Prosody expression in prelingually- and postlingually- implanted deaf adults

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Abstract
Speech prosody - its melody, accent, and quantity - plays a significant role in language communication, including the expression of emotions. Limited prosodic skills in individuals with profound hearing disabilities affect their communicative functioning. Modern hearing prostheses, such as cochlear implants, enable deaf people to develop and utilize auditory and oral language abilities, although not always prosodic ones. The presented results of our own research indicate the importance of the period of hearing loss and the duration of implant use for prosodic effectiveness in cochlear implant users. They also emphasize the need for rehabilitation activities that focus on early prosodic stimulation in prelingually deaf children and prosodic training in prelingually deaf adults.

Keywords: *speech prosody, prelingual and postlingual deafness, cochlear implant*

Introduction

Speech prosody: its melody, accent, and quantity are essential elements of language communication (see Crystal 2010). These factors, which have a musical background, significantly contribute to the reception and expression of speech. This also applies to the realm of emotions in oral communication, which are largely conveyed through prosody. The use of prosody is an intuitive skill acquired through the natural process of language development based on auditory perception. Therefore, in individuals with hearing impairments, both the development of prosodic patterns and their reflection in speech exhibit deficits due to the auditory barrier in their acquisition. An obvious example of this situation is seen in individuals with prelingual deafness, where the hearing impairment occurred during an early stage of language development, causing difficulties in acquiring prosodic patterns and later utilizing them in language interactions. Conversely, individuals who become deaf after the speech development period have a different prosodic background. In this case, prosodic patterns can be preserved, allowing for their reproduction in language communication.

Therefore, there is no doubt that in order to activate or re-activate prosodic skills in both pre- and post-lingually deaf individuals, it is necessary to effectively support their auditory abilities. Currently used hearing prosthetics technologies, such as cochlear implants, together with rehabilitation activities aimed at stimulating auditory and language functions, have significant effects, for the majority of individuals with profound hearing loss (Hand et al. 2021, Geers et al. 2003). This applies to the development of these functions in prelingually deaf children as well as their restoration in postlingually deaf individuals.

Considering the benefits of the implantation procedure, it is worth considering its effects on the prosodic abilities of deaf individuals. This reflection should particularly concern those who are prelingually deaf and implanted in adulthood. Early hearing loss and the lack of effective auditory support resulting from less advanced hearing aids at that time limited their prosodic abilities (see

Osberger and McGarr 1982, Kowalska 1989, La Bruna et al. 1990, Maniecka-Aleksandrowicz et al. 1998: 128). Despite the use of cochlear implants, it is challenging to overcome this deficit, as evidenced by the results of our own research presented in the article. These findings also serve as a contribution to reflecting on post-implantation rehabilitation efforts, their current effectiveness, and future modifications.

The article is an extension of my own text published in 2019 in the journal *Disability. Discourses of Special Education*, referring to the prosodic aspect of functioning in adults who are deaf.

The communicative and emotional dimension of prosody

Language plays a significant role in the development and subsequent cognitive, emotional, and social functioning of individuals (see Prillwitz 1996, Perier 1992). Experiencing the world from an intra- and intersubjective perspective is based on linguistic symbols. Through them, it becomes possible to acquire and process knowledge about the surrounding reality, as well as express subjective experiences and establish interpersonal relationships. Therefore, language enables individuals to navigate the "conversational reality" (Kvale 2004) that accompanies them throughout their lives.

This extremely important communicative aspect of language is manifested in its prosodic dimension, associated with the following elements of speech: accent, melody, and quantity (Crystal 2010, Dłuska 1976, Jadacka 2010, Ostaszewska and Tambor 2000). The first of these elements, accent, distinguishes a specific part of speech through changes in its loudness, length, or pitch. The next element, speech melody, is related to its pitch and dynamics, taking on characteristic intonation patterns specific to each language. These patterns allow for the interpretation of speech as different modes of communication: questions, statements, or commands. The final prosodic factor is quantity, which corresponds to the length of time the speech elements are pronounced and is primarily related to their rhythm and tempo, as well as intensity and pitch. It is also important to consider that in the process of communication, the various prosodic factors correlate with each other, creating what Adam Weinsberg describes as a "prosodic contour" (1983) or what Maria Dłuska refers to as "prosodic semantic units" (1976).

