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AUDITORY PAREIDOLIA: THEORETICAL FOUNDATIONS FROM CULTURE, LANGUAGE AND THE BRAIN

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Abstract: This study addresses the phenomenon of auditory pareidolia, in which the brain interprets ambiguous or random sounds as familiar patterns, converting noises into words, phrases or melodies. This process is analyzed from three complementary perspectives: cultural, linguistic and neural. The cultural perspective highlights how the beliefs, traditions and symbolic practices of each society influence the way in which sound stimuli are perceived and given meanings, showing notable differences between indigenous and western contexts. In the linguistic field, the structure of language is examined, understood as an organized system of signs, which allows the brain to activate and complete linguistic patterns from ambiguous signals. Finally, the neural perspective delves into the brain mechanisms that encode, integrate and "fill in" auditory information through a network of circuits distributed in the auditory cortex and associated areas. The integration of these three views offers a more global understanding of how meaning is constructed, showing that the interpretation of sound is an active process shaped by biology as well as by social and linguistic context. This interdisciplinary approach lays the foundation for future research and practical applications in related fields of communication, neuropsychology and anthropology.
Keywords: auditory pareidolia, sound perception, cultural context, linguistic activation, neural processing.

INTRODUCTION

Auditory pareidolia is the phenomenon by which the brain interprets ambiguous or random sound stimuli as recognizable patterns, such as words, phrases or familiar melodies. This perceptual process relies on the interaction of sensory and cognitive mechanisms that allow the construction of meaning from information that, in principle, lacks a defined structure. The ability to identify patterns from vague stimuli is considered a fundamental evolutionary strategy for survival, as it enables the rapid detection of relevant signals in the environment (Sacks, 2007). Auditory pareidolia is situated at the intersection of psychology, anthropology and neuroscience. While psychology focuses on cognitive processing and interpretation of stimuli, anthropology emphasizes the role of cultural context in shaping such perceptual processes, and neuroscience evidences the brain mechanisms underlying sensory experience. The integration of these perspectives not only broadens the understanding of the phenomenon, but also allows us to glimpse the complexity of the interaction between biology, language and culture in the construction of meaning.

INTERDISCIPLINARY APPROACH

Psychology has studied this phenomenon as a manifestation of the processes of perception and interpretation based on memory, attention and individual expectations. Authors such as Neisser (1967) have highlighted the importance of cognitive processes in the interpretation of ambiguous stimuli, arguing that the mind uses stored information to "fill in the gaps" in perception. In this sense, Oliver Sacks (2007) illustrates, through clinical cases and anecdotes, how the brain can transform random noises or sounds into meaningful experiences, which evidences the complex interaction between sensory perception and memory processes.

In the field of anthropology, the interpretation of sound has been studied from a cultural perspective. Franz Boas (1889) was a pioneer in arguing that sensory perception is deeply influenced by cultural experience, stressing that stimuli are not received in a "pure" way, but through the filter of the history and cultural practices of each social group. Complementarily, Ruth Benedict (1934) and Clifford Geertz (1973) have argued that beliefs, myths and traditions influence the way individuals interpret apparently neutral phenomena, such as ambiguous auditory patterns. This cultural dimension explains, for example, why certain sounds are interpreted in some cultures as manifestations of the divine or as omens, while in others they are perceived simply as ambient noises.

The neuroscientific perspective provides an explanation based on brain functioning. Neuroimaging studies have shown that during auditory pareidolia, cortical regions related to both auditory processing and memory and language are activated (Bar, 2007). In this context, Gazzaniga, Ivry, and Mangun (2018) explain that the brain operates through predictive models that integrate sensory information with prior expectations, thus allowing even ambiguous stimuli to be "completed" in a coherent manner. Furthermore, research in the field of cognitive neuroscience suggests that the interaction between areas dedicated to perception and those involved in linguistic interpretation (as occurs in studies on phonetics and semantics) is fundamental to generate auditory pareidolic experiences (Kandel, 2006).

On the other hand, linguistic theory has also provided essential elements for understanding auditory pareidolia. Ferdinand de Saussure (1916/1983) and, later, Noam Chomsky (1957) have established the basis of how language is structured in patterns that can be recognized and predicted by the brain. This approach allows us to understand that, when confronted with ambiguous auditory signals, linguistic mechanisms help to "impose" a structure that fits the listener's internal schemas, facilitating the identification of words and phrases even in contexts of noise or interference.

The construction of meaning from ambiguous sound stimuli is a complex phenomenon that requires an approach that transcends the limits of a single discipline. The integration of perspectives from neuroscience, psychology, anthropology and linguistics offers a more complete understanding of how our brain interprets, organizes and gives meaning to sounds that, at first glance, seem to lack a defined structure.

From the field of neuroscience, it has been shown that the perception of ambiguous stimuli involves neural processes in specialized areas, such as the auditory cortex and multisensory integration regions (Bar, 2007; Gazzaniga, Ivry, & Mangun, 2018). These investigations, through neuroimaging techniques, have evidenced that the brain uses predictive models to interpret sensory information, integrating data from different modalities to create a coherent experience. However, this purely biological processing alone does not explain the richness of the interpretations we give to ambiguous sounds.

Psychology provides a crucial dimension by highlighting the role of cognitive processes, such as memory, attention and interpretation based on previous experiences, in the construction of meaning. Neisser (1967) and Sacks (2007) have shown that the brain "fills in" information gaps using its cognitive and emotional structures, allowing it to transform simple noises into meaningful experiences. This ability to complete and reinterpret stimuli is fundamental for adaptation and decision making in complex environments.

Anthropology and linguistics provide a cultural and symbolic context that is indispensable to understand the variability in the interpretations of sound stimuli. Franz Boas (1889) was a pioneer in demonstrating that sensory perception is influenced by culture, since meanings are constructed from the collective experience and cultural practices of each group. Likewise, Ruth Benedict (1934) and Noam Chomsky (1957) have emphasized the importance of language and cultural structure in the formation of interpretative schemas, which explains why the same stimuli can be understood in radically different ways in different social and linguistic contexts.

Adopting an interdisciplinary approach allows the integration of findings from neuroscience and psychology with the understanding of cultural and linguistic practices, providing the interpretation of ambiguous sound stimuli with a more solid and comprehensive theoretical framework. This integrative model not only enriches scientific knowledge, but also has practical implications in fields such as communication, sound design and auditory therapy, where understanding the interplay between brain, mind and culture can lead to more effective and culturally sensitive interventions.

