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Review Article

Language intervention based on cognitive metaphor and time perception in cochlear implanted children

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Abstract

Introduction: Time perception is a fundamental element of human life. Time can offer a possibility to perceive the world around us, and a sense of self is shaped upon this perception. Unfortunately, current evidence indicates that hearing-impaired children have experienced major difficulties in time perception after cochlear implant surgery because of their early auditory deprivation.

Materials and Methods: This research was conducted through a narrative review method. To achieve the principal goal, we first searched some of the most scientific databases and publishers including Elsevier, PubMed, Google Scholar, and Science direct. Then, out of 215 most relative articles, 52 articles were selected and examined the role of cognitive metaphors and time perception in language intervention of cochlear implanted children using some main keywords in this field.

Results: Examining the structure of conceptual metaphors and the importance of time in language perception among children with cochlear implants indicated that applying intervention protocols based on learning conceptual metaphors and advancing the perception of time in terms of these metaphors is one of the important issues that should be considered in future research.

Conclusion: Concerning new educational and therapeutic approaches in language interventions for cochlear implanted children, it is necessary to consider some major issues such as the relationship between conceptual metaphors and understanding of time and strengthen language skills by improving time perception when developing rehabilitative programs.

Keywords: Cochlear implants, Cognitive metaphor, Language, Time perception

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Introduction

Language development is a complicated process by which children can understand the world around them and communicate with other people during their early childhood. This process is affected by various factors and conditions. One of the main factors vital for language acquisition is a sense of hearing. So, lack of auditory sensation from birth can have the power to take a great toll on every child's ability to develop language skills (1). For years, human societies have been unable to provide viable solutions to resolve hearing problems in infancy. However, two technological advances have been improved to address this problem in recent years. First, reliable screening methods can be used to measure the hearing threshold of newborns at birth which leads to the identification of hearing loss during the first couple months of life.

The second solution is the advent of Cochlear Implant (CI) technology, which has powerful effects on congenital hearing loss and language development of many infants with severe to profound hearing impairment. This device can bypass damaged or missing structures in the auditory system by exciting neurons in the auditory nerve directly with electrical stimuli (2). Although these stimuli are powerful, they are highly impoverished in frequency structure compared to the functioning of the normal cochlea. Consequently, the ability of this device to support refined phonological representations is highly restricted, and because of it, most CI children are often found to deal with some delay and impairment in their language skills even until adulthood (3,4).

On the other hand, there is ample evidence that a cochlear implant can successfully overcome a hearing deficit in many deaf children. However, most cochlear implanted children are at risk for significant difficulties in domain-general neurocognitive processes directly or indirectly dependent on typical auditory and language experience, including sequential processing, working memory, executive functioning, and perception (5,6). Accordingly, some recent research has demonstrated that cochlear implanted children may face perception problems because of their history of auditory loss (6).

In addition, the published literature on hearing impairment has consistently reported that hard-of-hearing children have difficulty perceiving time as an abstract and complex concept (7-9). However, the development of the concept of time in deaf children takes place differently, and it seems that the conceptualization of time is partly affected by their hearing impairment and an important factor in shaping time is the auditory sensation (10). As a result, it is predictable that children will suffer from time perception disorder if cochlear is implanted.

Numerous studies have shown that audition significantly impacts audio-visual temporal tasks (10).

For instance, some neuroimaging studies on hearing individuals indicated that the auditory cortex could perform a prominent role in on-time representation. In this regard, some researchers such as Coull et al. and Ferrandez et al. displayed that temporal processing of visual stimuli would lead to the activation of the superior temporal gyrus as the auditory cortex (11,12). Therefore, it is probable that complex temporal representations could be impaired when audition is not available.

This study examined time perception disorder in hearing-impaired children with cochlear implants. We have also intended to review the most important reasons underlying this problem among deaf people. Moreover, we have tried to introduce time perception as a specific goal for direct language intervention suitable for cochlear implanted children and many individuals with hearing loss.

