

Executive Functions and their Relationship to Emotional Regulation in Hard of Hearing

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ABSTRACT

Background. Executive functions are a collection of mental processes that play a crucial role in regulating behavior and emotions, with their development starting in childhood. Hearing loss can affect these functions, resulting in language acquisition, challenges with learning, and social interactions. By understanding the relationship between executive functions and emotional regulation in individuals with hearing loss, we can create effective support strategies. **Objective.** The current study aimed to reveal the relationship between executive functions and emotional regulation in hearing impaired children. **Methods** In this cross-sectional survey, data were collected from 135 students (78 males and 57 females) of hearing impaired in integration programs in Riyadh, Saudi Arabia (M age = 12.8 years, SD age = 1.68 years), the analytical descriptive method was used, and in order to achieve the objectives of this study, some tools were used, namely: The Barkley Deficits in Executive Functioning Scale-Children and Adolescents (BDEFS-CA) (Barkley, 2012) and the Emotional Regulation Scale (Gross & John, 2003). **Results** The results of the study indicated a positive correlation between executive functions and emotional regulation. It appears that there were no observable differences between males and females in terms of executive functions and emotional regulation in children with hearing impairment. Emotional regulation skills appeared to contribute to 75% of the variability in executive function scores. However, it is important to note that these findings require further validation through additional studies employing stronger methodologies. **Conclusion** This preliminary study offers valuable insights into potential strategies and programs for training executive function tasks, which have a significant impact on various aspects of development, particularly emotional development in children with hearing impairment.

Keywords: Executive Functions; Emotional Regulation; Hard of Hearing, Saudi Arabia

INTRODUCTION

Executive functions regulate complex behaviors by enabling individuals to assess and control their actions and thoughts, allowing for flexible initiation, monitoring, and termination of behaviors (Botting et al., 2017). Ter-Stepanian et al. (2017) characterize executive functions as abilities that promote independent and self-serving behavior, including processes such as planning, organizing steps to achieve goals, mental flexibility, adapting thoughts to situational changes, and inhibition, suppressing inappropriate responses. These functions also encompass the ability to initiate or stop actions, monitor behaviors, and adjust to changing outcomes (Demetriou et al., 2024).

Deficiencies in executive functions result in problems with memory, attention, behavioral control, responsiveness, and cognitive strategy development, which are crucial for knowledge acquisition (Cavalli et al., 2022). Furthermore, impaired executive function hinders social communication, making it difficult to use visual

cues, engage in dialogue, express emotions, and leads to excessive self-talk, ultimately disrupting social relationships. Successful life outcomes, academically, socially, and emotionally, depend not only on knowledge but also on cognitive skills known as executive functions (Groves, Wells, et al., 2022). Children with hearing impairments often exhibit deficits in these functions, negatively impacting various aspects of their personality, as confirmed by multiple studies (Figueras et al., 2008; Hall et al., 2017; Henry et al., 2012; Hintermair, 2013; Kronenberger et al., 2014). These impairments pose unique challenges, including poor social and emotional development (Ashori & Jalil-Abkenar, 2021), behavioral issues (Hintermair, 2013), social maturity (Marschark et al., 2017), literacy difficulties, and impaired spatial and visual perception (Botting et al., 2017), affecting many vital developmental processes and functions (Lantrip et al., 2016; Marschark et al., 2017).

Emotional regulation is a multifaceted process integral to an individual's emotional development (Bylsma, 2021). It plays a crucial role in non-verbal communication by enabling the recognition and management of both one's own emotions and those of others. This includes interpreting and predicting actions, controlling emotional states, and responding appropriately (Pereira et al., 2021). Techniques may involve reframing challenging situations to mitigate anger or anxiety, concealing signs of sadness or fear, or focusing on aspects that promote happiness or calmness (SOLTANIFAR et al., 2018). As a vital social-emotional skill, emotional regulation fosters adaptability and positive interactions in various emotional contexts (Tsou et al., 2021). Conversely, inadequate emotional regulation can lead to psychological issues such as introversion, isolation, anxiety, depression, low self-esteem, poor social interactions, and diminished academic performance (Joormann & Stanton, 2016; SOLTANIFAR et al., 2018).

