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Patient-Provider Communication and Health Disparities: An Experiment Exploring Language Proficiency and Communication Accommodation

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Abstract

Effective communication is critical for equitable healthcare delivery. In situations where there is language discordance between patients and providers, with one person speaking a shared language more proficiently, communication challenges may exacerbate disparities, particularly for racially or ethnically minoritized patients. Even when patients and providers are both fluent enough in English to not need interpretation, communication challenges intensify when patients are required to use their second language (L2) to interact with a native English (L1) speaking healthcare provider. Communication accommodation encompasses speech adjustments used to mitigate these barriers. Because communication accommodation strategies are not explicitly taught in healthcare training, it is unknown how healthcare providers adjust and the role a patient's English proficiency plays in guiding provider language choices. This experimental study tested how L1 physician assistant students modify their communication during intake interviews with Latine L2 avatar patients of varying English proficiency, using the mixed-reality simulation platform Mursion. Data from 41 physician assistant students in 2023–2024 were analyzed for acoustic (i.e., speech rate, pitch modulation) and lexical adjustments (i.e., word frequency, contextual diversity). Results revealed significant accommodations: students reduced their speech rate, narrowed their pitch range, and used higher-frequency vocabulary when interacting with lower-proficiency L2 avatars. The results demonstrate that communication accommodation occurs and could be a potential mechanism for the widening or narrowing of healthcare disparities in patient outcomes. Future work should consider identifying which accommodations improve patients' comprehension of medical advice and their relationships with healthcare providers.

Keywords Communication barriers · Healthcare disparities · Language · Cultural competency · Simulation training

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Introduction

Approximately 20% of people in the US speak English as a second language (hereafter referred to as "L2 speakers"), with over 70% of L2 speakers belonging to a racial or ethnic group that experiences health disparities [1]. Although addressing patient access to language resources and translation services is essential, little is known about the communication experiences of the 62% of U.S. residents who speak a language other than English at home and report speaking English "very well," according to 2017–2021 Census Bureau data [2]. Miscommunication between L2 patients and providers who are native speakers of English (hereafter "L1" speakers) may lead to documentation errors, misdiagnoses, and difficulties in developing effective treatment plans [3, 4]. During conversation, if the L1 speaker determines that the L2 speaker may not understand them due to limited proficiency, they may consciously or subconsciously alter their speech patterns to enhance understanding. This is referred to as *communication accommodation*.

Studies estimate that 50% to 85% of L1 speakers use communication accommodation in L1/L2 scenarios, whether intentionally or not [5, 6]. *Communication Accommodation Theory* (CAT; [7] explains how individuals adjust their speech, tone, and gestures to align with conversational partners, often simplifying language to enhance understanding. It offers a useful framework for understanding how and why healthcare providers adjust their communication. A range of accommodation behaviors exist but, in this context, the most common alterations include modifying *acoustic* (e.g., tone, pacing) or *lexical* (e.g., vocabulary, jargon) parameters of speech to align with perceived needs in L2 patients. According to Communication Accommodation Theory, these adjustments are aimed at improving understanding and reducing social distance based on limited cues regarding language proficiency [8]. This is especially relevant in those healthcare contexts where interactions are brief and high stakes (e.g., emergency rooms) and where L1 providers must make rapid judgments about how much to accommodate.

While studies have shown that moderate accommodation can support L2 understanding and learning [9], excessive modification—such as oversimplification or exaggerated tone—can come across as condescending or infantilizing [10, 11], particularly for more proficient L2 speakers. These behaviors may unintentionally communicate assumptions of L2 speakers' lower intelligence or cognitive ability. Furthermore, individual traits like anxiety and personality influence accommodation styles, which may impact language choices. Anxious individuals may hold back or withdraw, while extroverted and agreeable people are more likely to use expressive and supportive communication [12, 13]. Although previous studies offer plausible predictions about the effects of accommodation on patient relationships, experimental research on speech accommodation specifically in healthcare contexts remains lacking, leaving a notable gap in the literature [14]. Recognizing these patterns is essential for designing communication training that helps healthcare providers find the right balance of facilitating understanding without compromising respect. Outside of healthcare, L2 speakers generally perceive accommodation positively [6, 15], yet the balance between effective and excessive accommodation remains poorly understood. Accommodation is not monolithic—L1 speakers adjust multiple aspects of their speech, and these adaptations may trade off based on perceived listener needs [16, 17]. A more comprehensive analysis of accommodation patterns is necessary to understand how L1 speakers navigate these adjustments and what demographic or psychological factors shape their communication strategies in real-world interactions.

Communication accommodation plays a critical role in shaping patient-provider interactions and can significantly impact health disparities, particularly when language discordance is present. Terui's "Pathways and Processes Model" outlines how language barriers affect access to care, patient-provider communication, and post-care outcomes, emphasizing the roles of dissatisfaction, discrimination, and miscommunication [4]. Similarly, Hsueh et al. [18] show that language discordance can influence provider behaviors, interpersonal dynamics, and patient outcomes. A robust body of literature confirms that language discordance—especially among patients with limited English proficiency—can lead to mistrust and poor care experiences [19–21]. In contrast, language concordance, where the provider speaks the patient's native language fluently, improves communication and clinical outcomes [22, 23], highlighting the value of linguistic alignment in equitable healthcare delivery.

Communication accommodation towards L2 speakers has mostly been studied by focusing on *acoustic* measures such as speech rate, pitch, and intensity (loudness) [5, 24–28]. Acoustic accommodations play a particularly important role in L1-L2 interactions, where they can enhance intelligibility and reduce cognitive load for the listener [29]. Slower speech rates, such as in naturally produced clear speech, seem to improve comprehension, helping lower-proficiency L2 listeners to segment and understand incoming speech [30, 31]. Accommodation towards L2 speakers may include pitch modifications such as mean raised pitch or exaggerated pitch contours; pitch changes could result from an effort to articulate words more precisely, but whether L2 accommodation is characterized by high pitch is debated (see 28 for a review). Vocal pitch impacts rapport and engagement in social interactions

[32]. Intensity (loudness) adjustments are less studied but often involve an increase in loudness toward the L2 speaker to alleviate perceived L2 comprehension difficulties [33]. However, L2 listeners may perceive excessive intensity or pitch shifts as patronizing, akin to "elderspeak" where younger people simplify communication with older adults based on stereotypes [34]. While there is limited knowledge on the linguistic accommodation of L2 speakers by L1 speakers in healthcare environments [35], acoustic accommodations in healthcare have been found in the context of "elderspeak" [36]. Based on the literature cited above, we are focusing on modifications in *speech rate*, *pitch range*, and *intensity.*

Lexical accommodations, or adjustments in word choice, may play a crucial role in facilitating communication with L2 speakers. Speakers often modify their word choices based on who they are speaking to and the context of the conversation [37]. This also includes using more frequent words that appear across greater contexts, which makes words more recognizable across different situations [38]. These adaptations can enhance comprehension for L2 speakers by reducing cognitive processing demands [29]. Based on the literature cited above, we focused on four lexical measures: *word frequency*, *semantic and contextual diversity*, and *word recognition.* Frequency refers to how often a word appears per million words in a large corpus, serving as an indicator of commonality in language use. Contextual diversity captures the extent to which a word appears across different media sources (e.g., films), reflecting the breadth of its usage in varied communicative contexts. Word recognition was assessed based on the proportion of English speakers who report knowing the word, providing an estimate of lexical familiarity. Finally, semantic diversity quantifies the range of distinct semantic contexts in which a word is used, offering a measure of its ambiguity or flexibility in meaning.

