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ECHOES OF EMOTION: INVESTIGATING THE ROLE OF AMBIENT SOUNDSCAPES ON CODE-SWITCHING PATTERNS IN MULTILINGUAL DIGITAL COMMUNICATION

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Abstract
This study investigates the influence of ambient soundscapes—auditory environments such as café chatter, traffic noise, and natural soundscapes—on code-switching behaviors within multilingual digital communication. Despite the rich body of literature on code-switching in Computer-Mediated Communication (CMC), little attention has been paid to the affective and cognitive implications of the user's immediate auditory surroundings. Drawing upon interdisciplinary frameworks from sociolinguistics, psycholinguistics, and auditory cognition, this research posits that ambient soundscapes function as emotionally and cognitively charged contexts that modulate not only the frequency but also the pragmatic function of code-switching during digital text-based interaction. Using a convergent mixed-methods design, the study combines controlled laboratory-based digital chat experiments under three auditory conditions (silence, urban noise, and natural soundscapes), corpus-driven discourse analysis of real-world multilingual chats from platforms like WhatsApp and Telegram, and in-depth post-task interviews to capture participants' conscious and subconscious linguistic adaptations. Preliminary findings suggest that soundscapes with higher cognitive load (e.g., urban noise) significantly increase both the rate and strategic deployment of code-switching for emphasis, clarification, and emotional resonance, whereas nature-based soundscapes support greater linguistic cohesion and intra-language continuity. By foregrounding the acoustic ecology of digital communication, this research introduces an underexplored but critical dimension to understanding multilingualism in the digital age. It also offers actionable implications for the design of emotionally aware and context-responsive communication technologies, particularly in increasingly globalized and sonically dynamic interaction spaces.

Keywords: Ambient Soundscapes**,** Code-Switching**,** Multilingual Digital Communication**,** Computer-Mediated Communication (CMC)**,** Auditory Cognition

1. Introduction
In an era defined by global connectivity and multilingual interaction, the nature of human communication is increasingly influenced by not only digital interfaces but also by environmental context. Among these contextual factors, ambient soundscapes—the background sounds in users' physical surroundings during digital communication—are gaining recognition for their impact on cognition, emotion, and attention (Aletta et al., 2018; Medvedev et al., 2015). Yet, despite robust research on the visual and linguistic aspects of digital communication, the role of auditory context in shaping language use remains underexplored. Code-switching—the fluid alternation between two or more languages within a conversation or message—is a well-documented behavior in multilingual digital communication. It serves several pragmatic and affective functions, including emphasis, clarification, emotional expression, and identity positioning (Tagg & Seargeant, 2019; Androutsopoulos, 2015). On platforms such as WhatsApp, Facebook, and Telegram, multilingual users frequently employ code-switching not only as a linguistic strategy but also

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as a form of social signaling and cognitive adaptation (Lee, 2017; Badruddoja, 2022). However, while studies have extensively examined the linguistic and sociocultural drivers of digital code-switching (e.g., interlocutor role, topic shift, language proficiency), non-linguistic sensory influences—especially auditory ones—remain largely overlooked. Recent advances in auditory cognition and environmental psychology have demonstrated that background sounds, particularly those high in informational or emotional load (e.g., traffic noise or urban clutter), can influence attentional resources and task performance in significant ways (Kujala et al., 2017; Kawai et al., 2020). Natural soundscapes, by contrast, have been linked to enhanced emotional regulation and cognitive restoration (Ratcliffe et al., 2021; Zhang et al., 2020). This body of research suggests that ambient auditory stimuli may serve as cognitive-affective scaffolds during digital communication, subtly shaping linguistic choices and communicative strategies—including code-switching. In digital multilingual contexts, this implies that the presence of disruptive or soothing soundscapes could impact not only the frequency of code-switching but also its pragmatic function. For example, noisy environments may increase the likelihood of switching languages to manage communicative load or express irritation, while nature sounds may encourage linguistic cohesion and sustained use of a primary language. However, despite this plausible link between soundscape exposure and multilingual behavior, scholarly attention to this intersection remains minimal. Sociolinguistics has traditionally focused on interpersonal and cultural dimensions of code-switching, while psycholinguistic studies have rarely ventured into ecologically valid, real-time, digital settings. As such, this study aims to bridge these domains by exploring how ambient soundscapes influence code-switching in digital, text-based interaction.

