CORRELATION BETWEEN SPOKEN LANGUAGE AND EXECUTIVE FUNCTIONS IN CHILDREN WITH COCHLEAR IMPLANTS

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Abstract
The study aimed to investigate the relationship between spoken language and executive functions in children with cochlear implants. The study sample included 10 children with cochlear implants, aged 6 to 10 years, who did not suffer from any accompanying diseases or disabilities, whose hearing ages ranged from 5 to 7 years, and who were enrolled in an integrated section of the primary school. To achieve the study's objective an oral language production and comprehension assessment (ELO) was applied in addition to an executive functions assessment frontal assessment battery (FAB). The results showed a statistically significant relationship between oral language and executive functions in children with cochlear implants.

Keywords: spoken language, executive functions, cochlear implants, child.

1. Introduction

The construct of executive function (EF) encompasses the organizational and self-regulatory skills required for goal-directed, nonautomatic behavior. It has been variously described as including planning, initiating, monitoring, and flexibly correcting actions according to feedback; sustaining as well as shifting attention; controlling impulses and inhibiting prepotent but maladaptive responses; selecting goals and performing actions that may not lead to an immediate reward, with a view to reaching a longer term objective; holding information in mind whilst performing a task (working memory) and creatively reacting to novel situations with nonhabitual responses Recent theoretical conceptualizations of EF suggest that it is not a unitary function, but encompasses a range of dissociable skills, such that it is possible for an individual to fail on some executive tasks whilst succeeding on others Electroencephalogram evidence has shown differences in the neural organization of the bilateral frontal cortex (closely linked to EF abilities) and the left temporofrontal area (involved in expressive language) of deaf and hearing children. A weaker development of these cortical areas might be reflected in both poorer language and poorer EF in deaf children [1].

Deafness, or even hearing loss, often places a child in a problematic place. Even mild hearing loss can lead to changes in neural flexibility and executive functions [2].

The Cochlear Implant (CI), a prosthetic device that electrically stimulates the auditory nerve via a set of electrodes placed in the cochlea, is universally considered to be the standard of care for the medical treatment of severe-to-profound sensory-neural hearing loss in children and adults. Although CI allows stimulation of the auditory nerve and thus the development of the brain cortices in children who are deaf or hard of hearing (DHH), enabling communication skills there are notable variations in language and neurocognitive outcomes [3].

chronic lack of full access to a natural language (described as language deprivation) during critical periods of language development, generally 0–5 years of age, may lead to substantial deficits that affect the neuropsychological development of deaf children. Various technological advances have allowed for taking advantage of residual auditory capacity in people with hearing deficits to increase the possibility of oral understanding such as hearing aids and cochlear implants (CIs). The use of these interventions depends on etiology, age, damage localization, and hearing loss intensity.

2. Hearing deprivation and the development of executive functions

The scientific literature has consistently reported that deaf children show poorer performance on EF tasks than their hearing counterparts (e.g., Botting et al., 2017; Figueras, Edwards, & Langdon, 2008; Kronenberger, Colson, Henning, & Pisoni, 2014; Kronenberger, Pisoni, Henning, & Colson, 2013). Some authors explain these differences by recognizing the complex inter-relationship among audition, language, and EFs, with some proposing that hearing deprivation has direct effects on EFs (for a review, see Kral, Kronenberger, Pisoni, & O'Donoghue, 2016), whereas others emphasize that there is no evidence of a direct effect of hearing deprivation that could not be explained by language deprivation (e.g., Botting et al., 2017; Castellanos, Pisoni, Kronenberger, & Beer, 2016; Figueras et al., 2008; Hall et al., 2018; Nicastri et al., 2021). According to the first hypothesis, hearing loss can be considered an illness of the ''connectome," or the network of synaptic connections and neural projections that form the nervous system, whose development depends widely on sensorial experience. According to this hypothesis, deafness leads to an abnormal bias in development and neural connectivity, with consequences for EFs and other cognitive processes. The evidence supporting this biological factor (interacting with psychological and social factors) is based on neurobiological studies that support cortical reorganization and differences in functioning in brain regions associated with hearing loss such as the prefrontal cortex that are involved in EFs The second hypothesis argues that the differences in EFs exist due to a deficit in language development given that both are closely related. In this regard, it is crucial to establish the direction of the relationship between language and EFs because it could be hypothesized that the deficits in EFs prevent language development in this population or the reverse, namely that language development promotes the development of EFs [4].

