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A Review of Intonation Research at Home and Abroad

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Abstract

As a crucial component of linguistic prosody, intonation possesses significance for verbal communication. The theoretical frameworks of prosodic annotation systems, intonation research, intonation acquisition in second languages (L2), and prosodic focus are all thoroughly reviewed in this paper. The goal is to inquire into the significance and effects of intonation in linguistics. This paper offers fresh perspectives and strategies for the linguistic community's study of intonation, presenting the most recent developments and potential paths in intonation research. By means of a methodical analysis of these four areas, this study not only highlights the main findings and research approaches in the field of present intonation studies, but it also suggests possible future research directions and methodologies to stimulate more linguistics-related scholarly investigation.

Keywords

Theoretical research on intonation; Prosodic annotation system; Second language intonation acquisition; Prosodic focus.

1. Introduction

Tonality studies have attracted a lot of interest lately in linguistics, natural language processing, and language comprehension. As a fundamental part of language systems, intonation uses prosodic elements to convey pragmatic meanings at the sentence level, such as attitude, emotion, and information organization. In addition to conveying information during communication, intonation also provides important clues regarding the speaker's emotional state, the significance of the information, and the purpose of the utterance. Within the discipline of phonetics, intonation encompasses the prosodic elements of phrases, such as pitch, rhythm, duration, and intensity. In more precise terms, however, intonation is the unique pitch quality of sentences [28]. In spite of advancing our knowledge of pragmatic functions and language structure, intonation research is essential for speech technology, phonetics, and linguistics.

Four facets of intonation research will be expounded upon in this article: prosodic focus, theoretical foundations, prosodic annotation systems, and second language (L2) intonation acquisition. The primary goal of investigating intonation systems and fundamental properties is to explore the various types of pitch patterns, the rules governing pronunciation, and the functions they serve in the expression of speech in diverse languages. Furthermore, the goal of theoretical studies focusing on intonation is to create useful frameworks that explain the basic principles and mechanisms of intonation phenomena. Furthermore, it is critical to develop associated annotation systems in order to ensure accurate depiction and examination of intonation. Such systems provide invaluable resources for phonetics and linguistics scholars. Research examining the prosodic focus and intonation of a second language as taught by non-native speakers not only contributes to our understanding of the complexities and distinctions of language acquisition, but also provides insights that can inform and enhance cross-cultural communication.

These studies provide critical empirical and theoretical support for a better understanding of language expression and speech encoding. By conducting a thorough examination and

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assessment of domestic and international research on intonation, we not only improve our comprehension of the essence of language communication but also foster more promising prospects for cross-cultural communication and language instruction, thereby enhancing the practicality of speech technology. Domestically and internationally, the purpose of this paper is to conduct a systematic literature review on intonation research, investigate its primary content, methods, and development trends, and offer insightful references and recommendations for the field's continued development.

2. Theoretical Foundations of Intonation Research

In natural speech, intonation is a complex phonetic phenomenon primarily distinguished by pitch changes. It conveys a lot of linguistic information, such as differences between the imperative, interrogative, declarative, and exclamatory functions of intonation, as well as different rhythmic levels like focus, topic, continuity, and discontinuity. It also conveys paralinguistic information about interpersonal contact and communicative situations, such as emotions, mood, and speaking style. Not related to the linguistic content, intonation can also communicate non-linguistic information, including gender, age, health status, social standing, and regional background [20]. To elucidate and comprehend the functions and consequences of intonation in this multidimensional process of information transmission, numerous scholars have proposed diverse theoretical frameworks and methods. A succession of revisions and advances in theory have been applied to various theoretical concerns.

2.1. Main Theories Abroad

Early in the 20th century, linear analysis predominated in intonation research, which classified intonation as consisting of the onset, nucleus, and coda. The Linear Analysis Theory, initially introduced by Palmer [12], partitioned English intonation into three sequential components: the onset, nucleus, and coda. This theory had a significant impact on subsequent research in the field of intonation. The onset signifies the initial portion of intonation within this theoretical framework, while the nucleus represents the central segment, and the coda signifies the concluding portion. McLean (1996) analyzed ordinary English data using this theory to describe the fundamental characteristics and patterns of English intonation and identify three such patterns: rising, falling, and level.

