CLOSED SET VERSUS CORNER SPATIAL ARRANGEMENT IN THE SYMBOL IDENTIFICATION SKILLS OF CHILDREN WITH DOWN SYNDROME

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CERTIFICATE

This is to certify that this dissertation entitled **"Closed Set Versus Corner Spatial Arrangement In The Symbol Identification Skills Of Children With Down Syndrome"** is a bonafide work submitted inpart fulfillment for the degree of Master of Science (Speech-Language Pathology) of the student Registration Number: **P01II22S123016.** This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for an award of any other diploma or degree.

Mysuru

July 2024

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DECLARATION

This is to certify that this dissertation entitled "**Closed Set Versus Corner Spatial Arrangement In The Symbol Identification Skills Of Children With Down Syndrome"** is the result of my study under the guidance of Dr. Reuben Thomas Varghese, Scientist – B, Dept. of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysore and co-guidance of Dr. Gayathri Krishnan, Assistant Professor in Speech-Language Sciences and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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CHAPTER I

INTRODUCTION

Down Syndrome (DS) is a genetic condition caused by the presence of an extra copy of human chromosome 21 (Hsa21). Patients typically present with mild to moderate intellectual disability, growth retardation, and characteristic facial features (Bhokhari et al., 2023). According to Overk et al. (2023) , among 650 to 1000 individuals born, one infant is found to have trisomy 21. Manikandan (2017) reported that the prevalence of DS in India, is 1 in every 925 births. Numerous disorders affecting the respiratory system, sensory (organs), cardiovascular system, gastrointestinal, immunity, hematological, endocrine system, muscular or skeletal, renal, and genitourinary systems represent some of the ways they present themselves (Arumugam et al., 2016; Barbosa et al., 2018). According to the World Health Organization (WHO) report, one in every 1100 children born globally has DS (2018). In India, the incidences are one per 850-900 live births (Kaur & Singh, 2010; Malini & Ramachandra, 2006).

With a deep understanding of the morphology of pyramidal neurons, researchers were able to establish an association between anomalies in dendritic spines and axons seen in DS patients with cognitive impairment (Hamdan et al., 2024). It was able to understand how the extra Hsa21 copy can contribute to aberrant morphological presentation in neurons of these populations (Hatab et al., 2024). Physical traits commonly associated with DS include growth retardation, broad hands, dysmorphic facial features, hypotonia (reduced muscle tone), inherited cardiac issues, and intestinal disorders (Price et al. 2007). Mental and behavioural disorders such as attention-deficit disorder, and hyperactivity occur more frequently in DS than in the overall typical population (Roizen and Patterson, 2003; Antonarakis and Epstein, 2006). Dental problems are very often seen in the DS population. It includes microdontia, hypodontia, supernumerary teeth spacing, and delayed eruption. According to Miller and Leddy (1998), speech output of people with DS may be impacted by structural and functional variations in their oral structures. Oral structure variations in people with DS can include a large tongue that protrudes forward, an uneven dentition, a narrow high-arched palate, and a small oral /cavity (Roberts et al., 2007). There have been findings of several irregularities in the facial musculature including hyperextendable joints, variations in nerve innervations, and poorly differentiated muscles (Miller & Leddy, 1998). As an effect of these variations there is reduced speed, limited range of motion, and dyscoordination of the speech articulators are observed in individuals with DS which may impact speech intelligibility (Prince et al., 2007). In addition, apraxia (difficulty in executing the motor programming of speech movements), dysarthria (weakness or incoordination of the articulators that results in slow, weak, imprecise, or discoordinated speech), drooling, open mouth posture, velopharyngeal insufficiency, and weakened respiratory system have been reported (Malkin et al., 2007). The communication difficulties in children with DS include articulation, voice, resonance, phonology, prosody, fluency, and intelligibility. The communication difficulties result in receptive and expressive language deficits and impairments in activities of daily living.

Communication is a fundamental human need for people to communicate regardless of the existence of complex disabilities. The Convention on the Rights of Persons with Disabilities safeguards the freedom to communicate through any mode (CRPD, 2022). Federal and educational policies emphasize that all children including DS have a right to access effective communicative supporting systems to enhance their academic and functional outcomes (IDEA, 2004; NJC for the Communication Needs of Persons with Severe Disabilities, 1992). According to Durand (1993), such interventions can lessen problematic behaviours, permit service provision in less restrictive settings, and assist people with disabilities in achieving optimal functioning.

In addition to communication difficulties, children with DS show difficulties in executive functioning, such as difficulty in controlling one's attention, shifting thoughts into actions, storing information, and inhibiting distractions (Daunhauer et al., 2017; Daunhauer et al., 2020; Tungate & Conners, 2021). However, visuo-spatial perception and processing are generally viewed as relative strengths in an individual with DS (Fidler et al., 2006). In these situations, Augmentative and alternative communication (AAC) will support effective communication to meet their challenges.

In disordered populations, usage of AAC may foster both comprehension and expression of speech and helps with early language development (Sevcik, 2006). In addition , AAC also supports healthy functioning throughout life taking into account the shifting demands of entering adulthood or school-based contexts (Finestack & Rohwer, 2020; McNaughton et al., 2020) and also helps in adjusting to possible cognitive decline (Channell & Loveall, 2020).

Although research has identified the benefits of AAC in aiding the communication experiences of children and young people with DS, most of the research has focused on investigating and assessing the effects of AAC after intervention. This focus has led to an oversight of the lived experiences of individuals using AAC in their day-to-day lives. A survey was undertaken to gather insights from caregivers of individuals in this group regarding AAC strategies employed within home, school, and community contexts. The results revealed that challenges were being faced, specifically about context, practical aspects of AAC, and the skill level of communication partners. These challenges were found to restrict the scope and effectiveness of social interactions (Scougal, 2023).

Communication through assisted AAC usually includes external displays that may be viewed and displayed visually. Thus, it is critical to understand how people with developmental impairments interact with AAC displays and use the visual information they provide as emphasized by Wilkinson, Light, & Drager, in 2012. Examining this type of visual cognitive processing can help software developers and healthcare professionals create AAC systems. This design process is informed by a theoretical understanding of visual-cognitive processes as highlighted by Light & McNaughton, 2014.

Spatial arrangement is a perceptual cue that aids in the locating of target symbols. Participants with and without disabilities demonstrated increased speed and high accuracy when some spatial arrangement was provided (Wilkinson et al., 2008; Wilkinson & Mcllvane, 2013). This arrangement can assist participants in reducing the working memory load through the reduction in the overall amount of time required to compose a message and attend to display demands. In assisted AAC, dependable metrics like accuracy and response time are crucial. A key component of good communication is accuracy, which is accurately locating a target symbol. On the other hand, response time is the time taken to locate a target symbol and hinders assisted AAC. It may result in a message preparation pace that is slow. It may have detrimental effects, including stifling individual dialogue, speaking partner dominance, and frustration. Increasing the visual search response time speeds up message preparation.

The speed and accuracy of target symbol recognition behaviour outcomes may be affected by symbol arrangement.

Recent studies examining human visual processing, suggest that certain arrangements can lead to visual crowding for users (Van den Berg et al., 2007; Yildirim, Coates, & Sayim, 2020). Bulakowski et al. (2011) have reported that visual crowding has an impact on various perceptual tasks, including restricting object perception, eye and hand movements, and affecting visual research and reading speed in normal individuals. Frequently used spatial arrangements of symbols in AAC devices include closed sets and corners. In a closed set, the symbols are ordered from top to down according to grammatical categories and for corner arrangement symbols within each semantic category are clustered along the left, top, right, and bottom corners

Using an eye-tracking device, Wilkinson et al. (2022) examined the impact of spatial layouts on the visual attention skills of individuals with DS. The results revealed that compared to closed set spatial arrangements, corner spatial arrangements have a higher proportion of fixations to symbols belonging to the same grammatical class as the target.

