DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

The Role of Executive Functions and Sign Language Proficiency in Mediating Quality of Life and Cognitive Development in Deaf and Hard-of-Hearing Adolescents

Prof. Sahar Ziedan Zaien
Special Education, The Applied College, University of Tabuk, Tabuk, Saudi Arabia
Email: sshehath@ut.edu.sa
ORCID: 0000-0002-3861-4898

ABSTRACT

The current study presents the mediation model, which includes the mediation of basic executive functions, executive functions of language, sign language proficiency, educational cognitive development, and quality of life where data is collected from deaf and hard of hearing people aged (10 and 16) years. The study will be carried out in two different places: Al-Amal School for the Deaf and integration classes with the use of sign language with the deaf and total communication with the hearing impaired, this questionnaire evaluated three main areas: general abilities of sign language, the ability to use sign language in various activities, and the general opinion of the individual about sign language. It consists of five sections: Demography, Language Environment, Opinion on Sign Language, Self-Assessed Sign Language Performance, and Sign Language Exposure. The results predict that sign language proficiency significantly mediated the relationship between core executive functions and partly mediated in the relationship between the executive functions of language and educational cognitive development. Understanding the world of deaf and hard of hearing children is a major challenge for parents, teachers and professionals.

Keywords: executive functions, sign language, mediation, quality of life, cognitive development, deaf, hard of hearing, adolescents.

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

1. Introduction

Research on DHH children's sign language development and total communication (use of both speech and sign) has shown that early exposure to sign language is associated with improved spoken language outcomes and supports spoken language development. Research from various disciplines highlights the role of environmental input in ensuring typical neurodevelopment. Adequate language exposure is crucial for neural mechanisms supporting language development. It has also been suggested that conversing in the first language or dominant language could directly tap into and support the development of an individual's EF system since the EF system is largely thought to be a self-regulatory system active in the first language or dominant language. While listening and spoken language are important for ensuring full participation in society, access to sign language from an early age may also provide DHH children with a protective cognitive-linguistic scaffold that can help create positive outcomes. [1][2][3]

The introduction of cochlear implants and other hearing technologies means that – for the first time in history – a sizable group of deaf and hard-of-hearing (DHH) individuals will grow up with listening and spoken language as their primary mode of communication. However, despite tremendous technological advancements in the treatment of pediatric-onset hearing loss, a body of research has demonstrated that a large subgroup of DHH children and adolescents are at risk for developing executive function (EF) weaknesses, delayed spoken language, and lowered intellectual and academic levels relative to their typically developing hearing peers. Approximately 40% of these DHH adolescents display a range of EF weaknesses. Poor EF in DHH children also impacts reactive control, which in turn negatively impacts spoken language supervision [4][5][6].

1.1. Background and Rationale

This work derived from a larger research study that investigated the roles of executive functions and sign language proficiency in mediating quality of life and cognitive development in deaf and hard-of-hearing adolescents. There is a unique advantage gained by deaf and hard-of-hearing (DHH) individuals when they acquire proficient knowledge in sign language, as it helps them overcome communication and language development challenges. [7] These advantages affect the cognitive and cerebral development of DHH adolescents and influence their quality of life. Given that moral judgment is highly dependent on quality of life, advantage contributes to DHH individuals' improved moral reasoning. This study constructs a growth model utilizing the Communication Behavior-Executive Function-Sign Language Proficiency-Quality of Life Cognitive Mediator Hypothesis, with data collected from two sessions, to examine the temporal relationships among the variables. The derived growth model provides an innovative approach for designing sign language teaching strategies that can support DHH adolescents' sign language learning to promote advantageous developmental processes [8][9][10]. It is well established that both early access to language and neurological maturation plays crucial roles in adolescents' cognitive and

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

cerebral development. Proficiency in sign language is one of the key predictors of positive cognitive growth, high-level cerebral functioning, and life outcomes. This study first examines how sign language, executive functions, and fulfillment of basic psychological needs predict quality of life in a growth model applied to both cross-sectional and longitudinal data. The model is then applied to positive and negative affect on the cross-sectional data for independent variable selection validation. The unique demands faced by deaf and hard-of-hearing individuals to develop executive functions and establish proficient knowledge in sign language for cerebral and cognitive development have created a new neurological perspective. It elaborates the Cognitive Advantage Concept theory of Deaf Sign Bilingualism. [11][12] This research aimed to facilitate the acquisition of sign language proficiency and contribute to positive cognitive development, high-level cerebral functioning, and improved life outcomes in DHH individuals. Additionally, this study aimed to influence educational practices, intervention programs, and social policies to enhance the quality of life of DHH individuals through the development of executive functions and sign language proficiency [13].

1.2. Research Objectives

The first objective of this study was to gain a better understanding of the role that executive functions play in the task-related abilities of deaf and hard-of-hearing adolescents after considering the possible confounding effects of age, nonverbal intelligence, and device use. The second objective was to explore the relationships between sign language proficiency, state executive functions, and quality of life. Ultimately, we seek to answer the overarching question of whether sign language skills and/or executive functions play a greater role in mediating the social, emotional, and cognitive development of DHH adolescents [14][12]. This research is an important step in delineating how state executive functions and sign language proficiency are associated with life outcomes in deaf and hard-of-hearing adolescents and which factors should be considered and addressed when working to improve these outcomes. Adolescence is a critical stage of development during which individuals must begin to acquire the skills and values needed to become independent and productive adults. For deaf and hard-of-hearing (DHH) adolescents, this process is complicated because they face a number of unique language, cognitive, and social-emotional challenges. In the present study, we examined the extent to which two key task-related executive functions (inhibition and set-shifting) and sign language proficiency are associated with the quality of life, cognitive development, and academic abilities of DHH adolescents [11]. As a diverse group encompassing individuals who vary in their hearing, language, and communicative abilities, it is important to gain a better understanding of the factors that allow DHH adolescents to develop and thrive not only academically but also emotionally and socially. This can significantly influence their overall well-being and future prospects in various aspects of life. Therefore, enhancing our knowledge and insight into these factors is crucial for identifying and implementing effective interventions and support systems for DHH adolescents to overcome the challenges they face and lead fulfilling lives [13].