The emotional aspect of human language functioning mentioned earlier is nonetheless important. Emotions are one of the factors that shape and represent language (cf. Liwo 2023). Their significance can be observed already in the early stages of speech development. Behaviors that emerge during this period are primarily saturated with non-verbal, emotional meaning. Infants express them in the form of various melodic vocalizations, combining them with non-verbal elements such as facial expressions, gestures, eye contact, and touch. In doing so, they imitate the adult environment, which communicates with the child through emotional "exaggerations" carried out through pronounced intonation, pace, accentuation, and intensity of individual sounds or entire utterances, constituting their prosodic aspect. The emotional factor is also present in the diminutives and short forms that typically appear in parentese, exemplified by diminutive verbs (Milewski 2011: 30-33).

The emotional dimension of language significantly exposes the prosody of speech. It allows for the recognition and communication of emotions, which is manifested through changes in the acoustic characteristics of the voice (Śmiecińska 2020: 316-317). The melodic line of speech is the factor that has the greatest impact on the emotional message. For instance, the melodic line of speech expressing joy begins with a rising character and ends with a falling one. Similarly, speech expressing anger has a similar contour: it starts with an increase and ends with a sudden decrease. On the other hand, speech conveying sadness is characterized by a descending line. This particular type of melodic line is best recognized in natural speech, whereas the recognition of anger-related speech is weaker, and the recognition of joy-related speech is the weakest. Specific melodic contours allow the listener to intuitively interpret the emotions conveyed in the speech without prior learning or memorization. Similarly, the prosodic sender of emotions does so unconsciously, relying solely on prosodic intuition (see Waryszak 2020: 225-253).

In conclusion, prosody is an important factor that determines the emotional saturation of speech and makes it interesting for the recipient. It seems necessary in the process of communication to establish and maintain the relationship between the sender and the receiver. However, is the ability to use prosody in communication available to everyone, or are there limitations in this area related to biological or cognitive deficits in language skills? One of them is profound hearing impairment, which blocks the acquisition of prosodic patterns and their activation in communication. The issue of prosodic skills in deaf individuals and their support is addressed in the following part of the article.

Prosodic skills of deaf individuals and their support in the implantation procedure

The auditory organ serves as a natural pathway for the acquisition of a spoken language (comp. Domagała and Mirecka 2015: 88). Hearing is essential for mastering the individual elements of the language system: its phonology, grammatical and semantic rules, used for effective communication. It also serves as a foundation for acquiring prosodic patterns of speech. Hearing impairments can therefore be a significant cause of prosodic difficulties. A particularly striking example of this is profound prelingual hearing loss. This is an early, acquired damage to the receptive part of the auditory organ, occurring before the development of speech. In this case, a lowered threshold of hearing results in limited perception and understanding of sounds, including those crucial for language communication. The consequences of prelingual hearing impairment are difficulties in activating linguistic and communicative competencies necessary for the development and use of language, manifested as global and/or partial speech disorders, including its prosodic layer (see Osberger and McGarr 1982, Kowalska 1989, La Bruna et al. 1990, Szkiełkowska 2005: 635-637, Krakowiak 2012: 131-139, Lorenc 2015: 205-208). They are characterized by significant anomalies in terms of accenting, melody, and pace of speech, as well as distinct phonetic disorders related to voice adjustment and intensity during speech. The range of pitch is small, with a tendency for it to decrease. The duration of syllables, on the other hand, is generally prolonged, due to frequent breath pauses. There is also an observed dependence between the direction of speech melody and its intensity, as manifested by an increase in the intensity of melody at its higher registers (see Obrębowski 1992: 360-361, Obrębowski and Wika 2019: 295-297, Krakowiak 2012: 131-139, Lorenc 2015: 205-208). Currently, the problems mentioned are more discreet due to the possibility of quick implantation and hearing and speech rehabilitation. However, the prosodic quality of prelingually deaf individuals' speech thus exhibits deficits, which, combined with poor language and communication skills, often hinder their satisfactory participation in language interactions (see Liwo 2018).