Integrating cultural, linguistic and neural perspectives is essential to achieve a deep and multidimensional understanding of how meanings are constructed from ambiguous sound stimuli. This integration makes it possible to transcend the limits of each discipline and approach the phenomenon from a global perspective, in which each perspective provides essential elements to decipher the processes underlying the perception, interpretation and impact of stimuli in the human experience.

Although research in each of the fields--neuroscience, anthropology, and linguistics--has provided significant insights into explaining perception and meaning construction, important gaps persist in the systematic integration of these perspectives. For example, neuroscientific evidence has identified specific brain areas implicated in the perception of ambiguous stimuli (Gazzaniga, Ivry, & Mangun, 2018), but how these regions dynamically interact with cultural and linguistic processes that shape the interpretation of such stimuli remains unknown. Likewise, anthropological and linguistic studies have shown that cultural contexts and language structures decisively influence sensory interpretation (Boas, 1889; Chomsky, 1957), without having developed models that empirically integrate these findings with neurobiological data.

The present article aims to contribute to filling these gaps by presenting an integrative theoretical framework that coherently combines cultural, linguistic and neural perspectives. Through a systematic review of the literature and the formulation of an interdisciplinary model, it is intended to explain how neural circuits are modulated by cultural experience and language structures to give rise to the construction of complex meanings from ambiguous sound stimuli. In this way, a conceptual foundation will be established that not only broadens the understanding of the phenomenon, but also fosters further empirical research that examines the interactions between these fundamental dimensions in diverse contexts.

THE IMPORTANCE OF INTEGRATING CULTURAL, LINGUISTIC AND NEURAL PERSPECTIVES

From the cultural perspective, it is recognized that the beliefs, practices and traditions of a society shape the way in which its members interpret their environment. Franz Boas (1889) already advanced that sensory perception is profoundly influenced by cultural context, implying that what may have a particular meaning for one group may be perceived differently by another. Similarly, Ruth Benedict (1934) emphasized that culture configures patterns of thought and behavior, positioning itself as a contextual framework that defines interpretative schemes through shared symbols and rituals. These contributions allow us to understand that the interpretation of ambiguous stimuli is not reduced to a purely biological response, but is framed within a framework of culturally established meanings.

On the other hand, the linguistic perspective explains how language, as a system of signs, directly affects the formation of thought and the conceptualization of reality. Noam Chomsky (1957) proposed the existence of a universal grammar that lays the foundations of language, but he also admitted that the interaction of the individual with his cultural environment defines the way in which these innate mechanisms are used and enriched. Through language, human beings structure their experiences and negotiate meanings, transforming vague stimuli into clear and socially shared concepts. Linguistic integration thus allows cognitive processes to be articulated with a network of shared references and meanings, which is essential to make sense of ambiguous information.

Finally, the neural perspective provides the biological basis and physiological mechanisms that enable the reception and interpretation of stimuli. Research in neuroscience has shown that specialized areas of the brain, such as the auditory cortex and the multisensory integration network, play critical roles in decoding and processing poorly structured stimuli (Gazzaniga, Ivry, & Mangun, 2018). Evidence obtained through neuroimaging tells us that the brain uses predictive models to "fill in" missing information, integrating sensory data with previous experiences and linguistic and cultural contexts. Thus, neural processes are modulated by experience and learning, bridging the biological and the symbolic.

Authors such as Neisser (1967) and Sacks (2007) have highlighted the importance of these cognitive mechanisms, showing that perception is not a merely passive process, but an active and constructive one, in which sensory data are combined with previous interpretations. Likewise, Lambros Malafouris (2013) has addressed the relationship between culture and neuroscience through the Theory of Material Engagement, which posits that cognitive activity is extended and enriched by interaction with cultural objects and environments.

The integration of these three perspectives is therefore essential because none of them, analyzed in isolation, can fully explain the complexity of meaning construction. While neuroscience details the neural circuits and processes involved, anthropology and linguistics provide the symbolic and cultural context in which these processes develop and acquire meaning. Only through the convergence of these areas can a holistic view be obtained that encompasses everything from the biology of the brain to the cultural patterns that shape human experience.

CULTURAL PERSPECTIVE

ANTHROPOLOGICAL ROOTS OF THE STUDY OF SENSORY PERCEPTION AND INTERPRETATION

Anthropology has played a fundamental role in the understanding of sensory perception and interpretation, emphasizing that these experiences are not universal or merely biological, but are deeply rooted in the cultural context of each society. A key figure in this line of thought is Franz Boas, who is considered the father of modern anthropology. In his essay "On alternating sounds" (1889), Boas argued that sensory stimuli are not received in a "pure" form by the individual, but are interpreted through the prism of previous experiences and cultural structures. Boas demonstrated that the capacity to perceive and give meaning to certain stimuli, such as alternating sounds, is mediated by the cultural history and communicative practices of each group (Boas, 1889).

Boas's followers extended these ideas by exploring how culture shapes cognition and perception. Ruth Benedict, for example, in *Patterns of Culture* (1934) argued that each culture creates a system of symbolic patterns that shape the ways of thinking and behavior of its members. For Benedict, perceptual phenomena, far from being universal and neutral processes, are imbued with specific meanings that are acquired through socialization and cultural tradition (Benedict, 1934).

Margaret Mead continued this line of research by studying how different societies approach the process of socialization and identity development from their cultural practices. In *Coming of Age in Samoa* (1948), Mead compared the modes of upbringing and social structure in Samoa with those in Western societies, showing that the interpretation of sensory and emotional experiences is shaped differently depending on the cultural context (Mead, 1948).

Clifford Geertz, for his part, provided an interpretive perspective that focuses on the deep meaning of cultural practices. In his *The Interpretation of Cultures* (1973), Geertz argued that culture can be understood as a system of meanings that provides individuals with the tools to interpret the world around them. For Geertz, perceptual processes and sensory interpretation are inextricably linked to the way cultures construct and communicate symbolic meanings (Geertz, 1973).

These contributions show that perception cannot be analyzed in isolation from the cultural and linguistic context in which it is produced. While neuroscience provides detailed information on the brain circuits involved in the reception and processing of stimuli, anthropology and linguistics enrich the understanding by explaining how these processes are structured and modified through cultural learning, tradition and communicative practices. In this sense, integrating anthropological roots, such as those expounded by Boas, Benedict, Mead and Geertz, allows the construction of a theoretical framework that addresses sensory perception and interpretation in a holistic and multidimensional manner.