1.1 Need for the Study

Majority of the studies have focused on the symbol identification skills in typically developing children using various types of spatial arrangement of symbols in AAC display. The results consistently indicate enhanced accuracy and faster latency of locating the target symbols when the symbols were arranged in clustered (i.e. grouped) than distributed manner. Visuo-spatial processing and perception are generally regarded as relative strengths in an individual with DS (Fidler, Hepburn & Rogers, 2006; Jarrold, 1999; Klein & Mervis, 1999). However, studies have reported that people with DS have great difficulties inhibiting attention to distractions, and can exhibit over-selective attention with overcrowding of symbols in AAC devices (Dube & Wilkinson, 2014). Further, in children with DS, most of the studies have compared closed set and perimeter arrangements. A study conducted by Noora & Reuben (2023) compared the symbol identification skills in 20 Kannada children with DS in perimeter and closed set arrangement using a communication board. The results revealed a significant difference in the response time and identification accuracy scores in the symbol identification between the closed set and perimeter spatial arrangement conditions. Further, it was noticed that shows that the perimeter arrangement facilitates faster symbol search and better accuracy in the communication board when compared with the closed set arrangement. Limited studies are conducted in the Indian population comparing corner and closed set spatial arrangements in children with DS. Moreover, studies comparing symbol identification skills using low-tech modes such as communication boards are limited. Therefore, the present study aims to address these research gaps.

1.2 Aim of the Study

To evaluate whether changes in the spatial arrangement of symbols (closed set versus corner) influence the symbol identification skills in children with DS using a communication board.

1.3 Objectives of the Study

- To measure the response time and accuracy for identifying the target symbols using a closed set spatial arrangement for children with Down syndrome in the age range of 6-12 years using a communication board.
- To measure the response time and accuracy for identifying the target symbols using a corner spatial arrangement for children with Down syndrome in the age range of 6-12 years using a communication board.
- To compare the response time and accuracy for identifying the target symbols using a closed set spatial arrangement versus corner spatial arrangement for children with Down syndrome in the age range of 6-12 years using a communication board.

CHAPTER II

REVIEW OF LITERATURE

AAC systems assist individuals with DS in developing independence, boosting social relationships, and enhancing communication. For these populations, AAC can help in their early language developmental stage (Romski et al., 2020). These technologies range from advanced speech-generating equipment to sign language and gestures. Individualized evaluation, training, and continuous support are necessary for effective usage. Recent studies to investigate visual processing in humans found that certain spatial arrangements may result in users experiencing visual crowding (Yildirim et al., 2020). Making minor changes to the arrangement of a display can significantly impact the efficiency of finding a target in an array (both with the eye and with the mouse). Moreover, these modifications lowered the possibility of fixations to non-relevant distracters. Designing grid displays that enhance visual processing, could potentially reduce the initial learning demands and enhance the likelihood that a child will adopt and use the AAC system (Light et al., 2019).

It makes sense to suggest that knowledge of the fundamentals of visual processing can help therapies that make use of a visual form of aided AAC (Wilkinson et al., 2008). However, the relationship between visual processing and assisted AAC has received very little research. The majority of aided symbol displays are either made by medical professionals or acquired as components of ready-made commercial packages leaving clinical judgments to be made without a strong body of data.

Accurate symbol identification has direct consequences for good communication. response time, or latency to locate a symbol is also noteworthy. The slow rate of message preparation is a major obstacle to aided AAC communication. The rates of AAC message production are often “only a fraction of those achieved by natural speakers”, estimated at 15 words per minute as compared to 250 words per minute for spoken communication (Wilkinson et al., 2008). Slow production has several detrimental effects, including the speaking partner’s dominance in a conversation (Light, Collier, & Parnes, 1985), restriction of autonomous communication (Light, 1989), and user disappointment when faced with impeded communicative intent. Reducing the amount of time taken in visual search becomes a clear objective to speed up the message preparation pace. In another study, it was noticed that for all participants, when similar coloured symbols were grouped it took less time to find the target compared with the distributed arrangement. Many participants also reported higher accuracy when the symbols were clustered/grouped (Wilkinson et al., 2008; Wilkinson & McIlvane).

Visuo-spatial processing and perception are generally regarded as relative strengths in an individual with DS (Fidler, Hepburn, & Rogers, 2006; Jarrold, 1999; Klein & Mervis, 1999). Moreover, studies have reported that people with DS have great difficulties inhibiting attention to distractions, and can exhibit over-selective attention with overcrowding of symbols in AAC devices (Dube & Wilkinson, 2014). Based on the above studies, the effect of spatial arrangement on the symbol identification skills in children with communication disorders especially for DS has been less explored using low-tech devices as well as communication boards.

2.1 Speech and Language Difficulties in Children with Down Syndrome

Children with DS generally acquire language skills later in life than the typical population. This comprises both expressive language (speaking and writing) and receptive language (understanding and processing information). The majority of this population has trouble clearly articulating the words. This is caused by things like poor muscle tone (hypotonia) anatomical variations of the oral cavity and difficulties in motor planning.

People with ID may have trouble with written or signed language understanding, as well as have trouble communicating ideas clearly (Marrus & Hall, 2017). They could have challenges with social skills necessary for interactions such as topic maintenance, initiation, and turn-taking along with that they will speak with poor intelligibility and their speech will be incoherent (Coppens-Hofman et al., 2016**).** The severity of the intellectual disability is another important factor that affects the quality of communication (Belva et al., 2012**).** Individuals who have severe to profound ID usually operate primarily at the pre or proto-symbolic level (Cascella, 2005). They frequently exhibit restricted speech and language development and depend mainly on non-speech modalities including body postures, facial expressions, gestures, and muscle tone.

Channel (2020) examined the development of Mental State Language in the DS population. The study used a cross-sectional design to investigate how the capacity to comprehend and communicate ideas, opinions, and emotions varies as they age. The study included 40 school-aged DS children aged (6-11) years. The findings revealed that children with DS showed delayed but progressing mental state of language development compared to the typical population.

Linguistic patterns of school-aged children show that expressive language development is far behind receptive language development, with expressive syntactic and phonological processing showing the worst delays (Chapman, 2006). In particular, it is difficult to both comprehend and express language syntax which includes nouns, verbs, pronouns, grammatical morphemes, and sentence structure (Levy & Eilam, 2013). On the other hand, DS has a particularly negative impact on morphosyntactic processing and syntactic development (Vicari et al., 2002). In comparison to those with Williams and Fragile X syndromes, DS patients experience much more significant delays in the development of morphosyntactic skills.

Prelinguistic articulations and deliberate use of communication throughout pre-school years tend to develop normally during infancy. Sigman (1999) proposed that in qualitative terms abnormal communication patterns are linked to DS from a young age suggesting that excessive expression of the chromosome 21 gene has the potential to carry developmental implications for cognition though it may be difficult to measure these effects until performance capacities increase as well. Although opinions on how DS affects very early language development are still a topic of debate, most people believe that problems become more apparent around the age of 5-6 years (Rondal, 2006).