The central research questions guiding this study are:

1. How do different auditory environments (silence, urban noise, natural soundscapes) affect the frequency of code-switching in digital communication?
2. How do these soundscapes influence the pragmatic functions of code-switching?
3. Are users consciously aware of how their auditory environments impact their linguistic behavior?

By integrating frameworks from sociolinguistics, auditory cognition, and digital media studies, this research proposes a novel and interdisciplinary lens for understanding the ecological conditions that shape multilingual communication. In doing so, it introduces ambient sound as a critical, yet underexamined, variable in digital code-switching behavior—laying the groundwork for more emotionally responsive and environmentally aware digital communication systems.

2. Literature Review

2.1 Code-Switching in Computer-Mediated Communication (CMC)

In the past decade, research on multilingual communication in digital spaces has seen a surge of interest, particularly as platforms such as WhatsApp, Telegram, and Instagram foster real-time, text-based interaction across languages and cultures. Code-switching, defined as the alternation between two or more languages within a single conversation or message, is now widely recognized as a strategic and fluid practice shaped by sociocultural, pragmatic, and technological factors (Lee, 2017; Badruddoja, 2022). In Computer-Mediated Communication (CMC), code-switching serves multiple communicative functions—including the marking of social identity, alignment with audience, signaling of emotional states, and adaptation to genre and platform constraints (Tagg & Seargeant, 2019; Androutsopoulos, 2015). For example, bilingual users might insert English lexical items into Urdu or Punjabi base messages to convey humor or authority, especially in WhatsApp group chats (Dovchin, 2021). Recent studies also emphasize that digital code-switching is not random but

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systematically patterned—responding to both linguistic norms and the broader media ecology (Garcia & Otheguy, 2020). However, despite this rich body of work, few studies have examined how environmental variables—particularly auditory contexts—modulate these code-switching behaviors. This represents a crucial gap, especially as users often engage with digital platforms in sound-rich environments such as cafés, traffic, or nature settings.

2.2 Auditory Cognition and Soundscapes

Research in auditory cognition and environmental psychology has provided compelling evidence that background sounds influence mental performance, emotional state, and attentional capacity. Urban environments, characterized by high-intensity and irregular sound patterns (e.g., traffic, construction), have been linked to increased stress levels, impaired cognitive functioning, and emotional dysregulation (Kawai et al., 2020; Medvedev et al., 2015). Conversely, natural soundscapes—such as birdsong, rainfall, or forest ambiance—are consistently associated with cognitive restoration, reduced stress, and enhanced emotional well-being (Ratcliffe et al., 2021; Zhang et al., 2020). Exposure to these soundscapes can lower heart rate variability, reduce cortisol levels, and improve focus—making them effective tools in stress-reduction interventions (Franco et al., 2017; Alvarsson et al., 2010, cited in Zhang et al., 2020). hese findings suggest that auditory environments are more than passive backdrops; they actively shape cognitive-affective functioning, which, in turn, may influence communication processes. This is especially relevant in digital communication, where users are often multitasking and navigating complex acoustic contexts. As such, the auditory environment may act as an implicit contextual cue, shaping how language is processed, produced, and strategically deployed—including code-switching.

2.3 Affect, Cognitive Load, and Language Production

A growing body of psycholinguistic and neurocognitive research highlights how affective states and cognitive load impact language production. High-stress or emotionally arousing environments are associated with reduced lexical diversity, increased repetition, and reliance on automatic or habitual linguistic patterns (Zhang & Xie, 2021; Marsh et al., 2018). In such scenarios, bilinguals may turn to their dominant or emotionally resonant language to manage cognitive effort (Kharkhurin, 2021).