In this study, we examine communication accommodation in the context of L1/L2 healthcare interactions to identify additional mechanisms leading to racial and ethnic disparities in health. Our primary aim is to describe L1 clinical trainees' accommodation patterns when presented with low and high proficiency simulated L2 patients using the Mursion platform. Mursion allowed us to employ a live (human) actor trained to present themself as a patient following standardized scenarios. The actor was shown as a virtual avatar in a digitally simulated healthcare office environment. Secondarily, we sought to identify potential correlates of these accommodation patterns. To that end, we tested acoustic and lexical communication accommodation in a simulated healthcare setting with students in a clinical training program. Our central research question was: How do clinical trainees modify their speech when interacting with low- versus high-proficiency simulated patients, and what psychological factors predict the extent of these modifications? We further operationalized this with three hypotheses

Hyp_1: L1 trainees will exhibit communication accommodation when interacting with low-proficiency simulated L2 patients compared to high-proficiency simulated patients.

Hyp_{1a}: Acoustic accommodation will be reflected acoustically in slower speech rates, higher pitch, higher pitch ranges, and greater speech intensity and intensity range for low-proficiency than high-proficiency simulated patients.

Hyp_{1b}: Lexical accommodation will be reflected lexically by higher frequency words, lower semantic diversity, higher contextual diversity, and higher word recognition for low-proficiency than high-proficiency simulated L2 patients.

Hyp_2: A self-reported willingness to accommodate will be positively associated with L1 clinical trainees performing communication accommodation.

Hyp_3: Trainees with higher levels of anxiety or extraversion will demonstrate greater variability in speech modifications when communicating with L2 simulated patients than those with lower levels.

Method

Study Design

We used a within-person experimental design to assess participants' language accommodation in interactions with a higher and a lower proficiency L2 patient during clinical interviews. We leveraged a mixed-reality virtual avatar to create two standardized patient profiles that differed in their level of English proficiency, reflecting either a strong or weak accent, limited or extended vocabulary, and frequent or infrequent grammatical errors. We measured the degree to which participants accommodated each of these two virtual patients.

Participants

We recruited 41 students who were enrolled in a physician assistant (PA) program in North Carolina. Participants were recruited via flyers distributed both physically and electronically. The final sample size included 36 participants

and were predominantly female (78%). Participants were excluded for predominantly speaking Spanish during the interactions with the avatar ($n=4$) or because English was not their first language ($n=1$) for a final sample of 36. All participants received $20 in gift cards at the end of the second session. This study was approved by the East Carolina University and Medical Center Institutional Review Board under expedited review (#22–001084) and all participants provided informed, written consent.

Data Collection

Mursion software and avatars

Mursion is a virtual and mixed-reality simulation platform designed for professional training and development [39]. The platform employs a computer-based virtual environment where participants engage with an avatar controlled by a human (called an interactor). It generates immersive simulations of workplace scenarios, effectively eliciting natural interactions [40]. Using Mursion, it is possible to standardize features of the avatar, such as age, gender, race, accent, and medical history across different sessions. The platform's avatars, manipulated in real-time by an interactor, provide an interactive simulated environment for learners. Mursion has been utilized for immersive classroom simulations [41], mental health education [42], and cultural competency training [43, 44].

The interactor we worked with identifies as Latina and as English/Spanish bilingual; she used an accent reflective of her community (Puerto Rico). The same interactor controlled both patient avatars. While no formal pre-testing on proficiency/accent was conducted, the interactor was trained to portray the two avatars by the authors of this study through multiple sessions and test recordings. We utilized an identical office setting where the interactor portrayed two distinct patient avatars: Ms. Miranda, a low-proficiency L2 speaker who spoke using a pronounced Spanish-language accent, short sentences, limited vocabulary, and frequent Spanish phrases; and Ms. Walker, a high-proficiency L2 speaker with a subtle Spanish-language accent, advanced vocabulary, and no Spanish phrases (for detailed interactor instructions and detailed back stories and medical histories see Supplement S1). Avatar personas were kept the same across proficiency levels to facilitate the consistent portrayal of realistic characters. Care was taken to use appearances that had similar skin colors, gender presentation, and socioeconomic status as reflected by clothing.

Testing Procedure

Testing sessions were scheduled with the Mursion team at the University of West Georgia over Zoom, and participants joined from an on-campus research laboratory office at East Carolina University. Participants signed up for two sessions, and the order of avatars (low/high proficiency) was counterbalanced and alternated systematically. To further reduce potential carryover effects between the two interactions, the sessions were scheduled at least one week apart. This ensured that any observed differences in communication behavior were not simply due to repeated exposure or sequential interaction effects but could be attributed to the manipulated proficiency of the interlocutor. Before coming to the lab, participants received information about the task and a brief overview of the two avatar patients (see Supplement S1). On the day of testing, participants were informed about the procedures and signed a consent form. The participants were not informed about the proficiency manipulation until after the study concluded. To preserve participants' naïveté and minimize bias, individual difference measures were divided across sessions to avoid priming effects that could influence their natural responses during the experiment. After the first session, all participants filled out a demographic questionnaire, as well as the LSBQ (language background), STAI (trait anxiety), LexTale (English proficiency), and the TIPI (Big-5 personality). After the second session, they completed the CABS (accommodation behavior), and the IAT (implicit bias).

The participants' task was to interview the avatar patient and perform an intake as they would in a real primary care office, which included standardized questions about establishing care, known health issues, and family medical history. The conversations were proctored by a member of the study team, who also started and stopped the recording. The proctor stopped conversations going longer than 5 min at an appropriate moment.

Measures

Acoustic and lexical measures were extracted from audio recordings and transcriptions (see Table 1).