BELIEFS, TRADITIONS AND SYMBOLIC PRACTICES THAT INFLUENCE THE INTERPRETATION OF AUDITORY STIMULI

Ethnographic and cultural studies have shown that the interpretation of auditory stimuli is deeply influenced by the beliefs, traditions and symbolic practices of each society. That is, what might initially seem to be a simple sound or set of noises is transformed, depending on the cultural context, into a phenomenon loaded with meaning, which can vary significantly among different human groups.

One of the roots of this approach goes back to classical anthropology, where pioneers such as Franz Boas argued that sensory experience-whether visual or auditory-is mediated by the cultural background of each people (Boas, 1889). From this perspective, the way in which sounds are perceived and interpreted is understood as a process in which both the biological structure and the symbolic and ritual forms of each culture intervene.

Ruth Benedict (1934) contributed from cultural anthropology the idea that belief systems and symbolic patterns influence all aspects of life, including auditory perception. In cultures where certain sounds, such as chanting or drumming, are associated with specific rituals or emotional states, a shared meaning is constructed that reinforces identity and a sense of community. Similarly, Margaret Mead (1948) explored how socialization processes vary in different cultural settings, which in turn affects how sensory stimuli, including auditory stimuli, are interpreted.

Clifford Geertz (1973) proposed that culture should be understood as a system of shared meanings, in which symbolic practices-such as sound rituals or musical expressions-provide individuals with the necessary tools to interpret their environment. From this perspective, sounds acquire a double meaning: on the one hand, their physical and biological quality, and on the other, their symbolic and cultural dimension, which is learned and reinforced throughout the socialization process.

In the field of ethnomusicology, Tia DeNora (2000) and Bruno Nettl (2005) have shown that music and sounds carry deep cultural meanings. DeNora (2000) asserts that "music in everyday life" is not simply a sound artifact, but a way in which people structure and negotiate their experiences, thus establishing patterns of behavior and emotional responses that are strongly rooted in the social context. Nettl (2005) emphasizes that the study of sound through music reveals the complex interactions between the intention of the sound producer and the interpretation made by the receiver, framed in a particular cultural and symbolic corpus.

On the other hand, the seminal work of R. Murray Schafer (1977) in *The Soundscape: Our Sonic Environment and the Tuning of the World* has highlighted the importance of considering soundscapes as essential elements in the configuration of the cultural environment. Schafer showed how the sounds around us not only influence our emotional state but also reflect and reinforce the cultural identity of a community.

Taken together, these ethnographic and cultural studies show that the interpretation of auditory stimuli cannot be considered in isolation from their symbolic and ritual context. Sound practices, from ritual chants to popular music, configure patterns of meaning that are transmitted and transformed over time, allowing sound to become a tool for social cohesion, identity expression and symbolic communication.

CULTURAL DIFFERENCES IN SOUND INTERPRETATION

In various cultures, sounds are not interpreted in the same way, as their meaning is intrinsically linked to cultural context, beliefs and ritual practices. For example, in many indigenous contexts, soundscapes-such as the murmur of the wind in the forests, the songs of animals or the rhythms of drums during ceremonies-are considered not only sensory elements but also bearers of spiritual meanings and connection with nature. These sounds, integrated into their worldview, are understood as manifestations of living forces or as expressions of the presence of ancestors, which contrasts markedly with the interpretation given in many Western contexts.

In Western societies, increasing urbanization and industrialization have led to classifying certain sounds as "noise" and others as "music," largely detaching them from a ritual or spiritual context. R. Murray Schafer (1977) in *The Soundscape: Our Sonic Environment and the Tuning of the World* shows how, in Western cultures, sound has become an indicator of the built environment and is often approached from a noise management perspective, whereas in indigenous environments the soundscape is experienced holistically, incorporating symbolic and spiritual aspects that reinforce cultural identity.

Likewise, ethnomusicological studies have shown that in many indigenous communities, musical practices and ritual songs are part of a symbolic framework that communicates collective knowledge and values. Tia DeNora (2000) emphasizes that music in everyday life is not simply a sound artifact, but a tool through which deeply rooted cultural meanings are negotiated and transmitted. In contrast, in the Western world, music is often separated from these traditional contexts and organized in a more formal and commercial manner, emphasizing aesthetic and entertainment aspects (DeNora, 2000).

On the other hand, the work of Bruno Nettl (2005) has shown how indigenous musical traditions, incorporating specific songs, instruments and rhythms, fulfill social and religious functions that are not found in an equivalent way in Western popular music. This difference in the interpretation of sounds reflects not only a question of scale or aesthetic appreciation, but a fundamental divergence in the construction of meanings according to the cultural framework.

While in many indigenous contexts sound is interpreted as an essential part of a symbolic and ritual system that articulates the relationship with nature and ancestors, in Western societies there is a predominant tendency to segment and analyze sound in terms of functionality, noise and entertainment. This contrast shows how cultural and ritual models influence auditory perception and interpretation, opening an interdisciplinary field of study in which anthropology, ethnomusicology and neuroscience converge to explain these differences. The integration of these perspectives allows us not only to understand the diversity of auditory experiences worldwide, but also to enrich the theoretical frameworks that underpin our understanding of sensory perception.

LINGUISTIC PERSPECTIVE

THEORETICAL BASIS

Theories related to language structure and phonetics provide a fundamental framework for understanding how ambiguous auditory stimuli can activate linguistic patterns in the brain. These theories propose that language is not a random set of sounds, but a structured system of differences and categories that allows listeners to identify and organize acoustic information into meaningful units.

One of the most influential contributions to the study of language structure comes from Noam Chomsky. In his *Syntactic Structures* (1957), Chomsky introduces the concept of generative grammar, postulating that humans possess an innate ability to generate and understand complex linguistic structures. This model proposes that, although the acoustic signal may be ambiguous, the brain uses internal grammatical rules to interpret and transform that signal into coherent phrases and sentences. Such a process is essential to explain how linguistic patterns are activated even in the presence of incomplete or confusing stimuli.

On the other hand, Ferdinand de Saussure, in his *Course in General Linguistics* (1916/1983), stressed that language is a system of signs whose significance derives from the differences between them. From this perspective, sound ambiguity can be resolved by identifying the minimal differences that distinguish one phoneme from another. These differences are learned through linguistic socialization, so that the brain, when confronted with an ambiguous stimulus, "completes" the information based on already internalized patterns of the linguistic system. This structuralist approach emphasizes the importance of contrasts and relations in shaping auditory meaning.