Cognitive Load Theory (CLT), though traditionally applied in instructional design, has also been extended to linguistic behavior. Under high cognitive load, individuals simplify sentence structure, reduce use of subordinate clauses, and sometimes code-switch to more efficient or emotionally expressive linguistic resources (Wiklund & Harder, 2019). This suggests that code-switching may function as an adaptive mechanism—used not merely for sociolinguistic or stylistic purposes, but to regulate emotional expression and cognitive economy during challenging auditory conditions.

Moreover, studies using dual-task paradigms show that noisy environments impair performance on language-related tasks, especially among bilinguals, whose executive control systems are more engaged during language switching (Hervais-Adelman et al., 2015). These findings further support the notion that sonic environments affect language behavior at both the structural and pragmatic levels.

3. Methodology

This study employed a convergent mixed-methods research design to explore how ambient soundscapes influence code-switching behavior in multilingual digital communication. The convergent design was selected to allow for the parallel collection and analysis of quantitative and qualitative data, which were then merged to provide a comprehensive understanding of the phenomena under investigation (Creswell & Plano Clark, 2018).

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3.1 Research Design

The study was structured around three core components: (1) a controlled experimental study, (2) a naturalistic corpus-based discourse analysis, and (3) semi-structured post-task interviews.

3.1.1 Experimental Component

In the experimental component of this study, participants engaged in simulated messaging tasks within a controlled laboratory environment, exposed to three distinct auditory conditions: silence (serving as the baseline control), urban noise (including recorded traffic sounds, car horns, and construction activity), and natural forest soundscapes (comprising ambient nature sounds such as birdsong, flowing water, and wind rustling through trees). Each participant completed chat-based tasks under all three sound conditions, with task prompts carefully designed to simulate informal, real-life conversations—such as planning a weekend outing, discussing a recently watched movie, or helping a friend resolve a personal issue. These prompts were intended to elicit natural and spontaneous code-switching behavior. To ensure consistent exposure, auditory stimuli were standardized at approximately 65 decibels and delivered through high-quality, over-ear noise-isolating headphones. The order of auditory exposure was randomized across participants to mitigate order effects and bias. Each sound condition lasted 15 minutes and was separated by a brief rest interval.

3.1.2 Corpus Analysis

In the corpus analysis component of the study, naturally occurring multilingual chat data were collected from WhatsApp and Telegram, contributed voluntarily by participants over a two-week period. Participants were instructed to share recent conversation threads in which they interacted with friends or family in more than one language. Prior to data collection, informed consent was obtained, and participants were assured of complete confidentiality. All identifying information, including names, phone numbers, emojis, timestamps, and profile data, was removed or anonymized to protect privacy and adhere to ethical guidelines.

The purpose of this corpus analysis was to observe authentic code-switching behavior in real-world digital interactions, beyond the controlled lab setting. Using a discourse-analytical approach, the data were examined to identify the frequency and type of code-switching, with a distinction made between inter-sentential switching (language change between sentences) and intra-sentential switching (language alternation within a sentence). The analysis also focused on the pragmatic functions of each switch—such as signaling emphasis, clarifying a point, expressing emotion, or shifting conversational tone. Additionally, researchers explored lexical switching patterns, noting which types of words or expressions (e.g., greetings, exclamations, borrowed nouns) were more prone to be switched and in what contextual situations these switches tended to occur.

The chat data were manually coded using ELAN software, and analytical categories were cross-validated by two independent coders to ensure accuracy and reliability. This real-world corpus offered crucial insight into how multilingual speakers navigate language choice organically in informal digital communication—insight that was used to complement and triangulate the findings from the experimental and interview phases.

3.1.3 Post-Task Interviews

Following the completion of the experimental chat sessions, all participants took part in semi-structured post-task interviews aimed at uncovering their conscious awareness and subjective interpretations of how the different soundscapes influenced their language use, particularly code-switching behaviors. These interviews provided a qualitative layer of insight to complement the quantitative data gathered during the experimental and corpus phases. Each

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interview lasted approximately 20 to 30 minutes and was conducted in a quiet setting to facilitate open and reflective dialogue.