Participants completed a series of standardized tests that describe language proficiency (LexTALE; [45]) and language background (LSBQ; [46]), and tests that measure BIG 5 personality traits (TIPI; [47]) as well as state/trait anxiety (STAI; [48]). We also asked them to report interaction frequency with L2 speakers ("In the past week, how many times have you had one-on-one interactions with a non-native English speaker?"). The Communication Accommodation Behavior Scale (CABS) was developed by our group to assess attitudes towards L2 accommodation in

Table 1 Overview of extracted acoustic and lexical measures

Acoustic Measures	Definition
Speech rate	Total # syllables divided by total time
Mean pitch	Average of fundamental frequency (F0)
Pitch range	Range of fundamental frequency (F0)
Mean intensity	Average of intensity (in dB)
Intensity range	Range of intensity (in dB)
Lexical Measures	**Definition**
Frequency	Refers to the number of times a word appears per million words
Contextual diversity	Represents the percentage of media sources (e.g., films) in which a word appears, capturing how broadly a word is distributed across different contexts
Word recognition	Reflects the proportion of English speakers who report knowing a given word, offering a proxy for lexical familiarity
Semantic diversity	Quantifies the variety of distinct semantic contexts in which a word is used, serving as a measure of lexical ambiguity or flexibility

L1 speakers of English (see 6 for a longer version of the scale). It entails 8 items that measure the motivations behind speech accommodation adjustments, the perceived impact on conversation dynamics, and the underlying attitudes that influence cross-linguistic communication behavior (see Supplement S2 for a complete list of items). The response is recorded on a 5-point scale (1 = Strongly Disagree, 5 = Strongly Agree). The test has two subscales, with 4 items describing positive attitudes towards L2 accommodation (e.g., "*When I talk to a less proficient English speaker, I adjust my speech to improve my chances of successfully conveying a message*."), and 4 items describing negative attitudes (e.g., "*I sometimes avoid talking to a less proficient English speaker because I fear being judged*."). Because the Communication Accommodation Behavior Scale (CABS) is still under development, we opted for item-level analysis to evaluate how individual items relate to observed speech accommodation. This approach supports early-stage validation by highlighting which items are most predictive of communicative behavior, thereby informing decisions about scale refinement. Aggregating responses into subscale scores at this stage could obscure meaningful variability in item functioning and reduce sensitivity to key patterns in the data. The Implicit Association Test (IAT; [49]) measures implicit bias that people subconsciously hold towards groups of people. We used the "Hispanic American IAT", which is based on the concept that a preference towards one of two groups (e.g., Hispanic American vs. European American) can be measured by the way participants categorize associations between typical names and positive or negative words. The IAT is a commonly used measure of implicit attitudes toward racial/ethnic groups, and we used it to further describe our sample of mostly non-Hispanic, White physician assistant students.

For hypotheses 2 and 3, to quantify differences in acoustic and lexical accommodation based on participant characteristics, we created difference values between high and low proficiency measures. For example, to create a speech rate difference measure, we subtracted the low proficiency from the high proficiency speech rate value.

Data Analysis

Acoustic analysis

Acoustic recordings were transcribed, processed and analyzed using Praat, a widely used software tool for phonetic analysis [50]. Custom scripts were developed to automate the extraction of key acoustic parameters, including pitch, speech rate, and loudness (i.e., intensity). These parameters are critical for quantifying prosodic variation, which plays a central role in understanding how speech tone and delivery may influence listener perceptions and communicative success. All analysis scripts, data, and audio stimuli are openly shared on the Open Science Framework (OSF) to ensure transparency, reproducibility, and alignment with open science practices (https://osf.io/3bvry/).

Lexical analysis

Once recorded, speech was transcribed, and lexical data was extracted from the interaction using the phonetic software Praat. To analyze word-level features, the utterances were split using a custom R script that formatted each text file with one word per row. We focused our lexical analysis on four theoretically grounded lexical properties: word-level frequency, prevalence, contextual diversity, and semantic diversity (see Table 3). The measures we use here were analyzed through the *South CarOlina Psycholinguistic Metabase* (SCOPE; [51]), a curated collection of psycholinguistic properties of words from major databases such as SubtlexUS [52].

Statistical analysis

For both acoustical and lexical analysis, separate linear mixed-effects models were used to analyze the dependent acoustical (speech rate, mean pitch, pitch range, intensity, and intensity range) and lexical (word frequency, semantic and contextual diversity, and word recognition) variables. Models included sex as a covariate and the experimental condition (i.e., proficiency level) as the primary fixed effect (independent variable). Models included random intercepts for subject and session to account for variability at these

levels. Nested models were compared using likelihood ratio tests, with models fit via restricted maximum likelihood (REML) and refit using maximum likelihood (ML) for model comparisons. Significant effects were determined based on reductions in deviance and improvements in Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Planned pairwise comparisons of estimated marginal means were performed to assess differences between high and low proficiency levels. Degrees of freedom were calculated using the Kenward-Roger approximation, and statistical significance was set at $p<0.05$. All analyses were conducted using the lme4 and emmeans packages in R (Mac, version 2024.12.1+563), ensuring a robust examination of fixed effects while accounting for individual and session-level variability. To examine the extent to which between-person, individual differences in personality (anxiety, Big-5) and accommodation behavior (CABS) predicted variation in accommodation differences (focusing on significant adjustments only), multivariable linear regressions were conducted for all significant acoustic (pitch range, speech rate) and lexical measures (semantic diversity, contextual diversity, word recognition, word frequency). We did not adjust for multiple comparisons following the logic of Rothman [53]. Regarding missing data, we treated data as missing at random and used pairwise deletion.

Results

Participant Measures

Socio-demographic details can be found in Table 2. Frequency results by preference category show that, across our sample, participants generally either have no implicit preference or implicitly associate non-Hispanic European American names. Many participants do not typically interact with non-native English speakers (61%).

Hypotheses 1a and 1b were directional hypotheses regarding accommodation. Regarding Hyp_{1a} about acoustic accommodation, we hypothesized the low proficiency L2 patient interaction would be associated with higher pitch, higher pitch ranges, greater intensity, greater intensity ranges, and slower speech rates. As shown in Table 3, Hyp_{1a} was only partially supported. Pitch was higher, albeit not statistically significantly. Contrary to our hypothesis, the pitch range was significantly lower rather than higher. There was no difference in intensity. Speech rates were significantly slower.

Regarding Hyp_{1b} about the direction of lexical accommodation, we hypothesized the low-proficiency L2 patient interaction would be associated with higher frequency words, lower semantic diversity, and higher contextual diversity as well as word recognition. As shown in Table 4, Hyp_{1b} was only partially supported. As expected, use of higher frequency words and greater contextual diversity were significantly greater for the low-proficiency condition than the high-proficiency condition. Semantic diversity was significantly lower for the low-proficiency condition, as hypothesized. However, contrary to our hypothesis, word recognition was significantly lower for the low-proficiency condition than the high-proficiency condition.

Acoustic and Lexical Parameters

Table 3 presents mean values and confidence intervals for key acoustic and lexical features of speech across high- and low-proficiency L2 conditions, highlighting significant differences in speech rate, word frequency, and contextual diversity.

