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Visual-spatial working memory span of Indonesian children with deafness inoral, total, and sign language communication methods

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Visual-spatial working memory span of Indonesian children with deafness in oral, total, and sign language communication methods

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Abstract
Children with hearing impairment or deafness experience cognitive function delays but not limited visual-spatial working memory, which is commonly used to solve mathematical problems. Previous studies have discovered that visual or spatial working memory in such children is different because of the communication methods that rely on vision. This study explores the visual-spatial working memory in children with deafness by measuring the memory of 70 elementary school children with deafness and identifying their communication methods through questionnaires. The questionnaires were completed by the children's parents. The visual-spatial working memory measurement utilized the *Lion Game* through Zoom meetings. Consequently, it was found that there was no significant difference in visual-spatial working memory capacity in children with hearing impairment using oral, total communication, and sign language. It can be argued that in children with deafness, their visual-spatial working memory span with oral, total, and sign language communication methods have still not reached the maximum point. The use of hearing aids, popular among such children also did not significantly enhance visual-spatial working memory capacity. This research recommends parents be more attentive not only toward the communication methods of children with deafness but also to their cognitive function development.

Keywords
Children with Deafness, Cognition, Communication Methods, Visual-Spatial Working Memory

Every child with deafness experiences varying degrees of delay in cognitive development. The differences in hearing loss levels, the onset of hearing loss, the environment, and the communication method also vary from one child to another. These differences may also result in a unique variety of cognitive developments among children with deafness.

A developing research area in the distinctive aspect of cognitive functioning in children with deafness is visual-spatial working memory. Visual-spatial working memory is a temporary storage system used to retain visual and spatial information in short periods (Logie, 1995; MacAfoose & Baune, 2009). Visual-spatial working memory is a part of the brain's working memory system that stores short-term stimuli and functions by manipulating complex cognitive tasks, such as language comprehension, learning, and reasoning (Baddeley, 2010; Baddeley, 1992). In daily life, visual-spatial working memory is related to abstract thought processes and is used when working on mathematical questions (Allen, Higgins, & Adams, 2019; Fanari, Meloni, & Massidda, 2019; Ashkenazi, Rosenberg, Metcalfe, Swigart, & Menon, 2013; Holmes, Adams, & Hamilton, 2008).

There are two functional components in vis-

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ual-spatial working memory: visual working memory and spatial working memory. Visual working memory works passively in retaining visual information, which is usually measured by remembering through the appearance of colors. Spatial working memory does repetitions in maintaining spatial movement information. Measurements of spatial working memory are done by examining an individual's ability to retain information in the form of movement sequences (McConnell & Quinn, 2004).

In an individual's working memory development, visual-spatial working memory is most frequently used by children under eight years in processing information, and its development begins to slow when they reach nine–eleven years (Swanson, 2017; Pickering, 2001). Generally, normal-hearing children age 9-11 years are at the elementary school level. As the ages of children with deafness in school are different from those of normal-hearing children, this study focused on the elementary school Education level. Based on data by Allen (1989, 2002), children with deafness, especially those of elementary school age, do not experience delays and have abilities in accordance with their age when working on mathematical questions or counting skills; therefore, it can be assumed that children with deafness do not experience insufficiencies in their visual-spatial working memory capacities. The research result makes visual-spatial working memory an area in cognitive functioning that is noteworthy to be studied in children with deafness, although overall, children with deafness still experience cognitive developments that do not function optimally.

In children with deafness, the minimum functioning of hearing gravitates the working memory toward visual-spatial working memory. The process of retaining temporary information verbally in children with deafness is also visually done using visual-spatial working memory (Alvarado, Puente, & Herrera, 2008). A form of verbal information that is visually processed in children with deafness is communication.

Differences in children with deafness and normal-hearing children's communication lie in the communication method. Children with deafness have different communication methods than normal-hearing children in general, as children with deafness are unable to communicate by relying on auditory stimuli. The communication method of children with deafness replaces receptive hearing functions (Gravel & O'Gara, 2003), so children with deafness may experience communication processes similar to those of normal-hearing children, thus children with deafness' language comprehension is not hindered.