The interview protocol consisted of both open-ended and guided prompts, such as:

1. "Did the background sounds affect how you communicated?"
2. "Did you feel more inclined to use one language over another?"
3. "How did each sound environment influence your concentration?"
4. "Were there any moments you felt more expressive or distracted in certain sound conditions?"

Participants were encouraged to elaborate freely, and interviewers used follow-up questions to probe deeper into comments related to emotional responses, cognitive strain, language comfort, or intentionality behind code-switching decisions. All interviews were audio recorded with consent, transcribed verbatim, and then imported into NVivo 14 software for thematic analysis.

Using Braun and Clarke's (2006) framework for thematic coding, researchers identified recurring patterns and themes across responses. Key themes included perceived emotional disruption in urban noise conditions, increased mental focus and flow during natural soundscapes, and heightened linguistic flexibility when under auditory stress. Thematic saturation was reached by the 27th interview, confirming the reliability and depth of participant insights. These qualitative findings were later integrated with the experimental and corpus results to offer a holistic interpretation of how auditory environments modulate multilingual digital communication.

3.2 Participants

The participant pool for this study comprised 30 multilingual individuals (15 female, 15 male), aged between 18 and 35 years (Mean age = 25.7 years). All participants were based in urban centers of Pakistan and represented a linguistically diverse profile reflective of the region's multilingual population. Each participant demonstrated fluency in at least two spoken languages, with the following language pair distributions: Urdu-English (n = 14), Punjabi-Urdu (n = 8), Sindhi-English (n = 4), and Pashto-Urdu (n = 4). This linguistic composition allowed for the observation of code-switching patterns across different sociolinguistic contexts within Pakistani multilingualism.

Participants were recruited using purposive sampling, targeting individuals from universities, software development companies, and co-working spaces to ensure a high degree of both linguistic proficiency and digital literacy. A short screening questionnaire was used to confirm eligibility, focusing on daily digital communication habits and language use frequency. All selected individuals were frequent users of messaging platforms such as WhatsApp, Telegram, or Signal, with self-reported usage averaging more than three hours per day. These platforms served as both the setting for experimental tasks and the source of naturalistic chat data for corpus analysis.

To participate in the study, individuals were required to meet the following inclusion criteria:

1. Be between 18 and 35 years of age,
2. Be proficient in at least two spoken languages (one of which had to be English or Urdu),
3. Be a daily user of mobile or desktop-based digital messaging applications,
4. Have no reported hearing impairments, speech disorders, or diagnosed neurocognitive conditions.

Prior to participation, each individual provided written informed consent, in accordance with protocols approved by the Institutional Review Board (IRB). The consent process outlined the study objectives, potential risks, and privacy safeguards. Participants were informed that they could withdraw at any time without penalty.

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To protect participant identity and ensure data confidentiality, all personal identifiers in chat logs and interview transcripts were removed or pseudonymized. Data were stored on encrypted drives and accessible only to the principal investigators and authorized research assistants. Throughout the research process, strict ethical guidelines on human subject research and digital data handling were upheld, ensuring compliance with both local research regulations and international data protection standards (e.g., GDPR principles).

3.3 Procedure and Tools

3.3.1 Experimental Procedure

Each participant took part in a 90-minute individual laboratory session, conducted in a sound-insulated, distraction-free environment designed to simulate comfortable conditions for digital communication. The session was structured to include three 15-minute messaging tasks, each performed under a different auditory condition (silence, urban noise, and natural forest sound), a 10-minute rest interval between these sound conditions to avoid fatigue or auditory carry-over effects, and a 20-minute post-task interview aimed at capturing participant reflections and perceptions.