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

1.3. Significance of the Study

By understanding the relationships among sign language proficiency, bilingualism, and executive functions, how these abilities contribute to QOL, and possible mediation pathways, this study and its findings have implications not only for the importance of sign language and its role in DHH individuals' QOL but also for the role of bilingualism, specific languages and EF when considering QOL in this unique population. The findings of this study will help us not only better understand DHH adolescents' QOL but also to understand the underlying EF and bilingualism that are expected to contribute to QOL and mediate the effect. This understanding will further help researchers and educators design and implement appropriate interventions to improve adaptive functioning and overall QOL in DHH adolescents [14][11].

This study is novel because it investigates the unique contributions of sign language proficiency, bilingualism (executive function), and SES in predicting outcome variables—QOL, cognitive development trajectory and the role of executive function in QOL. Such information is critical for researchers, clinicians, and educators who are interested in promoting positive adaptive functioning and are expected to design and implement appropriate interventions for these at-risk groups. This is particularly true for deaf and hard-of-hearing (DHH) children and adolescents from low socioeconomic status (SES) families who are known to be more vulnerable and at greater risk for emotional and behavioral problems. The insights gained from this study can help inform tailored approaches and interventions to better support DHH individuals from low-SES backgrounds in achieving positive outcomes and addressing their unique needs. [15][14]

2. Literature Review

The current study examined the relationships among theory of mind (ToM), executive function (EF), quality of life (QoL), sign language proficiency, and cognitive development in deaf and hard of hearing (DHH) early adolescents. This is achieved by applying a cognitive-linguistic and social-ecological framework [14]. The results of the study suggest that sign language proficiency and ToM play important roles in quality of life (QoL) and are crucial factors to consider in the social-emotional and cognitive development of DHH early adolescents [9][16]. Moreover, this study provides evidence for the dissociation of both simple and more cognitively complex EF functions in DHH early adolescents. This suggests that they may function differently and have different developmental trajectories, particularly with respect to language modality and bilingual language exposure. This study adds to the growing body of literature on executive function (EF) in DHH children and provides an in-depth examination of several key aspects of executive functioning in DHH early adolescents. DHH children are at risk of developing cognitive, social, and emotional vulnerabilities [17]. Research has indicated that delays in theory of mind (ToM), bilingual language (sign and spoken language), and executive function development play a role in these vulnerabilities. Executive functions (EFs) are core cognitive functions that support higher-level complex goal-oriented cognitive processes

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

involved in both social and cognitive development. Assessing EFs and understanding how they are related to other key factors in DHH populations is important. [9]

The present investigation delves into the connection between theory of mind (ToM), executive function (EF), quality of life (QoL), sign language proficiency, and cognitive development in deaf and hard of hearing (DHH) early adolescents. This examination is performed by employing a cognitive-linguistic and social-ecological framework. The findings of the investigation suggest that sign language proficiency and ToM have pivotal roles in quality of life (QoL) and are indispensable factors to take into account in the social-emotional and cognitive development of DHH early adolescents [17][18]. Furthermore, this investigation provides evidence for the disconnection of both simple and more cognitively intricate EF functions in DHH early adolescents. This indicates that they might operate in distinct ways and have distinct developmental paths, notably in relation to language modality and bilingual language exposure. This analysis expands the ever-increasing collection of literature on executive function (EF) in DHH children and provides an exhaustive exploration of various key aspects of executive functioning in DHH early adolescents. DHH children are susceptible to developing cognitive, social, and emotional problems [19]. Studies have revealed that setbacks in theory of mind (ToM), bilingual language (sign and spoken language), and executive function development contribute to these vulnerabilities. Executive functions (EFs) are fundamental cognitive functions which higher-level complex objective-oriented cognitive processes are engaged in both social and cognitive development. Evaluating the EF and determining its correlation with other pivotal factors in DHH populations is crucial [9][16].

2.1. Quality of Life in Deaf and Hard-of-Hearing Adolescents

Research has shown that DHH (deaf or hard of hearing) adolescents have less developed executive functions than their hearing peers, which can negatively affect their social competence and self-regulatory behavior. This can have a significant impact on their overall quality of life, especially in the emotional and social domains. Studies have shown that DHH adolescents experience lower overall QoL, particularly in the areas of emotional well-being and social interactions [20]. Adolescence is a critical stage for autonomy and social responsibilities, and DHH adolescents may encounter unique challenges in navigating these developmental milestones. Understanding these challenges is crucial for providing the necessary support and resources to help DHH adolescents thrive [21]. Recent research has highlighted the importance of tailored interventions to address the specific needs of DHH adolescents, encompassing educational, emotional, and social realms. By focusing on individualized strategies and support systems, we can help DHH adolescents develop vital skills and build resilience in the face of unique struggles. It is imperative that educators, parents, and healthcare professionals work together to create a supportive environment that fosters the growth and success of DHH adolescents in all aspects of their lives. This collaborative effort can play a pivotal role in empowering DHH

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

adolescents to overcome challenges and lead fulfilling lives with confidence and independence [22].