Acoustic Accommodation Including avatar proficiency as a fixed effect significantly improved model fit for speech rate compared to a baseline model ($\chi^2(1)=14.57, p<0.001$), indicating that participants adjusted their speech rate based on the avatar's language proficiency. Planned comparisons showed that participants spoke significantly faster to the high-proficiency avatar than to the low-proficiency L2 patient (estimate=0.41, SE=0.099, $t(34.6)=4.13$, $p<0.001$). Proficiency also significantly improved model fit for mean pitch ($\chi^2(1)=4.08$, $p=0.043$), with marginally lower pitch observed when speaking to the high-proficiency L2 patient (estimate=−3.88, SE=1.93, $t(34.3)=-2.02$, $p=0.052$). For pitch range, proficiency again improved model fit ($\chi^2(1)=5.37$, $p=0.020$), with participants showing greater pitch variability when addressing the high-proficiency L2 patient (estimate=14.3, SE=6.19, $t(34.7)=2.31$, $p=0.027$). In contrast, proficiency did not significantly predict mean intensity ($\chi^2(1)=0.001$, $p=0.98$) or intensity range ($\chi^2(1)=0.30$, $p=0.58$), indicating no consistent changes in vocal intensity as a function of the patient's proficiency level.

Lexical Accommodation Including proficiency as a fixed effect significantly improved model fit for all four lexical variables, indicating that lexical choices varied based on the avatar's language proficiency. Participants used significantly lower-frequency words when speaking to the high-proficiency L2 patient compared to the low-proficiency L2 patient ($\chi^2(1)=22.41$, $p<0.001$; estimate=−0.083, SE=0.0146, $t(34.2)=-5.68$, $p<0.0001$). Similarly, contextual diversity was reduced in speech directed toward the high-proficiency L2 patient ($\chi^2(1)=25.45$, $p<0.001$; estimate=−0.0431, SE=0.00744, t(34.7)=−5.80, $p<0.0001$), suggesting less

Table 2 Participants' sociodemographic characteristics ($n=36$), North Carolina, USA

Variable	Mean ± Std Or Percentage (%)	Frequency (N)	Range
Age	25.06 ± 3.28	36	
Sex			
F	77.8	28	
M	22.2	8	
Lextale Score (English Proficiency)*	87.32 ± 11.18	34	0–100
LSBQ (Spanish Knowledge)*			
Speaking	15.58 ± 16.20	31	
Understanding	20.72 ± 20.44	32	
Reading	18.37 ± 20.84	30	
Writing	12.37 ± 18.04	27	
LSBQ (Bilingualism Rating)*	16.31 ± 28.82	35	0–100
Frequency Of Interactions With L2 Individuals Per Week			
0 Days	61.1%	22	
1–2 Days	27.8%	10	
3–4 Days	2.8%	1	
Every Day	5.6%	2	
Other	2.8%	1	
Implicit Association Test			
Strong Preference for Hispanic Americans	2.78%	1	
Moderate Preference for Hispanic Americans	2.78%	1	
Slight Preference for Hispanic Americans	5.56%	2	
No Preference/Neutral	30.56%	11	
Slight Preference for European Americans	22.22%	8	
Moderate Preference for European Americans	22.22%	8	
Strong Preference for European Americans	13.89%	5	
Trait Anxiety*	51.00 ± 2.40	36	20–80
Ten Item Personality Inventory*			1–5
Emotional Stability	4.40 ± 1.25	36	
Openness	4.83 ± 0.85	36	
Conscientiousness	4.83 ± 1.04	36	
Agreeableness	4.69 ± 0.82	36	
Extraversion	4.53 ± 1.47	36	
Communication Accommodation Behavior Scale			1–5
Item 1 – Positive – Message Clarity	4.22 ± 0.76	36	
Item 2 – Positive – Facilitate Understanding	4.19 ± 0.79	36	
Item 3 – Positive – Conversational Goals	4.08 ± 0.84	36	
Item 4 – Positive – Reduce Conflict	4.33 ± 0.79	36	
Item 5 – Negative – Fear Judgement	2.11 ± 0.85	36	
Item 6 – Negative – Arrogant Tone	1.83 ± 0.88	36	
Item 7 – Negative – Condescending Speech	2.00 ± 0.99	36	
Item 8 – Negative – Avoid Adjustment	1.92 ± 0.84	36	

* indicates we only have information for $n=34$ due to missing values

frequent use of words with broad contextual distributions. In contrast, participants produced more highly recognizable words when addressing the high-proficiency L2 patient ($\chi^2(1)=5.11$, $p=0.024$; estimate = 0.018, $SE=0.00776$, $t(34.5)=2.32$, $p=0.03$), and also showed greater semantic diversity in their word choices ($\chi^2(1)=10.70$, $p=0.001$; estimate = 0.0191, $SE=0.00564$, $t(34.7)=3.39$, $p=0.0017$).

Individual Differences Regarding Hypotheses 2 and 3, we predicted that willingness to accommodate—as measured using the Communication Accommodation Behavior Scale (CABS)—as well as anxiety and extraversion, would be associated with L1 speakers' greater use of acoustic and lexical accommodations. These hypotheses were partially supported using multivariable linear regression.

For speech rate, the overall model was significant, $F(14, 21)=3.02$, $p=0.011$, accounting for 67% of the variance (adjusted $R^2=0.45$). The CABS item regarding the use of accommodation to avoid conflict was a significant positive predictor ($\beta=0.81$, $p<0.001$, 95% CI [0.40, 1.21]). In contrast, the item of avoiding adjustment (i.e., accommodation) significantly predicted reduced speech rate accommodation ($\beta=-0.34$, $p=0.031$, 95% CI [–0.65, –0.04]). Additionally,

Table 3 Acoustic and lexical speech features as a function of L2 proficiency

	L2 (mean/SD) High proficiency	L2 (mean/SD) Low Proficiency	95% Cl (high)	95% CI (low)
Mean Speech Rate	4.55 (0.43)	4.14 (0.56) ***	[4.24, 4.68]	[3.83, 4.28]
Mean Pitch	202.96 (45.20)	207.07 (46.77)	[167,181]	[171,185]
Mean Pitch Range	447.00 (115.34)	442.13 (120.46)*	[417,442]	[403,4 28]
Mean Intensity	71.36 (1.73)	71.38 (2.46)	[70.4,72.4]	[70.4,7 2.4]
Mean Intensity Range	1.48 (1.89)	1.26 (1.53)	[0.53,2.68]	[0.32,2.48]
Word Frequency	4.83 (0.08)	4.91 (0.07) ***	[4.76, 4.89]	[4.85,4.98]
Contextual Diversity	3.67 (0.04)	3.72 (0.03) ***	[3.66, 3.69]	[3.71,3.74]
Word Recognition	2.29 (0.04)	2.27 (0.05)*	[2.28,2.31]	[2.26,2.30]
Semantic Diversity	2.06 (0.03)	2.04 (0.04)*	[2.05,2.08]	[2.03,2.06]

Asterisks indicate significance between experimental conditions (i.e., high and low proficiency), $p<0.05$', $p<.$ 01*, $p<.$ 001 ***

Openness was a strong negative predictor (β=–0.39, $p<0.001$, 95% CI [–0.59, –0.19]). No other personality predictors were significant.

