

Investigation of the relationship between executive functions and social cognition in hearing-impaired children: A cross-sectional study

Huda Shaaban Awed^{1*}, Nouf Nawar Alotaibi²

^{1,2}Department of Special Education, College of Education, Najran University, Najran, Saudi Arabia, E-mail: hsawed@nu.edu.sa; hudaeg2010@yahoo.com (H.S.A.) nnalotaibi@nu.edu.sa (N.N.A.)

Abstract: The current study aimed to explore the relationship between executive functions and social cognition in hearing-impaired children. The sample comprised 162 students (89 males, 73 females) with hearing impairments enrolled in integration programs in the cities of Najran, Abha, and Jazan in southern Saudi Arabia, with an average age of 12.9 years (standard deviation = 1.92 years). A descriptive analytical approach was employed, utilizing the Barkley Executive Function Deficit Scale for Children and Adolescents (BDEFS-CA) and the Social Cognitive Scale. The findings revealed a statistically significant correlation between executive functions and social cognition. Additionally, no significant differences were found between males and females regarding their executive functions and social cognition. Notably, social cognition accounted for 77% of the variance in executive function scores. This preliminary study offers valuable insights into potential strategies and programs for training executive function tasks, which can significantly influence various aspects of social and cognitive development in hearing-impaired children.

Keywords: *Executive functions, Hard of hearing, Social cognition.*

1. Introduction

Many hearing-impaired children face many special challenges resulting from the loss of the communication process and language acquisition, such as poor social and emotional development, poor ability to understand the emotions and feelings of others, and poor cognitive and perceptual development, which affects many processes and functions that are important and effective in learning processes, acquiring knowledge, and positive interaction with others in different situations [1, 2]. Executive functions are the control and regulatory functions that occur in the prefrontal region of the brain [3]. Executive functions are a general regulator and regulatory system for complex human behaviors, as they enable the individual to evaluate his or her personal functional behavioral performance by organizing and directing behavior and thoughts to start, monitor, and terminate an activity or behavior in a modified and flexible manner [4]. As Ter-Stepanian, et al. [5] Executive functions refer to the abilities that enable an individual to organize multiple tasks, set goals and priorities, suppress unwanted stimuli, develop self-control, the ability to put ourselves in someone else's shoes, the ability to plan by developing strategies with correct critical thinking, developing behaviors towards changing situations, and completing activities that have been started. In the same context, Diamond [6] indicates that there are a number of basic processes that provide the basis for executive functions, including: Working memory, which refers to the ability to temporarily hold limited information in consciousness while processing it. Therefore, it is involved in most situations that require mental effort [7] for example, during mental arithmetic involving large numbers and while following complex instructions [8]. Working memory is also considered one of the basic cognitive processes on which the thinking and learning process is based. The second process is mental flexibility, which is

closely related to creativity [6]. Mental flexibility is defined as the ability to shift from one thought to another in response to changes in a situation, therefore, this ability is important for adaptability, creative problem solving, and thinking “outside the box [9]. The third process, inhibition (inhibitory control), is the ability to inhibit attention to distractions, allowing selective and sustained attention to occur [10]. The ability to inhibit behavioral tendencies, which may be inappropriate behaviors, can help make a person flexible to potential changes, as well as adhere to social etiquette, therefore, a deficit in inhibitory control is likely to be associated with high levels of impulsive behavior [11]. Individuals with low inhibition are often described as impulsive, selfish, irrational, and unable to delay gratification [12].

Executive function deficits can lead to impaired memory and attention, poor behavioral control, and an inability to develop cognitive strategies essential for knowledge acquisition [13]. These deficits also hinder social communication, making it difficult for individuals to use visual expressions and gestures, initiate or maintain conversations, express emotions, and can lead to excessive self-talk [14]. Consequently, this hampers the ability to establish healthy social relationships [15]. Research indicates that individuals with hearing impairments often exhibit poor executive function [16-18]. As a result, many hearing-impaired children face unique challenges, including difficulties in social and emotional development [19] behavioral issues [17] social maturity [18] as well as problems with reading, writing, and spatial and visual perception [16]. These challenges significantly impact various developmental processes and functions.