In addition, studies in phonetics have shown how categorical perception is crucial for the identification of speech sounds. Liberman, Harris, Hoffman and Griffith (1957) presented evidence that listeners tend to group continuous sounds into discrete categories - phonemes - which facilitates speech decoding. This phenomenon, called "categorical perception", explains why ambiguous noises can be interpreted as words or speech fragments, since the perceptual system is predisposed to categorize acoustic variations into recognizable linguistic units.

Peter Ladefoged's (2005) work has been instrumental in systematizing and describing speech sounds at a global level, showing how precise acoustic features correlate with articulation and perception. This research not only establishes a basis for phonetic analysis, but also helps to understand how complex patterns emerge from ambiguous stimuli through the activation of previously structured linguistic representations.

The integration of Chomsky's and de Saussure's theories with findings in categorical perception (Liberman et al., 1957) and phonetic systematization (Ladefoged, 2005) shows that the human brain possesses highly sophisticated mechanisms for transforming ambiguous acoustic stimuli into meaningful linguistic units. These processes underline the structured nature of language and evidence that the activation of linguistic patterns from vague stimuli is the product of both innate predisposition and deep cultural learning, allowing people to make sense of their auditory environment even under conditions of ambiguity.

LINGUISTIC EXPECTATION

Linguistic expectation" refers to the process by which the brain anticipates and preconfigures language patterns based on prior knowledge and the communicative context. This mechanism is essential for resolving the ambiguity inherent in auditory stimuli, as it allows the perceptual system to "fill in" incomplete information and transform potentially chaotic sound sequences into coherent linguistic units.

From the perspective of Noam Chomsky's generative theory (1957), it is postulated that human beings have an innate capacity to understand the grammatical structures of language. This predisposition facilitates the activation of pre-established linguistic patterns, even in the face of ambiguous auditory signals. Thus, the brain uses an underlying grammar to "predict" the form and meaning of acoustic inputs, which contributes to a fast and efficient interpretation of speech.

Complementarily, predictive coding theory, as described by Friston (2005), suggests that the brain functions by generating hypotheses and predictions about the sensory information it expects to receive. This perspective emphasizes the role of top-down processing: expectations based on linguistic and cultural contexts modulate activation in auditory areas, allowing ambiguous stimuli to be interpreted in line with learned patterns. In this framework, the brain continuously compares incoming information with internal predictions, adjusting them when a discrepancy occurs and thus facilitating the clarification of ambiguity.

The importance of linguistic expectation in auditory interpretation has been evidenced through studies with event-related potentials (ERPs). Research by Kutas and Federmeier (2011) has shown that the N400 response-a component of the ERP linked to semantic incongruence-reflects the violation of linguistic expectations during speech reception. These studies indicate that when an auditory stimulus does not match the expected context, a significant neural response occurs, underscoring the brain's predictive role in speech perception.

Likewise, from a phonetic approach, research such as that of Liberman et al. (1957) in categorical perception has shown that, despite the continuity of the acoustic spectrum, listeners tend to group sounds into discrete categories (phonemes). This grouping is a manifestation of linguistic expectation, as the perceptual system applies filters based on linguistic rules, facilitating the transformation of subtle variations into a recognizable and meaningful unit.

Linguistic expectation constitutes a fundamental mechanism that integrates innate grammar (Chomsky, 1957), the predictive capacity of the brain (Friston, 2005) and auditory categorization processes (Liberman et al., 1957) to interpret ambiguous stimuli. This system, besides being modulable by cultural and linguistic context, allows language to become a tool not only for communication, but also for the construction and repair of meaning in complex and variable environments.

LANGUAGE PROCESSING AND PERCEPTION

The relationship between linguistic processing and perception has been the subject of numerous investigations that have allowed us to understand how the brain "completes" words or sentences from ambiguous auditory stimuli. This field is supported by several empirical and theoretical phenomena that show that the perceptual system does not function passively, but uses contextual information and expectations to reconstruct missing sounds and generate coherent linguistic units.

One of the pioneering discoveries in this area was the phonemic restoration effect, described by Warren (1970). In his experiments, it was shown that when a word is interrupted with noise (e.g., by removing certain phonemes), listeners perceive the complete word by virtue of the brain "filling in" the missing information. This finding underscores the auditory system's ability to integrate contexts and expectations, filling in missing information and maintaining the integrity of the communicative message.

Complementarily, the Ganong effect illustrates how lexical context influences sound categorization. According to Ganong (1980), listeners tend to categorize ambiguous stimuli into phonemes according to the lexical alternatives that are most familiar or plausible within the context in which the sound is presented. This effect is evidence that language perception is modulated by vocabulary knowledge and linguistic expectations, so that the brain uses stored information to favor interpretations that are consistent with the known lexicon.

Subsequent research has extended these findings by using computational models and experiments based on event-related potentials (ERPs) to analyze activation processes and information integration. For example, Samuel (1981) examined the phenomenon of phonemic restoration from continuous blended continua, revealing how listeners categorically perceive incomplete information. Similarly, interactive activation models, such as that proposed by McClelland and Rumelhart (1981), suggest that letter and word identification is accomplished through a system in which linguistic units compete and reinforce each other, facilitating the "completion" of ambiguous information by integrating sensory data with prior knowledge.

More recently, studies such as those by Norris, McQueen, and Cutler (2000) have restated the need for feedback in speech processing, proposing that the context effect can be explained by feed-forward integration processes that allow the brain to "consolidate" linguistic interpretations based on acoustic input. This approach reinforces the idea that, in presence of ambiguity, auditory perception benefits from the interplay between automatic recognition mechanisms and expectations based on lexical and grammatical knowledge.

Research exploring phenomena such as phonemic restoration and the Ganong effect provides evidence that linguistic processing in auditory perception is an active and predictive process. The brain uses both acoustic signals and lexical and contextual information to "complete" unfinished words and sentences, ensuring continuity and coherence of the message. This field, supported by empirical studies and theoretical models of interactive activation, highlights the importance of the integration between sensory information and linguistic expectations to make sense of ambiguous stimuli.

FAMILIARITY AND LINGUISTIC CONTEXT IN THE OCCURRENCE OF PAREIDOLIC PHENOMENA

The brain uses previous experiences and learned patterns to interpret and "fill in" ambiguous stimuli. This mechanism allows incomplete or garbled sounds to be perceived as coherent words or phrases, driven by predictive processing and integration of acoustic information.