There are three communication methods used by children with deafness: oral communication, sign language, and total communication (Hyde & Power, 1992; Power, Wood, & Wood, 1990). Oral communication is a method used to deliver and receive messages using the mouth and auditory senses (KBBI, 2020; Suparno, 1989). Sign language is a language used to deliver messages utilizing vocabulary and spelling through bodily gestures, hand movements, finger movements, and mimicking that form symbols based on existing language (Hoff, 2013; Brentari, 2010; Chaiorul Anam, 1989 in Mursita, 2015). Total communication is a communication method used by people with hearing disabilities by maximizing the remains of hearing, words, fingerspelling, sign language, and other media that can be used to communicate according to each user's comfort (Mayer, 2016; Hands and Voices, 2014; Suparno, 1989). In its use, total communication and sign language are termed "visual languages," as they rely on visual stimuli and functioning, whereas oral communication that uses auditory stimuli and functioning with minor visual function aids (through reading lip movements) is termed "verbal communication" (Gravel & O'Gara, 2003).

Based on these three communication methods, it is somewhat apparent that a direct influence on visual-spatial working memory capacity occurs, primarily those considered as a visual language. Although oral communication methods rely on hearing remains, children with deafness with oral communication methods also read lip movements to compensate for their hearing deficiencies. Lip reading causes children with deafness to communicate by relying on sight and visual stimuli with varying proportions. Hence, a deaf child's visual functioning is more accustomed to balancing the lack of auditory stimuli and usage (Bavelier, Dye, & Hauser, 2006). Children with deafness who communicate using visual languages, such as total communication and sign language, temporarily retain information in visual forms within their visual-spatial working memories. Therefore, visual capacity use levels in communication may affect or enhance visual-spatial working memory's capacity in children with deafness. Due to this, the visual-spatial working memory capacity of children with deafness may differ based on the proportion of received visual stimuli through their communication methods, whether they use visual or verbal languages.

Even though children with deafness' communication methods might be a direct stimulus for visual-spatial working memory, they still provide limited language abilities for children with deafness compared to normal-hearing children. Along with it, cognitive functioning is generally less optimal in children with deafness due to their limited language abilities. This argument is based on Vygotsky's theory that suggests how cognitive abilities are strongly influenced by language. The lack of language comprehension due to hearing obstructions in children with deafness causes their cognitive function and abilities to be less maximally developed when compared to normal-hearing children. This theory is supported by Mayberry's (2002) review on children with deafness' cognitive abilities, suggesting that language comprehension is closely associated with a child's cognitive development, either in hearing, deaf, or children with hearing impaired. This is due to the language's function as a symbolic system in mediating cognitive functioning (Radvansky & Ashcraft, 2014). Furthermore, hindrances in language ability are partially caused by using unsuitable communication methods (Marschark & Knoors, 2012). Thus, using the correct communication method for children with deafness should enhance their language ability and cognitive performance.

Not all communication methods used by children with deafness can make their visual-spatial working memory develop in the same way or better than normal-hearing children. In other words, there are communication methods that, in their use, may not maximize the development of children with deafness' visual-spatial functioning. This may occur particularly when one communication method is enforced for children with deafness- without paying attention to other developmental aspects (Rudyanto, 2020). Forcing the use of one communication method may cause a deaf child to receive inadequate cognitive stimulation, making their visual-spatial working memory's capacity inferior when compared to children with deafness who use other communication methods. Rudyanto (2020) explains that the lack of cognitive stimulation in children with deafness, such as in mathematics and reading, is frequently found in children with deafness who are forced to use oral communication methods. This enforcement commonly occurs at school, particularly in special education schools for children with deafness (Sekolah Luar Biasa) in Indonesia. For example, one Special Education School for Deaf (SLB/B) in Jakarta administers a curriculum focusing on hearing and vocational therapy, such as in culinary arts, fashion, and electronics. The curriculum's focus is to enable children to communicate orally and develop life skills rather than enhancing their general academic or cognitive skills (Rudyanto, 2020). In comparison, common schools that administer the Indonesian Nasional Curriculum 2013 for elementary school allocate more teaching time for Bahasa Indonesia and mathematics, which is known to stimulate children's cognition rather than enhancing life skills (Raji, 2019; Amsel, Byrnes, & James, 2002). From the references above, it can be said that mathematical stimulation is closely correlated with visual-spatial working memory capacity; therefore, mathematics is stimulating in itself.