In general language comprehension is still poor, and people frequently try to interpret what is spoken to them using lexical and contextual cues (Rondal & Comblain, 1996). As people get older their speech comprehension and expression slow down even more, they experience more dysfluencies such as pauses and hesitations, word selection gets harder and issues with speech organization and retrieval of words exist. (Rondal & Comblain,1996). Age-related changes in hearing, auditory discrimination, and a less effective respiratory system for speech may be partially responsible for these issues (Rondal & Comblain, 1996). Deficits in language comprehension processing can affect memory and learning, besides other aspects of cognition. People with DS have less lexical access, syntactic awareness, and phonological abilities. This will be more evident if articulation does not reach an automatic level or if long-term memory is unable to integrate representations of phonemic sequences (Conners et al., 2008).

Mc Carron et al. (2020) conducted a study of 601 adults with intellectual disabilities and found that 57.9% experienced communication difficulties, with 23.5 % reporting severe difficulties. Only 75.1% communicated verbally and others found difficulty in communication. The recognition, response, and interpretation of communication modalities as well as the perceived effectiveness of communicative interactions are significantly influenced by the environment and in particular by communication partners within that setting. Through interactions within sociocultural contexts, communication skills are developed. Because of this, contextual elements have a significant influence on interaction, communication, and the opportunities and obstacles to involvement. People with ID frequently have limited access to social networks to social networks and communication settings, particularly if they reside in a community (Brennan, & McCarron, 2020).

Children with DS benefit greatly from speech and language intervention because it improves their communication abilities, which in turn fosters better social participation and academic excellence. Early and regular therapy helps to minimize difficulties with speech production and language comprehension, enhancing their capacity to communicate their needs and to comprehend others. These intervention and support systems boost their self-esteem and independence in turn promoting their overall development.

2.2 Cognitive Skills in Down Syndrome

Persons with DS are more likely to have certain cognitive characteristics from an early age, which includes difficulties with language processing, retention of information, and behavioral goals (Daunhauer & Fidler, 2011). Most of the research depicts that DS may have competence, which is necessary for responsive and action-oriented behaviors (Lee et al., 2011). Additionally, the evidence supports the fact that the neuroanatomical structure of DS is quite different from the typical population, especially the reduction in the size of the frontal lobe (Nadel, 2003), which is very necessary for executive functions.

Grieco et al. (2015) in a literature review provides an in-depth analysis of the cognitive and behavioural traits of individuals with DS, it highlights the strengths in visual processing and social functioning, and challenges in verbal processing, memory, and executive functioning. The authors proposed that targeted treatments can address particular cognitive and behavioural requirements and they advocate the importance of early and ongoing support to maximize the developmental potential and quality of life. People with DS have a consistent pattern of deficits in language processing compared to visual information processing throughout the areas of cognitive functioning (Abbeduto et al., 2001). Children suffering from DS have shown improvement in their nonverbal cognitive skills (Channell et al., 2014), while linguistic abilities development tends to slow down from adolescence into adulthood (Naess et al., 2011).

The term executive function (EF) describes the interplay between cognitive and affective processes that are essential to goal-directed, adaptive behaviour. These processes include organizing, regulation of emotions, inhibition, etc (Hughes , 2011). The lowest level of EF deals with the aspects of attention, inhibition, and processing speed that are involved in regulating behavior and cognition (Alvarez & Emory, 2006). In contrast, higher-level EF deals with higher-order cognitive functions such as systematic search, organizational skills, and mental and behavioral flexibility that are included in higher-level EF (Alvarez & Emory, 2006). It also includes the capacity to self-monitor behavior, integrate goals with abilities, and focus energy toward a future objective (Alvarez and Emory, 2006; Willoughby et al., 2014). Previous investigations on EF in people with DS have shown deficiencies in motor control, attention, response time, processing speed, etc in comparison to teenagers of comparable mental age (Meyers et al., 2013). Additionally, as compared to peers with ID of different etiologies, weakness in the synchronous and sequential processing and organization of motor movements are noticed. Research conducted on people with DS shows varied results among the population who were tested in their early childhood when compared with the adult population.

Jacobson et. al (2011), conducted a study which involved children transitioning from elementary to middle school and assessed EF using neuropsychological tests and teacher reports. The results revealed that predictor of children's adjustment to middle school, with higher levels associated with better academic performance, greater social competence, and fewer emotional and behavioural problems.

Children with DS exhibit difficulty in a wide range of attention-related domains compared to age-matched peers such as auditory sustained attention and visual selective attention. Children with DS frequently struggle with their inhibition skills which include cognitive behavioural and emotional regulation which indirectly affects their impulse control and self-regulation. Throughout the developmental lifespan, poor response inhibition is obvious; it primarily appears in toddlers and persists into adulthood. According to a survey of parents of reports, around 37% of their children had clinically significant organizing, planning, and problem-solving skills (Lee et al., 2011). These skills are acquired slowly and lately so it is necessary to provide interventions like cognitive training, environmental changes, etc. These early interventions can enhance their daily functioning and social interactions.

2.3 Social, Emotional, and Behavioural Functioning in Down Syndrome

Children with DS are frequently described as lovely, caring, sociable, and affectionate (Fidler et al., 2008). Children with DS are less likely to develop psychopathology than other children with ID (Stores et al., 1998) and their families report less stress and a more positive outlook on life when compared with other disabled population caregivers (Fidler et al., 2008; Skotko et al., 2016).

2.4 Quality of Life in Persons with Down Syndrome

The quality of life of persons with DS is not a widely researched area even though it is known for misconceptions and cultural norms that might prevent people with DS from actively engaging in society. Many people with DS may lead quite independent lives if they get sufficient help throughout their lives. There has been some research done on the viewpoints of family members of people with DS. Not only may DS networks and support groups offer insightful guidance but families and individuals with DS should also be aware of regional and national organizations.

According to the review literature done by Graaf et al. (2012), in the current era, DS students attend conventional schools daily frequently receiving additional one-to-one or targeted help for their special needs. While some children with DS may benefit from inclusive settings in normal classrooms rather than from separate significantly distinct classrooms in terms of language and literacy development some may need to attend special school. Many people with DS have jobs and are generally satisfied with them many of them have become successive professionals such as actors, speakers, and artists.

2. 5 Communication Patterns of Children with Down Syndrome

A survey done by Scougal et al. (2023) revealed that individuals with DS often face significant challenges with verbal communication throughout their lives, with more than 95% of the population with DS experiencing difficulty being understood. This impediment to effective verbal communication can create obstacles to achieving independence and participating fully in social interactions. Indeed, this population often demonstrates cognitive abilities that exceed their language and speech skills (Martin et al., 2013), The significant decrease in speech intelligibility as reported by Chapman and Kay-Raining Bird, in 2012 potentially leads to an underestimation of their overall communication skills. Despite these challenges, they tend to exhibit relatively strong social skills and proficiency in social interaction (Martin et al., 2009).

Many persons with DS are often characterized as having complex communication needs. This is a consequence of difficulties with both speech production and pragmatic abilities (McNaughton et al., 2021). A recent survey results revealed that over 50% of parents of adults and adolescents with DS claimed that their child's speech was not intelligible to people other than their closest relatives (Van Gameren-Oosterom et al., 2013). Beyond difficulties with speech intelligibility, they also experienced difficulties in pragmatic abilities such as initiating a topic of conversation (Martin et al., 2009). These challenges mostly lead to communication breakdowns, and challenges in community relations (Graaf et al., 2019; Babb et al., 2021).