For pitch range, the model was not significant, $F(14, 21)=0.68$, $p=0.77$, with a negative adjusted $R^2=$–0.15, indicating poor model fit. No individual predictors reached significance, though Agreeableness showed a marginal positive trend (β=10.29, $p=0.11$).

Models for frequency ($F(14, 21)=0.58$, $p=0.85$), contextual diversity ($F(14, 21)=1.03$, $p=0.46$), semantic diversity ($F(14, 21)=1.70$, $p=0.13$), and recognition ($F(14, 21)=0.89$, $p=0.58$) were also non-significant. Among these, Emotional Stability significantly predicted semantic diversity differences (β=–0.01, $p=0.043$, 95% CI [–0.02, –0.0003]), suggesting that individuals with greater emotional stability showed less semantic accommodation. Supplement S3 shows estimates, 95% confidence intervals, and p-values for all predictors.

Discussion

Clear communication is foundational for effective healthcare delivery, especially in encounters where patients and providers do not share the same first language. This experimental study found that L1 clinical students adjusted both how they spoke and the words they used when interacting with simulated Latine patients with different levels of English proficiency. Our findings partially confirmed **Hyp$_{1a}$**, with L1 clinical students acoustically accommodating low-proficiency L2 speakers by using slower speech rates. Participants also made lexical adjustments when interacting with low- versus high-proficiency L2 avatars in a healthcare context, confirming **Hyp$_{1b}$**. In support of **Hyp$_2$**, individual differences in personality traits and self-reported accommodation behavior were associated with how individuals adjust their speech rate during interactions with low-proficiency avatars. While we did not find support for **Hyp$_3$** concerning anxiety and extraversion, openness to new experiences was negatively associated with adaptations in speech rate. These findings suggest that clinical trainees are sensitive to perceived language barriers and make intentional efforts to support understanding. Future research is needed to assess where these efforts may produce unwanted results such as feelings of condescension that could harm patient-provider communication, trust and, ultimately, outcomes.

Acoustic Accommodation

Our findings partially confirmed **Hyp$_{1a}$**, showing that L1 clinical students acoustically accommodated low-proficiency L2 speakers primarily through slower speech rates, underscoring L1 clinical students' sensitivity to perceived comprehension challenges. In contrast, interactions with high-proficiency L2 avatars featured faster speech rates and a broader pitch range, suggesting that L1 speakers perceived these higher proficiency L2 partners as better equipped for processing natural speech patterns [54]. Conversely, L1 speakers used slower speech rates and narrower pitch ranges with low-proficiency L2 avatars, suggesting deliberate efforts to enhance clarity and reduce potential misunderstandings [15, 25, 55]. These adjustments align with linguistic accommodation strategies, where communication is tailored to meet the perceived needs of conversational partners, enhancing intelligibility and minimizing linguistic barriers. L1 participants also used a narrower pitch range when addressing low-proficiency L2 patient, indicating an effort to reduce intonation variability. As a result, speech patterns may potentially be more predictable and easier for L2 listeners to process. In contrast, the broader pitch range for high-proficiency L2 avatars may reflect expressive differences rather than accommodation. It is possible that when speaking with the high-proficiency L2 avatar, L1 participants used more rapport-building language and prosody (e.g., social chit-chat, animated intonation). No significant effects were found for proficiency on mean intensity or intensity range, suggesting that volume adjustments were not a key strategy. Instead, speech rate emerged as a major

form of acoustic accommodation, consistent with research on phonetic convergence, where speakers adapt their speech rate to align with their interlocutors [56]. These findings highlight the nuanced dynamics of accommodation in L2 interactions and thus reflect only partial support for our hypothesis. Importantly, these adjustments may also reflect broader power dynamics inherent in language proficiency disparities, and failing to consider such factors risks overlooking the social and structural complexities of communication [4].

Lexical Accommodation

Our study identified significant lexical adjustments when participants interacted with low- versus high-proficiency L2 patients in a healthcare context, confirming $\mathbf{Hyp_{1b}}$. Participants used more common words and words that appear in a wider variety of situations, which likely helped make the conversation easier to understand. They also used words with simpler or more specific meanings, possibly to reduce confusion and make communication more efficient. These findings support the idea that speakers naturally modify their language to help listeners understand them—a well-known pattern in second-language communication [57, 58]. Unexpectedly, participants also used less prevalent words with low-proficiency patients. This counterintuitive finding may reflect the communicative demands of healthcare contexts, where technical but low-frequency vocabulary (e.g., "referral," “prescription”) is necessary for clinical accuracy and cannot be readily simplified. Thus, lexical accommodation in this context appears to be both adaptive and task-sensitive, balancing the goal of clarity with the need for precision [59]. Further research is needed to examine whether such modifications improve comprehension and recall in L2 listeners and to assess how speaker intentions align with listener outcomes.

These findings highlight lexical accommodation as a distinct communicative strategy that complements more widely studied acoustic modifications (e.g., speech rate, prosody). Importantly, while such adjustments may facilitate comprehension, they also risk unintended social consequences—such as reinforcing asymmetries in power or perceived competence—similar to patterns observed in “elderspeak” [4, 34]. Future work should examine whether these modifications improve L2 comprehension and recall, particularly in healthcare, where clear communication is critical. Finally, these insights hold implications for health communication technologies. Many AI-driven systems are optimized for L1 users and trained on L1-dominant data. Incorporating linguistic accommodation principles—particularly lexical tuning—into digital health tools (e.g., medical chatbots) could improve accessibility and reduce disparities for linguistically diverse patient populations. Overall, our results underscore the importance of tailoring lexical choices to listener language background as part of effective and equitable healthcare communication.

Individual Differences in Accommodation

Our findings indicate that individual differences in personality traits and self-reported accommodation behavior are associated with how individuals adjust their speech rate when interacting with avatars of differing language proficiencies. Physician assistant students who indicated the belief that speech adjustments help prevent conflict in encounters with L2 patients demonstrated greater speech rate adjustments when interacting with low-proficiency avatars. This supports $\mathbf{Hyp_2}$ and the notion that individuals who are motivated by concern for clarity and smooth interaction are more likely to slow down their speech. Both findings are predicted by assumptions of the Communication Accommodation Theory, suggesting that speakers are motivated in their accommodation behavior by a desire to do so. In contrast, those who reported circumventing interactions with less proficient English speakers to avoid modifying their speech exhibited less speech rate differences, possibly reflecting accommodation reluctance.