Materials and Methods

In this review, we have focused our attention on the issue of language intervention associated with conceptual metaphors and time perception in cochlear implanted children. To achieve this purpose, at first, we chose the main topic on language intervention based on a linguistic-cognitive theory in CI children because it was relevant to contemporary clinical practice in the field of cochlear implantation. The second step was to examine the literature.

Accordingly, we searched some of the most scientific databases and journal publishers, including Elsevier, PubMed, Google Scholar, and Science direct. Then, we identified the most relevant literature in the selected topic area, generally via keywords relevant to the research main topic, such as language intervention in cochlear implants, conceptual metaphors, and linguistic-cognitive rehabilitation in cochlear implantation time perception in CI users, and metaphorical time perception. In this step, we reviewed about 215 studies. The selection criteria were the most associated of collected evidence with the major topic of the paper and published during 1990 to 2020. Therefore, among the obtained resources, the references published before 1990 and the research that examined language intervention in cochlear implants based on different theoretical frameworks were excluded. In the third step, 52 articles were selected and examined the role of cognitive metaphors and time perception in language intervention of cochlear implanted children. Finally, we tried to indicate the importance of developing a new rehabilitative program based on the intense relationship between conceptual metaphors and understanding of time and strengthening language skills by improving time perception for cochlear implanted children.

Results

Time is a crucial and essential dimension of everyone's life, and the perception of time plays a major role in the cognitive system. Time is a powerful instrument for interacting with the environment. In order to perceive a coherent temporal representation, the brain should combine information derived from sensory modalities and create a uniform image (10). Some scientists, such as Paul Fraisse (1963), believed that hearing was recognized as the time since (13). Recently, some new researches support this idea and have shown that sensory sensation serves a prominent role in representing temporal information (14-16). Therefore, lack of auditory deprivation can be associated with time perception disorder.

Although cochlear implantation can provide adequate auditory sensation for children with severe to profound hearing loss, some hearing problems remain. Time perception is one of the major problems that cochlear implant children have encountered.

There are a large number of reasons why CI children experience some difficulties in perceiving time, including language barrier, limited imagination, difficulties in abstract thinking and abstract concept formation, deaf cultural perspective, general problems with sequencing, lack of relevant experiences, and lack of comprehension of cause and effect (7). Despite the importance of all the above reasons, three reasons show why hearing-impaired children with CI face serious problems in understanding time. The first reason is their lack of ability to construct abstract concepts. In order to create an understanding of time and historical events with causal connections, the brain must make an abstract concept representing a sense of historical time. To do that, the brain must connect the abstract concept of time with either some concrete facts in the past or future or remember its personal experiences in the past (7). Accordingly, all deaf children with CIs have severe difficulties associating time with concrete events and facts that do not belong here and now. Moreover, they hardly remember anything from their past since they did not have enough language skills in their early years of life to express their memories and bring information about the past events to their mind. Thus, they have difficulty coding time by past elements.

The second explanation for the time perception problem in CI children relates to the difficulties in language development. It was evident that language skills play a significant role in conceptualizing time among the deaf and hard-of-hearing children. However, this connection has not been entirely accepted. Some scientists, such as Bylholt (1997), believed that the connection between linguistic development and the cognitive concept of time was inevitable (7,17). The third reason for time perception problems in hearing-impaired children with CI is the sequencing problem that these children may encounter (18). There is an association between sequence and order, organization, and consistency (7).

The brain understands sequence by two processes: first, by decoding the whole sequence as one unit that can be analyzed by being broken down into parts and being reassembled, and next, by absorbing details that are put together to construct a whole. These two processes are important for creating the proper perception of sequence (7,19).

Understanding time requires understanding sequence, and someone who wants to remember a series of events that develops over time is supposed to understand the meaning of each point in time, fill in the gaps from his/her own experience, and construct the sequence of events that develops over time.

To do this, one must have the ability for abstraction (20), but hearing-impaired children have some serious difficulties forming abstraction. So, we can conclude that cochlear implanted children are confronted with a time perception problem.