In children with DS, speech development is often slower compared to normal children. The usage of word combinations has also been noted to occur at a slow pace. Other than these, additional challenges may arise in factors such as dysfluency, intonation, and articulation. Scougal et.al in 2023, did a study that involved children and young people with DS. Data was collected through interviews, surveys, and observations and results revealed that the quality of communication experiences was significantly influenced by the environment and attitude of the listener. Better communication was promoted by comfortable and encouraging situations.

Another study done by Scougal et al. (2023) found that over 95% of caretakers of children with DS think that their kid has trouble being understood by others, especially with new communication partners. Hence it is crucial to explore ways to facilitate communication beyond basic needs and desires from early years and throughout various communicative contexts and environments.

For the younger population with DS, it is important to consider cognition, development, and their learning process. This is because these individuals want to be amalgamated into society and enhance their independence of living. Considering that DS is a leading cause of intellectual disabilities, it is essential to make use of resources that support the development of communication. The improvement of communication skills can play a significant role in fostering better socialization for individuals with DS.

2.6 Impact of Communication Impairment: Complex Inter-relationships

As individuals with DS get older inadequate communication abilities and unfilled communication requirements may have severe consequences. Communication impairments have an impact on social interactions, career pathways, and educational options (Bryen, Potts, & Carey, 2007). By limiting choices for treatment, support systems, and health requirements they may make these populations weaker and more dependent on others. Strengthening communication abilities is a well-recognized intervention strategy to promote social inclusion and lessen health discrepancies for those populations with ID. However, a significant number of persons with ID can have unfulfilled needs regarding communication (Sutherland et al., 2014). To effectively serve the requirements of this group, it is important to identify the elements that enhance the likelihood of communication challenges.

Communication skills are the key to effective interactions and social involvement is essential for them to occur. Around 64% of the population reported that their colleagues barely understand their communication. The closest family and caregivers can comprehend their speech but in general, they were less likely to succeed in relationships with others and more likely to be able to connect with family and friends.

Beukelman & Mirenda (2013) surveyed the DS population and results revealed that although more than 92% of respondents reported having friends, only 52% had a closest friend, and more than 55 % reported they have difficulty communicating with others These findings emphasize the potential hazards of social isolation encountered by persons with ID who struggle with communication. Communication skills are developed in contexts where communication is accepted and expected. Individuals with severe ID who dwell in residential areas are more susceptible to social isolation when compared to other mildly ID populations (McCausland et al., 2017). A study done by Zijlstra and Vlaskam in 2015 investigated the recreational opportunities provided to persons with ID in a residential setting and revealed that in comparison to younger clients senior clients(>38 years old) received fewer interactions as well as lower diversity and choice of options. Furthermore, individuals with lower activity levels, and fewer adaptive and communication abilities, are offered only fewer engaging activities and need more institutional care (Maes et al., 2007). Based on the above reasons, it is possible to speculate that individuals with more severe communication issues may have less opportunity for social contact and thus, fewer opportunities to learn effective communication methods, which will vigorously affect their normal life.

2.7 Augmentative and Alternative Communication

People with communication difficulties frequently depend on (AAC) augmentative and alternative communication to actively participate in communication events. AAC encompasses aided communicative modalities that necessitate the use of extra materials or devices. It is further divided into low and high-tech approaches. Low-tech approaches include handwritten words on paper, communication books or boards, line drawings, photographs, etc. High-technology gadgets include (VOCAs) voice output communication aids, commonly known as ‘speech-generating devices’ in different parts of North America. Additionally, software on personal computers or laptops is utilized as a communication aid and produces written or recorded speech output to assist in communication for individuals with complex communication disabilities (Binger & Light, 2007; Barbosa et al., 2018).

2.8 AAC Studies in Down Syndrome

Aided AAC refers to strategies that enhance or support communication by providing representations of language components and concepts using pictures, symbols, words, or letters (Beukelman & Mirenda, 1998). These visual aids complement visuo-spatial processing strengths reported in people with DS (Fidler, Hepburn, & Rogers, 2006; Jarrold, Baddeley, & Hewes, 1999; Klein & Mervis, 1999). The Implementation of these AAC strategies can be either 'low-tech', involving paper-based tools, such as communication boards, symbols, or books, or 'high tech', utilizing electronic methods that enable digital voice output. The utilization of these types of AAC has been suggested to be beneficial for object naming for children with DS. Additionally, it supports learning and narrative skills in this population (Finestack et al., 2017).

According to Foreman and Crews (1998), young children with DS often encounter challenges in language and communication as well as visual and perceptual areas. This suggests that they may efficiently benefit from the use of AAC systems to enhance language, communication, and consequently pragmatics. Some research highlights the relevance of AAC intervention. Although research has identified the benefits of AAC in aiding the communication skills of children and adolescents with DS, most of the research has focused on investigating and assessing the effects of AAC after intervention. This focus has led to an oversight of the lived experiences of individuals using AAC in their day-to-day lives. A survey was undertaken to gather insights from caregivers of individuals in this group regarding AAC strategies employed within home, school, and community contexts. The results revealed that challenges were being faced, specifically to context, practical aspects of AAC, and skill level of communication partners. These challenges were found to restrict the scope and effectiveness of social interactions (Scougal et al., 2023).

2.9 Need for Spatial Arrangement in AAC

Spatial arrangement is a perceptual cue that aids in the locating of target symbols. Participants with and without disabilities demonstrated increased speed and high accuracy when some spatial arrangement was provided (Wilkinson et al., 2008; Wilkinson & Mcllvane, 2013). This arrangement can assist participants in reducing the working memory load through the reduction in the overall amount of time required to compose a message and attend to display demands. Recent studies examining human visual processing, suggest that certain arrangements can lead to visual crowding for users (Van den Berg et al., 2007; Yildirim, Coates, & Sayim, 2020). Bulakowski et al. (2011) stated that visual crowding has numerous effects on different perception tasks, such as restricting target perception, visual and hand motions, and reducing visual research and reading speed in normal individuals.

2.9.1 Effect of Spatial Arrangement in Typical Population

Jiali Liang (2019) conducted research that aims to provide insights that could enhance the design of AAC systems making them more effective and user-friendly. The study involved 20 typical populations. Material used in the study included target symbols which included various forms such as line drawings, photographs, etc. Grid display contained 12 or 16 line drawings, and in 2 conditions that were clustered (where the same color was grouped) and distributed (symbols were interspersed randomly across the grid). A visual search task was given, eye-tracking technology was used to monitor and record the visual fixation and movement patterns of the participants, and motor behavior recording was done. The study found that visual perceptual features significantly influence eye-hand coupling, with clustered symbols resulting in faster responses, efficient fixation patterns, and improved eye-hand coordination, indicating their crucial role while designing AAC. Limitations include a sample size of 20 participants, a controlled environment, a limited diversity of stimuli, and technical constraints while using an eye tracker.

Wilkinson, O'Neill, & McIlvane (2014) in a study aimed to better understand the impact of AAC display design on visual search efficiency in children without disabilities. Eye-tracking technology was used to monitor gaze patterns. The task was to engage in visual search with two AAC displays. The study included a total of 14 participants seven in the ISCAN group and seven in the TOBII group. One display shares internal colors that were clustered together. In other like colored symbols were distributed. The measures calculated were latency to fixate on the target and the number of fixations to target and distracters. The results revealed that when symbols were grouped by color, participants showed more effective search patterns and faster target identification, indicating that visual organization facilitates faster and more precise searches. The above studies underscores the importance of AAC display design in improving symbol search, selection speed, and accuracy for people with complex communication needs.