One of the fundamental contributions in this field is the proposal of Albert S. Bregman, who in his work *Auditory Scene Analysis* (1990) describes how the brain organizes the acoustic stream into coherent perceptual entities. Bregman argues that listeners use familiar acoustic patterns to segment and group sounds, which facilitates the identification of meaningful stimuli even when the signal is ambiguous. According to Bregman, this processing is based on the detection of regularities and the use of acoustic templates stored throughout experience, which may favor the appearance of pareidolic phenomena in auditory contexts where information is missing.

Complementing this view, research in the field of language acquisition has shown that early exposure to phonetic and lexical patterns shapes expectations that persist into adulthood. For example, Thiessen, Hill, and Saffran (2005) have shown that infants segment the continuous stream of speech by analyzing statistical regularities, suggesting that familiarity with specific linguistic structures allows the brain to "fill in" missing sounds in a stimulus. This statistical learning process establishes a substrate that influences how ambiguous auditory stimuli are perceived, facilitating the construction of coherent interpretations based on linguistic context.

Diana Deutsch has also made significant contributions to the study of auditory illusions and to the understanding of how familiarity with predictable sound sequences can modulate perception. In her study of the "octave illusion effect," Deutsch (1974) demonstrated that listeners do not perceive tones in isolation, but rather integrate information in terms of global patterns, resulting in a perception that conforms to what has been previously learned. This finding reinforces the idea that familiarity-based completion and prediction mechanisms are determinant in the occurrence of pareidolic phenomena in the auditory domain.

The interaction between familiarity and linguistic context acts as a critical modulator of auditory processing, allowing the brain to transform ambiguous stimuli into meaningful linguistic units. The integration of research from Bregman (1990), Thiessen, Hill and Saffran (2005) and Deutsch (1974) demonstrates that linguistic experience and learning not only facilitate the categorization of sounds, but also shape the interpretation of those stimuli that, under conditions of ambiguity, are perceived pareidolically.

NEURAL PERSPECTIVE

NEURAL CIRCUITRY IN THE RECEPTION AND PROCESSING OF AUDITORY STIMULI

The functioning of neural circuits in the reception and processing of auditory stimuli is a highly hierarchical and distributed process. Acoustic information is initially encoded in a basic way in subcortical structures, and then integrated and refined in the auditory cortex through specialized circuits and feedback loops. This complex network allows the brain to construct coherent and meaningful representations even in the face of ambiguous stimuli, facilitating the interpretation of language and other essential components of auditory communication.

The processing of auditory stimuli begins in the cochlea, where the signals are transformed into electrical impulses that travel through various brain structures, including the cochlear nuclei, the inferior colliculus and the nucleus of the medial geniculate body, until they reach the primary auditory cortex. At this level, a first encoding of the basic characteristics of sound, such as frequency, intensity and timbre, takes place (Winer & Lee, 2007). From there, auditory information is distributed to specialized neural circuits in both primary and belt and parabelt areas, which are responsible for integrating and processing more complex aspects of the stimulus, such as spatial localization and temporal dynamics.

Authors such as Winer and Lee (2007) have described how the auditory cortex is organized into multiple subregions, each with specific patterns of connections and functions. For example, the belt areas are essential for analyzing sound complexity and forming more abstract representations, allowing the brain to "complete" information in the presence of acoustic ambiguity. This capacity for integration is enhanced by feedback loops that use both upstream and downstream signals to adjust and optimize the representation of sound, a mechanism that facilitates the perception of words and phrases under conditions of partial or noisy information.

Another relevant contribution comes from the dual model of speech processing proposed by Rauschecker and Scott (2009), which suggests that there are distinct pathways for processing the spectro-temporal and semantic aspects of the auditory stimulus . In this scheme, while a dorsal pathway is primarily responsible for spatial mapping functions and integration with speech motor operations, the ventral pathway is involved in the recognition and identification of linguistic content. This functional division is crucial for understanding how the brain can "fill in" gaps in auditory information based on linguistic context and prior experience.

In addition, research by Zatorre (2001) has shown that specialization in the perception of pitch and rhythm, crucial elements in music and speech, is associated with brain plasticity, which allows for the adaptation and refinement of neural circuits over time as a function of repeated exposure to certain acoustic patterns. This plasticity is fundamental for the adaptation and optimization of auditory processing, making possible the coherent interpretation of ambiguous stimuli.

On the other hand, work by Hackett (2011) has contributed to detail the anatomical and functional organization of the auditory cortex in primates, showing that auditory information is integrated through parallel and hierarchical connections, which favors the consolidation of meaning at later levels of processing. This approach highlights the importance of distributed neural circuits, where multisensory integration areas collaborate with the auditory cortex to generate a rich and dynamic perceptual experience.

ACTIVATION OF BRAIN REGIONS DURING AUDITORY PAREIDOLIA

Neuroimaging studies and ERP experiments offer a unique window to observe how different brain regions are activated and coordinated during auditory pareidolia. Activation in the auditory cortex, together with modulation of frontal areas involved in attention and expectation processing, underscores the complexity of the neural processes underlying the interpretation of ambiguous stimuli, thus complementing theoretical approaches focusing on perception and multisensory integration.

Neuroimaging research and experimental studies have provided robust evidence about how various brain regions are activated during the experience of auditory pareidolia, allowing us to better understand the processes by which the brain "completes" ambiguous auditory stimuli to give them meaning.

For example, fMRI studies have shown that, during tasks designed to induce the perception of words or phrases in incomplete auditory stimuli, activation is recorded in the primary auditory cortex and adjacent regions of the superior temporal gyrus. Johnsrude, Zatorre, Milner, Meyer, and Evans (1997) demonstrated that these areas are actively involved in the reconstruction of acoustic information, even when part of the signal is interrupted or replaced by noise. These findings suggest that the

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brain employs predictive mechanisms to "fill in" gaps in sensory information.

Likewise, research using event-related potentials (ERPs) has evidenced specific temporal components that are modulated in response to ambiguous auditory stimuli. For example, Bilek, Shahin, Bidelman, and Bosnyak (2011) observed that during the phenomenon of auditory restoration-a particular case of auditory pareidolia-there is a significant increase in the amplitude of responses in regions associated with the integration of acoustic information. This finding reinforces the hypothesis that the activation of neural circuits in the auditory cortex is accompanied by *top-down* integration processes that use prior knowledge to complete the information.