Hearing-impaired children experience difficulties in emotional regulation, which include challenges in recognizing emotions, understanding others' feelings and actions in social contexts, and displaying negative emotional reactions (Awed & Hammad, 2022; Hammad & Shalhoub, 2024). They perform worse on emotion-related tasks compared to their hearing peers (Ashori & Jalil-Abkenar, 2021; SOLTANIFAR et al., 2018). Studies show that these children particularly struggle with facial emotion recognition and understanding complex emotions, such as false beliefs (Sidera et al., 2017). Auditory deprivation significantly hinders their social interactions, leading to increased loneliness and a poor grasp of others' mental states and emotional responses (SOLTANIFAR et al., 2018). Hammad et al. (2024) noted that these children often appear stubborn and face social challenges, likely due to their limited communication skills affecting their emotional competence. This limitation causes them to focus on outcomes rather than the emotional processes involved, making them less able to articulate their motivations (Knoors & Marschark, 2014). Consequently, in conflict situations, hearing-impaired children may express anger without explaining their feelings, thereby failing to prompt empathy from others (Hammad & Awed, 2020). Overall, they struggle to recognize the role of emotions in relationships and often overlook the effects of their emotional expressions, appearing insensitive to others' feelings (Ashori & Jalil-Abkenar, 2021).

Emotional issues are three times more prevalent among the hearing impaired compared to their hearing peers (Hintermair, 2013). Dammeyer (2010) found a 3.7-fold increase in emotional problems in hearing impaired children and adolescents. Additionally, Vissers and Hermans (2018) Vissers and Hermans (2018) reported that hearing impaired individuals experience poorer emotional and social development. Research in cognitive development indicates that effective emotional regulation relies on key executive functions, such as attention control, behavioral inhibition, and decision-making (Rueda & Paz-Alonzo, 2018). Numerous studies highlight the significant link between executive function and emotional development, noting that executive function training can enhance emotional discrimination (Holley et al., 2017), regulation (Yang et al., 2015), development (Rueda & Paz-Alonzo, 2018), and processing (Soncin et al., 2016). These findings suggest that hearing impaired individuals often struggle with executive functions, emotional regulation, and social cognition (Gu et al., 2019; Hall et al., 2017; Hintermair, 2013; Horton & Silverstein, 2008; Morgan, 2015). This study aims to explore the relationship between executive functions and emotional regulation in hearing impaired children.

METHODS

Participants

The study sample was selected purposively from children with hearing impairment who were diagnosed through the medical report attached to the student's file and enrolled in integration programmes in Riyadh, Kingdom of Saudi Arabia: The sample must be regular school attendees with mild and moderate hearing impairment (25-55 decibels). No other disabilities. The IQ level was recognised from the results of the Luxler IQ test found in the student's file. The sample was homogeneous in terms of socio-economic and cultural level, and this was identified using their school files. After applying these conditions, the original sample consisted of 135 students (78 males and 57 females) whose ages ranged between (10-14) years (M age = 12.8 years, SD age = 1.68 years).

Tools

Executive Functioning Scale:

The Barkley Deficits in Executive Functioning Scale - Children and Adolescents; BDEFS-CA (Barkley, 2012) aims to measure the level of executive functioning in children. The scale in its final form consists of (70) paragraphs, asking parents to assess the number of times their child faces certain issues, during the past six months, these paragraphs are answered according to a four-point Likert response scale ranging from (never to often) and you get scores (4, 3, 2, 1) for each response respectively, and higher scores indicate difficulties in executive functions, and the scale includes five sub-dimensions Time self-management (includes 13 paragraphs, e.g: Wasting or not managing time well), self-regulation and problem solving (including 14 items, e.g.: Does not seem to be able to process information quickly or accurately), self-control (including 13 items, e.g.: Makes decisions hastily), self-motivation (including 14 items, e.g.: Seems lazy and unmotivated), and emotion self-regulation (including 16 items, e.g.: Stays angry or upset longer than other children). The author calculated the reliability using the Cronbach's alpha method for the scale, and the reliability coefficient ranged between (0.91-0.96). In the current study, the executive function scale had high reliability with an internal consistency coefficient (Cronbach's α) of .087.