For the messaging tasks, participants interacted with a research assistant via a custom-built desktop chat interface, designed to closely emulate commonly used messaging platforms like WhatsApp or Telegram. The interface preserved familiar visual cues and layout to promote natural behavior but was programmed with logging capabilities to track linguistic activity in real time. It recorded data points such as message timestamps, typing duration, response latency, frequency and type of code-switching, and word count per message. This backend system ensured unobtrusive and objective data collection.

During each chat task:

1. Auditory stimuli corresponding to the current sound condition were played through Bose QC35 II noise-canceling headphones, selected for their high fidelity and active sound isolation to ensure that only the intended soundscape was heard.
2. Participants were presented with informal, scenario-based prompts (e.g., making social plans, reacting to news, offering advice) and were encouraged to "chat naturally", simulating how they would normally interact with a friend or peer in their preferred messaging app.
3. Importantly, participants were not informed that the study was measuring code-switching, as this could prime their language behavior and compromise the authenticity of the results. Instead, they were told that the study was examining general communication styles in different environments.

Participants were allowed to ask clarifying questions before each sound condition began, and brief on-screen instructions were provided to remind them of the task. To avoid confounding effects due to task order, the sequence of sound conditions was randomized across participants using a Latin square design.

The controlled and ecologically valid setup of this experimental procedure enabled researchers to capture naturalistic, spontaneous code-switching behavior while ensuring that external variables were minimized and participant comfort was maintained throughout the session.

3.3.2 Soundscapes

To examine the influence of environmental auditory conditions on code-switching behavior, the study utilized three carefully selected and standardized soundscape conditions. Each sound condition was applied during the experimental messaging tasks and was designed to represent a distinct auditory environment that participants might encounter during everyday digital communication.

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1. **Silence (Baseline Condition):** This condition served as the control. No auditory stimuli were played, and participants performed their messaging tasks in a completely quiet environment. The absence of background sound allowed for a baseline measurement of code-switching behavior without the influence of external auditory distractions or cognitive load.
2. **Urban Noise:** This condition replicated a high-stimulus, cognitively demanding auditory environment, consisting of traffic congestion, car horns, sirens, and distant construction clatter. The audio track was sourced from the International Soundscape Database (ID: URB-0034), which provides validated urban acoustic recordings for experimental use. The track was looped and edited to eliminate abrupt volume spikes or unnatural transitions, maintaining realism while minimizing startle effects. This soundscape was selected to simulate the type of auditory stressors commonly experienced in metropolitan environments.
3. **Natural Forest Soundscape:** This condition recreated a low-stimulus, restorative auditory environment using ambient nature sounds, including birdsong, rustling leaves, flowing water, and gentle wind. The track was extracted from a curated natural ambiance library frequently used in environmental psychology and restorative sound studies (Franco et al., 2017; Zhang et al., 2020). The soundscape was designed to evoke a calm, immersive auditory experience intended to reduce cognitive load and support emotional regulation.

All three soundtracks were normalized to a uniform loudness level of approximately 65 dB to ensure consistency across participants and prevent volume-related biases. The tracks were played using VLC Media Player with a fixed gain setting to avoid automatic volume adjustments that could distort perception. Participants listened through Bose QC35 II noise-canceling headphones, which provided high-quality playback and ensured that external noises from the lab environment were effectively blocked. By carefully standardizing sound quality, volume, and delivery method, the study ensured that differences in participant responses could be attributed to the nature and content of the soundscape itself, rather than to variations in playback conditions. These three conditions—silence, urban stress, and natural calm—provided a robust basis for analyzing how acoustic context modulates language behavior in digital multilingual communication.

3.3.3 Annotation and Analysis Tools

To ensure a rigorous and multidimensional analysis of the collected data, a combination of specialized annotation software and statistical tools was employed for both the experimental chat transcripts and interview responses.

Chat Data Annotation

All chat transcripts from the experimental tasks were exported and processed using the following annotation tools:

ELAN 6.5 (EUDICO Linguistic Annotator): ELAN was used for the fine-grained linguistic annotation of code-switching instances. Researchers labeled each switch according to its structural type, including:

1. Inter-sentential switching (language change between complete sentences),
2. Intra-sentential switching (language change within a single sentence),
3. Tag switching (switching of short tags or fillers such as “ok”, “haan”, “you know”). Time-aligned annotations allowed researchers to link each linguistic event with its corresponding auditory condition and response latency.

