Journal of Clinical Outcomes Management* 19(11), 491-500.

Ryherd, E., Okcu, S., Hsu, T., and Mahapatra, A. (2011). Hospital noise and occupant response. *Ashrae Transactions* 117, 248-255.

Ryherd, E. E., West, J. E., Busch-Vishniac, I. J., and Waye, K. P. (2008). Evaluating the hospital soundscape. *Acoustics Today* 4(4), 22-29.

Sandage, M. J., Hamby, H. A., Barnett, L. A., Harris, M. L., Parker, C. R., and Allison, L. H. (2022). Vocal function differences before and after sorority recruitment. *Journal of Voice* 36(2), 212-218.

Shekaraiah, S., and Suresh, K. (2021). Effect of face mask on voice production during COVID-19 pandemic: A systematic review. *Journal of Voice* 38(2), 446-457.

Smiljanic, R., Keerstock, S., Meemann, K., and Ransom, S. M. (2021). Face masks and speaking style affect audio-visual word recognition and memory of native and non-native speech. *The Journal of the Acoustical Society of America* 149, 4013-4023.

Toscano, J. C., and Toscano, C. M. (2021). Effects of face masks on speech recognition in multi-talker babble noise. *PLOS ONE* 16(2), e0246842.

Truong, T. L., and Weber, A. (2021). Intelligibility and recall of sentences spoken by adult and child talkers wearing face masks. *The Journal of the Acoustical Society of America* 150, 1674-1681.

Van Engen, K. J., and Chandrasekaran, B. (2012). Sentence recognition as a function of the number of talkers in competing multi-talker babble. *The Journal of the Acoustical Society of America* 132, 1969.

Van Engen, K. J., Baese-Berk, M., Baker, R. E., Choi, A., Kim, M., and Bradlow, A. R. (2010). The Wildcat Corpus of native-and foreign-accented English: Communicative efficiency across conversational dyads with varying language alignment profiles. *Language and Speech* 53(4), 510-540.

Wilson, M. (1988). MRC psycholinguistic database: Machine-usable dictionary, version 2.00. *Behavior Research Methods, Instruments, and Computers* 20(1), 6-10.

About the Authors

Melissa Michaud Baese-Berk mmbb@uchicago.edu

Department of Linguistics
University of Chicago
Chicago, Illinois 60637, USA

Melissa Michaud Baese-Berk is an associate professor of linguistics at the University of Chicago, Illinois. Previously, she was the David M. and Nancy L. Petrone Faculty Scholar and professor of linguistics at the University of Oregon, Eugene. She completed postdoctoral training at the Basque Center on Cognition, Brain, and Language at Michigan State University, East Lansing. She holds a PhD in linguistics with a specialization in cognitive science from Northwestern University, Evanston, Illinois. Her research focuses on speech perception and production, with special attention to communication across language backgrounds. She is an active member of the Speech Communication Technical Committee of the Acoustical Society of America.

Tessa Bent tbent@iu.edu

Department of Speech, Language, and Hearing Sciences
Indiana University
Bloomington, Indiana 47408, USA

Tessa Bent is a provost professor and department chair in the Department of Speech, Language and Hearing Sciences at Indiana University, Bloomington. She holds a PhD in linguistics from Northwestern University, Evanston, Illinois. Her research focuses on speech perception across the lifespan. She is a Fellow of the Acoustical Society of America where she has held several leadership roles, including serving on the Executive Council and chairing the Member Engagement Committee.

Erica Ryherd eryherd@unl.edu

Durham School of Architectural Engineering and Construction
University of Nebraska
Omaha, Nebraska 68128, USA

Erica Ryherd is an associate professor of architectural engineering at the University of Nebraska-Lincoln (UNL). She holds a PhD in architectural engineering from UNL and was a recipient of the Acoustical Society of America (ASA) Hunt Postdoctoral Fellowship to study occupational and environmental medicine at the Sahlgrenska Academy of Medicine in Gothenburg, Sweden. Her primary research interests are noise, architectural acoustics, human response to sound, engineered building systems, and engineering education. She is a member of the Technical Committees on Noise and on Architectural Acoustics of the Acoustical Society of America.