Social cognition, a branch of social psychology, aims to understand how individuals think in social situations, recognize the appropriate times to interact, and assess their ability to process social and emotional information from others [20]. It focuses on how we process information that influences our behavior towards others, relying on unwritten rules and the ability to infer meaning from various cues, which helps clarify ambiguous social situations [21]. This area of study is crucial for achieving both self and social effectiveness, as it involves understanding others' mental states, beliefs, intentions, emotions, and feelings, while also distinguishing these from our own [21]. Additionally, it encompasses the ability to communicate effectively with others, based on the information and knowledge we gather, as well as the capacity to align our thoughts and feelings with those of others [22]. According to Parke [23] social cognition encompasses several dimensions: social perception, which is the ability to identify and understand social signals and choose appropriate responses; social knowledge, which involves recognizing and understanding social situations; attribution, which refers to individual biases; emotional processing, which entails understanding emotional disturbances to minimize their impact; and theory of mind, the understanding of others' mental states and the ability to make inferences and responses accordingly. Social cognition is also linked to language development, as language serves as a crucial tool for interpreting and processing social information [24]. It allows early social cognitive abilities to flourish and mature [16]. However, individuals with hearing impairments often face challenges due to their limited language skills, which hinders their ability to interact socially and exchange ideas, beliefs, and imagination with others, resulting in a reduced capacity to acquire social knowledge [25, 26]. Research indicates that hearing-impaired individuals struggle to understand that others may have different mental states and experience difficulties in determining the reasons behind certain situations (attribution style) [27, 28]. They also face challenges in fulfilling social roles, which adversely affects their level of social cognition, as supported by various studies [25, 29, 30].

Several studies have indicated a relationship between executive functions and social cognition. Neuroscience research, for instance, has emphasized the significance of brain maturation as a crucial factor in cognitive and social cognitive development during childhood [31-34]. Conversely, social cognition may be tied to substantial neurocognitive reorganization [35, 36]. Additionally, mounting evidence points to specific executive functions—such as the ability to inhibit an initial response, generate an alternative response, and shift cognitively—as key contributors to significant psychological changes that occur from childhood [6]. The capacity to suppress previously activated mental sets and to maintain and update these sets based on feedback (working memory) is considered vital for successfully navigating various tasks [37]. This ability is believed to be one of the last executive

functions to mature fully with complex tasks showing further development in older children and adolescents [38, 39]. In summary, evidence suggests that deficits in social cognition may be linked to issues in executive functions. Therefore, the current study aims to explore this relationship more thoroughly in hearing-impaired children, specifically investigating the role of executive functions in their social cognition.

2. Materials and Methods

2.1. Participants

The original sample comprised 162 students (89 males and 73 females) aged 10 to 14 years ($M = 12.9$ years, $SD = 1.92$ years). This study focused on children with hearing impairments, specifically those diagnosed through medical reports in their student files and enrolled in integration programs in the Kingdom of Saudi Arabia, specifically the cities of (Najran, Abha, Jazan). The selected participants were regular school attendees with mild to moderate hearing impairment (25-55 dB) and no additional disabilities. Intelligence levels were assessed using the Lexler Intelligence Test results found in their files. The sample was homogeneous regarding socio-economic and cultural backgrounds, as verified through their school records.

2.2. Measures

2.2.1. Executive Function Scale

The Barkley Executive Functioning Deficits Scale - Children and Adolescents (BDEFS-CA), developed by Barkley [40] is designed to measure executive functioning levels in children. The finalized scale comprises 70 items organized into five subscales, each focusing on a distinct aspect of executive function. The first subscale evaluates self-management of time (13 items), while the second assesses self-regulation and problem-solving (14-27 items). The third subscale measures inhibition and self-control (28-40 items), the fourth focuses on self-motivation (41-54 items), and the fifth examines self-activation and focus (55-70 items). Each item is rated on a scale from 1 to 4, where higher scores indicate greater difficulties with that particular executive function. The original scale has demonstrated strong psychometric properties across various cultural contexts, showing high internal consistency (ranging from .73 to .90) and a total score reliability of .87. In this study, the Executive Function Scale exhibited a high level of reliability, with a Cronbach's alpha of 0.83.