More recent research has also examined cognitive development in pediatric CI users. Several studies have shown that when children with CIs as a group are compared to typically hearing (TH) peers, children with CIs show deficits in cognitive abilities, such as executive functioning, verbal working memory, sequence processing, cognitive flexibility, planning, and concept formation [5].

3. Research problem

Auditory experience also affect EF in several different ways. For example, auditory stimulation provides temporal patterns to the developing brain, which have been shown to be important for developing sequential processing abilities such as pattern detection, serial memory, and sustained attention. Auditory experience and activities also give valuable practice with selective attention (to target sounds), resisting distraction (from extraneous sounds), and working memory (storage of auditory information in the face of competing cognitive demands; Kronenberger & Pisoni, 2018), all of which are core components of EF. Additionally, auditory experience underlies the development of spoken language, which offers tools to support EF, such as encoding and representing information in working memory, holding goal-related information in mind, and using self-talk to inhibit and regulate behavior.

Because of deficits in auditory experience and language exposure, prelingually deaf children with CIs show considerable variability and are at risk for delays in EF.

Deficits in auditory verbal working memory, the EF subdomain required for concurrent auditory verbal memory storage and information-processing activities, have been well documented in numerous studies of CI users (Figueras et al., 2008; Kronenberger, Colson, et al., 2014; Kronenberger, Pisoni, Henning, & Colson, 2013). Children with CIs have also shown delays in the EF domains of inhibition and controlled attention (concentration) under time pressure (collectively referred to as "inhibition concentration speed"; Kronenberger, Colson, et al., 2014), even on visual tasks with minimal language.

Language and EF are reciprocally, bidirectionally related, particularly early in childhood. Controlled attention, working memory, and planning, all of which are critical components of EF, are also used to acquire and process. EF also regulates the effort that is allocated to listening, and more efficient allocation of this effort contributes to more effective listening skills and language processing experiences, particularly in challenging conditions such as processing degraded/coarsely coded input from a CI.

Language, in turn, supports EF by serving as a tool for representing goalrelated information in memory and for representing plans for appropriately regulated, goal directed behavior.

Consistent with a reciprocal bidirectional model of language and EF development in prelingually deaf, early implanted children, numerous studies have demonstrated close links between EF and language outcomes in samples of CI users. Auditory verbal working memory is associated with speech perception, vocabulary, word learning, and verbal communication skills in CI users. Measures of inhibition and controlled attention are also related to speech-language outcomes in samples of CI users, particularly when time demands are present.

The Ease of Language Understanding theory and the Framework for Understanding Effortful Listening propose that CI users have to allocate additional effortful resources to listening and language processing because of degraded/coarsely coded stimulation from the CI, resulting in a greater dependence on EF during language-related tasks. As a result, the association between EF and spoken language skills is stronger in CI users than in peers with normal hearing.

Correlations of EF measures of auditory verbal working memory and inhibition concentration speed with speechlanguage skills in CI users exceed those of NH control samples. Additionally, depletion of working memory resources results in poorer real-time language processing in CI users but has less impact on NH peers, indicating that working memory plays a greater role in language functioning in CI users.

Longitudinal studies using digit span tests have demonstrated early deficits in verbal working memory starting at very early school ages, which persist through adolescence, Furthermore, early vocabulary (assessed about 1 year on average after implantation) predicted verbal working memory and controlled fluency speed scores 11 years later. Conversely, verbal working memory was associated with later vocabulary, language, and reading scores in school-age children. Hence, some longitudinal analyses have shown bidirectional predictive relationships between EF and language during school ages [6].