2.9.2 Effect of Spatial Arrangement in the Down Syndrome Population

Using an eye-tracking device, Wilkinson et al. (2022) examined the impact of spatial layouts on the visual attention skills of individuals with DS. A visual search task was administered to ten adults and adolescents with DS and their patterns of visual attention were tracked using an eye-tracking device. The spatial arrangement minimized the visual crowding and helped to cue the grammatical category of symbols. The results revealed that compared to closed set spatial arrangements, corner spatial arrangements have a larger proportion of fixations to symbols that belong to a similar grammatical class as the target. The background was useful in reducing the latency to find the target.

In a study done by Wilkinson et al. (2022), the researchers investigated whether displays that arrange physically distinct spatial areas using grammatically related symbols (eg, small clusters of symbols in each of a grid's four corners that is Corner arrangement) improved visual search in adults and adolescents with DS when compared with traditional raw-column grids that are Closed set arrangement. The efficacy of visual search was assessed using automated eye-tracking research tools that collected visual gaze samples for every 16 milliseconds. This methodology enabled the researchers to pinpoint where visual attention was focused during the search. Notably, when symbols on displays were organized into distinct spatial groupings, visual attention was significantly focused on the target item, and there was considerably less visual attention focused on irrelevant symbols when compared to a traditional grid layout. These findings suggest that spatial arrangement is a crucial factor to consider, in general, in AAC displays (Wilkinson et al., 2023).

Individuals with DS may exhibit faster response times if they have fewer fixations on distractions (Wilkinson & Madel, 2019). Moreover, individuals with DS might be more susceptible to distraction because they face challenges in controlling their attention from irrelevant stimuli (Lanfranchi et al., 2009; Wilkinson et al., 2014). The arrangement of symbols likely improved sustained attention, categorization, and fluid reasoning ultimately enhancing the ability to navigate the display. This, in turn, led to better response times for symbol identification. Wilkison et al. (2014) revealed that fixations on the target were faster under the clustered condition compared to the distributed condition. Additionally, there were significantly more fixations to nonrelevant distracters under the distributed condition than the other.

Reducing visual crowding by spreading symbols apart had a significant impact on lowering the possibility of fixations to nonrelevant distracters (Wilkinson et al., 2021). There were significantly more fixations on distracters in the closed set grid condition than in any of the others. This reveals the fact that visual crowding exhibited in the closed set grid, which closely mimics the current standard norm in the AAC display design can increase the possibility of fixations to nonrelevant items. On the contrary, dispersing symbols apart from one another in the widely spaced grid significantly lowered the fraction of fixations to distracters dramatically (Wilkinson et al., 2022). In the same study, they made a comparison between the corner and perimeter organization of symbols and discovered that in the corner condition, only 30% of the participants shifted their attention from the target to distracters, whereas 60%–70% did under the other conditions. Therefore, it reveals that spatial signals provide a benefit beyond reducing visual crowding (Wilkinson et al., 2022).

Light et al. (2024) investigated the relationship between visual fixation patterns and motor selection in individuals with DS and autism spectrum disorder when interacting with AAC displays. The researchers used eye-tracking technology specifically TOBII Pro Glasses 2 to measure participant's gaze fixations in real time as they engaged with simulated AAC displays. The study involved ten individuals with ASD in one study and nine individuals with DS in another study. Participants were instructed to select specific target thumbnail VSDs in a task-based paradigm. The study concluded that significant correlations between visual fixation patterns and motor selection, highlighting the importance of understanding and considering visual attention in designing AAC systems for individuals with special needs.

A study conducted by Noora & Reuben (2023) compared the symbol identification skills in 20 Kannada children with DS in perimeter and closed set arrangement using a communication board. The results revealed a statistically significant difference in the response time and identification accuracy scores in the symbol identification between the closed set and perimeter spatial arrangement conditions. Further, it was noticed that shows that the perimeter arrangement facilitates faster symbol search and better accuracy in the communication board when compared with the closed set arrangement.

2.10 Visual Attention And AAC

Communication through aided AAC typically incorporates an external device that is visually displayed and accessed. Therefore, it is crucial to comprehend how the developmentally disabled population interacts with it and how they extract visual information from AAC displays (Wilkinson, Light & Drager, 2012). Investigation into this form of visual-cognitive processing can guide both clinicians and software engineers in designing AAC systems. This design process is guided by scientific knowledge of visual-cognitive processes (Light & McNaughton, 2014; O'Neill et al., 2020). The four specific areas of visual processing that may be particularly significant while designing AAC: (a) symbol arrangement (b) grid-based symbol organization versus natural scenes (c) symmetry and axial orientation and (d) color cueing and symbol contrast (Wilkinson et al., 2014).

2.11 Research Gaps

The previous research which focused on the spatial arrangement of symbols in AAC display was primarily carried out in a normal population. The results consistently indicate enhanced accuracy and faster latency of locating the target symbols when the symbols were arranged in a clustered rather than distributed manner and when background colors were given. Studies have also compared the effect of different kinds of spatial arrangements such as widely spaced, perimeter, and corner other than the closed set arrangement in persons with DS. However, the majority of the studies were conducted in the Western context and limited studies were conducted in the Indian context.

In addition, majority of the studies were small sample sizes of children with DS. Spatial arrangement design and background color cues were done on high-tech devices and were less focussed on low-tech devices such as communication boards which are also commonly used in AAC intervention. Hence there is an urgent need for research in this area to address these gaps. The present study explores whether changes in the corner and closed set spatial arrangement of symbols influence the symbol identification skills in children with DS using a communication board and whether it influences response time and accuracy while selecting the symbols.

CHAPTER III

METHOD

The present study aimed to determine if the variations in the spatial arrangement of symbols (closed set vs corner) influence the symbol identification skills in children with DS using a communication board.

3.1 Research Design

Between-group design was used in this study to compare the effects of closed set and corner spatial arrangement on symbol identification in children with DS using a communication board.

3.2 Ethical Considerations

The study was carried out while adhering to the AIISH ethical committee guidelines for Biobehavioral Sciences for human subjects. All ethical standards were met for participant selection and participation. Before the field testing, the study and its purpose were explained to the caregivers, and consent was obtained from them (Appendix I).

3.3 Participants

Twenty Malayalam-speaking children with DS in the age range of 6-12 years, 12 males and 8 females (*Mean age = 7.7 years*) were recruited for the study. The participants were selected from special schools, therapy centers, and AIISH. Consent from parents was taken before initiating the study. Table 3.1 below includes details of children with DS, including the chronological age, receptive language age, and intellectual quotient (IQ) score. The children were further divided into two groups consisting of 10 participants each. Participants were assigned to each group on a random basis. Participants from Group I were evaluated using a closed spatial arrangement and Group II was evaluated using a corner spatial arrangement.