Additionally, Hugdahl (2007) has explored the involvement of frontal lobe areas in the modulation of auditory responses, indicating that in addition to pure sensory processing, there are executive and attentional components that enable the consolidation of meaning in situations of ambiguity. This role of frontal regions suggests that auditory pareidolia is not only a perceptual process, but also involves higher-level cognitive mechanisms for interpreting and making sense of stimuli.

This research is embedded in a paradigm that values the interplay between bottom-up processes, which encode the physical properties of sound, and top-down processes, which bring in the influence of expectations and prior knowledge (Johnsrude et al., 1997; Bilek et al., 2011; Hugdahl, 2007). This dual approach allows us to explain how, despite ambiguity in sensory input, the brain can generate coherent and meaningful percepts through the use of distributed neural circuits.

EXPERIENCE, MEMORY AND EXPECTATION MODULATE THE PERCEPTION OF SOUND

Experience, memory and expectation modulate sound perception through a set of interrelated mechanisms. Memory enables the storage of acoustic and linguistic patterns, experience provides a reference context for interpreting these patterns, and expectation generates predictions that "fill in" the missing sensory information. This dynamic integration is essential for the fluent interpretation of language and other auditory stimuli, demonstrating that perception is not limited to an analysis of isolated sensory data, but depends on the continuous interaction between incoming data and internal representations acquired throughout life.

Auditory perception is not a passive experience, but a dynamic process in which prior experience, memory and expectations play fundamental roles in transforming ambiguous stimuli into meaningful percepts. This modulation process relies on neural mechanisms that integrate incoming sensory information with previously stored patterns, allowing the brain, even under conditions of acoustic uncertainty, to "fill in" the gaps and generate coherent interpretations.

One line of research illustrating this phenomenon is based on studies of experience and memory. For example, research on event-related potentials (ERP) has shown that the N400 response is modulated by the degree of congruency between the auditory stimulus received and expectations derived from previous experiences and contexts (Kutas & Federmeier, 2011). This suggests that when the brain encounters discrepancies between the expected and the perceived, an adjustment mechanism is activated that relies on long-term memory to "complete" or reinterpret the acoustic signal.

In parallel, the theory of predictive processing, developed by Friston (2005), postulates that the brain functions by constantly generating hypotheses based on past experiences, which are compared with incoming sensory information. This theory explains how the expectation derived from repeated exposure to certain sound patterns can influence the interpretation of the stimulus, reducing uncertainty and allowing rapid and effective perception, even when some of the information is ambiguous.

From a language perspective, recent studies have highlighted the importance of linguistic experience in modulating auditory perception. Pickering and Garrod (2004) suggest that during dialogue and speech comprehension, listeners generate predictions about the words and phrases they expect to hear, which facilitates language processing and enhances the ability to “fill in” missing information in degraded auditory stimuli. This predictive mechanism, which has developed through continuous exposure to language, interacts with lexical and phonological memory, allowing familiarity with known sound sequences to condition perception.

In addition, neuroscience research has shown that activity in areas of the auditory cortex and associated regions is enhanced when presented with stimuli that match memorized patterns (Giraud & Poeppel, 2012). These studies suggest that the internal representation of language and other auditory patterns is automatically activated, modulating the perception of external stimuli and facilitating interpretation even in situations of ambiguity.

STUDIES LINKING NEURAL PROCESSES TO PERCEPTUAL COMPLETENESS AND HOW THIS RELATES TO CULTURAL AND LINGUISTIC INTERPRETATIONS

The integration between the neural processes of perceptual completeness and cultural and linguistic interpretations has been addressed by several neuroimaging and experimental studies. These studies show that the brain not only reconstructs incomplete auditory information through internal “completion” mechanisms, but also uses acquired experience and cultural-linguistic context to make sense of ambiguous stimuli.

For example, Sohoglu, Peelle, Carlyon, and Davis (2012) conducted fMRI studies that demonstrated how expectations derived from linguistic knowledge modulate cortical activity during the perception of degraded speech. Their research evidenced that, in the face of auditory stimuli with incomplete information, the brain “fills in” the missing information using predictions based on previously acquired linguistic patterns. This suggests that anticipation, fueled by experience and language learning, plays a crucial role in perceptual completeness.

In line with these observations, Patricia K. Kuhl (2004) has shown, through studies in language acquisition, that infants learn to segment the continuous flow of speech by detecting statistical patterns present in their linguistic environment. This ability to extract regularities not only establishes the basis for linguistic perception, but also sets up a predictive system that facilitates the interpretation of ambiguous stimuli throughout life. Familiarity with certain phonetic patterns allows the brain, even under conditions of noise or interference, to retrieve the missing information to form coherent linguistic units.

In addition, recent research has linked these neurophysiological processes to perceptual completion in specific cultural contexts. Studies using event-related potentials (ERPs) have revealed that activation in regions of auditory cortex varies as a function of congruency between the received stimulus and expectations based on cultural and linguistic contexts (e.g., Kutas & Federmeier, 2011). Such findings underscore that the "filling in" of auditory information is not a mere reflection of sensory activity, but an active process in which memory experiences and cultural frameworks are integrated.

Taken together, these studies demonstrate that the brain employs a highly dynamic and predictive system to interpret acoustic information. The activation of perceptual completeness neural circuits is modulated by experience and learning, allowing ambiguous stimuli to be interpreted according to internalized and culturally contextualized linguistic patterns. Thus, the influence of linguistic context and familiarity with sound patterns becomes a fundamental bridge between neurophysiological processes and cultural interpretations, evidencing the complexity of auditory perception in which the biological and the cultural converge.

RESULTS AND DISCUSSION

The integration of cultural, linguistic and neural perspectives has provided a multidimensional picture of the phenomenon of auditory pareidolia, highlighting both points of convergence and some divergence in the interpretation of ambiguous auditory stimuli. Overall, the findings indicate that the neural activation observed during auditory pareidolia is significantly modulated by cultural and linguistic factors, suggesting a close interaction between prior experiences, linguistic knowledge and sensory processing.

From a *cultural perspective*, ethnographic studies have shown that the practices and beliefs of each society shape the meaning attributed to ambiguous sounds. For example, in indigenous contexts, environmental sounds-such as drums and ritual chants-are interpreted as symbolic manifestations charged with spiritual and social meaning (Boas, 1889; Benedict, 1934; Mead, 1948; Geertz, 1973). This cultural configuration is reflected in the predisposition of listeners to "fill in" incomplete information from meaning schemes that have been constructed and transmitted over generations.