Association of Time Perception with Brain and Language

Some neuroscientists believe in a clock on the brain (21). It means that the brain produces some rhythmic or repetitive patterns of neural activity in the central nervous system, and it can generate oscillatory activity in many ways. This neural oscillation can adjust the neural firing in the brain, and it is believed that it can form the basis among many of the bodily rhythms that give a person a perceptional sense of timing and time (21). Thus, there is a strong relationship between neural firings in the body and perceiving the sense of time.

Some regions in the brain seem to be associated with the sense of time, including the frontal cortex, basal ganglia, parietal cortex, cerebellum, and hippocampus (22). These regions are responsible for receiving, associating, and interpreting information in fractions of milliseconds, seconds, and minutes (23). The neural processes of these regions define their function concerning memory, attention, and other emotional states.

The frontal cortex has a major role in time perception in the brain. The perception of time depends on the interaction between the cortical structures connected to the internal clock and some areas associated with temporal information processing in short- and long-term memory (24). The close relationship between the frontal cortex and memory storage justifies its participation in detailed time duration. This participation in terms of time perception may differ based on the activities of the left and right hemispheres. Accordingly, some evidence shows that the dorsolateral prefrontal right cortex is involved actively in time perception.

The Basal Ganglia (BG) is another region in the brain that plays a role in time perception. This part of the brain is also associated with emotions, motivation, cognition, learning, procedural memory, reward, reinforcement, and formation of habits (25). It was indicated that basal ganglia were involved in time perception, particularly the dorsal striatum (26). Therefore, representation of time is influenced by the ability of striatum to detect similar patterns of cortical and thalamic oscillations and then synchronize neural firing in response to different requirements of time perception (27). Moreover, the parietal cortex performs a central role in integrating sensory information (28). It is also related to a variety of cognitive functions. The parietal cortex has an anatomic-functional relation with the temporal and dorsolateral prefrontal cortex. These relations are associated with action control and spatial reference (29). The parietal cortex also plays a key role in planning movements based on sensory information and codification of cognitive functions. Therefore, the parietal cortex integrated the perception of external stimuli to the time scales for a count of milliseconds and seconds intervals (30).

The cerebellum is the fourth part of the brain whose participation on the biological basis of time perception has been indicated, but its function is yet not well established (22). It seems that time synchronization processes are partly linked to the lateral cerebellum (31). In this sense, the cerebellum encodes discrete periods compared to basal ganglia that take part in the perception of rhythms (32). On the other hand, it has been shown that lateral cerebellar hemispheres serve a prominent role in time perception (22).

The hippocampus is the last region considered to have an essential role in time perception. The hippocampus is a structure of the CNS that is associated with memory formation, environmental exploratory process, and the initial storage and transition of the ability to acquire, retain and recall information relevant to the long-term memory (33,34). Different kinds of memory require a temporal sequence of successful encodings between events to revive and stir up memories (35). Once the information is retained for a long period, it is consolidated in the memory and brought back later (36). Therefore, to rekindle memory, time perception is essential in the processing of sequential events, and this matter includes the participation of the hippocampus for the organization and recruitment of episodic memory (37).

In addition to the connection of time with the brain, time also has a close connection with language. When we say language, we do not mean that language is just about words and decoding information, but we mean that language is employed to facilitate the expression of our thoughts, and it can constitute a key tool in investigating the nature of the conceptual organization (38). So, in the case of perception of time, when we talk about the language dimension of time, it means how mental representation of time can be constructed and decoded in language as an abstract concept through conceptual and cognitive metaphors. Thus, in the following, we will focus on the role that cognitive metaphors and basic conceptual representations can play in constructing the concept of time among hearing-impaired children with CI.

Time Perception and Cognitive Metaphor

Every person can see colors, hear sounds and feel textures, so it seems that some aspects of the world are understandable by a particular sense. Like shape and space, others are perceived through more than one sense. However, some aspects of the world are not associated with one particular sense or combination of more than one sense. Time is an excellent example of this. It seems odd to say that a person can see, hear or touch time passing. Furthermore, even if all the senses in the brain of a person were prevented from functioning for a while, he/she could still notice the passing of time through the changing pattern of their thought. Perhaps, then, we have another special mechanism in our brain, distinct from the five senses, for detecting time, or as seems more likely, we may notice time through the perception of other things.