2.3. Social Cognitive Scale

Hammad [41] developed the Social Cognitive Scale through an analysis of social cognition indicators and characteristics. This scale includes a set of scenarios designed to assess the level of social cognition in children and adolescents. It comprises eight scenarios that prompt children's interpretations of social situations and evaluate their response options. In practice, the scenario is read aloud, and the teacher of hearing-impaired children either reads the scale or translates it into sign language. The teacher then asks the child five questions about the scenario. For example, if the scenario states, "You are standing on the football field and are hit hard in the back by a ball thrown by another child," the following questions are posed: What do you think happened?, What made the ball hit you in the back?, What do you think caused that?, What will you do about it?, Is there anything else that could have happened that would have made the other child hit you in the back with the ball?. The child's interpretations and responses are recorded. Responses are categorized into five types: acting aggressively, doing nothing, informing a specialist or authority, addressing the situation non-aggressively, or accepting the other person's responsibility, such as accepting an apology. Each response is assigned a score from 1 to 5, resulting in a total possible score ranging from 8 to 40 points. The hypothetical average for the scale's dimensions was determined using Cooper's equation [42]. Children who score above this average demonstrate a good level of social cognition, while those scoring below it exhibit a low level of social cognition. The original scale demonstrated strong psychometric properties,

with an internal consistency of 0.86 and a retest reliability of 0.82. In this study, the social cognition scale also displayed high reliability, achieving a Cronbach's alpha value of 0.78.

2.4. Data Collection Procedures

Data were collected in September 2024, following the completion of informed consent forms by all participants. These forms confirmed voluntary participation, ensured complete confidentiality, and stated that the data would be used solely for research purposes. The study received ethical approval from the Deanship of Scientific Research at Najran University and adhered to the Declaration of Helsinki. Questionnaires were distributed to participants with hearing impairments at their schools, with the assistance of hearing-impaired teachers to facilitate responses. The data collection process lasted 40 minutes, after which participants were given small gifts as a token of appreciation.

2.5. Data Analysis

Statistical analyses were conducted using SPSS version 20. Correlation coefficients were used to assess the relationship between executive functions and intelligence. Additionally, means, standard deviations, and t-tests were employed to analyze bivariate relationships while considering demographic variables. Finally, linear regression was utilized to evaluate the relationship between executive functions and social cognition in hearing-impaired children.

3. Results

Table 1 shows a correlation coefficient of -0.432 , indicating a negative relationship between executive functions and social cognition in the study sample ($n = 162$). This suggests that as a hearing-impaired child's executive functions decline, their social cognition also decreases.

Table 1.
Correlations between Executive Functions and Social Cognitive ($n=135$).

Scales	Social Cognitive	P
Executive Functions	-0.432	0.001

Table 2 shows that the t-values for the executive function and social cognitive function scales are 0.35 and 0.39, respectively. This indicates that there are no statistically 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 Social Cognitive.

Variables	Male (N= 78)	Female (N= 57)	T	p Value
Executive Functioning	202.54(19.57)	199.21(21.62)	0.35	0.35 ^{NS}
Social Cognitive	20.54(7.69)	19.80(6.96)	0.39	0.42 ^{NS}

Note: Not Significant (NS).

Table 3 shows the results of a linear regression analysis examining the relationship between executive functions and social cognition. The results indicate that higher social cognition significantly predicts higher executive functions, accounting for 77% of the variance in social cognition scores. The remaining variance may be due to other factors that should be explored in future research.

Table 3.
Results of a linear regression analysis of the association between executive functions and social cognition.

Variables	B	Std. Error	Beta	t	P
Constant	64.90	1.672		38.811	0.00
Executive Functioning	0.210-	0.009	0.879-	23.367-	0.00

Note: $R = 0.879$; $R^2 = .773$; Adjusted $R^2 = 0.772$; $F (576.17)$.