Table 3.1

Details of the Participants in Group I and Group II

Group I				Group II			
Sr.No.	Age(yrs)	RLA(yrs)	IQ	Sr.No.	Age(yrs)	RLA(yrs)	IQ
1	10.4	5.1-5.6	60	1	6.11	3.0-3.6	52
2	8.1	3.7-4.0	52	2	7.8	3.0-3.6	57
3	6.2	3.0-3.6	51	3	10.5	3.7-4.0	56
4	7.8	3.0-3.6	54	4	9.4	3.0-3.6	51
5	8.11	3.7-4.0	52	5	7.2	3.7-4.0	52
6	9.4	3.7-4.0	51	6	6.5	3.0-3.6	53
7	8.1	3.0-3.6	62	7	10.8	5.1-5.6	58
8	10.7	3.7-4.0	59	8	6.11	4.0-4.6	53
9	11.2	4.0-4.6	60	9	7.11	3.0-3.6	52
10	8.3	3.7-4.0	58	10	8.9	3.7-4.0	55

Note‘Yrs’=’Years’

3.3.1 Inclusion Criteria (for both groups)

The participants were selected based on the following inclusion criteria:

- Receptive Language Age (RLA) above three years checked using (Assessment was done using Checklist for Speech-Language Skills, ACSLS; Swapna et al.,2010)
- Native speakers of Malayalam

- Adequate/ Corrected vision- checked using ZEISS online visual screening tool (https://www.zeiss.co.in/vision-care/eye-health-and-care/zeiss-online-vision screeningcheck.html)
- Mild intellectual disability within the range of 50-69 (Wechsler's IQ Classification, Wechsler, 2014).
- Should not have any associated behavioral impairments.
- First-time AAC users, the AAC Assessment Kit (Saxena & Manjula, 2005) will be administered to check the AAC candidacy.
- Adequate pointing skills. Pre-assessment testing on participant's accuracy and pointing abilities was administered using 4, 8, 12, and 16 grids (Checked using grid hierarchy criteria in AAC; Vineetha & Goswami, 2022), and only participants who correctly point to 16 grid symbols was taken in the present study
- Right-Handed (Handedness evaluated using Edinburgh Handedness Inventory, Oldfield,1971).

3.3.2 Exclusion Criteria (for both groups)

The participants with the following characteristics were excluded from the study.

- Those who have attended AAC therapy before this study.
- Those who have any associated major behavioural issues.

3.4 Materials

An array of 16 picture symbols with a white background was chosen from the AVAZ application (version 6.6.4) under four semantic categories: food items, animals, common objects, and fruits (as shown in Table 3.2). All the picture symbols had consistent dimensions of 5 cm x 5 cm The picture symbols were arranged in a closed set and corner spatial arrangement manner on a black communication board with a dimension of 29 cm x 38.5 cm. Figures 3.1 and 3.2 depict the closed set and corner spatial arrangement of picture symbols on a communication board.

Table 3.2

Selected Categories for the Study

Sr.No.	Categories	Items in each category
1	Food items	Idli,Masala dosa,Water,Milk
2	Animals	Hen, Cow, Dog, Cat
3	Fruits	Apple,Orange,Banana,Grape
4	Common Objects	Window, Chair, Table, T.V
	TOTAL	16 items

Figure 3.1

Closed set spatial arrangement of 16 Picture Symbols on the Communication Board

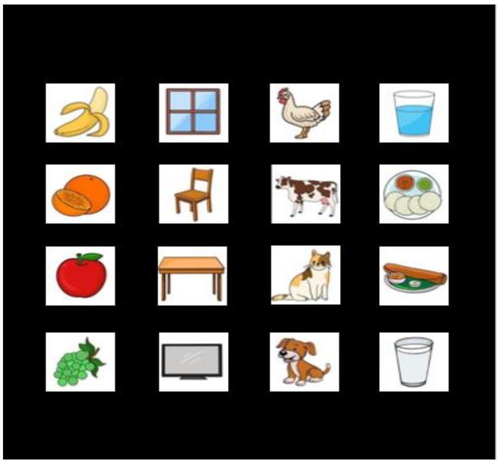
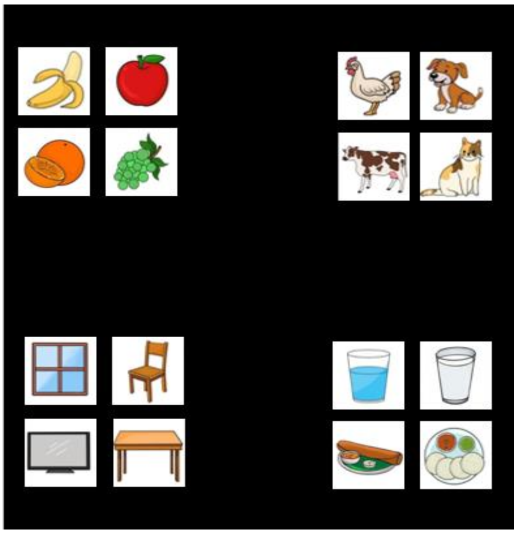


Figure 3.2

Corner spatial arrangement of 16 Picture Symbols on the Communication Board



3.5 Pre-assessment Measures

To select participants for the study, the student researcher conducted a thorough assessment of the child's language skills using the Assessment Checklist for Speech-Language Skills (ACSLS; Swapna et al., 2010). AAC assessment protocol kit was administered (Saxena & Manjula, 2005) before finalizing the participants for the study. Detailed evaluation of all other skills required for the study was documented, and children who fit the inclusion criteria were chosen. Initially, the student researcher did pre-assessment testing on participant's accuracy and pointing abilities using 8,12, and 16 grid sizes. Only those participants who could point to 16 grid symbols were taken in the present study.

3.6 Clinical Conditions

Group I comprised ten participants who were evaluated for their symbol identification skills using closed set spatial arrangement. Similarly, group II comprised ten participants who were evaluated for their symbol identification skills using corner spatial arrangement.

3.7 Clinical Procedure

The testing for both conditions was administered in a silent room with the caregiver's presence and adequate lighting. The symbols on the communication board were introduced to the participants. After the introduction of the symbols, the auditory output of the target symbols was presented using computer speakers one after another. The participant has to identify the correct target symbols from the array of 16 picture symbols. Three trial stimuli not included in the testing conditions were provided initially for familiarization with the procedure.

The outcome measures, such as response time for the target identification and the accuracy of the identified target symbol were measured. The response time was measured using a Flutter tool kit (Google Alpha (v0.0.6), 2017) by another experimenter to reduce procedural bias. Figures 3.3 and 3.4 depict the measurement of accuracy and response time of the target symbol using a closed set and corner spatial arrangement conditions.

Figure 3.3

Photo Depicting Measurement of Accuracy and Response Time of Target Symbols Using Closed Set Spatial Arrangement

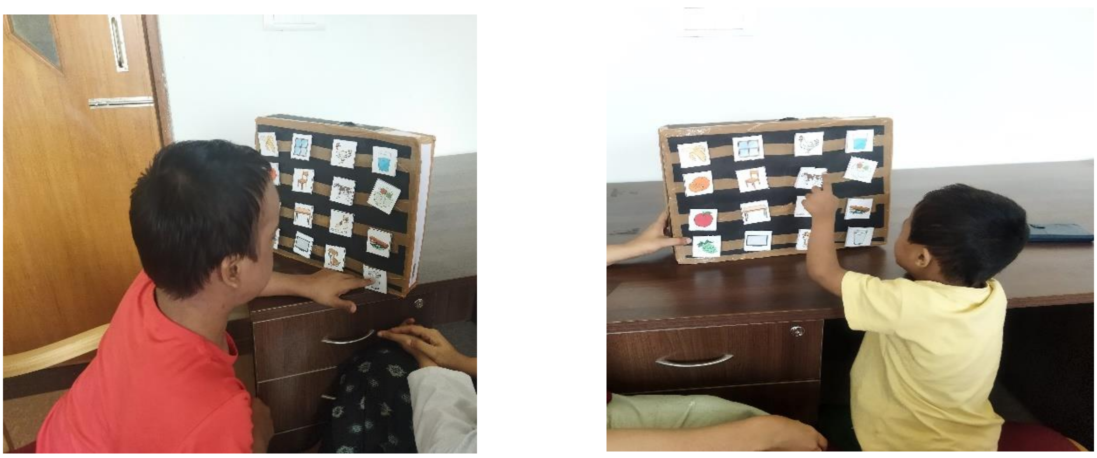


Figure 3.4

Photo Depicting Measurement of Accuracy and Response Time of Target Symbols Using Corner Spatial Arrangement