UAM Corpus Tool: This tool was used for functional annotation, focusing on the pragmatic intent behind each instance of code-switching. Annotated categories included:

1. Emphasis (e.g., stressing a point through language shift),
2. Clarification (e.g., rephrasing for better understanding),
3. Affective expression (e.g., conveying emotion through language choice),
4. Topic shift, identity signaling, and discourse marking.

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Each chat session was annotated independently by two trained coders. The inter-coder reliability was calculated using Cohen's Kappa (κ), resulting in a score of 0.84, indicating strong agreement (Landis & Koch, 1977). Discrepancies were resolved through discussion and re-coding to ensure consistency.

Quantitative Data Analysis

All quantitative linguistic metrics—including frequency of code-switches, length of utterances, switching density, and response time—were analyzed using IBM SPSS Statistics 28. The following statistical procedures were applied:

1. **Descriptive Statistics:** Mean and standard deviation were calculated for code-switching frequency and utterance length under each sound condition.
2. **Repeated Measures ANOVA**: This test was used to examine whether the different soundscape conditions (silence, urban noise, nature sounds) led to statistically significant differences in code-switching frequency and usage patterns within participants.
3. **Post hoc Bonferroni Tests**: To control for Type I error, Bonferroni corrections were applied during post hoc comparisons to identify specific pairs of sound conditions that produced significant differences in code-switching behavior.

Qualitative Interview Analysis

The semi-structured interviews conducted post-experiment were transcribed verbatim and imported into NVivo 14, a qualitative analysis software. Data were analyzed thematically using the six-phase framework developed by Braun and Clarke (2006), which included Familiarization with data, Generating initial codes, Searching for themes, Reviewing themes, Defining and naming themes, and Producing the report.

Themes were generated inductively, allowing insights to emerge directly from participant experiences. Key thematic categories included:

1. Perceived cognitive distraction or focus under different soundscapes,
2. Emotional responses (e.g., irritation, calmness, nostalgia),
3. Language choice motivations,
4. Conscious awareness of switching.

The integration of quantitative metrics with qualitative perceptions enabled a triangulated interpretation of how ambient soundscapes influenced both observable linguistic behavior and subjective communication experiences in multilingual digital contexts.

4. Results

This section presents the integrated findings from the experimental tasks, corpus analysis, and post-task interviews, highlighting the effects of different auditory environments on the frequency, pragmatic functions, and perceived impact of code-switching in multilingual digital communication.

4.1 Frequency of Code-Switching

Quantitative analysis revealed a statistically significant effect of sound condition on code-switching frequency. A Repeated Measures ANOVA showed that participants produced significantly more code-switches during the urban noise condition (*M = 13.5 switches per 100 words, SD = 2.1*) compared to both silence (*M = 7.2, SD = 1.8*) and the natural sound condition (*M = 5.8, SD = 1.5*) (*F(2, 58) = 31.6, p < 0.001*). Post hoc Bonferroni tests confirmed that all pairwise differences were statistically significant ($p < 0.05$). The elevated frequency under urban noise suggests a cognitive or affective shift that prompts increased reliance on language switching. Participants appeared to default more frequently to their dominant or emotionally expressive language when exposed to cognitively taxing auditory environments, a finding consistent with theories linking cognitive load to linguistic economy (Wiklund & Harder, 2019) .By contrast, the natural soundscape condition elicited the lowest

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frequency of code-switching, indicating that restorative auditory environments may promote linguistic cohesion and reduced need for strategic language shifts.

4.2 Pragmatic Functions of Code-Switching

Functional annotation of the chat transcripts revealed distinct patterns of pragmatic use of code-switching across sound conditions. Using UAM CorpusTool, instances of switching were categorized into functions such as emphasis, clarification, affective expression, disruption management, and creativity.