Visual-spatial working memory in children with deafness is often related to the communication methods they use. Prior research that has examined the correlation between visual-spatial working memory and communication methods in children with deafness has been conducted with different emphases. Wilson, Bettger, Niculae, & Klima (1997) studied the spatial working memory of children with deafness who used sign language and compared it to normal-hearing children. The study found that children with deafness who used sign language as a communication method outperformed normal-hearing children in spatial working memory capacities. The study also discovered that children with deafness who used sign language demonstrated that sign loops replaced articulatory loops in working memory's phonological loop. Sign loops that function in children with deafness affect them in a way that trains their short-term memory in visual-spatial patterns. Through this mechanism, the spatial working memories of children with deafness are better than those of normal-hearing children.

Another study by López-Crespo, Daza, & Méndez-López (2012) also compared visual working memory capacities between normal-hearing children and children with deafness who used oral, total, and sign language communication. It was found that the visual working memory capacities of children with deafness with total communication methods were similar to those of normal-hearing children. The study also revealed how children with deafness who used oral and sign communication had lower visual working memory capacities. Based on the study's findings, children with deafness who used communication methods that are visually reliant, such as total communication, exhibited similar visual working memory capacities as normal-hearing children.

Similar research was also conducted by Marshall et al. (2015) by comparing ranges in the spatial working memory capacities of children with deafness who used sign language, children with deafness who did not use sign language, and normal-hearing children. The study showed that children with deafness who had used sign language since birth did not show differences in spatial working memory from normal-hearing children but differed from children with deafness who had not used sign language since birth. The study observed how the duration of exposure to sign language plays a role toward spatial working memory, as children who had used sign language since birth exhibited greater spatial working memory capacities when compared to those without sign language usage.

Not all studies substantiate that visual or spatial working memories in children with deafness who use visual communication methods are equal or superior to normal-hearing children. A study by Marschark, Sarchet, & Trani (2016) found that the visual working memory of normal-hearing children was still superior to sign language-using children with deafness, even more so when compared to those using oral communication methods. This observation contradicts previous findings, which warrants further investigation of children with deafness' visual-spatial working memory capacities with various communication methods.

Existing research shows various emphases on visual-spatial working memory. The first study by Wilson, Bettger, Niculae, & Klima (1997) discovered that children with sign language communication have better spatial working memories when compared to normal-hearing children. Whereas López-Crespo, Daza, & Méndez-López (2012) showed no significant differences in visual working memories between normal-hearing children and children with deafness with total communication methods. However, the visual working memory abilities of children with deafness with oral and sign communication methods were more inferior when compared to those who use total communication.

These findings suggest that children with deafness' communication methods cause differences in their visual or spatial working memory capacities. Visual working memory and spatial working memory functions are part of the same working memory component; therefore, the researcher assumes that measurements should be done on visual-spatial working memory as a whole. Based on these accounts, there is a possibility that the communication methods of children with deafness who rely on visual stimuli may receive more cognitive stimulation upon their visual-spatial working memory capacities. Therefore, children with deafness who use oral, total, and sign language communication methods will demonstrate differing visual-spatial working memory capacities. Based on previous studies, the researcher assumes that children with deafness who use communication methods categorized as visual methods (i.e., total communication or sign language) will demonstrate higher averages in visual-spatial working memory capacities. This further raises the research question of the functioning of visual-spatial working memories of children with deafness who use oral, total, and sign language communication methods.