Michael Halliday, a British linguist, proposed three systems for analyzing the English intonation system: tonality, tonicity, and tone, using theoretical construction and language analysis. Subsequent scholars further synthesised and enhanced these concepts, culminating in the development of the 3T intonation theory [15]. Tonality refers to the manner in which speakers divide significant intonation clusters throughout an uninterrupted flow of speech. Information units in written language are established predominantly through syntactic structure and punctuation. Conversely, speakers employ pauses and intonation changes to segment and organize information in spoken language. As a reflection of how speakers organize and perceive information, these intonation groups correspond to the speaker's perception of information segments. "Tonicity" designates the syllable or word that conveys the primary information or emphasizes a particular aspect of an intonation group. The tonic position of a sentence generally designates the information focus or emphasis point. To illustrate, when a speaker wishes to highlight a particular piece of information, the tonic is frequently placed on the word that contains that information. The pattern of pitch variation among syllables within an intonation group is referred to as"tone." Typical English tones consist of a level tone, a falling tone, and a falling tone. Tone can be utilized to communicate a variety of information or emotions. A falling tone is typically used to denote completed information or inquiries, whereas a rising tone is commonly used to signify inquiries or incomplete information. Furthermore, it interacts in a complex manner with both grammar and semantics, playing a vital role in the

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construction of dynamic speech discourse. The purpose of this theoretical framework is to clarify the operation of intonation in linguistic exchange, emphasize its critical function within sentences, and demonstrate how it contributes to the transmission of information and pragmatic meaning. Since the 1970s, non-linear phonology theory has begun to form and develop. This theory focuses on the interactions and relationships between the components within linguistic units, breaking away from the constraints of traditional linear analysis. It views linguistic phenomena as a network interwoven by multiple factors. The emergence of non-linear phonology theory has enabled researchers to gain a more comprehensive understanding of the nature of intonation phenomena. Among these, the influence and application of the IPO (Intonation, Prosody, and Organization) theory and the AM (Autosegmental-Metrical) theory have been continuously expanding.

The innovative framework known as the IPO theory establishes a link between the conceptual representation of intonation and its concrete expression in speech sounds [30]. It primarily employs phonetic perception experiments to identify the acoustic correlates of intonation phenomena. The result is the phonetic realization of the representation of intonation. Intonation patterns are delineated as discrete occurrences of pitch, wherein segments and movements of pitch are symbolized by intonation contours. This theory describes pitch variation in terms of relative "high" and relative "low" differences in pitch levels, and the speech melody is formed by the alternation of these "high" and "low" pitches.

Established by Pierre Humbert in 1980, the AM (Autosegmental-Metrical) theory is comprised of two essential elements: the metrical theory and the autosegmental theory. Constraints by the prosodic structure, this theory considers intonation contours to be autonomous entities distinct from the text and consisting of two fundamental level tones, H (high) and L (low). The theory's methodology entails combining the binary oppositions H and L into distinct shapes and stress patterns of pitch events. This process establishes a natural correlation between the intonational representation and the phonetic level via tone mapping rules. In brief, the AM theory lays out four main ideas: (a) tone structures are organized in a linear way; (b) metrical accent and pitch accent are different; (c) boundary tones and pitch accents are studied using two basic level tones (H and L) and their combinations; and (d) downstepping affects the overall pitch contours of intonation. These principles enrich our understanding of intonation phenomena by providing diverse approaches and viewpoints for intonation research.

2.2. Main Theories at Home

The examination of intonation in Western languages has a longer historical background, particularly in intonation-based languages such as English and French, where systematic theories regarding intonation have been firmly established. By contrast, the examination of Chinese intonation is still relatively underdeveloped, and a coherent theoretical structure has not yet been established. The majority of Chinese intonation research is closely intertwined with experimental linguistics. Renowned scholars, including Yuen Ren Chao, Wu Zongji, Shen Jing, and Xu Yi, have made significant contributions to the fundamental research on Chinese intonation. They have proposed their own theories and perspectives by integrating experimental phonetic knowledge.