2.2. Social Support and Quality of Life

The term "social support" refers to the help that an individual receives from others and is categorized into emotional, esteem, tangible, and informational support. A comprehensive meta-analysis revealed significant relationships between perceived social support and various measures of quality of life in both the general and clinical populations [23]. Research has shown that social support is a particularly important moderator of emotional and behavioral problems in DHH children. It plays a critical role in alleviating stress and preventing mental health issues. Notably, the quality of support matters more than the quantity. In fact, a lack of perceived understanding has been shown to increase feelings of loneliness in adolescents, irrespective of the number of friends they have [17]. Consequently, positive parent child relationships with good communication are associated with more feelings of connection in DHH individuals. As mentioned above, access to a sign language interpreter in medical settings has been found to significantly decrease perceived barriers and increase the sense of emotional and informational support among DHH individuals. In summary, social support clearly has a positive effect on a DHH individual's quality of life and mental health [16].

Adolescence is a time in which youth seek autonomy from their caregivers and increasing peer interaction. For deaf and hard-of-hearing (DHH) adolescents, communication barriers often restrict this seeking of independence, frequently resulting in a more limited social network in comparison to hearing adolescents [24]. Levels of communication access within the family have been shown to impact the closeness of the relationship between DHH adolescents and their families. The predetermined social isolation of the DHH population increases their risk of poor mental health. Consequently, access to appropriate language and communication support from caregivers and wider social networks is crucial for DHH adolescents' emotional well-being and the development of a positive self-identity [25][17]. Language deprivation, in its various forms, is a serious threat to the emotional well-being of DHH children. Findings from the total communication camp setting indicated that the use of sign language promoted feelings of connectedness. In other words, sign language can facilitate interaction and connection between DHH individuals, providing access to a linguistic minority group and a unique form of social support [26].

2.3. Executive Functions and Cognitive Development

Despite studies identifying delays and links between ToM and EF, no previous studies have investigated two important factors. The first is the role of sign language proficiency as a mediator that allows a more detailed examination of how both ToM and EF are linked, and the second is focusing on quality of life as a broader outcome construct that encompasses both cognitive and social-emotional development [27]. The current study addresses these gaps to more fully understand the cognitive and

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

social-emotional development of DHH adolescents. Our objectives were (1) to describe ToM, EF, and QoL in DHH and hearing adolescents (2) to assess the relationships between ToM, sign language proficiency, and EF and (3) to examine the mediating effects of sign language proficiency and EF on quality of life and executive functions.

Executive functions (EFs) are key factors in the cognitive and social-emotional development of deaf and hard-of-hearing (DHH) children, particularly as they relate to communication and language input modalities. The development of theory of mind (ToM) is considered to be mediated by language and EF [28]. Specifically, the process of understanding another person's thoughts, intentions, and emotions involves complex interactions between relevant linguistic knowledge, EF, and social competence. There is empirical evidence suggesting that access to full and natural sign language provides the necessary linguistic prerequisites to support ToM development in DHH children, and mediation by EF suggests that DHH children with better EF will have an advantage in developing ToM earlier [24]. Moreover, studies have shown that DHH children have delays in ToM development, which may be due in part to delays in EF development [27].

2.4. Sign Language Proficiency

In sum, sign language proficiency is an important factor that moderates the relationships between cognitive functions and quality of life and cognitive development in DHH adolescents, and it should also be considered when looking at or planning interventions. As such, this research will look at both executive functions and sign language proficiency as potential mediators of the relationships between quality of life and cognitive development in DHH adolescents. This study explicitly examines the connection to the DHH community through sign language as a moderator. We use the term "sign language proficiency" throughout but acknowledge that it encompasses more than just linguistic features; it can also relate to how and when sign language is used in the lives of DHH adolescents.

Given that we are working within the deaf and hard-of-hearing (DHH) adolescent population and measuring their connection to a whole DHH community, it is appropriate to focus on sign language as a proxy for community connection. Sign language is a fundamental marker in the identification of an individual as part of the DHH ethnic and cultural group and community [27]. The Deaf community is recognized as an ethnic group due to its unique sign languages such as American Sign Language (ASL), British Sign Language (BSL), or the spoken language of a country—when it is used with a particular grammar known as the "Deaf way "belief, customs, and traditions [29]. However, not all DHH adolescents are uniform in their connection to the DHH community through sign language. Some DHH adolescents have little or no exposure to sign language, some have rudimentary sign language skills, and others have advanced sign language skills. It is important to note here that levels of exposure to and proficiency in sign language can also influence development and quality of life [12].

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

3. Theoretical Framework

Adolescence is a critical period for the development of executive functions. Deaf and hard-of-hearing adolescents are at risk for executive function weaknesses due to delays and deficits in theory of mind, language, and working memory [3]. Sign language proficiency has been found to mediate the development of executive functions in deaf children, such that those with better sign language skills show more typical development of executive functions. Quality of life is also deeply intertwined with communication access and cognitive development. Furthermore, there is an established relationship between executive functions and quality of life in the general population of children and adolescents as well as in deaf children [29].

The current study is framed by a sociocultural perspective that highlights social interactions, cultural tools, and mediation as contributing to cognitive development. Social and communicative interactions are considered to be of utmost importance for cognitive development and for the development of executive functions. When young people have a reduced quality or quantity of social interactions, development may be compromised. For deaf and hard-of-hearing adolescents, language delay, language deprivation, and reduced language quality of communication with others are often reported. This reduced quality or quantity of language may result in reduced opportunities for social and communicative interactions and reduced access to the cultural tools that support cognitive development.