Based on prior studies, it is critical to identify the communication method that may enhance better cognitive functioning for children with deafness or, at minimum, better visual-spatial working memories. It calls for the present study to overview the visual-spatial working memory capacities of children with deafness with oral, total, and sign language communications in Indonesia, as this has never been done before. To examine the interaction of communication methods on visual-spatial working memory, this study observes the capacity when it has almost reached its peak development for children with deafness, being above nine years of age (Swansson, 2017). Children with deafness over nine years old are in elementary school, and in this stage, children are generally already able to read and are therefore able to work on games that are used as instruments in this study. The measurement of visual-spatial working memory capacities is done with the *Lion Game*, developed by Weijer-Bergsma, Kroesbergen, Prast, & Luit (2015); and the measurement of children with deafness' communication method was through questionnaires to be completed by parents. The data retrieved from the communication methods questionnaire will be used to categorize children with deafness into oral, total, or sign-language communication methods groups.

Measuring children with deafness' communication methods cannot be separated from the usage of hearing aids, as most of children with deafness in Indonesia use them. Hearing aids have been found useful for children with deafness' cognitive development in parts of concept formation (Mayberry, 2002). The usage of hearing aid has not been proved as playing any role in children with deafness' visual-spatial working memory capacities, so the fact that most participants will be users of hearing aids made this study also analyze whether there is a significant visual-spatial working memory capacity difference between deaf children with and without hearing aids.

The study results will provide a descriptive overview and compare the visual-spatial working memory capacities of children with deafness who communicate with oral, total, and sign language methods, which will be reported as score proportions and *Lion Game* levels. In addition, the study results will show whether or not hearing aids differentiate children with deafness' visual-spatial working memory capacity.

Research Methods

Samples

The study's sample consisted of 70 children with deafness who were currently in elementary school and were already able to read. Participants' ages were M = 10.8 years (SD = 2.1). The study's participants were children with deafness who experienced prelingual severe (n=18) and profound hearing loss (n = 52) and children with deafness who did not have comorbidities based on parent, teacher, or guardian information. Some used hearing aids (n = 45) of the sample, and some did not (n = 25).

Samples were recruited through a Special Education School for the Deaf intermediary. The researcher contacted each child with deafness' parents who met the criteria and requested parents' accompaniment throughout the research process.

Research Design

This study used a quantitative descriptive and comparative design. The data used in this study were descriptions of the children with deafness' communication method. The respondents' communication methods were obtained through questionnaires completed by their parents. The questionnaire consisted of questions such as, "Overall, the child's communication method is…." with the following answers, "Always in sign language," "partially in sign language and sometimes orally," "balanced between oral, sign, reading, writing, and other media (total communication)," "mostly oral and sometimes sign language," and "always oral communication."

The instrument used to measure visual-spatial working memory was the *Lion Game* developed by Weijer-Bergsma, Kroesbergen, Prast, & Luit (2015). The *Lion Game* included 4 x 4 matrix boxes that gave a grass picture in each box. During the game, the colored lions would appear one by one and could be repeated in different spots in the grasses. The task was to remember where the last specific colored lion appeared. This game consisted of five levels, and with each increasing level, the participant was asked to remember the last location of more colored lions. At each level, the participant was given four chances, and even if the participant got all the answers wrong, the game would go on until the fifth level. This was the first time using the *Lion Game* for children with deafness, so the participants' parents accompanied participants to help and made sure the participants understood the instructions.

The *Lion Game*'s scores were the proportion of total correct answers from all items and the highest level that a child was able to answer a sequence correctly. Score proportions were the total correct answers when compared to the total number of items. The lowest level that a child could answer a sequence correctly was also a determinant of their visual-spatial working memory capacity. The higher the score achieved in the *Lion Game* showed how a child was able to recall multiple color positions in a one-time span. The analysis technique in this study was a descriptive analysis. Both score proportion and level achieved are positively correlated. The score proportion analysis was adequate to measure visual-spatial working memory capacity, but the level achieved could complement the data of this capacity much more.

Procedures

The research started with a parent completing the informed consent and the online questionnaire relating to demographic data and the child's communication method. After the parent completed the questionnaire, parents indicated their time availability to be video called via Zoom for data retrieval. Based on the time availability, the researcher made the Zoom call appointments.