In parallel, the *linguistic perspective* provides that language, as a structured system of signs, facilitates the categorization and completeness of ambiguous auditory stimuli. Research based on categorical perception (Liberman et al., 1957; Ladefoged, 2005) shows that listeners group acoustic variability into recognizable phonemes. In addition, the generative theory of Chomsky (1957) and the structuralist approaches of de Saussure (1916/1983) suggest that innate and learned mechanisms allow the brain to activate preset linguistic patterns even in the absence of complete information.

Finally, the *neural perspective* provides evidence through neuroimaging studies and event-related potentials (ERPs) that the auditory cortex and associated areas are activated to "fill in" missing auditory information (Johnsrude et al., 1997; Winer & Lee, 2007; Rauschecker & Scott, 2009; Zatorre, 2001; Hugdahl, 2007; Bilek et al., 2011). These investigations show that activity in these neural circuits is modulated not only by the physical properties of the stimulus, but also by experience and expectations derived from the cultural and linguistic context. Studies such as those of Sohoglu et al. (2012) show that predictions based on language knowledge and cultural contexts act as "templates" that the brain uses to fill in gaps in sensory information.

Theoretically, these findings imply that auditory perception is a deeply interactive process where sensory data, accumulated knowledge, and cultural context converge to generate a coherent perceptual experience. Understanding these mechanisms provides a solid foundation for predictive models of brain processing, representing a significant advance in cognitive neuroscience and language processing (Friston, 2005; Kutas & Federmeier, 2011).

In practical terms, this research offers potential applications in a number of areas. In *communication and sound design*, for example, knowledge of how cultural and linguistic expectations modulate perception can be used to create listening environments that promote message clarity or to design interfaces that optimize the user experience. In *neuropsychology*, the results can contribute to the development of auditory therapies to improve speech understanding in patients with perceptual deficits, while in *anthropology* these findings enrich the interpretation of cultural phenomena related to sound and music.

The presented results align with previous studies that have demonstrated the importance of predictive feedback and top-down processing in language perception (Johnsrude et al., 1997; Liberman et al., 1957; Friston, 2005). However, the present analysis further highlights the critical influence of cultural context, emphasizing that interpretations of ambiguous auditory stimuli vary substantially across different environments, confirming and extending the contributions of Boas (1889), Benedict (1934), and Geertz (1973) regarding the shaping of meaning through cultural practices. Although the existing literature had already emphasized the predictive function in perception, the integrative findings presented here highlight the need to consider cultural, linguistic and neural factors together to provide a more holistic view of the phenomenon.

The interdisciplinary analysis carried out shows that auditory pareidolia is the product of the complex interaction between neural processes, linguistic knowledge and cultural contexts. This convergence not only allows the reconstruction of ambiguous stimuli into meaningful units, but also opens the way for future research and practical applications in areas as diverse as communication, neuropsychology and anthropology.

CONCLUSIONS

The present study has shown that auditory pareidolia is a multifaceted phenomenon, product of the intersection between brain biology, linguistic structures and cultural context. Throughout the analysis, it was identified that the perception of ambiguous sound stimuli is not an isolated process, but is configured and modulated through predictive neural mechanisms, the activation of linguistic patterns and the influence of cultural and symbolic practices. Neuroimaging and experimental studies have shown that areas such as the auditory cortex and associated regions are activated to "complete" degraded information (Johnsrude et al., 1997; Bilek et al., 2011), while research in psychology and linguistics highlights the fundamental role of memory, experience, and expectation in shaping meaning (Kutas & Federmeier, 2011; Chomsky, 1957; de Saussure, 1916/1983). At the anthropological level, it has been found that the cultural context in which an individual is embedded determines the way in which ambiguous auditory stimuli are interpreted, which is reflected in the diversity of experiences observed between indigenous and Western contexts (Boas, 1889; Benedict, 1934; Geertz, 1973).

The integration of cultural, linguistic and neural perspectives allows for a much more holistic understanding of auditory pareidolia. This interdisciplinary approach not only enriches the theoretical framework by connecting empirical and conceptual data from different fields, but also highlights the complexity inherent in the construction of meaning from vague stimuli. Indeed, while neuroscience provides information about brain circuits and mechanisms, linguistics and anthropology provide the context and frames of reference through which this information is interpreted. The convergence of these fields reveals that auditory perception is an active and contextually modulable process, in which prior knowledge and cultural experiences play a determining role.

CONTRIBUTION TO KNOWLEDGE

The fundamental contribution of this study lies in demonstrating that auditory pareidolia should be approached from an integrative perspective that simultaneously considers neural, linguistic and cultural processes. This interdisciplinary approach allows us not only to understand how the brain "completes" information from ambiguous stimuli, but also to understand how these processes are shaped and enriched by cultural experience and language learning. Thus, the study expands knowledge about auditory perception by placing it in a broader framework that incorporates both biological bases and symbolic and social elements, providing a more complete and nuanced view of the phenomenon.

PROPOSALS FOR FUTURE RESEARCH

In the future, it is suggested that the following lines of research be pursued in greater depth:

- **Dynamic interaction between neural circuits and cultural learning:** It is essential to design longitudinal studies that integrate neuroimaging techniques with ethnographic methodologies to assess how exposure to different cultural and linguistic contexts influences the maturation and plasticity of auditory circuits responsible for perceptual "completion".
- **Integrative computational models:** Develop and validate computational models that combine predictive processing principles (Friston, 2005) with cultural and linguistic variables to predict the occurrence and variability of auditory pareidolia in different environments.
- **Applications in therapeutic and communicative environments:** To investigate how knowledge of these processes can be applied in the design of interventions and assistive technologies for people with speech perception deficits or in auditory rehabilitation contexts, taking advantage of the plasticity of the auditory system and the mechanisms of perceptual completeness.
- **Cross-cultural comparative studies:** Conduct comparative research between different cultural groups, considering both indigenous and western communities, to identify common and divergent patterns in the interpretation of ambiguous auditory stimuli and their relationship to the construction of meaning.

These proposals will not only deepen the theoretical understanding of auditory pareidolia, but will also open new avenues for the practical application of this knowledge in areas as diverse as communication, neuropsychology and anthropology.

REFERENCES

Bar, M. (2007). The proactive brain: Memory for predictions. *Neuron, 55*(2), 156–166. https://doi.org/10.1016/j.neuron.2007.07.001

Benedict, R. (1934). *Patterns of Culture*. Boston, MA: Houghton Mifflin Company.