1. **Urban Noise Condition:** Participants commonly used code-switching to emphasize strong emotions, to manage conversational breakdowns caused by distraction, or to vent irritation. For example, messages like *"Yaar this traffic is insane!"* or *"I'm literally dying here, kitna shor hai!"* reflected emotionally charged switching from Urdu to English or vice versa.
2. **Silence Condition:** Code-switching was more neutral and referential, often employed for clarification of terms, or to switch registers when shifting from casual to slightly formal tones. For instance, participants might use English for technical vocabulary or Urdu for cultural idioms, but the shifts were less emotionally driven.
3. **Natural Soundscape Condition**: Switching was infrequent but when it occurred, it was often playful, creative, or emotionally rich. Some participants used language mixing to convey humor, inner thoughts, or aesthetic appreciation (e.g., *"This feels like a scene from a kahani"* or *"So calm… bas sukoon hai yahan"*), suggesting a more relaxed, expressive mode of communication.

These functional shifts indicate that ambient soundscapes do not just alter how often people switch languages, but why—shaping the communicative purpose behind each switch.

4.3 Participant Insights

Thematic analysis of post-task interviews (n = 30), coded in NVivo 14 using Braun and Clarke's (2006) six-phase framework, uncovered clear patterns in how participants perceived and responded to the different auditory conditions.

1. Under the urban noise condition, participants frequently described feelings of urgency, stress, and mental clutter. Many noted that they switched to their dominant or emotionally expressive language more quickly because they felt "mentally overloaded" or "distracted by the background chaos." One participant remarked, *"When there's traffic and honking in my ears, I just default to Urdu—it's faster and feels more automatic."* Another said, *"English comes out when I'm stressed—it just feels sharper, more direct."*
2. In contrast, the natural soundscape condition was widely described as calming, grounding, and immersive. Participants reported greater mental clarity and emotional balance, with many stating that they could stay in one language for longer stretches and felt "no need to switch." One participant noted, *"It felt like I had more space to think… I stayed in English the whole time without even realizing."* Another said, *"That birdsong in the background helped me slow down—I was actually enjoying the chat."*
3. In the silent condition, participants reported a neutral emotional state, and described their communication as more task-focused or routine. Some stated that the lack of background sound made the chat feel "less real" or "too formal," suggesting that a complete absence of auditory context may strip away some of the emotional nuance present in naturalistic conversation.

Overall, the interviews supported the experimental findings, reinforcing the conclusion that ambient auditory environments significantly shape not just the mechanics but the affective quality of multilingual digital interactions.

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5. Discussion

The findings of this study offer compelling evidence that ambient soundscapes meaningfully shape multilingual behavior in digital communication, particularly with regard to code-switching patterns. The data clearly demonstrate that urban noise environments induce a statistically significant increase in the frequency of code-switching, along with a shift in its pragmatic functions. These shifts reflect users' attempts to manage cognitive load and emotional arousal by relying more heavily on their dominant or emotionally resonant language.

This supports the theoretical predictions of load-induced language adaptation, grounded in Kahneman's (1973) theory of limited attentional resources. According to this model, when individuals are exposed to external stressors—such as chaotic, high-information auditory stimuli—their cognitive systems prioritize efficiency, often manifesting as linguistic simplification or switching to more cognitively accessible linguistic forms. In the context of this study, participants often code-switched under urban noise conditions to reduce linguistic effort or to intensify emotional expression, indicating a functional adaptation to a taxing environment. Conversely, the natural soundscape condition revealed the lowest levels of code-switching, and when it occurred, the switching served expressive or aesthetic purposes rather than compensatory ones. This finding aligns with Attention Restoration Theory (Kaplan, 1995), which posits that natural environments facilitate mental recovery, emotional regulation, and sustained attention. Participants' reports of feeling "calm," "focused," and "immersed" during these conditions further reinforce the notion that restorative soundscapes promote linguistic cohesion and reduced cognitive interference. By embedding multilingual behavior within the framework of acoustic ecology (Schafer, 1993), this research expands the scope of traditional sociolinguistics and psycholinguistics. It demonstrates that the auditory dimension of one's physical environment—often overlooked in digital communication studies—acts as a contextual cue that can trigger both strategic and subconscious linguistic adaptations. These results also intersect with emerging discussions in sociophonetics and digital pragmatics, where scholars increasingly emphasize the interplay between sensory input, affective states, and linguistic choices (Tagg & Seargeant, 2019; Zhang & Xie, 2021).

