



AI-DRIVEN SOLUTIONS FOR ENHANCING LISTENING COMPREHENSION FOR ROUTINE AND EMERGENCY COMMUNICATION

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Abstract. An effective verbal marine interaction depends on the level of listening comprehension of the parties involved in communication process. Listening is an important perceptual skill, which supports the appropriate feedback and facilitates smooth communication. Consequently, listening provides an essential competence, necessary to develop the future seafarers' ability to implement a safe ship-to-ship, ship-to-shore and onboard verbal communication. Accordingly, maritime educators shall deliver an appropriate training in accordance with the requirements of the STCW Code (Table A-II/1) and corresponding level of the Common European Framework of Reference for Languages. Thus, the paper is aimed to present the results of conducted research, based on reveal of listening requirements, comprehension barriers and involvement of AI solutions to fill in detected gaps. The implemented comparative analysis of the STCW required communication competence and the teaching aids, recommended by the IMO Model Course 3.17 "Maritime English" resulted in detection of the lack of teaching resources, directly aimed at listening skills development and improvement. The research implemented among the students of Marine Navigation educational programme and active seafarers of operational level, detected the next priorities of factors, impeding the effectiveness of listening comprehension: speech speed, national accents, background noises, and content difficulty. Accordingly, the research offers the audio examples of AI platforms-created (OpenAI, Microsoft Edge TTS, Google Text-to-Speech, NaturalReader, TTSMP3, iSpeech, VoiceMaker, Text to Speech Reader by 101 Soundboards, ElevenLabs) teaching data, recorded in compliance with the IMO SMCP's requirements, but providing the simulation of marine communication, performed in different speech levels, national accents, and with imitated natural and man-made noises. The paper-based teaching aids are proposed to become the background of the IMLA members' mutual project, aimed at creation of a network to share teaching and testing resources, supporting an effective development and improvement of listening comprehension.

Keywords: Perceptual Skill; Comparative Analysis; AI Solutions.

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1. INTRODUCTION

In the multifaceted and high-risk environment of maritime operations, effective communication serves as the cornerstone for ensuring safety of navigation, crew wellbeing, operational efficiency, and compliance with the international maritime regulations. The maritime domain, characterized by its transnational workforce, complex machinery, and dynamic environmental conditions, demands precision and clarity in information exchange. Among the core communication skills, listening remains underexplored and frequently undervalued, despite its foundational significance in facilitating accurate message interpretation, informed decision-making, and synchronized team coordination. Unlike speaking or orders-giving, which often receive greater emphasis in training, listening is an inherently receptive process that requires active cognitive engagement. It is not limited to the passive reception of auditory information, but involves interpreting, processing, and acting upon verbal instructions, acoustic signals, and ambient auditory cues. The lack of effective listening is a known precursor to many maritime incidents, as evidenced by numerous accident reports and scholarly investigations. For example, the modern researches identified communication breakdowns, particularly those related to inadequate listening, as a recurrent root cause in events such as collisions, groundings, and machinery mishandling. (Hetherington et al., 2006) The operational demands of maritime work further accentuate the importance of listening. Maritime activities-ranging from navigation and cargo handling to SAR operations and emergency drills-require seamless coordination among crew members, interaction with port authorities, and real-time communication with shore-based stakeholders. These activities often occur under challenging conditions such as high workload, fatigue, inclement weather, loud operational environments, and the presence of multiple accents and languages. In such contexts, the listener's ability to accurately comprehend instructions, alarms, and situational cues is critical to both safety and performance. Moreover, maritime industry has seen increasing multiculturalism aboard ships, necessitating greater linguistic and cultural sensitivity. The presence of multinational crews underscores the need for active and empathetic listening, particularly when Standard Marine Communication Phrases (SMCP) and Maritime English are used as lingua franca across different cultural contexts. The capacity to listen across accents, interpret non-native expressions, and validate understanding contributes directly to trust, morale, and operational cohesion. Therefore, listening is a core maritime competency, integral not only to individual performance but to collective safety, effective teamwork, and the overall reliability of shipboard operations.

2. LISTENING COMPREHENSION AS THE PART OF HUMAN ELEMENT AT SEA

Human factors are increasingly recognized as central to the understanding and prevention of maritime accidents. The International Maritime Organization (IMO) and numerous safety reports, including those from the Marine Accident Investigation Branch (MAIB), estimate that human error accounts for over 75% of marine casualties globally. Within this broad category, communication failures are consistently highlighted as key contributors to incidents involving collisions, groundings, and equipment mishandling. (MAIB, 2013)