We did not find support for $\mathbf{Hyp_3}$ concerning anxiety and extraversion. One likely explanation is that the structured and relatively constrained nature of the simulated task limited opportunities for participants to display individual differences in anxiety and personality that are expected in unstructured interactions. The sample was also quite homogenous on these individual difference measures, leaving less room for strong correlations. However, openness to new experiences was negatively associated with adaptations in speech rate, which does seem counterintuitive at first glance, since previous studies have shown the opposite – open individuals do adjust to other speakers in their speech production [60], and our own data has shown that more open individuals are more likely to report accommodation towards L2 speakers [6]. Indeed, other studies have shown that openness is difficult to capture in relation to speech production [61]. One possible explanation is that open individuals are often more confident [62] and mentally flexible [63]. Thus, the negative correlation between openness and speech rate accommodation may stem from a combination of confidence in the listener’s understanding, rather than a lack of willingness to adapt. Another possibility is that since open individuals are more prone to providing accommodation [6], they may do so regardless of listener language proficiency.

The finding that higher emotional stability was associated with less reduction in semantic diversity suggests that

emotionally stable individuals (typically calm, less anxious, and less prone to emotional fluctuations) may be less likely to modify their lexical choices in response to their conversational partner's perceived proficiency. This may reflect lower sensitivity to social or communicative pressure, or greater confidence in maintaining one's typical speech patterns. In contrast, individuals with lower emotional stability may exhibit greater flexibility in adapting their language, possibly due to heightened social vigilance or a desire to avoid miscommunication. This interpretation aligns with findings from Mairesse et al. [64], who demonstrated that emotional stability influences linguistic style, with less stable individuals using more emotionally expressive and variable language. These personality-linked linguistic tendencies likely extend to accommodation behavior, shaping how flexibly individuals adjust to different interlocutors. Taken together, the findings highlight the importance of considering motivational and trait-based explanations for accommodative speech behavior.

Strengths and Limitations

This paper has notable strengths including its use of theory and an experimental, within-person design. However, it also has important limitations. First, participants are from a single clinical training program in a single state and thus may not represent the experiences of other disciplines or locations. Larger studies with greater power might allow for more nuanced identification of between-person predictors of accommodation. Our data are experimental and show significant differences in accommodation between experimental conditions, but the mechanisms and decisions behind those accommodations cannot be explored in this design. Future qualitative studies may be warranted. In addition, while the avatars were designed to represent varying levels of English proficiency, the interactor's Puerto Rican accent may have influenced how participants perceived and adjusted their communication. This may limit generalizability to interactions with speakers of other Latine dialects, and future work should examine accommodation across a broader range of dialects. Because the study participants were mostly White, non-Hispanic female PA students located in eastern North Carolina, this may constrain generalizability, and we recommend broader sampling in future research. Finally, although this study identifies potential mechanisms through which healthcare disparities could emerge, it is exploratory in nature and does not directly link accommodation patterns to patient experiences or outcomes. Rather, the goal is to characterize modifications in speech that may inform future research on how these patterns affect clinical communication and health equity.

Implications for Communication Accommodation Theory

Our findings have important implications for Communication Accommodation Theory, particularly in linguistically and culturally diverse contexts such as healthcare interactions. The observed acoustic and lexical adjustments refine Communication Accommodation Theory for a healthcare context by demonstrating how providers modify their speech—slowing speech rate, narrowing pitch range, and simplifying language—when communicating with low-proficiency interlocutors to mitigate communication barriers [65]. However, these results also underscore the need to balance clarity with relational alignment, as overly simplified accommodations may risk being perceived as patronizing [5, 28]. While this study focuses on describing accommodation behaviors, the findings generate important hypotheses within the context of Communication Accommodation Theory. Specifically, how are these accommodations perceived by both L1 and L2 speakers? What trade-offs exist between different accommodation strategies, such as between acoustic and lexical modifications? Additionally, do some clinician trainees overaccommodate, potentially reinforcing power imbalances? To address these questions, future studies can repurpose the recorded interactions from the current dataset as experimental stimuli to assess comprehension and perception in actual L2 listeners. For example, by systematically manipulating acoustic and lexical features, we can evaluate their individual and combined effects on L2 speaker comprehension and relational judgments (e.g., perceived warmth, competence). This approach would allow us to move beyond descriptive patterns to identify which specific accommodations are most effective—and which may be counterproductive—in supporting equitable, high-quality communication in healthcare settings.

Implications for Health Disparities

Our findings highlight the need for awareness training in communication accommodation within healthcare education. While trainees adjusted their speech intuitively based on English proficiency, many likely lack formal instruction on when and how to accommodate effectively. A recent international survey by Zota et al. [66] found that many European speech-language pathologists lacked formal training in how to adapt communication for linguistically diverse patients, despite frequently encountering them in clinical practice. Clinicians reported uncertainty about how to modify their speech without appearing condescending, revealing key gaps in education. While informative, this study was conducted in Europe, and similar data are lacking in U.S. contexts. To address this gap, we are currently analyzing data

from a qualitative study designed to explore clinician trainees' experiences with and their training needs when working with L2 patient populations. This work aims to clarify how trainees interpret the balance between making speech more comprehensible and maintaining respectful, patient-centered communication. Insights from this study will help fill critical gaps in knowledge regarding U.S. clinicians' training experiences in linguistically diverse healthcare settings, thereby providing a foundation for future work aimed at developing targeted educational interventions. To help clarify these issues, future studies should focus on developing evidence-based training on accommodation strategies, including structured simulations and guidance on balancing clarity with relational alignment. Future research should also assess whether such training improves communication effectiveness and reduces healthcare disparities. By incorporating targeted education on linguistic accommodation, clinical programs can better prepare providers to navigate cross-linguistic interactions, ultimately fostering more equitable and effective healthcare communication.

Conclusion

Our findings reveal that L1 clinical students intuitively adjust their speech and lexical choices to accommodate low-proficiency Latine L2 English speakers by using slower speech rates, narrower pitch ranges, and higher-frequency, more contextually diverse, and less ambiguous words. These adaptations align with linguistic accommodation strategies to enhance intelligibility and reduce misunderstandings. These results underscore the importance of training clinicians to adapt their communication strategies to address linguistic diversity and reduce health disparities. Future research should examine how these adjustments impact patient outcomes to improve inclusivity and equitable care.

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Data Availability Data are publicly available at https://osf.io/3bvry/ under CC BY 4.0 license.

Declarations

Ethical Approval This study was approved by the Institutional Review Board at East Carolina University, approval number #UMCIRB 22–001084, and was conducted in accordance with the Declaration of Helsinki.

Informed Consent Informed consent was obtained from all participants included in the study.

Conflicts of interest The authors declare no conflicts of interest.