On the other hand, individuals with postlingual deafness possess better prosodic skills. In this case, the hearing impairment occurs after the period of speech development, often in adulthood, which provides an opportunity to acquire prosodic patterns, consolidate them in auditory memory, and later utilize them in communicative situations.

However, auditory, habilitative and rehabilitative support is essential for effective use of prosody in individuals with hearing deficits. Modern hearing prosthetic technologies, such as cochlear implants, along with interventions targeting auditory and language functions, offer the possibility of both developing prosodic patterns in prelingually deaf children and rebuilding them in individuals with postlingual deafness.

The cochlear implant is a microprosthesis of the internal part of the hearing organ, replacing inactive auditory cells. In this case, the perception of acoustic stimuli and their transfer to the auditory centers in the central nervous system occurs through direct electrical stimulation of the auditory nerve. As a result, a profoundly deaf person has the ability to perceive varied auditory sensations. To effectively recognize and identify them, targeted habilitative and rehabilitative actions are necessary, which vary depending on the age and auditory skills of the deaf person (see Liwo 2018 and 2020). For prelingually deaf children, these actions take the form of auditory and language education, aiming to stimulate their

auditory and verbal abilities. In the case of postlingually or prelingually deaf adults, the rehabilitation procedure takes the form of auditory training based on previously acquired auditory and linguistic skills (compare Löwe 1995, Ling et al. 2000, Szuchnik 2005: 653-675). Considering linguistic skills, including prosodic ones, post-implant rehabilitation mainly focuses on auditory speech perception, involving differentiation and identification of the phonological sources of language and its intonational patterns.

The available data from the subject literature emphasize significant effects on improving listening and language skills in the majority of implanted and (re)habilitated children and adults. These data mainly concern the syntactic and semantic layers of language, both in terms of their effective development and their use in communication. To a lesser extent, they relate to the prosodic layer of speech, primarily analyzing groups of postlingually implanted adults (see Wojewódzka 2012) and prelingually deaf implanted children (see Osberger et al. 1991, Cleary et al. 2002, Chin et al. 2003, Dillon et al. 2004, Most and Peled 2007, Lenden and Flipsen 2007, Snow and Ertmer 2009, Binos et al. 2013, Holt 2013, Van de Velde et al. 2019, Liwo 2020).

To a limited extent, prosodic skills of prelingually deaf implanted adults have been analyzed. Such studies have been conducted by N. Jiam, A. Catalano, M. van Zyl (Catalano et al. 2017, van Zyl 2014, Jiam et al. 2017, Cosentiono et al. 2016, Pak and Katz 2019, Christensen et al. 2019, Amichetti et al. 2021, Arias-Vergara et al. 2022, Karimi-Boroujeni et al. 2023), and the author of the presented article (see Liwo 2019). Due to the need for more extensive data in this area, I have undertaken my own research.

Methodology

Considering the aforementioned research limitations regarding the analysis of prosodic skills in deaf, specifically prelingually deaf adults with implants, I conducted a preliminary study aimed at evaluating prosodic elements in the speech of these individuals. The study has been carried out in a Specialized Diagnosis and Rehabilitation Center PZG in Gdańsk in the period from 2017 to 2023. The study included the following groups of implant users:

- 21 prelingually deaf individuals aged 19-63 years old (14 women and 7 men);
- 25 postlingually deaf individuals aged 25-79 years old (19 women and 6 men).

The causes of hearing loss in the group of postlingually deaf people were diverse (sudden deafness in 2 individuals, Menier's disease in 1 individual, progressing hearing loss in 11 individuals, unknown causes in 11 individuals). In the group of prelingually deaf people the majority of causes were unknown.