Emotional Regulation Scale

The Emotional Regulation Scale (Gross & John, 2003) was utilized to assess emotional regulation in hearing-impaired children. The final version comprises 10 items divided into two strategies: cognitive reappraisal (6 items: 1, 3, 5, 7, 8, 10) and expressive suppression (4 items: 2, 4, 6, 9). For instance, item 2 states, "I keep my emotions to myself," while item 7 states, "I control my emotions by changing the way I think about the situation." Responses are given on a five-point Likert scale from strongly agree (5) to strongly disagree (1), with higher scores indicating a greater tendency to use that emotional regulation strategy. The original scale demonstrated good psychometric properties across various cultural contexts, showing high internal consistency (0.79 for cognitive reappraisal and 0.73 for expressive suppression) and a test-retest reliability of 0.7. In this study, the emotional regulation scale exhibited high reliability, with a Cronbach's α of 0.86.

Data Collection Procedure

Data were collected in September 2024, following the completion of informed consent forms by all participants, which emphasized voluntary participation, strict confidentiality, and that the data would be used solely for research purposes. The study obtained ethical approval from the Deanship of Scientific Research at Imam Mohammed Ibn Saud Islamic University, and adhered to the Declaration of Helsinki. Questionnaires were administered to participants with hearing impairments at their schools. Written consent was obtained from the parents of the participants, as well as from the participants themselves. The data collection lasted 60 minutes, after which participants received small gifts as a token of appreciation.

Data Analysis

Statistical analyses were performed using SPSS version 20. Correlation coefficients assessed the association between executive functions and emotional regulation, while means, standard deviations, and t-tests analyzed bivariate relationships considering demographic variables. Lastly, linear regression evaluated the relationship between executive functions and emotional regulation in hearing-impaired children.

Table 1 presents a correlation coefficient of -0.653, indicating a negative relationship between executive functions and emotional regulation in the study sample (n=63). This suggests that higher scores in executive functions correspond to lower scores in emotional regulation.

RESULTS

Table 1 presents a correlation coefficient of 0.653-, indicating a negative relationship between executive functions and emotional regulation in the study sample (n=135). This suggests that higher scores in executive functions correspond to lower scores in emotional regulation.

Table 1. correlations between executive functions and emotional regulation (n=135)

scales	Executive Functioning	P
Emotional Regulation	-0.653	0.001

Table 2 highlights that the t-values for executive functions and emotional regulation scales are 0.33 and 0.53, respectively, showing no significant differences between males and females at the 0.05 level.

Table (2). Means (M), standard deviations (SD), and t values for Executive Functioning and Emotional Regulation

Variables	Male (N=118)	Female (N=70)	T	P Value
Executive Functioning	214.58(27.07)	210,11(26.62)	0.33	0.35 NS
Emotional Regulation	24.43(5.9)	23.77(6.1)	0.53	0.49 NS

Note: Not Significant (NS)

Table 3 shows the results of a linear regression analysis investigating the relationship between executive functions and emotional regulation. The findings indicate that higher executive functions significantly predict higher emotional regulation, accounting for 75% of the variance in emotional regulation scores ($R^2 = .751$, $F = 402.01$, $p < .001$). The remaining variance may be due to other factors that should be explored in future research.

Table 3. Linear Regression Analysis Results of Association between Executive Functioning and Emotional Regulation

Variables	B	Std. Error	Beta	t	P
Constant	65.70	2.088		31.459	0.00
Executive Functioning	0.195-	0.010	0.867-	20.05-	0.00

Note. $R = 0.86$; $R^2 = .751$; Adjusted $R^2 = 0.750$; $F (402.01)$

DISCUSSION

The study found a significant positive correlation between executive functions and emotional regulation in hearing-impaired children, aligning with previous research (Holley et al., 2017; Marschark et al., 2017; Rueda & Paz-Alonzo, 2018; Soncin et al., 2016; Yang et al., 2015). Hintermair (2013) also reported this correlation, supported by Vissers and Hermans (2018). Since executive functions are crucial for social and emotional development, hearing-impaired individuals with executive function impairments may experience challenges in emotional and social growth. Emotional development involves recognizing and differentiating emotions and controlling impulsive behaviors through appropriate emotion regulation strategies, which are vital for adapting to social environments and achieving goals. Emotional regulation is closely linked to cognitive flexibility, as noted by Rueda and Paz-Alonzo (2018), who emphasized that key executive functions like attention control, behavioral inhibition, and decision-making mediate emotional regulation development. This neurocognitive system's vulnerability presents opportunities to enhance children's emotional regulation. Additionally, Marschark et al. (2017) demonstrated that training in emotional regulation skills significantly improves executive functions in preschoolers, highlighting that children with poor inhibitory control tend to have more negative peer relationships than those with better control.