In this paper, we shall explore a mechanism in our cognitive system through which we can conceptualize time and perceive temporal patterns by connecting them with perceivable experiences. We also aim to show how we can help cochlear implanted children by introducing this mechanism to face their time perception problem and influence how they think time. This mechanism is called "cognitive/conceptual metaphor".

Lakoff and Johnson proposed cognitive metaphor theory for the first time in 1980. According to this theory, cognitive metaphor is not a language tool, but it is a cognitive mechanism by which we can conceptualize abstract concepts and construct our world through these concepts (39). This viewpoint maintains that one conceptual domain, 'any coherent organization of experience,' is understood through another conceptual domain, and it is written in the following way: Domain A is domain B (40). In this sense, domain A refers to any abstract concepts (source domain), and domain B refers to concrete objects (the target domain). Therefore, it has been mentioned that one domain is understood in terms of another.

Moreover, it is said that understanding the source domains implies understanding the correspondences existing between the two domains. These correspondences are referred to as mappings. These mappings are the presupposed and underlying knowledge used when speaking about the different domains (41). According to this theory, time is one of the most important source domains, which can be understood in terms of different kinds of physical and concrete domains such as container, valuable entity, space, motion, etc. So, if we want to treat time perception disorder among hard-of-hearing children with CI, it is recommended to work on this theory to be applied to intervention programs for these children. Numerous studies have indicated how the applications of conceptual metaphor theory and embodied cognition promise to improve current techniques to treat some disorders in the health domain (42-44).

Language Intervention based on Cognitive Metaphor of Time

Beyond the establishment of hearing, the primary goal of cochlear implantation is to improve language skills in hearing-impaired children and adults. Cochlear implants have proved to be very effective in permitting many children with severe to profound hearing loss to acquire language proficiency with the support of intervention following implantation. In this sense, most studies have demonstrated the general success of language intervention programs in children with CIs (45-48). However, despite these positive language outcomes, there are some serious problems that these children encounter, particularly in terms of neurocognitive factors such as perception, memory, learning, programming, and problem-solving (49-51). Therefore, in recent years, the vast majority of the studies focusing on children with CIs have employed some practical framework and new cognitive theories for addressing the special needs of these children. Accordingly, the language intervention programs of these children have undergone fundamental changes (6).

In order to put into practice some substantial reforms in language intervention programs for cochlear implanted children, the researchers and clinicians should set some specific goals based on one of the three major aspects of language, including form, content, or use. In this sense, form refers to syntax, morphology, and phonology. The content consists of semantic and conceptual components of language, which are more than vocabulary knowledge and include perception and comprehension skills associated with cognitive functioning. Use is also connected to the realm of pragmatics or the ability to use language in context for social purposes (52).

Because many children with CIs have multiple perception problems, it is helpful to have some criteria for setting priorities among the deficits connected to perception. On the other hand, ample evidence pointed to the existence of time perception problems among cochlear implanted children. Therefore, one of the most important contents included in the intervention program for these children is a program based on conceptual metaphors to affect their time perception.

Conclusion

Considering the complexity of understanding time in the brain and its multidimensional existence, many cochlear implanted children, have faced a time perception problem. Moreover, there is a lack of formal language intervention programs for deaf and hard-of-hearing children that focus on conceptual metaphors and time perception. Thus, in this paper, first, we have tried to introduce a new cognitive theory of conceptual metaphor to explain the mechanism through which time can be understood in terms of our perceivable physical experiences. Next, we have attempted to display different ways for setting appropriate goals in the educational program for CI children according to the contents they need most. Finally, we tried to show the importance of considering some major issues such as the relationship between conceptual metaphors and understanding of time and strengthening language skills by improving time perception when developing rehabilitative programs for cochlear implanted children.

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