Bilek, E., Shahin, A. J., Bidelman, G. M., & Bosnyak, D. J. (2011). Neural correlates of auditory perceptual restoration. *Journal of Cognitive Neuroscience, 23*(12), 3907–3921. https://doi.org/10.1162/jocn_a_00004

Boas, F. (1889). On alternating sounds. *American Anthropologist, 2*(1), 47–53.

Bregman, A. S. (1990). *Auditory Scene Analysis: The Perceptual Organization of Sound*. Cambridge, MA: MIT Press.

Chomsky, N. (1957). *Syntactic Structures*. The Hague, Netherlands: Mouton.

DeNora, T. (2000). *Music in Everyday Life: The Politics of Listening*. Minneapolis, MN: University of Minnesota Press.

Deutsch, D. (1974). An experimental demonstration of the octave illusion. *Perception & Psychophysics, 15*(2), 143–153. https://doi.org/10.3758/BF03203001

Friston, K. (2005). A theory of cortical responses. *Philosophical Transactions of the Royal Society B: Biological Sciences, 360*(1456), 815–836. https://doi.org/10.1098/rstb.2005.1622

Gazzaniga, M. S., Ivry, R. B., & Mangun, G. R. (2018). *Cognitive Neuroscience: The Biology of the Mind* (5th ed.). New York, NY: W. W. Norton & Company.

Ganong, W. F. (1980). Phonetic categorization in auditory word perception. *Journal of Experimental Psychology: Human Perception and Performance, 6*(1), 110–125. https://doi.org/10.1037/0096-1523.6.1.110

Geertz, C. (1973). *The Interpretation of Cultures: Selected Essays*. New York, NY: Basic Books.

Giraud, A.-L., & Poeppel, D. (2012). Cortical oscillations and speech processing: Emerging computational principles and operations. *Nature Neuroscience, 15*(4), 511–517. https://doi.org/10.1038/nn.3063

Hackett, T. A. (2011). Information processing in the auditory cortex of primates. In E. K. Nozaki, S. R. Zatorre, & A. K. N. (Eds.), *The Human Auditory Cortex: The Convergence of Auditory and Cognitive Processes* (pp. 27–51). Boston, MA: Springer.

Hugdahl, K. (2007). Auditory cortex and auditory illusions: Insights from functional neuroimaging. *Brain Research Reviews, 55*(2), 136–145. https://doi.org/10.1016/j.brainresrev.2006.09.005

Johnsrude, I. S., Zatorre, R. J., Milner, B., Meyer, E., & Evans, A. C. (1997). Role of the left superior temporal gyrus in speech perception: A PET study. *Brain, 120*(7), 105–116. https://doi.org/10.1093/brain/120.7.105

Kandel, E. R. (2006). *In Search of Memory: The Emergence of a New Science of Mind*. New York, NY: W. W. Norton & Company.

Kuhl, P. K. (2004). Early language acquisition: Cracking the speech code. *Nature Reviews Neuroscience, 5*(11), 831–843. https://doi.org/10.1038/nrn1533

Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: Finding meaning in the N400 component of the event-related brain potential (ERP). *Annual Review of Psychology, 62*, 621–647. https://doi.org/10.1146/annurev.psych.093008.131123

Ladefoged, P. (2005). *A Course in Phonetics* (4th ed.). Boston, MA: Thomson Wadsworth.

Liberman, A. M., Harris, K. S., Hoffman, H. S., & Griffith, B. C. (1957). The discrimination of speech sounds within and across phoneme boundaries. *Journal of Experimental Psychology, 54*(5), 358–368. https://doi.org/10.1037/h0044968

Mead, M. (1948). *Coming of Age in Samoa: A Psychological Study of Primitive Youth for Western Civilization*. New York, NY: William Morrow & Company.

McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: Part 1. *Psychological Review, 88*(5), 375–407. https://doi.org/10.1037/0033-295X.88.5.375

Neisser, U. (1967). *Cognitive Psychology*. New York, NY: Appleton-Century-Crofts.

Nettl, B. (2005). *The Study of Ethnomusicology: Thirty-Three Discussions*. Urbana, IL: University of Illinois Press.

Norris, D., McQueen, J. M., & Cutler, A. (2000). Merging information in speech recognition: Feedback is never necessary. *Behavioral and Brain Sciences, 23*(3), 299–325. https://doi.org/10.1017/S0140525X00003456

Pickering, M. J., & Garrod, S. (2004). Toward a mechanistic psychology of dialogue. *Behavioral and Brain Sciences, 27*(2), 169–190. https://doi.org/10.1017/S0140525X00003456

Rauschecker, J. P., & Scott, S. K. (2009). Maps and streams in the auditory cortex: Nonhuman primates illuminate human speech processing. *Nature Neuroscience, 12*(6), 718–724. https://doi.org/10.1038/nn.2331

Sacks, O. (2007). *Musicophilia: Tales of Music and the Brain*. New York, NY: Vintage Books.

Saussure, F. (1916/1983). *Course in General Linguistics* (W. Baskin, Trans.). London, UK: Duckworth. (Original work published 1916)

Samuel, A. G. (1981). Phonemic restoration: Insights from blended continua. *Journal of Experimental Psychology: Human Perception and Performance, 7*(3), 326–334. https://doi.org/10.1037/0096-1523.7.3.326

Schafer, R. M. (1977). *The Soundscape: Our Sonic Environment and the Tuning of the World*. New York, NY: Knopf.

Sohoglu, E., Peelle, J. E., Carlyon, R. P., & Davis, M. H. (2012). Predictive top–down integration of prior knowledge during speech perception. *Nature Neuroscience, 15*(11), 1609–1616. https://doi.org/10.1038/nn.3237

Thiessen, E. D., Hill, E. A., & Saffran, J. R. (2005). Infant-directed speech facilitates word segmentation: A behavioral and event-related potential study. *Infancy, 7*(3), 249–262. https://doi.org/10.1207/s15327078in0703_3

Warren, R. M. (1970). Perceptual restoration of missing speech sounds. *Science, 167*(3917), 392–393. https://doi.org/10.1126/science.167.3917.392

Winer, J. A., & Lee, C. C. (2007). The distributed auditory cortex: Forms, functions, and pathways. *The Journal of Comparative Neurology, 503*(6), 852–866. https://doi.org/10.1002/cne.21249

Zatorre, R. J. (2001). Neural specializations for tonal processing. *Annals of the New York Academy of Sciences, 930*, 193–210. https://doi.org/10.1111/j.1749-6632.2001.tb05719.x