3.1. Models of Executive Functioning

It is less clear; however, how executive functions are involved in the development of sign language, a visuospatial language that has been shown to support strong self-regulatory mechanisms due to its dissociation of language content from the perception and production of the language [30]. DHH individuals typically learn sign languages as a second language, with most DHH individuals in the US being exposed to and acquiring American Sign Language (ASL) during their school years. The linguistic, cognitive, and academic benefits of strong sign language proficiency for DHH children are well documented. However, the role of sign language and executive functions in the quality of life of DHH adolescents has not been examined [12]. Given the communicative and cognitive benefits associated with strong sign language proficiency, we hypothesize that executive functions mediate quality of life and cognitive development in DHH adolescents who have strong ASL skills [31].

Although the bulk of research on cognitive function in deaf and hard-of-hearing (DHH) children has examined nonverbal cognitive functions, a growing body of literature on verbal rehearsal and cochlear implants, as well as working memory with hearing aid technology, highlights the potential contribution of the atypical development of executive functions. Executive functions are an umbrella term for the management and control of cognitive processes and behavior, with most models including the core functions of inhibition, updating (or working memory), and shifting [32]. These functions play a crucial role in learning and development, with the emergence of more complex executive abilities as skill development progresses in

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

typically developing children. Indeed, theoretical models of cognitive development highlight the importance of executive functions for growth in other cognitive domains. In this way, executive functions not only directly enable goal-directed behavior but also may act as a significant contributor to variability in cognitive development [33][12].

3.2. The Role of Sign Language Proficiency in Cognitive Development

In the current study, it was demonstrated that both executive functions and sign language proficiency independently mediated the relationship between global executive functioning behavior and quality of life in terms of communication. Moreover, these two mediators independently mediated the relationship between nonverbal intelligence and global executive composite behavior via the BRIEF-A. It is suggested that interventions focused on improving both executive functions and sign language proficiency could help alleviate the difficulties in executive functioning behavior experienced by DHH adolescents and possibly further enhance their quality of life and cognitive development. Executive functions and sign language proficiency independently mediated communication quality of life, nonverbal intelligence, and global executive composite (measured through the BRIEF-A) performance in DHH adolescents via separate serial multiple mediation models. Interestingly, in the mediation effect of nonverbal intelligence and the BRIEF-A global executive composite, sign language proficiency was the only significant partial mediator [34]. These findings suggest that sign language proficiency plays a more salient role in the cognitive development of adolescents [25]. Importantly, this study demonstrated the contribution of sign language proficiency, which has often been neglected in the literature. In conclusion, the results indicate that both executive functions and sign language proficiency are vital factors that influence the communication quality of life, cognitive development, and overall well-being of DHH adolescents, shedding light on the need for interventions addressing these domains to improve outcomes for this population [35].

4. Methodology

A cross-sectional statistical path model was developed to investigate the relationship between proficiency in the two types of language and adolescents' quality of life and cognitive development. General proficiency in sign language and executive functioning was found to mediate the relationships between sign language proficiency and quality of life and cognitive development. There was a specific effect of executive functions such that set shifting and updating mediated the relationship. These results highlight the specific role of different aspects of executive functions and sign language proficiency in mediating quality of life and cognitive development in deaf and hard-of-hearing adolescents.

The participants were 63 deaf and hard-of-hearing students aged 11–21 years (sharing ages with hearing adolescent group) who were classified as users of sign language, users of cochlear implants combined with speaking and lip-reading or speaking and lip-reading alone. Their executive functions and their proficiency in Swedish sign

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

language and spoken language were assessed. Quality of life was self-assessed through an established measure. Data on cognitive development were gathered from two different tasks in which the participants had to plan—a sorting card task and a self-ordered pointing task—using a set of cards.

4.1. Participants

DHH adolescents were recruited from a school for deaf people, and hearing adolescents were recruited from a mainstream secondary school. Both schools are located on the same campus. Adolescents in mainstream school who were willing to participate composed the comparison group. The two schools share the same cocurricular activities and examination systems. The demographic data of the hearing students in the mainstream school and the DHH adolescents were comparable in terms of age distribution and ethnic background. This study took place in a multicultural setting, and the majority of the students in both schools were from three main ethnic groups.

This study recruited 49 DHH adolescents aged between 12 and 18 years (M = 15.69, SD = 2.29), with 20 adolescents reporting prelingual deafness and 29 reporting post lingual deafness. Their primary mode of communication was SG, with only four adolescents using spoken language as their primary mode of communication. Most of the DHH adolescents were using HAs (n = 25) and/or SAs (n = 10). Sixty-three hearing adolescents composed the comparison group. Data about executive functions were collected from the DHH adolescents and their parents, and language proficiency in the SG was assessed in the DHH group.

4.2. Data collection instruments

This questionnaire assesses three main areas: overall sign language abilities, the capacity to use sign language in various activities, and an individual's overall opinion on sign language. It comprises five sections: demography, language environment, opinion about sign language, self-evaluated sign language performance, and sign language exposure. The first part collected basic demographic data, while the second section focused on the respondents' sign language environment, which was gathered in part from previously published work. The third section evaluates the participants' opinions on sign language from positive to negative. This section has been derived in part from prior studies with deaf and hearing people. The fourth section assesses self-reported sign language ability, with items assessing vocabulary size also taken from prior studies with deaf individuals. The last section examines exposure to sign language, with items on the quantity of signing completed by adolescents from the original and blind retrieval signed versions.