Both groups were diverse in terms of the duration of hearing loss. In the case of prelingually deaf people, this period depended on their biological age (shorter in younger people than in older people). It is also worth noting that prelingually deaf individuals had used a traditional hearing aid prior to implantation. In the group of postlingually deaf people, the duration of hearing loss differed significantly: in the case of persons who became suddenly deaf, it was about 1 year, in the case of persons with progressive hearing loss even a dozen or so years.

In both groups, the auditory analysis method was used to assess speech utterances in two periods:

- after approximately six months of implant use and auditory training;
- after approximately two years of implant use and auditory training.

The auditory training was based on exercises in differentiating the characteristics of sound (their discrimination and identification) in the field of ambient sounds, music and speech. In particular, it concerned the stimulation of auditory speech perception (phoneme and prosodic hearing).

The conducted auditory analysis was based on subjective auditory impressions elicited by the speech of the participants from prelingually and postlingually groups. The set of speeches used in the study consisted of sentences that varied in terms of length and intonational contour (interrogative, declarative, and imperative). The participants were asked to read different types of sentences, and their statements were recorded on a dictaphone. The prosodic indicators (rhythm, accent, and melody) were evaluated in the listened statements by researcher on a scale of 0-5 in uttered speech. Undertaking this

type of analysis was related to the author's previous research on the evaluation of prosody in deaf infants (Liwo, 2020). Based on previous experience, it was recognized that audit analysis can determine the actual measure of changes in the prosodic area of speech. In comparison, individual prosodic factors in the speech of 23 individuals with normal hearing were subjected to auditory analysis evaluation.

The analysis of the collected data involved comparing the initial and final values of the prosodic indicators (rhythm, accent, and melody) in the examined groups and relating them to the prosodic norm presented in the speech of individuals with normal hearing. Taking into account different numbers in each of the groups, the average values of individual indicators per person in the group were assumed. The gathered data allowed for the assessment of speech prosody quality in implanted adults differentiated in terms of the period of hearing loss.

Results

The conducted analysis indicated significant disparities in the prosodic quality of utterances produced by pre- and postlingually deaf individuals. Additionally, both groups displayed deviations in this aspect compared to the hearing group (see Fig. 1 and 2).

Figure 1: Comparison of prosodic features (rhythm, accent, melody) in groups of prelingually and postlingually implanted persons at equivalent time intervals, with reference to the norm represented by hearing individuals. The height of the histograms corresponds to the average value of prosody indicators per person in the group.