3.8 Analysis

In the present study, the outcome measures, such as accuracy for correct response and response time for identifying the target symbol, were assessed using a closed set and corner spatial arrangement to examine the preparation of accurate and timely messages. The response time in seconds was measured for each participant only for correctly identified symbols using a customized communication board with an inbuilt timer. Moreover, a score of "1" was given for correct response, and for incorrect response or no response "0" score was given and converted into a percentage. The raw scores obtained from the two group participants were tabulated and subjected to statistical analysis using the IBM SPSS software (Statistical Package for the Social Science package, version 26) to compare the performance of both groups. Descriptive statistics were done to obtain the mean, standard deviation, median scores, and interquartile range for closed set and corner spatial arrangement conditions. Normality was checked using the Shapiro-Wilks test of normality. Since the collected data followed the assumptions of normality, Multivariate Analysis of Variance (MANOVA) was done to determine whether a significant difference exists between the response time and accuracy scores for closed set versus corner spatial arrangement conditions in both groups.

CHAPTER IV

RESULTS

The current study investigated the accuracy and response time of closed set spatial arrangement compared to corner spatial arrangement in children with DS aged between 6-12 years using a communication board. Twenty children with DS have participated in the study. Group I consisted of 10 children with DS who were exposed to the closed set spatial arrangement and Group II consisted of 10 children with DS who were exposed to the corner spatial arrangement. All the participants were instructed to identify the target symbol on the communication board when the auditory sample was presented through a computer speaker. The response time and accuracy for identifying all the 16 picture symbols in both closed set spatial arrangement and corner spatial arrangement on a communication board was measured. Further using IBM SPSS software (version 26), the results of the response time and accuracy for the tasks administered to the participants were analyzed.

4.1 Measurement of Response Time and Accuracy for Identifying the Target Symbols Using Closed set and Corner spatial Arrangement in a Communication Board

The response time and accuracy for the correctly identified target symbols were computed for a closed set spatial arrangement for group I and a corner spatial arrangement for group II. The mean, standard deviation (SD), median, and interquartile range scores were calculated for response time and accuracy for correctly identified target symbols in a closed set, and corner spatial arrangement conditions are tabulated in Table 4.1, Fig 4.1, and Fig 4.2 respectively.

Table 4.1

Mean, Standard Deviation (SD), Median, and Interquartile range scores of Response Time and Accuracy for Closed Set and Corner Spatial Arrangement Conditions in Both Groups

	Response Time (sec)				Accuracy (%)			
Conditions	Mean	SD	Median	IQR	Mean	SD	Median	IQR
Closed set spatial arrangement	15.25	2.68	14.83	4.73	60.62	9.79	59.37	14.06
Corner spatial arrangement	7.11	0.88	7.4	1.84	78.12	10.72	78.12	18.75

Thus, the above results clearly indicates that symbol identification had a faster response time and better accuracy in corner spatial arrangement than in closed set spatial arrangement..

Figure 4.1

Bar Graph Representing Mean Response Time (in sec) Obtained by Closed Set and Corner Spatial Arrangement Conditions

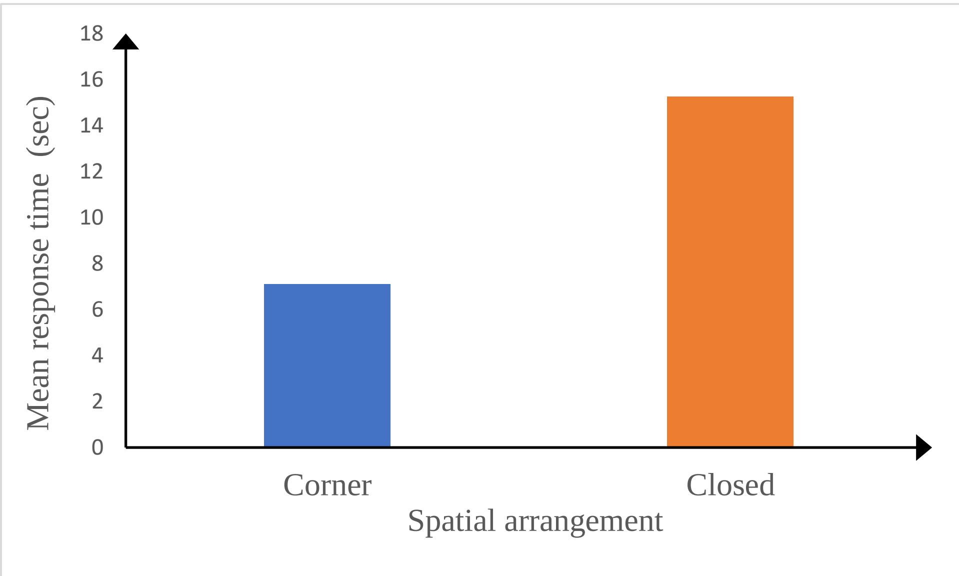
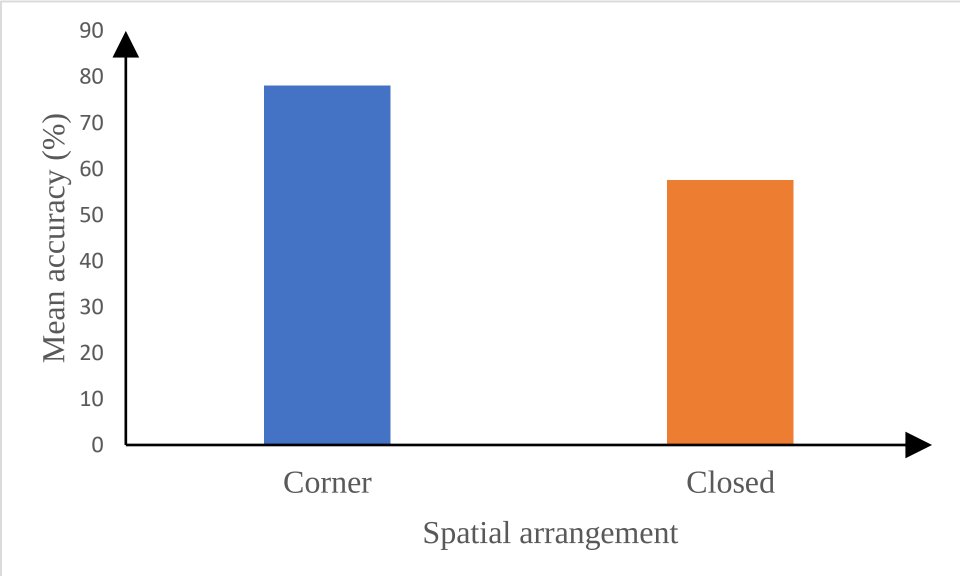


Figure 4.2

Bar Graph Representing Mean Accuracy Score (in %) Obtained by Closed Set and Corner Spatial Arrangement Conditions



4.2 Comparison of Response Time and Accuracy for identifying the Target symbols Using Closed set versus Corner Spatial Arrangement in a Communication Board

First, the Shapiro-Wilk test of Normality was done to check the normality distribution of the data. The result of the Shapiro-Wilk test revealed that the data followed assumptions of normality. Hence a parametric test Multivariate Analysis of Variance (MANOVA) was administered to compare both group's response time and identification accuracy between the closed set and corner spatial arrangement conditions. The MANOVA test results revealed a significant effect on the spatial arrangement of the combined dependent variables [V=0.96, F (2,17) =229.33, $p < 0.05$, with a very large effect size ($\eta p^2=0.96$)].