During the Zoom meetings, the researcher shared their computer screen, displaying the *Lion Game* with the game's instruction transcript. The researcher also shared the computer's cursor control so that the child may play the Lion *Game* themselves through the shared Zoom screen.

Results

The first study results were from a survey on the children with deafness' communication methods. Based on the parents' answers in the questionnaire, 19 children were categorized as oral communication users, 27 as total communication users, and 24 as sign language users. The use of communication methods among study participants was evenly distributed. Participants were distributed into groups based on their communication methods, and from those groups, children with deafness were analyzed based on their visual-spatial working memory capacities.

Table 1 shows that the highest average proportion score of visual-spatial working memory is among oral communication users. The visual-spatial working memory's mean score proportions show no differences between total communication and sign language users, which are considered small. The table also presents that based on visual-spatial working memory capacity, the highest mean level is also within the oral communication group. In conclusion, children with deafness' using oral communication might have a better visual-spatial working memory capacity in comparison to deaf children using other communication methods.

However, there was not a statistically significant score proportion difference between communication method groups as demonstrated by one-way ANOVA ($F(2.67) = 0.633$, $p = 0.534$), and level differences between communication method groups were also not significant by one-way ANOVA $F(2.67) = 0.388$, $p = 0.68$. Thus, there is no significant difference in visual-spatial working memory capacity between children with deafness in oral communication, total communication, and sign language.

Table 1.

Analysis for Visual-Spatial Working Memory Capacities in Children with Deafness Who Use Oral, Total, and Sign Language Communication Methods

	Oral			Total (Balance between oral and sign language)			Sign Language		
Visual-Spatial Working Memory Capacity	**n**	***M***	***SD***	**n**	***M***	***SD***	**n**	***M***	***SD***
Score proportions	19	0.439	0.150	27	0.391	0.160	24	0.391	0.159
Levels	19	2.47	1.073	27	2.19	1.145	24	2.21	1.285

This study also did a statistical analysis of whether hearing aids in children with deafness would differentiate visual-spatial working memory capacity. This study found no statistically significant visual-spatial working memory score proportion differences between the group of children with deafness with hearing aids and the group without hearing aids, $t(68) = -1.853$, $p = 0.068$. There was also no statistically significant visual-spatial working memory level difference between children with deafness with hearing aids and the group without hearing aids $t(68) = -1.463$, $p = 0.148$. To have a complete result, this study also compared scores proportions and levels between the group of deaf children with hearing aids and the group without hearing aids in each communication method group. As a result, there is no statistically significant difference in score proportion or level between hearing aid usage in each communication method group.

Furthermore, a statistical analysis was also done to notice any correlation between the age of the children with deafness and their visual-spatial working memory capacity. As a result, this study did not find any significant correlation between children with deafness' age and their *Lion Game* score proportion $r = .101$, n = 70, $p = 0.204$, but there was a significant correlation between children with deafness' age and their *Lion Game* level $r = 0.267$, n = 70, $p = 0.13$.

Discussion

This study's objective was to measure the visual-spatial working memory capacities of Indonesian children with deafness using the *Lion Game* in each communication method group. Based on existing literature, studies on visual-spatial working memories of children with deafness in Indonesia using the *Lion Game* have only been conducted in this present study. Prior research by López-Crespo, Daza, & Méndez-López (2012) and Wilson, Bettger, Niculae, & Klima (1997) only measured visual working memory with Delayed Matching-to-Sample (DMTS) Task or spatial working memory with the Corsi Test in children with deafness as two different systems. The *Lion Game* is considered inclusive of both aspects in measuring visual and spatial working memory interactions.

Measurement in this study showed there were no statistically significant differences in visual-spatial working memory capacities between children with deafness who use oral, total, and sign language communication. Both levels and score proportions from the *Lion Game* show there was no statistically significant difference among the children with deafness. This might indicate that communication methods do not have a role in children with deafness' visual-spatial working memory. Researchers suspect that the children with deafness' proficiency in using the communication methods, which was is not considered in this study, might have affected the results (Alvarado, Puente, & Herrera, 2008; Wilson & Emmorey, 1997). Furthermore, one thing that might be used in measuring their proficiencies is seeing how much vocabulary they understand in the communication methods they are using (Harris & Moreno, 2004).