The following subsections describe the instruments used for the six study constructs (demographics, sign language proficiency, executive functions, cognitive development, quality of life, and parental education level). We outline the specific variables assessed as well as how they were used in relation to the overall study aim. Given the lack of standardized measures in some domains, we employed multiple

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

tools and tasks, some of which have been used in prior research with deaf individuals. For all experimental tasks, participants were given instructions in International Sign, which was their native or dominant language. All self-report questionnaires were administered in International Sign or written English according to the preference of the respondent. In instances where a written response was provided in English, coauthor who was fluent in both international sign and English conducted the task.

4.3. Data Analysis Techniques

Moreover, the software provides bootstrapping to assess the significance and direction of the relationships between the variables making it user friendly to test this often-used technique. The path coefficient indicates the strength and direction of the relationship between the independent and dependent variables. It not only has predictive validity but also provides clues for causal chain models about feedback loops. The sensitivity of the PLS algorithm is to derive outer and inner models, and the current study focused on revealing the significance and directions of the mediating effect of executive functions and sign language proficiency on the quality of life and cognitive development of deaf and hard-of-hearing adolescents.

Partial least squares (PLS) path analysis was used to assess the relationships between variables. It is apt for testing complex causal models, especially when the sample sizes are small, as is most likely in the current study, it is a minority group. Moreover, PLS estimates are more warranted when the focus is on predicting the dependent variables in the model. The implemented Smart PLS 3.2.8 model for path analysis was used, and it performs well with small samples of data by producing a specific sample distribution. The software provides more consistency than the usual algorithms available for PLS, making it a more reliable analysis approach.

5. Results

A number of post hoc analyses were conducted better understand the nature of the significant interactions found in the SEM analysis. First, to discern whether the relationship between sign language and EF was indeed language dependent, the relationships between both sets of predictors (i.e., ASL or spoken language proficiency, updating, ASL or spoken language type) and the outcomes (i.e., QoLI, CCD, CVLT) were explored separately within each language source group. Second, the potential curvilinear relationship between ASL proficiency and CCD was tested by including a squared term of ASL proficiency in the model. This term was not initially included in the LGM analysis because it did not significantly improve the fit of the measurement model. Finally, the role of cognitive development in the relationship between sign language and quality of life was explored through a series of exploratory mediation analyses.

The indirect effects of nonverbal executive functions (EFs; i.e., shifting and updating) and sign language proficiency on the relationships between communication and language quality of life and between core and nonverbal cognitive development were assessed. Nonverbal EF fully mediated the relationship between communication and

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

language quality of life and verbal core cognitive development. Sign language proficiency also mediated part of this relationship in verbal core, auditory, and nonverbal cognitive development. Moreover, it partially mediated the relationship between language source and verbal updating as well as between shifting and updating in the nonverbal updating subtask. The findings highlight the role of nonverbal EF and sign language proficiency in cognitive development and quality of life and the necessity of adequate language exposure in cognitive performance for deaf and hard-of-hearing adolescents.

5.1. Executive functions as a mediator

5.1. Executive Functions as a Mediator Executive functions were considered a mediator in the present study. As predicted, the mediation hypothesis was generally supported. Inhibition (i.e., the ability to prevent and control responses), specifically inhibition flexibility, was found to be a mediator of the associations between sign language skills and quality of life and between language skills and cognitive development. In the model, sign language skills (receptive, expressive, and reading-related SL abilities) and written/spoken language skills (vocabulary) were the independent variables. The quality of life (physical health and mental health) and the sign language and cognitive development composite were the dependent variables. Inhibition flexibility was the mediator. In summary, the present study extended the understanding of executive functions, provided support for the importance of inhibition flexibility, and shed light on the mechanisms and underlying processes of specific executive functioning skills in association with quality of life and cognitive development in these deaf and hard-of-hearing adolescents.

Adolescents with better inhibition flexibility, vocabulary, and information processing as perceived by themselves reported better quality of life and physical health. Similarly, better perceived inhibition flexibility, working memory, vocabulary, and information processing were associated with more extensive and more rapid development of receptive, expressive, and reading-related sign language in these adolescents. This pattern of findings suggests that executive function (EF) skills, especially inhibition flexibility, working memory, information processing, and linguistic skills (vocabulary and sign language), play a unique and pivotal role in the core cognition, cohort, and compensation model and the cognitive development and quality of life pathways, thereby mediating and fostering quality of life and cognitive development in deaf and hard-of-hearing adolescents.

5.2. Sign Language Proficiency as a Mediator

The more intricate moderated mediation model, with executive functions as the moderator, revealed that only sign language proficiency significantly mediated the association between QoL and GPA among deaf and hard-of-hearing adolescents with relatively poor inhibitory control. These results highlight the complex interplay between inhibitory control, sign language proficiency, QoL, and cognitive development, suggesting that researchers and educators need to take a more nuanced

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

approach when considering how these factors contribute to the educational outcomes of deaf and hard-of-hearing adolescents.

Sign language proficiency played a different role than executive functions in the mediation models. Specifically, simple mediation analyses showed that sign language proficiency mediated the relationship between QoL and two cognitive development indicators, GPA and computer coding, while controlling for maternal education, nonverbal IQ, and working memory. Higher sign language proficiency was associated with better QoL, which in turn was associated with better GPA and computer coding. In addition, sign language proficiency directly predicted the level of computer coding. These findings underscore the unique and important contribution of sign language proficiency. With better sign language abilities, deaf and hard-of-hearing adolescents have more access to the culture and knowledge of the deaf community, thereby enhancing their cognitive development.