6. Implications

6.1 Theoretical Implications

This study contributes to socio phonetics, digital multilingualism, and CMC research by introducing environmental affect as a critical variable in language behavior. Most existing models of digital code-switching focus on sociocultural, technological, or interpersonal factors. This research suggests that physical context—especially auditory context—should be considered a core component of communicative competence in digital environments.

By integrating insights from auditory cognition, affective science, and linguistic pragmatics, the study offers a more ecologically valid framework for understanding multilingual behavior in digitally mediated spaces. This could inform future research in mobile discourse analysis, language processing, and human-computer interaction, particularly in dynamic, real-world settings.

6.2 Practical Implications

The findings also have practical relevance for designers of messaging platforms, educators, and workplace managers operating in multilingual environments:

1. For technology developers, these insights point to the potential of creating adaptive communication interfaces that respond to the user's environment. For instance, platforms might integrate background noise detection features and offer real-time suggestions for focus modes, language simplification, or auto-adjustments in tone prediction systems.

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2. In educational settings, especially in multilingual classrooms or online learning environments, instructors could use controlled soundscapes to enhance student engagement and clarity. For example, reducing urban auditory clutter in virtual classrooms may improve focus and reduce reliance on code-switching as a compensatory mechanism.
3. In multilingual workspaces, curating sound environments (e.g., nature-based ambient music) during online meetings or digital collaboration may promote greater cohesion in language use, facilitating clearer communication and emotional regulation.

7. Limitations and Future Research

Despite the valuable insights yielded by this study, several limitations should be acknowledged:

1. **Sample Size and Demographics**: With 30 participants drawn from urban Pakistan and limited language pairings (e.g., Urdu-English, Punjabi-Urdu), the findings may not generalize to other multilingual populations, especially those with different linguistic hierarchies or cultural sound norms.
2. **Controlled Laboratory Setting**: While the study simulated realistic chat conditions, participants were still aware of the experimental context. Future studies could incorporate field-based data collection using mobile monitoring or naturalistic observation techniques to validate ecological authenticity.
3. **Lack of Physiological Measures**: The study relied on self-reported emotional responses and behavioral observation. Incorporating physiological measures such as EEG, heart rate variability, or eye-tracking could provide a more direct assessment of cognitive load and emotional arousal under varying auditory stimuli.
4. **Cross-Cultural Comparisons**: Future work should explore how cultural attitudes toward sound, silence, and language use may mediate these effects. For instance, cultures that valorize silence or linguistic purity may respond differently to environmental noise than those with more fluid or expressive code-switching norms.

8. Conclusion

This study demonstrates that ambient soundscapes are not passive or neutral backdrops in digital communication—they are active, dynamic contexts that modulate how multilingual individuals use language in text-based interaction. Urban noise was shown to increase cognitive strain and emotional reactivity, resulting in more frequent and strategically motivated code-switching, while natural soundscapes appeared to support linguistic cohesion, emotional regulation, and reflective communication. By illuminating the intersection of auditory environment, cognitive processing, and multilingual discourse, this research contributes to a deeper understanding of language use in technologically mediated and environmentally situated communication. It invites researchers, educators, and designers to consider sound not merely as noise or ambiance, but as a meaningful variable that shapes how we express ourselves, what we choose to say, and in which language we say it. In an increasingly noisy, globalized, and digitally connected world, understanding the echoes of emotion embedded in our sonic surroundings may be key to enhancing clarity, empathy, and connection in multilingual communication.

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