Apart from the significance value, it can be seen that children with deafness using the oral communication method showed the highest visual-spatial working memory capacity. In addition, the average proportion of scores and the level of the visual-spatial working memory capacity of children with deafness with total communication methods and sign language were at the same number. The similarity between total and sign language communication is that both communication methods rely on vision and information reception, therefore categorized as visual languages (Gravel & O'Gara, 2003). Total communication relies on the remains of hearing, writing, sign language, and other media to aid children with deafness in receiving information while communicating. Other than hearing remains, other aspects used in total communication methods rely on visual abilities, processing numerous pieces of visual information, and consolidating them into one whole information piece. Similar to total communication, sign language also rely on sight in its use. Visual abilities used in sign language are the ability to perceive shapes and hand gestures, and reading expressions. Therefore, it can be said that visual-spatial learning capacities are strongly shaped in visual communication due to the excessive use of vision while communicating. Contrary to this, the results showed no significant difference in visual-spatial working memory capacity, so it can be concluded that visual languages did not play a significant role in differentiating children with deafness' visual-spatial working memory. However, other than visual-spatial working memory, other cognitive aspects might be superior due to the visual communication used in children with deafness. Those cognitive aspects include visual attention, visual imagery, visual-spatial abilities, and visual perception (Marschark & Wauters, 2003; Emmorey, Kosslyn, & Bellugi, 1993). These abilities may serve as another cognitive ability that is correlated with visual abilities in other studies.

The other important thing that was measured and analyzed in this study was the usage of hearing aids. Most of the study participants (n = 45) used hearing aids, despite their communication methods, and thus researchers considered and took this into account. The statistical analysis results showed no significant difference in visual-spatial working memory capacity between children with deafness with hearing aids and those who did not use hearing aids. This result indicated that the usage of hearing aids did not help increase children with deafness' visual-spatial working memory capacity. It should be noted that in statistically analyzing the significance of the difference in visual-spatial working memory capacity between children with deafness with hearing aids and those without, the length of time using hearing aids was taken into account, and there was still no statistically significant correlation.

Based on this result, a statistical analysis was also done to determine whether there was a significant difference in visual-spatial working memory capacity between the users of hearing aids in each group of communication methods. This analysis was performed based on suspicious thought that hearing aids might be useful in increasing the capacity of visual-spatial working memory when used with specific communication methods. The result showed no statistically significant visual-spatial working memory differences among the children with deafness with or without hearing aid in each communication method group.

This study also statistically analyzed the significance of the correlation between visual-spatial working memory the children with deafness' ages. The results showed that the visual-spatial working memory capacity of children with deafness was correlated with age, as in the normal-hearing children. However, based on the score proportions, the visual-spatial working memories of children with deafness were not parallel to their age development. Score proportions for each communication method group did not yield scores above 0.5, considered to be the maximum. The visual-spatial working memory score proportion calculations of children with deafness overall in the average age of 10.8 (SD = 2.1) years in Indonesia were equal to the capacities of 5–6-year-olds in the Netherlands, where the *Lion Game* was developed (Weijer-Bergsma, Kroesbergen, Prast, & Luit, 2015). From this explanation, it is concluded that despite their communication methods, the visual-spatial working memory of children with deafness is delayed or less developed.

Children with deafness' limited capacity in visual-spatial working memory may be due to their lack of language abilities. Language ability play a role in visual-spatial working memory development. Alloway, Pickering, & Gathercole (2006) assert that verbal information processing and visual-spatial working memory are located in the same area, and hence, processing and storing temporary information work simultaneously. Therefore, based on this study, communication methods cannot directly influence visual-spatial working memory's capacity, except through language development. The low capacities of children with deafness' visual-spatial working memory in this study showed that a specific communication method is inadequate for children with deafness to have equivalent language or cognitive developments as normal-hearing children.