Listening, though often overshadowed by speaking and command issuance in communication training, is critical to the feedback loops essential for coordinated action and situational awareness. The Bridge Resource Management (BRM) paradigm emphasizes closed-loop communication. This model stresses that for communication to be effective, the recipient must not only hear but also comprehend and confirm the message. In high-stakes scenarios where time is limited and stress levels are elevated, the ability to listen actively and respond accurately becomes essential for safe navigation, resource allocation, and decision-making. Listening is frequently the weakest link in team-based operations during critical phases such as pilotage, berthing, and emergency response. Therefore, to address the persistent and complex challenges of international communication in the maritime domain, the International Maritime Organization (IMO) introduced the Standard Marine Communication Phrases (SMCP) in 2001. The SMCP was developed with the explicit goal of reducing ambiguity and enhancing clarity in verbal interactions between ships, and between ships and shore-based authorities, particularly in high-stakes scenarios. These standardized phrases serve to facilitate precise, unambiguous exchanges across multilingual crews and among maritime professionals occupying various ranks and responsibilities. They are especially critical during emergency maneuvers, pilotage, navigation in congested waters, and coordination with traffic control services. Despite the structured clarity offered by the SMCP, its operational effectiveness is heavily dependent on the listening competencies of seafarers. While the standardization of phrases reduces variability in linguistic output, the comprehension of these phrases by the receiver-often under stress and in acoustically challenging environments-is equally essential. Real-world conditions aboard vessels, such as engine noise, poor radio quality, open-deck wind interference, and overlapping communications, can significantly degrade the intelligibility of spoken language. Furthermore, seafarers may encounter diffi-

culties in decoding SMCP when they are spoken in diverse non-native English accents or when local intonations and speech rhythms affect articulation. This is particularly evident in bridge operations, where rapid and simultaneous communications are routine, and any lapse in comprehension may compromise navigational decisions. Training programs in Maritime English, while mandatory in many maritime education and training (MET) institutions, have traditionally prioritized written and spoken proficiency over receptive auditory skills. Curricula often focus on the correctness and fluency of speech production, leaving listening skills underdeveloped. As Cole and Trenkner observe, a significant proportion of cadets can accurately recite SMCP in a classroom setting, yet struggle to interpret the same phrases during real-life operations when stress, noise, and accent variation are introduced. This reveals a gap between theoretical knowledge and practical competence. (Cole et al., 2009) In multinational crew environments, where English serves as a lingua franca, the stakes are even higher. Variability in language proficiency across crew members often results in uneven communication capabilities, which increases the reliance on effective listening as a compensatory skill. In such contexts, listening is not merely about understanding words but about interpreting intent, identifying urgency, and ensuring mutual confirmation-skills that require intentional development and reinforcement. Without structured listening training integrated into Maritime English instruction, the potential of SMCP to enhance safety and operational coordination remains only partially realized. Therefore, to close this competency gap, a pedagogical shift is needed-one that repositions listening as a core skill in language training and maritime safety strategy.

Contemporary merchant vessels are characterized by a high degree of cultural and linguistic diversity. Ships frequently operate with crews composed of multiple nationalities, including officers and ratings from Asia, Europe, Africa, and the Americas. While this diversity offers operational benefits, it also introduces a range of communicative complexities. Variations in accent influenced communication styles can impede mutual understanding, increase cognitive load, and lead to misinterpretations.

The bridge is the command center of a ship, and listening is an indispensable component of safe and efficient navigation. Bridge team members are continuously engaged in receiving and interpreting auditory information from various sources such as VHF radio communications, navigational orders from senior officers, engine room coordination, and equipment alarms. Effective listening is essential for ensuring the correct execution of helm orders, main-

taining situational awareness, and identifying potential hazards. Misinterpretation or partial reception of commands, particularly during high-stress operations such as port entry, collision avoidance, or pilot boarding, can result in severe consequences. The 2002 collision involving the MV Tricolor exemplifies this risk. In this case, inadequate listening under conditions of restricted visibility and VHF miscommunication contributed to a multi-ship accident in the English Channel. This incident underscores the need for listening training tailored to real-world noise levels and stress-inducing environments.

Active listening-defined as a structured and intentional effort to understand the speaker, involving clarification, summarization, and non-verbal feedback-is crucial in such environments. It helps bridge linguistic gaps, enhances mutual respect, and supports efficient information exchange. Trenčansky and Lalík emphasize the concept of "culturally competent listening," wherein listeners are aware of their own cultural biases and remain open and attentive to different communicative norms. (Trenčansky et al., 2014) They note that failure to engage in culturally sensitive listening can result in operational friction, low morale, and in extreme cases, safety hazards due to incorrect task execution or failure to follow safety procedures.