For over 60 years, Zhao Yuanren extensively documented Chinese intonation from multiple perspectives, spanning from the 1920s to the 1980s. He introduced three renowned metaphors—the "rubber band," the "algebraic sum," and the "big waves and small waves" that revolutionized the scientific examination of Chinese intonation structure. He noted that the tone's shape can only be considered average because when it is particularly intense, the highest and lowest points of the pitch will stretch, and when it is particularly soft, they will contract. Figuratively speaking, it is like drawing a median curve on a partially stretched and partially relaxed elastic band. When the band is moved in both an upward and downward direction, the

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amplitude of the curve's vertical displacement increases. When the band is released, the curve becomes less steep, and the amount of fluctuation in the vertical position decreases. He used a metaphor to compare stress to the expansion or contraction of a "rubber band." [36,37].

The original notion of "big waves" and "small waves" pertained to the correlation between the fundamental frequency and harmonics. Later, it was used to describe the relationship between lexical tones and intonation, with lexical tones resembling small waves riding on top of larger intonational waves [1]. In this context, the term "algebra sum" refers to the idea that Chinese intonation is the result of combining the lexical or inherent tones of words with the intonation itself [36]. Nevertheless, this metaphor has sparked extensive controversy in subsequent academic deliberations.

Wu Zongji, a student of Zhao Yuanren, not only carried on his teacher's ideas about Chinese intonation, but also measured the "rubber band effect" and the "small waves and big waves" connection. He analyzed the patterns of intonation variation from the viewpoints of grammar, phonetics, and phonology. Mr. Wu's intonation theory, as outlined by Cao [20], centers around the concepts of "inevitable intonation change" and "probable intonation change." By conducting meticulous experimental analysis on tone changes in two-word, three-word, and four-word combinations in Mandarin, he discovered that tone changes within sentences are complex and diverse. Certain changes in language are considered "inevitable" and are influenced by factors such as pronunciation physiology, grammar, and phonological elements. On the other hand, there are changes that are considered "probable" and depend on factors like mood and discourse.

Shen Jiong [31] introduced the concepts of "tonal domain" and "intonational struture," which shed light on acoustic interfaces and intonation at the sentence level. According to his argument, Chinese intonation can be characterized as a form of tonal modulation that is conveyed through a consistent pattern of stress throughout a sentence. This pattern consists of four components: onset, head, nucleus, and tail. Tone and intonation are assigned to distinct levels and scales of phonological units, and they operate autonomously. Tones and light tones use basic modulation techniques to incorporate pitch regions or contour arches. In contrast, intonation types involve more complex modulation by manipulating the pitch contour line of tone domains, which is referred to as high-order modulation.

Xu Yi's PENTA model and "The Parallel Encoding and Target Approximation Model" suggest that the fundamental frequency curve is a secondary representation of the underlying elements of tone and intonation. In this model, the local pitch targets correspond to syllables. The encoding parameters encompass the dimensions of height, inclination, and magnitude of pitch targets. Encoding parameters govern how each specific objective is implemented in ongoing communication. Parallel encoding is the simultaneous and separate processing of different types of functional information, such as tone, word stress, sentence type (question or statement), focus, and topic. These different types of information are processed independently in different local targets [16].

The domestic theories mentioned above focus primarily on various aspects of Chinese intonation, including its structure, tonal structure, and variations. These theories are specifically designed to capture the fundamental nature and patterns of Chinese intonation. Although they have varying emphases and lack a unified research standard system, all of these approaches offer significant theoretical frameworks and methodologies for studying Chinese intonation. They provide valuable insights and references for further investigating the nature of Chinese intonation.

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3. Prosodic Annotation System

The prosodic annotation system is a framework used to analyze and describe intonation phenomena in language in a detailed manner. The process usually entails marking suprasegmental characteristics such as pitch, duration, and intensity in speech signals to uncover how speakers express meaning, emotion, and attitude through these characteristics. Large-scale corpus availability has made prosodic annotation of them a popular research tool in speech engineering and language studies. Internationally, the two widely used prosodic annotation systems are IViE and ToBI. Each has its own advantages, which vary in terms of annotation levels and phonetic terms used to represent prosodic features.