Other findings in this study pointed to the distribution of children with deafness' communication methods. The most used communication method is total communication, followed by sign language communication methods based on the obtained data. The almost equal number of children with deafness' communication methods usage shows that it is not yet proven which communication method could mostly support children with deafness' cognitive development. These findings should encourage researchers to discover which communication methods will work best for children with deafness cognitive development, especially in Indonesia.

The limitation of this research was the measuring tools or instruments used to measure visual-spatial working memory. The instrument was the *Lion Game* with the help of an additional computer application with written instructions. During the implementation in the field, children with deafness were found able to read instructions, but not all could understand them when reading themselves. Therefore, during implementation, parents need to explain instructions to children using communication methods that are commonly used at home so that children can understand game instructions. Instructions conveyed by parents can be biased toward measuring instruments because most parents want their children with deafness to perform well, while in addition to delivering instructions, parents mostly try to help their children.

Conclusions

This study aimed to overview the visual-spatial working memory capacities of children with deafness who use oral, total, and sign language communication methods. Based on the retrieved data, these are the conclusions:

There were no significant differences in children with deafness' visual-spatial working memory capacities with oral, total communication, and sign language based on score proportion means and the highest level of completed answers. This shows that this study's communication methods might not be one of the factors that could enhance the visual-spatial working memory capacity of children with deafness.

There were no significant differences found in the visual-spatial working memory capacities of children with deafness with and without hearing aids in children with deafness using oral communication, total communication, and sign language. Consequently, hearing aid usage in oral communication, total communication, and sign language was also not proven to enhance children with deafness' visual-spatial working memory capacity.

The visual-spatial working memory capacity of children with deafness significantly correlated with age, as it is in normal-hearing children, so it is concluded that the older a children with deafness is, the higher their visual-spatial working memory capacity, regardless of the communication methods they use. Nevertheless, the visual-spatial working memory capacity of 70 children with deafness with an average age of 10.8 was equal to the capacities of 5-year-old normal-hearing children. Finally, it could be said that the children with deafness' visual-spatial working memory capacities were not well developed and cannot be compared to normal-hearing children.

Suggestions

Methodological Recommendations

It is recommended for future studies to directly measure the cognitive abilities of children with deafness without parental mediation or accompaniment. If a translator is needed to instruct or question the participant, the same individual or institution should be assigned for all participants as a control method, as parental assistance may bias a child's responses. Further studies should also be done offline to control for devices, media, and the research environment to avoid further biases .

For further research on communication methods, the researcher suggests qualitative measures to be included. Qualitative research can be done through interviews related to parental expectations toward their children's communication, how long they have used a particular communication method, how comfortable the child is with such methods, how well they use such methods, and whether the child has also been introduced to other communication methods. Studies on children with deafness' communication methods may also improve when school observations, at home, and in peer settings are included.

Other methodological recommendations are the need to maintain participant homogeneity by age, onset, and hearing loss level, among others. Participant homogeneity criteria are needed to generate more significant results and may focus on measuring a particular aspect on minimizing the influence of confounding factors in research.

Practical Recommendations

The researcher recommends for parents be attentive to their deaf child's needs in terms of cognitive development. Children with deafness' ability to communicate might be the priority, but leads to a lack of attention on other developments, such as cognitive development. By acknowledging that communication methods were not the factor that enhances visual-spatial working memory capacities or cognitive development in general, parents should also pay attention to any possible cognitive stimulation for their child with deafness. Therefore, the researcher hopes that parents will accept their children's conditions as a primary concern and give more effort so that their children with deafness could optimally develop their cognitive function.

This study is hoped to prompt further comprehensive research on children with deafness' cognitive abilities and their communication methods. A more comprehensive overview of their cognitive abilities and communication methods can serve as a consideration piece to evaluate children with deafness' learning processes. Evaluations can be made on the learning processes that occur at school and home. In learning, a child with deafness requires communication methods as mediators. The use of communication methods in children with deafness also functions as an early intervention provided by schools and the home. Educational institutions can develop learning or intervention modules that benefit or best suit children with deafness' needs, adaptability, and cognitive development through evaluations.

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Conflict of Interest Declaration

There is no conflict of interest between the researcher and the publication of this paper.

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