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References

1. Dietrich S, Hernandez E. Language Use in the United States: 2019. American Community Survey Report. Washington, DC: US Census Bureau; 2022. https://www.census.gov/library/publications/2022/acs/acs-50.html. Accessed 08 Oct 2025.
2. US Census Bureau. Census.gov. [cited 2025 Oct 6]. New data on detailed languages spoken at home and the ability to speak English. Available from: https://www.census.gov/newsroom/press-releases/2025/2017-2021-acs-language-use-tables.html.
3. Meuter RF, Gallois C, Segalowitz NS, Ryder AG, Hocking J. Overcoming language barriers in healthcare: a protocol for investigating safe and effective communication when patients or clinicians use a second language. BMC Health Serv Res. 2015;15(1):1–5.
4. Terui S. Conceptualizing the pathways and processes between language barriers and health disparities: review, synthesis, and extension. J Immigr Minor Health. 2017;19(1):215–24.
5. Margić B. Communication courtesy or condescension? Linguistic accommodation of native to non-native speakers of English. J Engl Lingua Franca [Internet]. 2017 Jan 1 [cited 2021 Mar 17];6(1). Available from: https://www.degruyter.com/document/doi/10.1515/jelf-2017-0006/html.
6. Rothermich K, Baker R, Falkins SM, Kum J, Capps MR, Bobb SC. Reported use of second-language speech accommodation in everyday interactions: the role of individual differences. J Speech Lang Hear Res. 2023;66(9):3307–27.
7. Dragojevic M, Gasiorek J, Giles H. Communication accommodation theory. Int Encyclop Interpersonal Commun. 2015;11:1–21.

8. Zhang YB, Imamura M. Communication accommodation theory and intergroup communication. In: Oxford research encyclopedia of communication [Internet]. 2017 [cited 2025 Mar 24]. Available from: https://oxfordre.com/communication/display/10.1093/acrefore/9780190228613.001.0001/acrefore-9780190228613-e-484.
9. Piazza G, Kalashnikova M, Martin CD. Phonetic accommodation in non-native directed speech supports L2 word learning and pronunciation. Sci Rep. 2023;13(1):21282.
10. Duggan A. When rapport building extends beyond affiliation: communication overaccommodation toward patients with disabilities. Perm J [Internet]. 2011 Apr 1 [cited 2020 Sept 15];15(2). Available from: http://www.thepermanentejournal.org/issues/2011/spring/728-patients-with-disabilities.html.
11. Gluszek A, Dovidio JF. The way they speak: a social psychological perspective on the stigma of nonnative accents in communication. Pers Soc Psychol Rev. 2010;14(2):214–37.
12. MacIntyre PD, Charos C. Personality, attitudes, and affect as predictors of second language communication. J Lang Soc Psychol. 1996;15(1):3–26.
13. Oz H. Big five personality traits and willingness to communicate among foreign language learners in Turkey. Soc Behav Pers. 2014;42(9):1473–82.
14. Rothermich K, Harris HL, Sewell K, Bobb SC. Listener impressions of foreigner-directed speech: a systematic review. Speech Commun. 2019;112:22–9.
15. Bobb SC, Mello K, Turco E, Lemes L, Fernandez E, Rothermich K. Second language learners' listener impressions of foreigner-directed speech. J Speech Lang Hear Res. 2019;62(9):3135–48. https://doi.org/10.1044/2019_JSLHR-S-18-0392.
16. Baese-Berk MM, Drake S, Foster K, Lee D yong, Staggs C, Wright JM. Lexical diversity, lexical sophistication, and predictability for speech in multiple listening conditions. Front Psychol [Internet]. 2021 June 18 [cited 2025 Mar 9];12. Available from: https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2021.661415/full.
17. Ostrand R, Chodroff E. It's alignment all the way down, but not all the way up: speakers align on some features but not others within a dialogue. J Phonetics. 2021;88:101074.
18. Hsueh L, Hirsh AT, Maupomé G, Stewart JC. Patient-provider language concordance and health outcomes: a systematic review, evidence map, and research agenda. Med Care Res Rev. 2021;78(1):3–23.
19. Binder P, Borné Y, Johnsdotter S, Essén B. Shared language is essential: Communication in a multiethnic obstetric care setting. J Health Commun [Internet]. 2012 Nov 1 [cited 2025 Mar 9]; Available from: https://www.tandfonline.com/doi/abs/10.1080/10810730.2012.665421.
20. Peprah P, Lloyd J, Harris M. Responding to health literacy of refugees in Australian primary health care settings: a qualitative study of barriers and potential solutions. BMC Health Serv Res. 2024;24(1):757.
21. Yeheskel A, Rawal S. Exploring the 'patient experience' of individuals with limited english proficiency: a scoping review. J Immigr Minor Health. 2019;21(4):853–78.
22. Diamond L, Izquierdo K, Canfield D, Matsoukas K, Gany F. A systematic review of the impact of patient-physician non-English language concordance on quality of care and outcomes. J Gen Intern Med. 2019;34(8):1591–606.
23. Quigley DD, Qureshi N, Predmore Z, Diaz Y, Hays RD. Is primary care patient experience associated with provider-patient language concordance and use of interpreters for spanish-preferring patients: a systematic literature review. J Racial Ethnic Health Dispar. 2025;12(2):1170–83. https://doi.org/10.1007/s40615-024-01951-z.
24. Hazan V, Uther M, Granlund S. How does foreigner-directed speech differ from other forms of listener-directed clear speaking styles? In: Proceedings of the 18th international congress of phonetic sciences [Internet]. Glasgow, UK: University of Glasgow; 2015. Available from: http://hdl.handle.net/2436/623993.
25. Scarborough R, Dmitrieva O, Hall-Lew L, Zhao Y, Brenier J. An acoustic study of real and imagined foreigner-directed speech. J Acoust Soc Am. 2007;121(5):3044.
26. Uther M, Knoll MA, Burnham D. Do you speak E-NG-L-I-SH? A comparison of foreigner- and infant-directed speech. Speech Commun. 2007;49(1):2–7.
27. Zuengler J. Accommodation in native-nonnative interactions: Going beyond the "what" to the "why" in second-language research. In: Giles H, Coupland J, Coupland N, editors. Contexts of accommodation: Developments in applied sociolinguistics [Internet]. Cambridge, England: Cambridge University Press; 1991. p. 223–44. Available from: https://doi.org/10.1017/CBO9780511663673
28. Piazza G, Martin CD, Kalashnikova M. The acoustic features and didactic function of foreigner-directed speech: a scoping review. J Speech Lang Hear Res. 2022;65(8):2896–918.
29. Piazza G, Carta S, Ip E, Pérez-Navarro J, Kalashnikova M, Martin CD, et al. Are you talking to me? How the choice of speech register impacts listeners' hierarchical encoding of speech [Internet]. bioRxiv; 2024 [cited 2025 Mar 18]. p. 2024.09.02.610805. Available from: https://www.biorxiv.org/content/10.1101/2024.09.02.610805v1
30. Bradlow AR, Bent T. The clear speech effect for non-native listeners. J Acoust Soc Am. 2002;112(1):272–84.
31. Smiljanić R, Bradlow AR. Bidirectional clear speech perception benefit for native and high-proficiency non-native talkers and listeners: intelligibility and accentedness. J Acoust Soc Am. 2011;130(6):4020–31.
32. Wu HX, Li Y, Ching BHH, Chen TT. You are how you speak: the roles of vocal pitch and semantic cues in shaping social perceptions. Perception. 2023;52(1):40–55.
33. Pittman AL, Wiley TL. Recognition of speech produced in noise. J Speech Lang Hear Res. 2001;44(3):487–96.
34. Kemper S, Finter-Urczyk A, Ferrell P, Harden T, Billington C. Using elderspeak with older adults. Discourse Process. 1998;25(1):55–73.
35. Iurciuc S, Sava-Rosianu R, Tanase AD, Cosoroaba R, Serafin A, Miscodan D, Tigmeanu C, Popovici RA. Tackling barriers in access to healthcare services: a review. Res Clin Med. 2020;4(2):21–4.
36. Shaw CA, Gordon JK. Understanding elderspeak: an evolutionary concept analysis. Innov Aging. 2021;5(3):igab023.
37. Baese-Berk MM, Drake S, Foster K, Lee D yong, Staggs C, Wright JM. Lexical diversity, lexical sophistication, and predictability for speech in multiple listening conditions. Front Psychol [Internet]. 2021 June 18 [cited 2025 Mar 18];12. Available from: https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2021.661415/full.
38. Brysbaert M, Keuleers E, Mandera P. Which words do English non-native speakers know? New supernational levels based on yes/no decision. Second Language Res. 2021;37(2):207–31.
39. Hartle L, Kaczorowski T. The positive aspects of Mursion when teaching higher education students. Q Rev Distance Educ. 2019;20(4):71–100.
40. Woods DM, Doornbos L, Carver C. Using mixed reality simulations to prepare justice-oriented teachers. Contemp Issues Technol Teacher Educ. 2024;24(1):95–124.
41. Hudson ME, Voytecki KS, Owens TL, Zhang G. Preservice teacher experiences implementing classroom management practices through mixed-reality simulations. Rural Spec Educ Q. 2019;38(2):79–94.