Pierrehumbert proposed the Autosegmental-Metrical (AM) analysis theory, which has important theoretical implications for English intonation and serves as a fundamental basis for the ToBI annotation system [13]. This theory goes beyond the limits of linear analysis by seeing intonation structure as a complex system made up of syllables, prosodic feet, and other sound sequences. The ToBI system utilizes Pierre Humbert's AM theory to analyze intonation structure and prosodic features. The system examines speech signals and categorizes them into various levels of intonational units, providing a standardized method for describing and analyzing intonational characteristics in speech signals. The ToBI annotation system employs a more systematic and standardized approach to intonation analysis, as opposed to traditional British English intonation analysis methods and Pike's American English Intonation Four-Level Scale.

Conventional approaches and Pike's four-level pitch accent method typically define intonation as a sequence of distinct pitch levels or stages, whereas the ToBI system emphasizes the continuous and dynamic nature of intonation. The ToBI system analyzes intonation by breaking it down into a continuous sequence consisting of two fundamental elements: high (H) and low (L) tones. This allows for different combinations to provide a more precise description of the intonation structure in speech signals. The ToBI annotation system is primarily composed of four tiers: the tone tier, the break index tier, the miscellaneous tier, and the orthographic tier. Additional annotation tiers can be included based on the specific research objectives. To be more precise: (a)Tone Tier: This tier represents the intonational patterns in the speech signal, indicating sequences of high (H) and low (L) tones, as well as their variations and inflection points. (b)The Break Index Tier: it is responsible for identifying the intonational boundaries and pause positions in the speech signal. It also helps to identify the breakpoints between different intranational units. (c)Miscellaneous Tier: This tier denotes additional attributes in the speech signal, such as tonal qualities, speech tempo, and so on. (d)The orthographic tier is responsible for indicating the written content in the speech signal, which represents the transcription or spelling of the spoken text or sentence.

The IViE annotation system, developed using the IViE corpus, aims to investigate the rhythmic variations between dialects. The IViE system has the following tiers, which are derived from the ToBI system. (a) Orthographic Tier: This tier captures the accurate words or sentences uttered by the speaker and transcribes them into written format. (b) Prominence Tier: This tier identifies the syllables in a sentence or discourse that are emphasized or considered important, such as stressed syllables or other significant speech units. The phonological tier encompasses linguistic representations of intonation forms, which detail the linguistic characteristics and structures of phonetic phenomena. (d) Phonetic Tier: This tier represents the diversity in intonation and phonetic attributes, encompassing aspects such as pitch, syllable duration, volume, and so on. (e)Tier Label: This tier provides annotations on the data, including explanations of intonation variations, evaluations of phonetic features, and other relevant information.

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In the 1990s, advancements in computer and digital signal processing technology made it possible to construct and study large-scale speech corpora in China. The Speech Research Lab, pioneers and leaders in this field, took the initiative to create a set of extensive speech data resources. They developed appropriate speech annotation systems, such as C-ToBI and SAMPA-C, to meet Chinese phonetic annotation requirements. Drawing on this basis, they carried out a number of studies on speech rhythm features with an eye toward speech engineering applications. Discourse rhythm structure, intonation structure, stress hierarchy, speech prosody variation, and emotional prosodic expression were among the many topics this research covered.

4. Research on Second Language (L2) Intonation

As globalization progresses, the frequency and intimacy of communication and interaction among people increase. Research on intonation has become particularly crucial, especially in the fields of second language acquisition and intercultural communication. As a crucial subfield of language acquisition, second language intonation research investigates how second language learners come to know and employ the intonation characteristics of the target language. Proficiently acquiring the intonation characteristics of the desired language in intercultural and interlinguistic communication can not only amplify the efficiency of language exchange but also enhance communication and comprehension between language learners and native speakers. Nevertheless, when it comes to acquiring intonation in a second language, there are numerous obstacles to overcome. On the one hand, phonetics, grammar, and pragmatics are among the several elements that affect intonation characteristics. To master them, learners must devote more time and effort because of their complexity and variety. However, because intonation is frequently unconscious, learners may not be aware of how to precisely express the intonation features of the target language, which creates certain challenges for intonation acquisition.