Verbal working memory is significantly associated with speech perception, grammar, vocabulary, reading, word learning, and conversational communication in CI users. Because of the foundational role that VRS plays in verbal working memory, VRS is therefore a likely contributor to long-term outcomes in speech and language skills in CI users and may explain the relation between verbal working memory and long term spoken language outcomes. For example, Pisoni and Cleary (2003) reported that digit span scores correlated with speech and language measures, but this relationship could be attributed to their shared variance with VRS. Furthermore, measures of verbal rehearsal speed obtained during elementary school reliably predicted speech and language outcomes measured more than 10 years later [7].

Auditory experiences are fundamental for the EF devel-opment, while auditory deprivation may alter them. Cochlear implantation helps to enable functional hearing and spoken language development in children with severe to profound hearing loss. Likewise, it has been reported how cochlear implanted children (CIC) are able to develop EF skills within the average range of typically hearing chil-dren (THC). However, some CIC (~ 1/3) seem to be at risk to show EF delays, with a rate that is 2–5 times greater than that observed in THC [8].

A large body of research has demonstrated that EFs and language are dependent on each other for development, particularly through childhood and because they are part of an information-processing system and interconnect at various levels in the cerebral cortex, both are affected by the period of auditory deprivation in children with HL.

knowledge of the developmental relations between EF and language processes in children with CIs is critical to understanding not onlyoutcomes proximal to language, but also more distal outcomes such as learning, self regulation, and social cognition.

This study aimed to knowledge of the relation between oral language and executive functions (EF) in children with cochlear implants.

3.1.We pose the following mainquestion

3.1.1. Is there a correlation between **s**poken language and executive functions in children with cochlear implants?

3.2. Sub-questions

3.2.1 Is there a correlation between lexical reception and Conceptualization (similarity) in children with cochlear implants.
3.2.2. Is there a correlation between lexical production and Mental flexibility in children with cochlear implants.
3.2.3. Is there a correlation between word repetition and Motor programming in children with cochlear implants.
3.2.4. Is there a correlation between the level of oral comprehension and conflicting instructions in children with cochlear implants.
3.2.5. Is there a correlation between phrase production and Inhibitory control command in children with cochlear implants.
3.2.6. Is there a correlation between phrase repetition and prehension behavior in children with cochlear implants.
3.3. Study hypothesis: Main Hypothesis
3.3.1. There is a correlation between spoken language and executive functions in children with cochlear implants.
3.4. Sub-hypotheses:
3.4.1. There is a correlation between lexical reception and Conceptualization (similarity) in children with cochlear implants.
3.4.2. There is a correlation between lexical production and Mental flexibility in children with cochlear implants.
3.4.3. There is a correlation between word repetition and Motor programming in children with cochlear implants.
3.4.4. There is a correlation between the level of oral comprehension and conflicting instructions in children with cochlear implants.
3.4.5. There is a correlation between phrase production and Inhibitory control command in children with cochlear implants.
3.4.6. There is a correlation between phrase repetition and prehension behavior in children with cochlear implants.

4. Study variables

4.1. Spoken language: is a complex faculty comprised of several components: prosody (the melody of speech), phonetics (the articulation of individual speech sounds), phonology (the sequencing of speech sounds), lexicon (the repertoire of words), syntax (the organization of words into sentences), pragmatics (the use of language in communication, taking into account the interlocutor's knowledge and the context), and semantics (access to meaning). Language has two aspects: an expressive aspect that allows the production of a message, and a receptive aspect that allows its comprehension. The semantic and pragmatic components require a good command of syntax and a good vocabulary. All these different components have an expressive aspect and a receptive aspect. They develop asynchronously, but in continuous interaction with one another, the development of one leading to the development of the others [9].

4.2. executive functions (EF): is composed of neurocognitive skills in distinct, yet interrelated, domains including working memory, inhibition, and shifting. Working memory involves the capacity to retain and manipulate novel information. Inhibition refers to the ability to resist and overcome initial impulsive, prepotent responses to achieve goal-directed behavior. Shifting encompasses the ability to adjust to novel or competing stimuli in problem-solving. Working memory has been the most-frequently investigated EF domain involved in language processing and learning in typically hearing (TH) children. Working memory is thought to enable and maximize in-the-moment language processing that supports higher order language development as well as play a reciprocal role in vocabulary learning and retention [10].