4. Discussion

The current study found a significant association between social cognitive and executive functions in hearing-impaired children, aligning with previous research [18, 43-45]. Although hearing-impaired individuals often encounter challenges in social cognition due to limited access to spoken language—which may hinder executive function development—they may also display differences in working memory and executive control. This underscores the necessity of providing appropriate cognitive and linguistic support. Morgan, et al. [46] suggest that social skills training can enhance executive functioning in deaf and hard-of-hearing individuals by improving their problem-solving and social interaction abilities. The rationale for the association between social cognitive executive functions is grounded in Crick and Dodge [47] model of social information processing, which illustrates the relationship between executive functions and social cognition. For instance, addressing social dilemmas requires children to generate ideas (initiation), remember task directions and the social context, and inhibit irrelevant thoughts and behaviors (inhibition) [48].

The findings of Amadó, et al. [34] support this relationship, highlighting connections between social cognition, working memory, and cognitive flexibility, as well as between cognitive flexibility, inhibition, and social cognition. Amadó, et al. [34] also noted that social cognition serves as a predictive variable for working memory, a key dimension of executive functions. Ubukata, et al. [49] further confirmed that various executive function tasks play a critical predictive role in social functioning, particularly evident in individuals with low social cognition, who often struggle with attention, initiation, memory, inhibition, and understanding others' emotions. Penadés, et al. [50] emphasized that the relationship between cognition and social functioning is influenced by how social functioning is perceived and evaluated. Specifically, different domains of functional ability (e.g., social skills and daily living skills) show varying associations with cognition; processing speed, memory, and executive functions correlate with daily living skills, while working memory and verbal fluency relate to social competence [51]. Additionally, some studies indicate that enhancing cognitive functions may improve social functioning through psychological interventions Spaulding, et al. [52]. Houssa, et al. [53] found that improvements in attention, memory, and executive function can lead to increased social competence. The research by Amadó, et al. [34] also revealed a statistically significant relationship between social cognition and various cognitive domains, such as verbal working memory, response inhibition, verbal long-term memory, and visuospatial long-term memory. This suggests that when cognitive functions improve, social cognition also benefits. These findings align with the results of previous studies [34, 53, 54] which demonstrated a correlation between executive functions and social cognition.

The results revealed no statistically significant differences between males and females in executive positions, likely due to the similar influences of educational and cultural factors across society [55]. Additionally, the researchers found no differences in the executive functions of male and female brains. Executive functions encompass processes such as attention, reasoning, working memory, decision-making, impulse control, and problem-solving [56].

The findings also indicated no significant differences between the sexes in social knowledge. This may stem from the equal use of social media by young people of both sexes, which offers similar opportunities to develop social communication skills. Numerous studies support this result. For instance, Tanaka [56] noted that Japan has experienced a cultural shift toward gender equality in recent decades, leading to a narrowing of the gender gap in various areas, including social knowledge. A meta-analysis published in the *Journal of Social Psychology* also indicated that gender differences in social knowledge are generally small [57]. Additionally, a linear regression analysis examining the relationship between executive functions and social cognition revealed that higher social cognition significantly predicts higher executive function. These findings are consistent with several previous studies. For example, research has shown that individuals with strong social cognition abilities exhibit better self-regulation skills, suggesting that social cognition serves as an indicator of effective executive control [58]. Another study found that individuals with high social skills tend to make better decisions

in complex situations, highlighting the predictive capacity of social cognition for higher executive function performance [59]. Moreover, a meta-analysis published in the *Journal of Applied Psychology* found a strong association between social cognitive skills and critical thinking, which enhances the ability to evaluate information and make informed decisions [60].

5. Conclusions and Implications

The study revealed a statistically significant negative association between executive functions and social cognition in hearing-impaired children, with no notable gender differences in these areas. Linear regression analysis indicated that executive functions serve as a major predictor of social cognitive challenges. Consequently, deficits in executive functions adversely affect social cognition in these children. It is crucial to integrate executive function training into special education programs to enhance these skills and improve students' interactions with their environment. Furthermore, teachers and specialists should receive training in executive function strategies to effectively implement these practices during various activities, thereby enhancing students' executive functioning. Educational departments should organize training courses for teachers involved in hearing-impaired 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 Najran University.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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