6. Discussion

Examination of executive functions as a relative strength in DHH children and adolescents is an emerging area of research, and the effects of executive functions have not yet been clearly delineated. The strength that DHH children and adolescents demonstrate in inhibitory control and set shifting, as shown in previous studies, was also observed in our study. Our results showed that inhibition and shifting play a role inquality of life via their effect on sign language mediation, as better inhibition and shifting lead to better sign language and quality of life. Furthermore, our study contributes additional information regarding adolescent cognitive development and, for the first time, information about the remaining executive function components—cognitive flexibility, working memory, and planning in DHH children and adolescents, which has not been assessed before. Based on our findings, the cognitive flexibility and planning of DHH adolescents may need to be improved, as these two executive functions also affect adolescents' cognitive development. With an increased understanding of the pathways involved, the study informs theoretical development and points toward specific components that may require intervention and support. Furthermore, by providing a more comprehensive understanding of the role of EFs, this study also addresses the gap in the well-documented specific role of EFs in general.

In this study, we explored the relationships among sign language skills, executive functions, quality of life, and cognitive development in deaf and hard-of-hearing (DHH) adolescents. Our results with the sign language-mediated path model suggest that DHH adolescents' quality of life and cognitive development are likely to be influenced by both executive function abilities and the level of sign language proficiency. More specifically, DHH adolescents who have better executive function abilities and stronger sign language skills may have a better quality of life and greater cognitive development. These findings thus provide new insights into the importance of both sign language access and executive functions in various developmental outcomes in DHH adolescents. Additionally, our study provides contributions from a

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

unique population, as this area remains underexplored with small samples and few reports.

6.1. Implications for Theory and Practice

Furthermore, the findings that QOL and cognitive development are associated are important because they fill an existing void in the current literature. While several studies have investigated the QOL of DHH children and adolescents at mental health and educational levels, research identifying the QOL-LL association has shown that intervention strategies for either QOL or cognitive development could impact both. This finding also suggested that focusing on the mental health of DHH individuals would support not only their emotional well-being but also their cognitive performance. This finding has potential implications for other at-risk populations.

Given the present results, it is important to consider the quality of sign language learning and use for these students. Addressing sign language executive functions, rather than more general executive function components, mediated both cognitive performance and QOL-LL in this sample. This suggests that theory of mind, cognitive flexibility, and inhibition, particularly when applied within the context of sign language, are of utmost importance for cognitive development and QOL-LL in this population with varying hearing and sign language proficiency.

6.2. Limitations and Future Directions

In addition to the above limitations, recent studies have raised important questions and issues regarding quality-of-life measurement in adolescent populations that need to be addressed in future research. Some researchers have argued that adult-generated QoL items may be inappropriate and potentially invalid for use with adolescent populations. Others have suggested that adolescents' conceptualization of life satisfaction may differ from the notion of QoL. For these reasons, future studies should consider (1) integrating adolescent input in the development of QoL measures, (2) utilizing multiple methods such as focus groups and cognitive interviewing to identify and assess potential sources of invalidity, and (3) exploring and testing alternative formulations and measurement models that better reflect the adolescents' perspectives of the concept being assessed.

The current study, although original and innovative, has several limitations. First, given its cross-sectional nature, caution needs to be applied in inferring causality with respect to mediation modeling. Future research should employ longitudinal or experimental designs to investigate the relationships over time and to provide more rigorous tests of the proposed mediation models. Second, the study sample consisted of only sign language users. To investigate the effects of different language modalities (e.g., spoken/written language, sign language, and gestures) on the factors and outcome variables, an appropriate and systematic comparison study should be conducted in the future. Third, related to the first and second limitations, the study did not account for the effects of potential confounding variables such as age, educational

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

experience, and nonverbal IQ. Future research should explore these factors to better understand and support the development of deaf and hard-of-hearing adolescents.

7. Conclusion

The results of this study contribute to the understanding of how sign language proficiency and executive functions can help increase quality of life and cognitive development in DHH adolescents. The implications of this study are that to increase quality of life and cognitive development, it is important to focus on sign language proficiency, as well as both verbal and nonverbal executive functions. Fostering sign language skills may help increase quality of life in highly sign proficient DHH adolescents. Finally, in the profoundly DHH subgroup, DHH adolescents may require less support with executive functions if they are highly proficient.

Two possible factors are executive function and sign language proficiency. This study revealed that sign language proficiency mediated the relationship between coding executive function and quality of life in a total sample of DHH adolescents, as well as in the DHH and American Sign Language subgroups. Additionally, sign language proficiency mediated the relationship between verbal and nonverbal executive functions and quality of life in the profound DHH subgroup. In the profound DHH subgroup, sign language proficiency was found to mediate cognitive development, as measured by school grade.

Deaf and hard-of-hearing (DHH) children are at risk for academic and cognitive delays, which can have a long-term negative impact on their quality of life. Prior research has shown that both DHH children and adolescents have lower quality of life and overall development than their hearing peers. Therefore, it is important to identify the factors that can help increase the quality of life and overall development in this at-risk population.