There is general agreement among cognitive psychologists and neuroscientists that several different aspects of EF play important roles in language perception and production via top-down feedback and control of processing activities in a wide range of behavioral tasks [11].

4.3. cochlear implants (CIs): cochlear implantation became available as a medical treatment for children with SSHL. The electric stimulation provided by cochlear implants (CIs) has enabled speech perception and the development of spoken language skills in many severe to profoundly deaf children. The CI has crucial importance in stimulating the auditory cortex which, after a period of auditory isolation, begins to detect sensory stimuli [12].

5. Materials and methods

5.1. Method

The descriptive correlational method is a widely used research approach that aims to examine relationships between variables as they naturally occur, without any manipulation or experimental intervention by the researcher. This method focuses on identifying the direction and strength of associations between two or more variables, whether positive or negative, through statistical techniques such as correlation coefficients [13]. It does not establish causation but provides valuable insights into patterns and trends, particularly in educational, psychological, and social research contexts. Furthermore, the descriptive correlational approach is useful for generating predictions and forming a basis for future experimental studies that may further explore causal relationships [14].

5.2. Participants

All children in the CI had congenital hearing loss and were diagnosed within the first three months of life through. To ensure developmental appropriateness and reliability, the age range of 6-10 years was agreed upon based on findings from previous literature supporting claims on increased reliability of executive function assessment in school aged children. Inclusion criteria for both sufficient compliance and cooperation to complete the tests, absence of any medical condition or injury affecting cognitive function, such as a history of head trauma or intellectual disability, and the absence of neurological conditions, such as epilepsy, or psychiatric disorders. Exclusion criteria severe visual impairments that could affect test administration and/or results, arm motor dysfunction or limited arm movement, and a history of learning disabilities and/or communication disorders such as Autism Spectrum Disorder, Attention Deficit Hyperactivity Disorder, or Specific Learning Disabilities. additional inclu sion criteria were regular use of cochlear implants and use of verbal communication; and living with typically hearing parents.

All cases underwent cochlear implantation at Al-Hakim Zarban Hospital, Al-Jisr Al-Abyad, Annaba Province, the Ear, Nose and Throat (ENT) Department, and receive speech therapy and psychological care within the same department.

This study has been conducted in hospital of the Annaba - algeria on ten children with cochlear implants, aged 6 to 10 years and with hearing ages ranging from 5 to 7 years, are enrolled in schools with typically developing children.

5.3. Materials

5.3.1. Spoken Language Production and Comprehension Assessment (ELO)

The test was adapted for Algerian children by the researcher Adda (2017). is a standardized instrument designed to evaluate children's spoken language abilities, with a particular focus on expressive (production) and receptive (comprehension) skills. It is widely used in research and clinical contexts within educational psychology and speech-language pathology to identify typical and atypical language development in early childhood.

The assessment is structured around two core domains. The oral production component examines the child's ability to generate language, including lexical retrieval, syntactic organization, and narrative skills. Tasks may involve picture description, sentence formulation, and spontaneous verbal expression. The oral comprehension component evaluates the child's capacity to understand spoken language, including vocabulary recognition, grammatical processing, and the interpretation of verbal instructions or short discourse. Together, these components provide a comprehensive profile of a child's functional language competence.

A key strength of the ELO lies in its standardized design, which allows for age-referenced comparisons and supports reliable identification of language delays and disorders, including Developmental Language Disorder. The test has been normed on child populations and is frequently employed by clinicians, educators, and researchers to inform diagnosis, guide intervention planning, and monitor developmental progress over time. Its structured yet flexible administration makes it suitable for both educational and clinical settings [15].

5.3.2. Description of the Frontal Assessment Battery (FAB)

According to current theories, the frontal lobes control conceptualization and abstract reasoning, mental flexibility, motor programming and executive control of action, resistance to interference, self-regulation, inhibitory control, and environmental autonomy. Each of these processes is needed for elaborating appropriate goaldirected behaviors and for adapting the subject's response to new or challenging situations functions that are mediated by the prefrontal cortex. For that reason, the designed battery consists of six subtests, each exploring one of the aforementioned functions related to the frontal lobes.