Numerous studies show that the development of executive functions, such as inhibitory control and executive attention, closely correlates with improved emotional regulation in preschool children. Their performance on inhibitory control tests significantly relates to their ability to manage emotions and is positively associated with empathy, which involves interpreting others' distress or happiness (Lantrip et al., 2016; Latronica, 2016; Rueda & Paz-Alonzo, 2018). Executive functions serve as essential higher-level cognitive abilities that facilitate lower-level processes needed for effective emotion regulation (Holley et al., 2017). Consequently, impairments in either executive functioning or emotional regulation often result in deficits in the other, highlighting their interrelatedness. Marceau et al. (2018) propose three potential links between executive functions and emotional regulation: first, that general inhibitory processes are necessary for effective emotional regulation; second, that emotional regulation enables successful inhibitory control by freeing cognitive resources for problem-solving; and third, that an integrative model combines these ideas, suggesting that emotion-dependent self-regulation arises from conscious cognitive processes.

The results showed no statistically significant differences between males and females in executive positions, likely due to the influence of educational and cultural factors, which are similar across society (Schmeichel & Tang, 2015). Additionally, researchers found no differences in the executive functions of male and female brains. Executive functions include processes such as attention, reasoning, working memory, decision-making, impulse control, and problem-solving (Pergantis et al., 2024). The results also indicated no significant differences in

emotional regulation between genders, which may be attributed to the rise of social media, allowing individuals with hearing impairments to express their opinions and emotions more freely. This equal expression can be influenced by contemporary family socialization methods, especially for children with disabilities. Linear regression analysis revealed that high executive functioning significantly predicts effective emotional regulation, explaining 75% of the variance in emotional regulation scores. Thus, individuals with strong executive functions tend to regulate their emotions effectively, and vice versa. Furthermore, executive function is positively associated with adaptive emotion regulation and negatively with maladaptive emotion regulation (Alqarni & Hammad, 2021; Navas-Casado et al., 2023). Groves, Chan, et al. (2022) suggested that cognitive training to enhance executive function can improve emotion regulation skills.

This study contributes to the literature on individuals with disabilities, particularly the hearing impaired. However, several limitations should be considered in interpreting and generalizing the findings. Firstly, the small sample of hearing-impaired students from Riyadh, Saudi Arabia makes it challenging to generalize to other populations. Moreover, the cross-sectional design of the study prevents the determination of causality between variables. Future research should address these methodological limitations by utilizing larger and more diverse samples and employing longitudinal and qualitative approaches to explore the causes of impaired executive functions and their impact on personality, specifically among the hearing impaired. The results of this study can be added to the existing literature on people with disabilities, especially among the hearing impaired. However, the study has several limitations that must be taken into account when interpreting and generalizing these findings. First, it is difficult to generalize the results to other population groups because this study was conducted on a small sample of hearing-impaired students in Riyadh, Saudi Arabia. In addition, the sectional design used in this study does not allow to determine the nature and direction of causality between variables. These methodological limitations can be addressed through future studies focusing on executive functions with larger and more diverse samples, and conducting longitudinal and qualitative studies to determine the causes of impaired executive functions and their effects on the personality aspects of individuals in general and the hearing impaired in particular.

CONCLUSIONS AND IMPLICATIONS

The study found a statistically significant negative correlation between executive functions and emotional regulation in hearing-impaired children, with no notable gender differences in these areas. Linear regression analysis suggested that executive functions are a key indicator of emotional regulation difficulties. Thus, impaired executive functions adversely affect emotional regulation skills in hearing-impaired children. It is crucial to integrate executive function training into special education programs to enhance these skills and improve their interaction with the environment. Additionally, teachers and specialists should receive training in executive function strategies to effectively teach these practices during various activities, thereby improving students' executive functioning, educational administrations conduct training courses for teachers in hearing impairment programs.

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Institutional Review Board Statement:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study. In addition, the protocol for the study was approved by Research Ethics Committee at Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia.

Consent For Publication

N/A.

Data Availability Statement:

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

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