Based on the AM theory, Mennen initially put forth the Second Language Intonation Learning Theory (LILt) in the field of second language intonation. Mennen's (2015) L2 Intonation Learning Theory (LILt) provides a fresh theoretical framework for understanding how second language intonation is acquired. This theory analyzes the disparities in intonation between individuals learning a second language and those who are native speakers. It explores these differences from four distinct perspectives. (a)The system dimension (phonology) examines the disparities in phonological structures between second language learners and native speakers, including variations in pitch, accent, and boundary tones. This research enhances our comprehension of the challenges encountered by second language learners in phonological domains. (b)The phonetic dimension of intonation examines how intonation is expressed at the phonetic level, including the alignment of stress and the shape of pitch curves. This study aims to investigate how second language learners accurately reproduce the intonation features of the target language during speech production. (c)The semantic dimension explores the function of intonation in conveying meaning, particularly in indicating emphasis in interrogative sentences. Second-language learners must acquire the ability to communicate precise semantic information using intonation. (d) Frequency dimension: analyzes the occurrence rate of intonation features. While second language learners and native speakers may possess similar intonation features, their actual frequency of use in communication can vary. This study aims to enhance our comprehension of how second language learners acquire the intonation patterns of the target language. Essentially, the LILt proposal offers a structured framework for acquiring intonation in a second language. This framework helps researchers gain a more thorough understanding of the multiple factors that play a role in the process of acquiring intonation in a second language. Within this theoretical framework, research has been

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conducted on the acquisition of intonation in second language learning, providing novel insights for both theoretical understanding and practical application.

Research conducted on second language intonation abroad encompasses a wide range of topics, such as the acquisition of phonetic characteristics, the perception and production of speech, teaching methodologies and approaches, and intercultural communication. The study participants range from children to adults. Infants can already differentiate their native language from other languages by recognizing the rhythmic aspects of language, including pitch, stress, and pauses. This suggests that even in the early stages of development, infants possess a certain degree of consciousness regarding a second language. During their development, children primarily concentrate on acquiring intonation through the study of pitch characteristics. When studying English, learners focus specifically on pitch variations in intonation. In contrast, when studying Chinese, pitch primarily refers to tones, but it also encompasses aspects of intonation. Current research on adult intonation primarily centers around the contrast between native language acquisition and second language acquisition [4, 5, 7, 18]. In terms of intonation acquisition characteristics, for example, Mennen's study identified bidirectional interference phenomena when Dutch speakers learned Greek intonation [11]. According to the research, the intonation patterns of Dutch speakers have an impact on their ability to learn Greek intonation, and vice versa. The study conducted by Liu and Marnie centered on contrastive and implicational sentence stress [9]. They investigated the intricacies of the English intonation system and examined how Mandarin-English bilinguals and native English speakers employ diverse acoustic characteristics (including pitch range, pitch level, duration, and intensity) to communicate contrastive and implicational information. Zhang and Munro examined the efficacy of intonation instruction through the implementation of audio feedback in the context of intonation instruction [19]. It was discovered that students' pronunciation skills were improved as a result of the facilitated comprehension and correction of intonation errors through personalized intonation feedback. Li and Thompson investigated the influence of intonation instruction on the English pronunciation of Chinese students [8]. They discovered that with systematic instruction in intonation, both English pronunciation and intonation improved noticeably, especially in terms of fluency and naturalness of speech.

An important focus of linguistics has always been the domestic study of L2 intonation, which integrates theories of pragmatics, semantics, and second language acquisition to give life to the static realm of language. Nonetheless, the L2 acquisition of intonation is hindered by the physical characteristics of pitch, intensity, and duration, along with the social aspects of research subjects and perspectives. At present, developing a comprehensive and systematic analysis model for intonation remains challenging [33]. Most domestic research on second language (L2) intonation focuses on the differences between English and Chinese intonation [27, 34] and how to teach L2 English intonation [26, 32]. Furthermore, the research primarily focuses on adults and healthy children, with comparatively less emphasis on studying how children acquire intonation and comparing intonation patterns in different languages. Zhang conducted an analysis of intonation patterns and values, which demonstrated that English has three distinct types of contour tones: T513, T351, and T3513 [35]. In contrast, Mandarin only possesses one contour tone, namely T214. Mandarin also has a pitch contour that starts low and ends high, while English has the opposite pattern, starting relatively high and ending low. It follows that English intonation is far richer and more complex than Mandarin's in terms of pitch values and contour, which facilitates more successful emotional expression and semantic communication. Ji and Li examined the distinct impacts of two training methodologies [25]. The findings of the study revealed the following: (a) explicit training was found to be more effective than implicit training in facilitating intonation acquisition, particularly for general interrogative sentences featuring focal points at the beginning and middle; (b) the effects of both training methods on intonation remained consistent over time, although implicit training exhibited a