The total scores are calculated by adding the notes of the six subtests. The overall duration of the battery is approximately 10 minutes [16].

The six subtests of this instrument were evaluated in this study as below:

a) Conceptualization (similarity): Patients were asked to determine the category of two or more objects from the same semantic group. For example, apple, peach, and banana belong to which category?.

b) Mental flexibility (fluency): For this task, patients were asked to name as many words as they can that begin with the sound "B" except for proper nouns, within the 60 s.

c) Motor programming (Luria motor series): to evaluate the ability of programming, patients were first trained how to play the Luria series 'fist, edge, palm' and then, they were asked to do it repetitively by themselves for six times.

d) Sensitivity to interference (conflicting instructions): In this task, patients were asked to tap on the table twice, if the examiner tapped once and to tap once if the examiner tapped twice.

e) Inhibitory control (Go-No-Go Task): This time, the patients were asked to tap on the table once, if the examiner tapped once and to tap twice as the examiner tapped twice.

f) Environmental autonomy (prehension behavior): While the patients' hands were placed palms up on their knees; the examiner touched the patients' palms without saying anything. Examiner tried this again and said "Do not take my hands" if the patient had grabbed her hands in the first time.

According to the FAB scoring system, the minimum and maximum score for each task are 0 and 3 respectively. Calculated scores for the sixsubtests of this battery were summed up and reported as the "total FAB score" [17]. The validity and reliability of the test on Algerian children were calculated by the researcher.

6. Statistical analysis and Results

Presentation and discussion of the main hypothesis results: The main hypothesis states the following:

6.1. There is a correlation between spoken language and executive functions in children with cochlear implants. To verify the main hypothesis, the correlation coefficient was calculated between the scores of the study participants on the research instrument. The following table shows the results obtained:

Table 1: illustrates the relationship between spoken language and executive functions in children with cochlear implants using Pearson's correlation coefficient

The two variables	Number of individuals in the sample	Correlation coefficient (R)	Value sig	Level of significance
Spoken language and executive functions	10	0.895*	0.000	0.05

It is clear from the previous table that the value of the correlation coefficient between lexical reception and Conceptualization (similarity) reached (0.895) at the probability value (0.000), which is less than the significance level (0.05), which indicates the existence of a correlation between spoken language and executive functions. Therefore, we reject the zero chance and accept the alternative hypothesis, which states that there is a correlation between oral language and executive functions in children with cochlear implants. This relationship was a strong positive correlation, meaning that the more the executive functions increased, the more oral language increased.

Presentation and discussion of the results of the first sub-hypothesis: The first sub-hypothesis states the following:
6.1.1. There is a correlation between lexical reception and Conceptualization (similarity) in children with cochlear implants.
To verify the first sub-hypothesis, the correlation coefficient was calculated between the scores of the study participants on the research instrument. The following table shows the results obtained:

Table 2: shows the relationship between lexical reception and Conceptualization (similarity) in children with cochlear implants using Pearson's correlation coefficient

The two variables	Number of individuals in the sample	Correlation coefficient (R)	Value sig	Level of significance
Lexical reception and Conceptualization (similarity)	10	0.657*	0.039	0.05

It is clear from the previous table that the value of the correlation coefficient between lexical reception and Conceptualization (similarity) reached (0.657) at the probability value (0.039), which is less than the significance level (0.05), which indicates the existence of a correlation between lexical reception and Conceptualization (similarity). Therefore, we reject the zero chance and accept the alternative hypothesis, which states that there is a correlational relationship between lexical reception and Conceptualization (similarity) among children with cochlear implants. This relationship was a moderate positive one, meaning that the more lexical reception there is, the more Conceptualization (similarity) there are.
Presentation and discussion of the results of the second sub-hypothesis: The second sub-hypothesis states the following:
6.1.2. There is a correlation between lexical production and Mental flexibility in children with cochlear implants.
To verify the second sub-hypothesis, the correlation coefficient between the scores of the study participants on the research instrument was calculated. The following table shows the results obtained:

Table 3: shows the relationship between lexical production and Mental flexibility in children with cochlear implants using Pearson's correlation coefficient

The two variables	Number of individuals in the sample	Correlation coefficient (R)	Value sig	Level of significance
Lexical production and Mental flexibility	10	0.842**	0.002	0.05

It is clear from the previous table that the value of the correlation coefficient between lexical production and Mental flexibility recall reached (0.842) at the probability value (0.002), which is less than the significance level (0.05), which indicates the existence of a correlation between lexical production and Mental flexibility. Therefore, we reject the zero chance and accept the alternative hypothesis, which states that there is a correlation between lexical production and Mental flexibility among children with cochlear implants. This relationship was a strong positive correlation, meaning that the more lexical production there was, the Mental flexibility there was.
Presentation and discussion of the results of the third sub-hypothesis: The third sub-hypothesis states the following:
6.1.3. There is a correlation between word repetition and Motor programming in children with cochlear implants.

To verify the third sub-hypothesis, the correlation coefficient between the scores of the study participants on the research instrument was calculated. The following table shows the results obtained:

Table 4: shows the relationship between word repetition and Motor programming in children with cochlear implants using Pearson's correlation coefficient

The two variables	Number of individuals in the sample	Correlation coefficient (R)	Value sig	Level of significance
Word repetition and Motor programming	10	0.702*	0.024	0.05

It is clear from the previous table that the value of the correlation coefficient between word repetition and Motor programming reached (0.702) at the probability value (0.024), which is less than the significance level (0.05), which indicates the existence of a correlation between word frequency and motor sequences. Therefore, we reject the zero chance and accept the alternative hypothesis, which states that there is a correlation between word repetition and Motor programming in children with cochlear implants. This relationship was a moderate positive one, meaning that the more words there were, the more motor programming there were.
Presentation and discussion of the results of the fourth sub-hypothesis: The fourth sub-hypothesis states the following:
6.1.4. There is a correlation between the level of oral comprehension and conflicting instructions in children with cochlear implants.
To verify the fourth sub-hypothesis, the correlation coefficient between the scores of the study participants on the research instrument was calculated. The following table shows the results obtained:

Table 5: shows the relationship between the level of oral comprehension and conflicting instructions using Pearson's correlation coefficient

The two variables	Number of individuals in the sample	Correlation coefficient (R)	Value sig	Level of significance
The level of oral comprehension and conflicting instructions	10	0.645*	0.044	0.05

It is clear from the previous table that the value of the correlation coefficient between the level of oral comprehension and conflicting instructions was (0.645) at the probability value (0.044), which is less than the significance level (0.05), which indicates the existence of a correlation between the level of oral comprehension and conflicting instructions. Therefore, we reject the zero chance and accept the alternative hypothesis, which states that there is a correlation between the level of oral comprehension and conflicting instructions among children with cochlear implants. This relationship was a moderate positive one, meaning that the higher the level of oral comprehension, the more conflicting instructions there were.
Presentation and discussion of the results of the fifth sub-hypothesis: The fifth sub-hypothesis states the following:
6.1.5. There is a correlation between phrase production and Inhibitory control command in children with cochlear implants.
To verify the fifth sub-hypothesis, the correlation coefficient between the scores of the study participants on the research instrument was calculated. The following table shows the results obtained:

Table 6: shows the relationship between phrase production and Inhibitory control command using Pearson's correlation coefficient.

The two variables	Number of individuals in the sample	Correlation coefficient (R)	Value sig	Level of significance
Phrase production and Inhibitory control command	10	0.709^{*}	0.022	0.05

It is clear from the previous table that the value of the correlation coefficient between phrase production and Inhibitory control command reached (0.709) at the probability value (0.022), which is less than the significance level (0.05), which indicates the existence of a correlation between between phrase production and Inhibitory control command. Therefore, we reject the zero chance and accept the alternative hypothesis, which states that there is a correlation between phrase production and Inhibitory control command in children with cochlear implants. This relationship was positive and high, meaning that the more statements are phrase production, the more Inhibitory control command is produced.