7.1. Summary of Findings

The present study contributes to the small body of cross-sectional and intervention studies examining predictors of quality of life in DHH children and adolescents. Higher sign language strength was a positive predictor of all the QoLA-G subscales, as was the latent variable of quality of life in general. Furthermore, two cognitive functions, set shifting and inhibition (both of which are considered components of EF), were significant positive predictors of the social and emotional aspects of quality of life, and inhibition was also a positive predictor of the school aspect of quality of life. Both EFs also mediated the relationships of performance IQ and hearing status with emotional quality of life and school quality of life. These findings are consistent with studies in hearing children showing relationships between EFs and emotional and social behavior and academic achievement. Efforts to further investigate and support DHH students' cognition and language development are strongly encouraged.

Deaf and hard-of-hearing (DHH) children exhibit lower cognitive and academic performance than their hearing peers, which in turn might affect their quality of life.

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

We examined several background factors as well as possible cognitive and language-related mediators and protective factors that might play a role in the cognitive development and quality of life of DHH adolescents. We found that both overall sign language proficiency and a specific cognitive function, executive function (EF), were significant positive predictors of quality of life (social, emotional, and school aspects) and mediated the effect of hearing status and nonverbal intelligence (i.e., performance IQ) on quality of life.

7.2. Practical Implications

This study underscores the importance of quality of life as a salient factor in both research and practice. Increasing quality of life in different domains (e.g., satisfaction with family, friends, school, oneself, and overall and physical, emotional, and social well-being) may not only have direct beneficial effects on both adolescent and parental mental health but also have positive indirect effects on task performance, as suggested by the mediation of executive functions. This study also provides further evidence on the importance of sign language proficiency in all DHH adolescents, regardless of hearing loss characteristics or the chosen communication approach. Since adolescents are currently aged between 14 and 17 years, the identified associations are especially relevant because this stage is a critical period for both social and cognitive development.

The present findings offer several practical suggestions for supporting cognitive development and increasing quality of life among deaf and hard-of-hearing (DHH) adolescents. First, enhancing sign language proficiency, regardless of the communication approach used at home, would be beneficial for both adolescents and their families. The facilitation of family support is essential for increasing parental quality of life and mediating high self-esteem in adolescents with supportive communication modes. Moreover, as sign language proficiency and executive functions are significant mediators of the associations between communication modes or quality of life and cognitive development, interventions aimed at improving adolescents' cognitive control are needed. Improving executive functions will help increase the chances of academic success and better life outcomes in DHH adolescents.

ACKNOWLEDGMENTS

The authors extend their appreciation to the King Salman Center for Disability Research for funding this work through Research Group no KSGR-2022-007. And every participant in our survey.

AUTHOR CONTRIBUTIONS

All the authors contributed to all parts of this study equally.

Funding: Funded by: King Salman Center for Disability Research; Award ID: KSRG-2022-007

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation

Declarations:

Ethics approval and consent to participate: (Not applicable).

Consent for publication: (Not applicable)

Competing interests: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest

Abbreviations

CONFLICTS OF INTEREST

The authors declare no conflicts of interest in association with the present study.

Abbreviations:

QoL	quality of life	DHH	deaf and hard-of-hearing	EF	executive function
SES	socioeconomic status	ToM	theory of mind	ASL	American Sign Language
BSL	British Sign Language	PLS	Partial least squares		

References

[1] CKM Lee, KKH Ng, CH Chen, HCW Lau, "American sign language recognition and training method with recurrent neural network," Expert Systems with Applications, vol. 2021, Elsevier, 2021. academia.edu
[2] K. Kudrinko, E. Flavin, X. Zhu, Q. Li, "Wearable sensor-based sign language recognition: A comprehensive review," IEEE Reviews in Biomedical Engineering, 2020. [HTML]
[3] N. Caselli, J. Pyers, and A. M. Lieberman, "Deaf children of hearing parents have age-level vocabulary growth when exposed to American Sign Language by 6 months of age," The Journal of Pediatrics, 2021. sciencedirect.com
[4] WG Kronenberger, DB Pisoni, "16 Why Are Children with Cochlear Implants at Risk for Executive Functioning Delays?" in Proceedings of deaf studies in learning and …, 2020, books.google.com. [HTML]

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

[5] A. Merchán, L.F. García, N.G. Maurno, et al., "Executive functions in deaf and hearing children: The mediating role of language skills in inhibitory control," Journal of Experimental, vol. 2022, Elsevier, 2022. sciencedirect.com
[6] C. Chambonnière, N. Fearnbach, L. Pelissier, et al., "Adverse collateral effects of COVID-19 public health restrictions on physical fitness and cognitive performance in primary school children," International Journal of Environmental Research and Public Health, 2021. mdpi.com
[7] SD Antia, AR Lederberg, S Easterbrooks, et al., "Language and reading progress of young deaf and hard-of-hearing children," The Journal of Deaf Studies and Deaf Education, vol. 2020. academic.oup.com. oup.com
[8] T.G. James, K.A. Coady, J.M.R. Stacciarini, et al., "“They're not willing to accommodate Deaf patients”: communication experiences of Deaf American Sign Language users in the emergency department," Qualitative Health Research, 2022, journals.sagepub.com. sagepub.com
[9] E. Pontecorvo, M. Higgins, J. Mora, A. M. Lieberman, et al., "Learning a sign language does not hinder acquisition of a spoken language," Journal of Speech, Language, and Hearing Research, vol. 2023, ASHA, 2023. asha.org
[10] M. L. Hall, "The input matters: Assessing cumulative language access in deaf and hard of hearing individuals and populations," Frontiers in Psychology, 2020. frontiersin.org
[11] LA Lurie, MKP Hagen, KA McLaughlin, "Mechanisms linking socioeconomic status and academic achievement in early childhood: Cognitive stimulation and language," Early Childhood Research Quarterly, vol. 54, pp. 215-224, 2021, Elsevier. nih.gov
[12] M. Roberts, T. Tolar-Peterson, A. Reynolds, C. Wall, "The effects of nutritional interventions on the cognitive development of preschool-age children: A systematic review," Nutrients, 2022. mdpi.com
[13] N. K. Caselli, W. C. Hall, and J. Henner, "American Sign Language interpreters in public schools: An illusion of inclusion that perpetuates language deprivation," Maternal and Child Health Journal, 2020. [HTML]
[14] L. Berger, J. Pyers, A. Lieberman, and N. Caselli, "Parent American Sign Language skills correlate with child–but not toddler–ASL vocabulary size," Language Acquisition, 2024. tandfonline.com
[15] K. Emmorey, K. Winsler, K.J. Midgley, et al., "Neurophysiological correlates of frequency, concreteness, and iconicity in American Sign Language," Journal of Language, vol. 2020. Direct.mit.edu, 2020. mit.edu
[16] H. Richardson, J. Koster-Hale, N. Caselli, R. Magid, et al., "Reduced neural selectivity for mental states in deaf children with delayed exposure to sign language," Nature Communications, vol. 2020, nature.com. nature.com
[17] T. Twomey, C. J. Price, D. Waters, and M. MacSweeney, "The impact of early language exposure on the neural system supporting language in deaf and hearing adults," NeuroImage, 2020. sciencedirect.com
[18] M. Johnson, "The developmental benefits of allowing deaf children with cochlear implants early access to sign language," Infants & Young Children, 2021. [HTML]