Emergencies at sea-such as man overboard incidents, onboard fires, or collision response-require immediate, coordinated action based on verbal communication. Seafarers must be able to comprehend rapidly delivered instructions, often delivered under duress, in challenging auditory environments. Delays in recognizing or misunderstanding key emergency orders, such as "abandon ship," "don lifejackets," or "close watertight doors," can compromise the safety of both individuals and the entire crew. Furthermore, during lifeboat drills or firefighting exercises, listening skills are essential for learning procedural nuances and ensuring synchronized team responses. A proactive safety culture is one in which communication flows freely across ranks, and listening is practiced as a deliberate, valued behavior. When senior officers actively listen to feedback, safety concerns, and suggestions from junior crew members, they create an environment where crew feel psychologically safe and empowered to speak up. This two-way communication strengthens team cohesion and enhances risk detection, as frontline workers often notice safety hazards before they escalate. The act of listening also conveys respect and attentiveness, reinforcing morale and professionalism. Conversely, when listening is lacking-especially from leadership-crew may become disengaged, stop reporting safety issues, or even adopt risk-prone behaviors due to perceived indifference. Embedding listening as a cultural norm requires

formal leadership training, structured debriefings, and feedback mechanisms where listening behavior is recognized and rewarded. Listening is a high-level cognitive function that requires attention, working memory, language processing, and situational interpretation. During stressful conditions-such as during emergencies, night shifts, or extended operations-these cognitive faculties can become impaired. Fatigue, emotional strain, and time pressure reduce the brain's ability to focus, increasing the risk of listening errors. Seafarers working under such cognitive loads may miss key details in safety briefings, misinterpret commands, or become delayed in responding to time-sensitive communications. Training should, therefore, include stress inoculation techniques-exposing seafarers to simulated high-pressure conditions where they practice maintaining listening accuracy. This not only enhances individual performance but contributes to team resilience and error reduction during real operations.

2.1. Enhancing Maritime Communication Competency via Text-to-Speech (TTS) AI and IMO SMCPs with Varied National Accents

Recent developments in TTS models (e.g., OpenAI, Microsoft Edge TTS, Google Text-to-Speech, NaturalReader, TTSM3, iSpeech, VoiceMaker, Text to Speech Reader by 101 Soundboards, ElevenLabs) allow for high-quality speech generation with accurate accent control. These systems can produce speech in a variety of English dialects (e.g., Indian, Nigerian, British, Filipino, etc.), simulating requested communication conditions in the maritime domain. For this study, we evaluated above mentioned TTS platforms capable of generating audio in multiple English accents. A test set of SMCP phrases was created and synthesized in 6 different national accents (Indian, Chinese, Filipino, Spanish, French, German) using the mentioned above TTS platforms. The cadets (50 cadets of Batumi State Maritime Academy), participated in the research were trained using AI-generated audio with SMCPs spoken in varied accents at different speech speed with some background man-made and natural noises.

3. CONCLUSION

The integration of national accent variability, different speech speeds and background noises into SMCP (Standard Marine Communication Phrases) training provided the following pedagogical and operational advantages. These benefits extend beyond mere listening skill development, contributing to greater situational awareness, reduced miscommunication, and improved safety culture on board. Seafarers rarely communicate in environments where English is

spoken in a neutral or native-standard accent. In reality, English as a lingua franca in maritime contexts is shaped by the phonological influences of speakers' first languages. By exposing cadets to a wide spectrum of English accents-such as Indian, Chinese, or West African-AI-generated SMCP audio enables more accurate anticipation and recognition of real-life speech patterns. This reduces cognitive load during actual operations and increases comprehension accuracy in high-pressure situations, such as collision avoidance or distress communication. Repeated exposure to multiple accents enhances learners' ability to parse meaning from less familiar or nonstandard pronunciations. This auditory flexibility mirrors the adaptive processing required in global maritime settings, where environmental noise, VHF radio interference, and variable speech clarity are routine. Training with accent-diverse SMCPs simulates these unpredictable conditions and cultivates a stronger capacity for contextual inference and linguistic resilience. Traditional maritime English training has often centered around native-speaker models (e.g., British or American English), inadvertently marginalizing the linguistic realities of the global maritime workforce. Incorporating national accents into training validates the presence of non-native English speakers and shifts the focus from accent elimination to intelligibility and shared understanding. This approach fosters inclusive communication practices, aligns with IMO's multicultural operational standards, and builds intercultural competence among cadets. The cadets report worries when communicating in English with colleagues from unfamiliar linguistic backgrounds. Early and repeated exposure to diverse accents during training significantly reduces this apprehension. By normalizing accent variation as part of the learning experience, future seafarers develop greater self-confidence and communicative readiness, leading to more assertive and effective participation in bridge team interactions, drills, and real-time navigation commands. Misunderstandings due to misheard SMCPs have been cited in incident reports related to grounding, collision, and near-miss scenarios. Training cadets to recognize and respond to SMCPs spoken in a wide variety of accents equips them with the auditory skills necessary to detect meaning despite phonetic differences. This increases the likelihood of correct interpretation and execution of safety-critical instructions, especially when time-sensitive decisions must be made. With TTS-AI platforms, maritime institutions can rapidly generate SMCP training modules tailored to the demographic composition of their cadets or anticipated crew compositions. This customizable and scalable approach is cost-effective compared to hiring multiple human voice actors or running multinational simulation exercises.

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