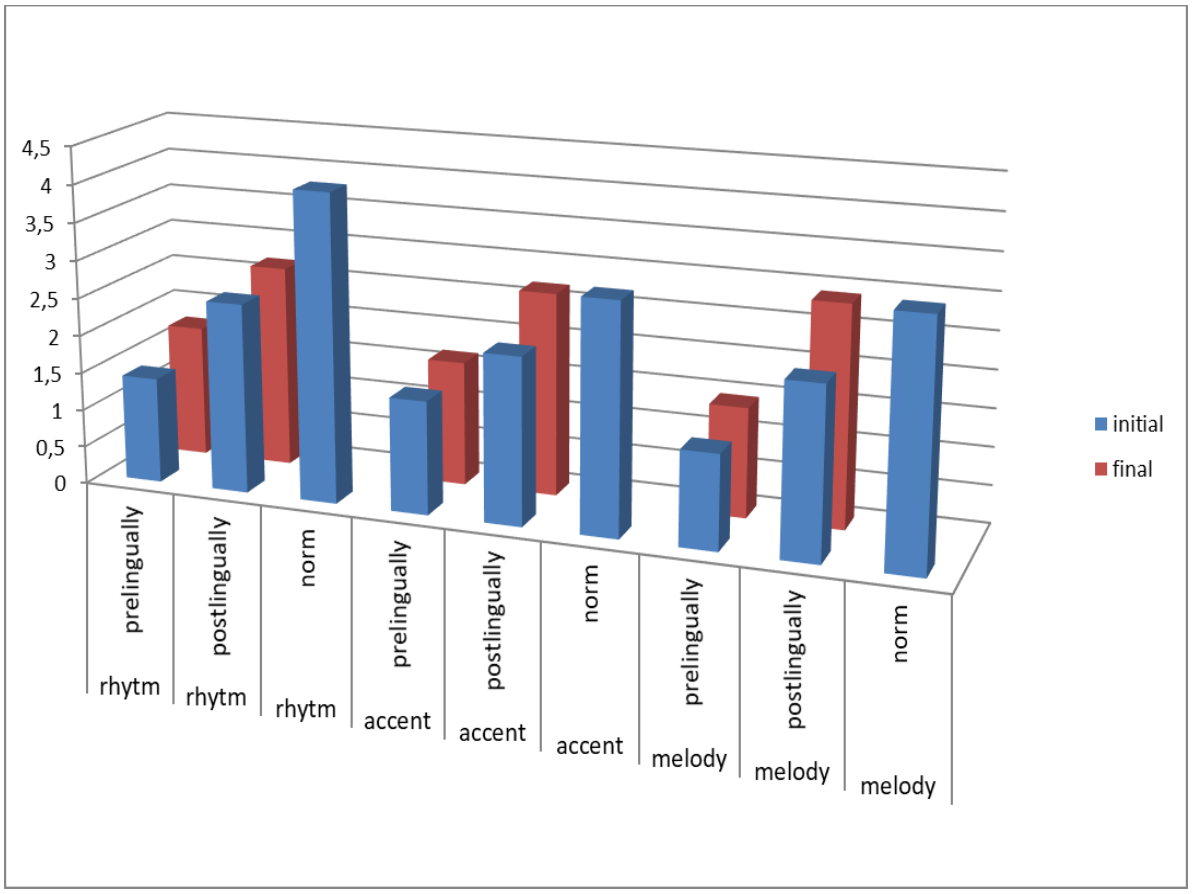
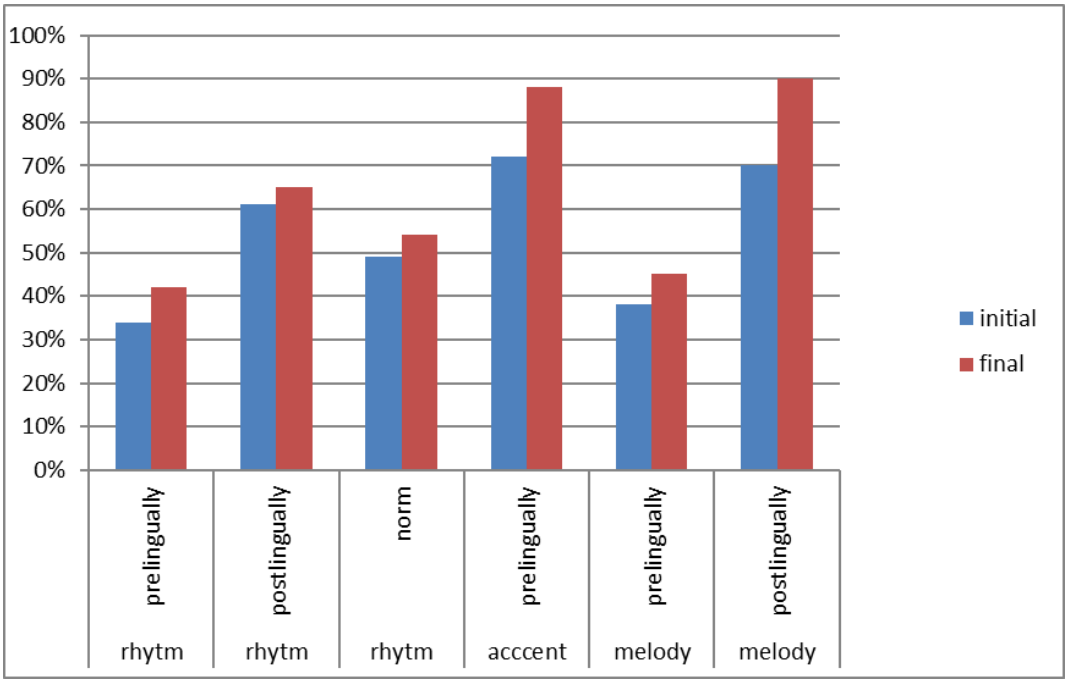


Figure 2:% of prosody (rhythm, accent, melody) achieved by persons from the prelingual and postlingual groups in the initial and final assessments.