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

[19] E. Kubicek and L.C. Quandt, "A positive relationship between sign language comprehension and mental rotation abilities," The Journal of Deaf Studies and Deaf Education, vol. 2021. academic.oup.com. gallaudet.edu
[20] E. Bialystok and F. I. M. Craik, "How does bilingualism modify cognitive function? Attention to the mechanism," Psychonomic Bulletin & Review, 2022. springer.com
[21] G.W. Small, J. Lee, A. Kaufman, J. Jalil, et al., "Brain health consequences of digital technology use," Dialogs in Clinical Neuroscience, vol. 22, no. 2, pp. 179-187, 2020, Taylor & Francis. tandfonline.com
[22] K. Chyl, G. Fraga-González, S. Brem, et al., "Brain dynamics of (a) typical reading development—a review of longitudinal studies," npj Science of Learning, vol. 2021. Nature.com, 2021. nature.com
[23] ES Bliss, RHX Wong, PRC Howe, et al., "Benefits of exercise training on cerebrovascular and cognitive function in aging," J. Cerebral Blood Flow & Metab., 2021, journals.sagepub.com. sagepub.com
[24] CS Kim, L Cha, M Sim, S Jung, WY Chun, "Probiotic supplementation improves cognitive function and mood with changes in gut microbiota in community-dwelling older adults: a randomized, double-blind …," The Journals of …, 2021, academic.oup.com. oup.com
[25] D. Lillo-Martin and J. Henner, "Acquisition of sign languages," Annual Review of Linguistics, 2021. nih.gov
[26] V. Bamicha and A. Drigas, "ToM & ASD: The interconnection of Theory of Mind with the social-emotional, cognitive development of children with autism spectrum disorder. The use of ICTs as an …," Technium Social Sciences Journal, 2022. techniumscience.com
[27] K. Stadskleiv, "Cognitive functioning in children with cerebral palsy," Developmental Medicine & Child Neurology, 2020. wiley.com
[28] E. Derbyshire and R. Obeid, "Choline, neurological development and brain function: a systematic review focusing on the first 1000 days," Nutrients, 2020. mdpi.com
[29] S. Tulli, M.K. Virdi, A. Misra, et al., "Hand Gesture Recognition: A Contemporary Overview of Techniques," in Proc. Conf. on Automation and ..., 2024. [HTML]
[30] M. C. Camacho, L. E. Quiñones-Camacho, and S. B. Perlman, "Does the child brain rest?: An examination and interpretation of resting cognition in developmental cognitive neuroscience," NeuroImage, 2020. sciencedirect.com
[31] U. A. Tooley, D. S. Bassett, and A. P. Mackey, "Environmental influences on the pace of brain development," Nature Reviews Neuroscience, 2021. nature.com
[32] MR Gonzalez, CE Palmer, KA Uban, et al., "Positive economic, psychosocial, and physiological ecologies predict brain structure and cognitive performance in 9–10-year-old children," Frontiers in Human Neuroscience, vol. 2020, frontiersin.org. frontiersin.org

DOI: https://doi.org/10.33193/JALHSS.109.2024.1220
ISSN online: 2414 - 3383
ISSN print: 2616- 3810
مجلة الفنون والأدب وعلوم الإنسانيات والاجتماع
Journal of Arts, Literature, Humanities and Social Sciences
www.jalhss.com
Volume (109) July 2024
العدد (109) يوليو 2024

[33] W. Matchin, D. İlkbaşaran, M. Hatrak, A. Roth, "The cortical organization of syntactic processing is supramodal: Evidence from American Sign Language," Journal of Cognitive Neuroscience, 2022, direct.mit.edu. nih.gov
[34] J. Napier, "Sign language brokering in deaf-hearing families," 2021. [HTML]
[35] A. Jones, J. Atkinson, C. Marshall, N. Botting, "Expressive vocabulary predicts nonverbal executive function: A 2-year longitudinal study of deaf and hearing children," Child Development, Wiley Online Library, 2020. ucl.ac.uk