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marginally weaker effect on declarative sentences featuring focal points in the middle and conclusion; (c) under implicit training, intonation acquisition was positively correlated with procedural memory and working memory, while under explicit training, it was negatively correlated with procedural memory and positively correlated with declarative memory. Regarding procedural memory, neither training method contributed to the persistence observed.

Generally speaking, pedagogical approaches to intonation teaching and the comparative analysis of intonation patterns between native and non-native speakers continue to be the main topics of study into second language intonation, both domestically and internationally. With an increasing focus on rigorous and varied research methods, this research includes adult learners, children, and people from different linguistic backgrounds. Such research provides a strong theoretical foundation and methodological support for furthering studies into cross-linguistic comparisons

5. Research on Prosodic Focus

Investigations into intonation, a crucial field in phonetics and linguistics, have long captivated scholars. In addition to investigating intonational phenomena, recent scholarly discussions have increasingly focused on the intricate notion of prosodic focus, which has become a central aspect of intonational studies. The important information conveyed in spoken communication is known as prosodic focus, which is often expressed through changes in pitch and duration.

International research on international focus is showing an interdisciplinary trend in which academics from many disciplines offer their own interpretations of its definition, categorization, and marking characteristics. Chomsky defines focus as “a phrase that contains the tonal center,”[3] whereas Jackendoff describes it as “information that is not known by the speaker’s assumed listener.”[6] Since its inception in the mid-1980s, focus theory has emerged as a prominent area of study in Chinese grammar. Throughout the process of localizing this concept, a wide range of perspectives have surfaced. For instance, Fan presented Chomsky’s notion of perceiving focus as the focal point of interest in communication, as indicated by psychological emphasis [22]. According to Gu, in addition to stress, specific sentence structures can also be used to highlight certain elements within sentences [24]. Furthermore, most empirical studies of intonational focus look at the acoustic features of focus in speech signals, such as changes in pitch, volume, and duration. And A variety of individuals are frequently included in research studies, including adults and monolingual or bilingual children [2,5,14,17,29].

A precise understanding and use of prosodic prominence are essential for efficient information transmission in practical communication. As a result, investigating prosodic focus not only improves our understanding of language structure and function, but also has substantial implications for the advancement of speech technology and the improvement of speech pedagogy. By conducting extensive research on prosodic prominence, we can enhance our understanding of how information is conveyed in language communication. This will contribute to the advancement of linguistic theory, provide a theoretical basis for the use of speech technology, and improve language instruction.

6. Conclusion

Intonation, a well-established linguistics research subject, has become an important field of study in linguistics, phonetics, and sociolinguistics. In domestic intonation research, there have been certain developments in theoretical investigation, empirical study, and methodological innovation. Nevertheless, there are several areas where future intonation research in China can be expanded and strengthened:(a) Theoretical Construction and Integration: Enhancing comprehensive investigation and integration of intonation theories, assimilating research

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discoveries from international sources, and establishing a unique Chinese intonation theoretical framework. (b) Empirical Research and Application: carrying out additional empirical investigations to explore the specific features and patterns of Chinese intonation, and utilizing the findings in areas such as speech technology and language instruction. (c)Interdisciplinary Collaboration: Strengthening collaboration with fields such as computer science and psychology, investigating the connections between tone research and other disciplines, and fostering the advancement of interdisciplinary research.(d) Methodological Innovation and Technological Support:Actively investigating novel research methodologies and technological tools, such as speech signal processing and big data analysis, to offer extensive and profound assistance for intonation research.

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