Presentation and discussion of the results of the sixth sub-hypothesis: The sixth sub-hypothesis states the following:

6.1.6. There is a correlation between phrase repetition and prehension behavior in children with cochlear implants.

To verify the sixth sub-hypothesis, the correlation coefficient between the scores of the study participants on the research instrument was calculated. The following table shows the results obtained:

Table 7: shows the relationship between phrase repetition and prehension behavior using Pearson's correlation coefficient.

The two variables	Number of individuals in the sample	Correlation coefficient (R)	Value sig	Level of significance
Phrase repetition and prehension behavior	10	0.452	0.190	0.05

It is clear from the previous table that the value of the correlation coefficient between the frequency of statements and the comprehension of behavior reached (0.452) at the probability value (0.190), which is greater than the significance level (0.05), which indicates that there is no correlation between the frequency of statements and the comprehension of behavior. Therefore, we reject the alternative hypothesis and accept the null hypothesis, which states that there is no correlation between the frequency of statements and the comprehension of behavior in children with cochlear implants.

7. Discussion

CI users displayed a fundamentally of correlations among language, and EF skills whose language measurements were correlated with both conceptualization and abstract reasoning, mental flexibility, motor programming and executive control of action, resistance to interference, self-regulation, and inhibitory control. Because rapid naming tasks require efficient retrieval of verbal codes and inhibition of previous competing responses from long-term memory, it is also not surprising An alternative account of the relation between articulation rate and verbal working memory this relation could emerge not from development of verbal rehearsal speed, but rather from the development of more robust and efficient speech-motor output processes during verbal recall of working memory tasks [18].

Some theorize that language is a driver in the development of EF abilities in children (e.g., Zelazo et al., 2003), whereas others describe working memory and EF as a precursor for language development (e.g., Baddeley, 2003). Language not only relates to EF but also has a role in mediating EF performance.

Either EF skills do not develop optimally in the context of poor language development or EF tasks (even nonverbal ones) are implicitly verbally encoded, and therefore low language skills impair performance on EF tasks. These scenarios are not mutually exclusive, and a combination of these is likely. A study on typically developing children and hearing children at risk of language/literacy difficulties suggested that EF and language were concurrently but not longitudinally related, which may support the latter explanation (e.g., Gooch et al., 2016). That is, deaf children's EF performance may be affected by language at the time of testing, but language may not predict later EF development. suggesting that rich language environment matters for EF development.

Some studies propose a model whereby EF is a driver of language development in typical (e.g., Baddeley, 2003; Gandolfi & Viterbori, 2020; Traverso et al., 2022; Verhagen & Leseman, 2016) and atypical groups (e.g., Blom & Boerma, 2020; Pellicano, 2010). Gandolfi and Viterbori (2020) showed that early inhibition control in typically developing 2–3-year olds predicted future language outcomes in receptive grammar.

EF skills can facilitate language development by enabling children to focus attention, handle multiple sources of information simultaneously, consolidate meaning, monitor mistakes and make decisions in light of information received.

Several studies show (e.g., Botting et al., 2017; Figueras et al., 2008; Goodwin et al., 2022; Hall et al., 2018; Jones et al., 2020; Remine et al., 2008) EF growth is linked to deaf children's knowledge of vocabulary and grammar that is language influences EF [19].

8. Conclusion

The real-world assessment of EF and language carried out in the present study may assist clinical and educational specialists when guiding parents in intervention programs in which the context is considered. These interventions could foster better promotion of language and EF in learning situations. Given the strong relationships between language and EF in both children with cochlear implants, early difficulties in EF may serve as a warning sign for later difficulties in the language domain. Early assessment of these neuropsychological aspects is essential to detect and prevent difficulties in both skills, as well as to define linguistic profiles in deaf children.

Prioritizing the early restoration of EF postcochlear implantation is imperative in speech therapy rehabilitation. EF, vital in regulating cognition and behavior, have a profound impact on longterm outcomes, including language abilities and overall quality of life. This underscores their enduring significance, extending beyond the immediate improvements observed post-implantation.

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