42. Rincon E, Rodriguez-Guidonet I, Andrade-Pino P, Monfort-Vinuesa C. Mixed reality in undergraduate mental health education: a systematic review. Electronics. 2023;12(4):1019.
43. Chae D, Yoo JY, Kim J, Ryu J. Effectiveness of virtual simulation to enhance cultural competence in pre-licensure and licensed health professionals: a systematic review. Clin Simul Nurs. 2021;56:137–54.
44. Elendu C, Amaechi DC, Okatta AU, Amaechi EC, Elendu TC, Ezeh CP, et al. The impact of simulation-based training in medical education: a review. Medicine (Baltimore). 2024;103(27):e38813.
45. Lemhöfer K, Broersma M. Introducing LexTALE: a quick and valid lexical test for advanced learners of English. Behav Res Methods. 2012;44(2):325–43.
46. Anderson JAE, Mak L, Keyvani Chahi A, Bialystok E. The language and social background questionnaire: assessing degree of bilingualism in a diverse population. Behav Res Methods. 2018;50(1):250–63.
47. Gosling SD, Rentfrow PJ, Swann WB. A very brief measure of the big-five personality domains. J Res Pers. 2003;37(6):504–28.
48. Spielberger CD, Gonzalez-Reigosa F, Martinez-Urrutia A, Natalicio LF, Natalicio DS. The state-trait anxiety inventory. Rev Interam Psicol J Psychol. 1971;5(3-4):3–24.
49. Greenwald AG, McGhee DE, Schwartz JL. Measuring individual differences in implicit cognition: the implicit association test. J Pers Soc Psychol. 1998;74(6):1464.
50. Boersma P. Praat, a system for doing phonetics by computer. Glot Int. 2002;5910:341–5.
51. Gao C, Shinkareva SV, Desai RH. Scope: the South Carolina psycholinguistic metabase. Behav Res Methods. 2023;55(6):2853–84.
52. Brysbaert M, New B. 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. Behav Res Methods. 2009;41(4):977–90.
53. Rothman KJ. No adjustments are needed for multiple comparisons. Epidemiology. 1990;1(1):43–6.
54. Lesnov R, Nava SW, Bogorevich V. Can successful L2 pronunciation facilitate listening comprehension? The role of speech rate and pitch range. Pronunciation Second Lang Learn Teach Proc [Internet]. 2020 [cited 2025 Mar 26];11(1). Available from: https://www.iastatedigitalpress.com/psllt/article/id/15429/.
55. Biersack S, Kempe V, Knapton L. Fine-tuning speech registers: a comparison of the prosodic features of child-directed and foreigner-directed speech. In: Proceedings of the Ninth European Conference on Speech Communication and Technology; 2005; Lisbon, Portugal. p. 2401–04.
56. Pardo JS. Reflections on phonetic convergence: speech perception does not mirror speech production: reflections on phonetic convergence. Lang Linguist Compass. 2012;6(12):753–67.
57. Hatch EM. Second language acquisition: a book of readings. Rowley, Mass.: Newbury House Publishers; 1978.
58. Long MH. Linguistic and conversational adjustments to non-native speakers. Stud Second Lang Acquis. 1983;5(2):177–93.
59. Ishikawa H, Kiuchi T. Health literacy and health communication. Biopsychosoc Med. 2010;4(1):18.
60. Lewandowski N, Jilka M. Phonetic convergence, language talent, personality and attention. Front Commun [Internet]. 2019 May 15 [cited 2025 Apr 10];4. Available from: https://www.frontiersin.org/journals/communication/articles/10.3389/fcomm.2019.00018/full.
61. Culnan J. Length, speech style, and acoustic characteristics of speech impact perceptions of personality. J Acoust Soc Am. 2021;150(4 Suppl):A311.
62. Schaefer PS, Williams CC, Goodie AS, Campbell WK. Overconfidence and the big five. J Res Pers. 2004;38(5):473–80.
63. Chen X, He J, Fan X. Relationships between openness to experience, cognitive flexibility, self-esteem, and creativity among bilingual college students in the US. Int J Bilingual Educ Bilingual. 2022;25(1):342–54.
64. Mairesse F, Walker MA, Mehl MR, Moore RK. Using linguistic cues for the automatic recognition of personality in conversation and text. J Artif Intell Res. 2007;28(30):457–500.
65. Baker RP, Mello K, Ragsdale H, Rothermich K, Bobb S. Exploring natural speech accommodation in L1–L2 interactions: implications for pedagogy. Babylonia J Lang Educ. 2023;31(3):22–9.
66. Zota D, Diamantis DV, Katsas K, Karnaki P, Tsiampalis T, Sakowski P, et al. Essential skills for health communication, barriers, facilitators and the need for training: perceptions of healthcare professionals from seven European countries. Healthcare. 2023;11(14):2058.

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