The rhythm indicator in both groups of implanted deaf individuals showed a slight increase between the initial and final assessments, as well as a significant discrepancy in comparison to its value in the hearing group. In the prelingually deaf group, the accent indicator exhibited a slight increase relative to its initial and final values, along with a large deviation from the hearing group. Conversely, in the postlingually deaf group, the accent indicator significantly increased in the final assessment, approaching the norm presented in the hearing group. The melody indicator in the prelingually deaf group showed significant deviations from the norm, as well as minimal growth compared to its value in the final assessment. On the other hand, in the postlingually deaf group, this indicator considerably increased throughout the study, and its presented value in the final assessment slightly differed from the hearing group.

Taking into account the presented research results, it can be stated that the period of hearing loss plays a significant role in prosody acquisition in adult cochlear implant users. Prosodic expression in implanted deaf individuals, due to preserved prosodic patterns, does not significantly differ from the norm presented in the speech of hearing individuals. In this case, cochlear implantation and auditory training provide the opportunity to rebuild prosodic patterns and enhance the chances of effective prosody use in communication. On the other hand, for prelingually deaf individuals, difficulties in using prosody stem from insufficiently developed and consolidated prosodic patterns, which probably may be related to poor auditory stimulation during the period of speech development. Implantation combined with auditory training in adulthood thus does not significantly impact the prosodic quality in this group of deaf adults.

It can also be stated that the effectiveness of cochlear implantation and auditory training in relation to the production of specific prosodic factors varies: it is greatest in relation to rhythm in prelingually deaf individuals and melody in postlingually deaf individuals.

Discussion

The presented research results can imply a discussion focused on several areas. The first one is related to the significance of prosody in human communicative functioning. This aspect was addressed in the first part of the article, emphasizing the importance of prosody in the linguistic trajectory of human life, both in terms of its production and perception. The significance of prosody in communication is also highlighted by situations involving its disorders, which consequently hinder effective communication with their surroundings. A particularly vivid example of prosodic difficulties is the speech of individuals with profound hearing impairment, characterized by impairments in rhythm, melody, and accent, which was highlighted earlier in the article.

Therefore, a crucial aspect is working on supporting prosodic skills in deaf individuals, including activities in the field of hearing and speech rehabilitation supported by modern hearing prosthesis such as implants. As our own research shows, in the case of prelingually deaf adults, such actions are not always effective. This is due to the lack of effective auditory support using an implant during the critical period for prosodic pattern development. This is different for postlingually deaf individuals who often reactivate previously acquired prosodic skills during post-implant rehabilitation.

An important context of the presented research is therefore the focus on medical-rehabilitative actions aimed at achieving optimal prosody quality in individuals who are deaf. Firstly, this involves early auditory and language stimulation of prelingually deaf children with implants. This is made possible through widespread newborn hearing screening tests, which serve as the basis for prosthetic-rehabilitative actions in the early stages of a deaf child's life, and consequently, the swift stabilization of prosodic speech patterns.

Another course of action pertains to prelingually deaf individuals who receive implants after the period of speech development, particularly in adulthood. In this case, intensive auditory training is necessary in terms of speech perception, including prosodic training, as well as exercises enhancing musical abilities. Due to phonation disorders and respiratory tract issues in this deaf group, phonation and breathing exercises should be incorporated into the rehabilitation program. It is also important to control the settings of the speech processor in the implant towards optimal values for prosodic contours.

In conclusion, the perspective of prosodic skills in individuals with profound hearing dysfunction should be the subject of greater research interest. This applies both to assessing the quality of this speech element in relation to the larger population of the deaf, as well as to analyzing emotional prosody, which conditions the communication of the emotions of deaf individuals.

From the standpoint of therapeutic practice, on the other hand, activities aimed at supporting prosodic skills should become one of the priorities in the rehabilitation of the deaf.

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