4.3 Between Group (corner versus closed) Effects

4.3.1 Response Time (RT)

The univariate testing of between-group effects for response time revealed a significant effect on the condition [F (1,18) = 83.26, $p < 0.05$, with a partial Eta Squared of 0.82] indicating a large effect (Jacob Cohen Classification, 1988).

4.3.2 Accuracy (AC)

The univariate testing of between-group effects for accuracy revealed a significant effect on the condition [F (1,18) =14.51, $p < 0.05$, with a Partial Eta Squared of 0.44 indicating a large effect (Jacob Cohen Classification, 1988).

Thus in the present study, the MANOVA results indicate that the condition (spatial arrangement) significantly affects both response time and accuracy. The significant multivariate effect supported by large effect sizes in the univariate tests underscores the substantial influence of the condition (spatial arrangement) on the performance metrics measured in this study.

CHAPTER V

DISCUSSION

Previous studies conducted in Western contexts have demonstrated that spatial arrangement of symbols in AAC systems can significantly enhance the response time and accuracy for children and adolescents with DS as well as typically developing children. These studies suggest that organized symbol placement aids in communication development. However, there is a notable lack of research in this area within the Indian Context. The present study aims to fill this gap by exploring how different spatial arrangements of symbols on a communication board influence the symbol identification skills of children with DS in the Indian context in terms of response time and accuracy.

For persons with DS, the arrangement of symbols on AAC display can have a large impact on their visual attention. Studies done in children and adolescents with DS and typically developing children have proven that more efficient visual attention during search tasks results from spatial designs that minimize visual crowding and utilize spatial structure to signal the grammatical category of symbols. Specifically displays that minimize visual crowding and offer spatial cues can lower the chance of fixation on nonrelevant distracters during the search and reduce the likelihood of fixation away from the target once it is located. Additionally, another way to maximize visual attention on AAC displays is by the use of background color cues for each grammatical category. It can be noticed that background color cueing has been found to help reduce the latency to find the target symbol, thus facilitating speed in locating targets for individuals with DS.

On a communication board,16 picture symbols were selected and placed in a closed set and corner spatial arrangement. Twenty children with DS were divided into two groups (ten each) for the study. Both the groups were evaluated in a quiet environment using a closed set and corner spatial arrangement respectively. When the auditory sample is presented through the computer speaker both groups have to identify the target symbols out of the 16-picture symbol array and the response time and accuracy were calculated for each symbol identification.

5.1 Response Time Between the Closed Set versus Corner Spatial Arrangement Conditions

It was noticed that the response time was faster for corner spatial arrangement compared to closed set spatial arrangement. This study is in agreement with a similar study done by Wilkinson et al. (2022) where it was proved that spatial arrangement significantly affects symbol selection. Specifically DS population demonstrated faster response time under corner spatial arrangement conditions compared to the closed spatial arrangement. This suggests that organizing symbols in a corner layout on AAC boards can significantly enhance the speed and efficiency of symbol identification. The reduction in response time can help minimize frustration, leading to a more positive communication experience for the users. Additionally, quicker symbol identification can lead to more fluid and natural interactions, thereby improving the overall communication skills of children with DS.

5.1.1 Reasons for Faster Response Time in Children with DS Using a Corner Spatial Arrangement

The difference in response time between closed set and corner spatial arrangement conditions may be attributed to the way symbols are organized on the AAC display. In the corner spatial arrangement symbols are clustered. This clustering of symbols might help in spatially distinguishing symbols. This might inturn help the DS population to focus their attention more effectively leading to quicker response times when searching for target symbols (Wilkinson et al.,2022).

On the other hand in the closed set spatial arrangement condition where symbols are placed closely together in a grid, it accounts for visual crowding making it more challenging for individuals to distinguish symbols due to the presence of neighbouring symbols or distracters. This visual crowding effect can slow down the search process and increase the likelihood of fixations on nonrelevant distracters ultimately leading to longer response times compared to corner spatial arrangement. According to Robillard et al. (2013) fluid thinking, categorization, and sustained attention were all very important markers of navigational ability. A symbol arrangement may be likely able to improve all these markers resulting in better response time for symbol identification.

5.2 Accuracy Between the Closed Set versus Corner Spatial Arrangement Conditions

The findings of the current study indicate that there is a statistically significant difference in the accuracy for identifying the target symbols in a closed set and corner spatial arrangement conditions, and the accuracy was better and highly accurate for choosing the desired symbols under a corner spatial arrangement condition. In corner spatial arrangement, the children with DS symbol selection was more accurate which reduces the delay in communication, as well as discomfort while using AAC devices. A study done by Wilkinson et al. (2022), found that the accuracy in target identification was higher in corner spatial arrangement when compared to closed set, perimeter, and widely spaced arrangement. Similar results were found in other studies (Wilkinson et al., 2008; Wilkinson & McIlvane, 2013).

5.2.1 Reasons for Better Accuracy in Children with DS Using Corner Spatial Arrangement Condition

The corner spatial arrangement condition likely reduces visual crowding compared to other spatial arrangements, such as closed-set grids. Visual crowding occurs when nearby objects interfere with the perception of a target object, leading to difficulties in distinguishing individual symbols. By clustering symbols in spatially distinguishable groups in corners the visual crowding effect is minimized making it easier for children with DS to focus on and also it restricts the over-selective behavior in this population (Bulakoswki et al., 2011) thus improving the accuracy in identifying target symbols (Wilkinson et al., 2022). The spatial organization of symbols in the corner arrangement might help children with DS maintain better attentional focus on the target symbols. Clustering symbols in specific locations can guide attention and streamline the search process, leading to improved accuracy in identifying target symbols. And also this type of arrangement may reduce distractions by spatially separating symbols into distinct groups. This organization minimizes the likelihood of fixations on nonrelevant distracters and enhances the clarity of target symbols contributing to better accuracy during symbol selection (Wilkinson et al., 2022).

CHAPTER VI

SUMMARY AND CONCLUSION

Augmentative and alternative communication systems are crucial for children with DS because they meet their communication needs, improve their self-expression, and encourage social participation and academic achievements. These populations frequently struggle with speech and language deficits which will hinder their effective communication and participation in the environment. AAC provides alternative methods such as symbols, pictures, and speech-generating devices that can bridge the communication gap and help them to interact more effectively and confidently.

Children with DS often experience difficulty inhibiting fixations on distractions and also show over-selective behaviour, due to their disturbed EF. This makes it challenging for them to use AAC devices. But by altering the spatial arrangement of these symbols one can improve the visual search process for symbol selection and reduce the fixations on irrelevant distractors. Along with that these arrangements can enhance the accuracy and reduce response times resulting in much easier and faster message generation. Thus, it reduces the frustrations and discomfort while using AAC and increases their willingness to use AAC devices.

The present study included two groups of participants, with 10 children with DS in each group. Four categories such as fruits, animals, common objects, and food items were selected from ACSLS, and each category included four items taken from the Avaz application.16 picture symbols were arranged into a closed set and corner spatial arrangement conditions on a communication board. The participants had to select the target picture symbols when the audio sample of the target symbol was delivered via a computer speaker. Response time and identification accuracy scores using both closed set and corner spatial arrangement conditions were measured. Statistical analysis was done to determine if there was a significant difference in the response time and identification score between the closed set and corner spatial arrangement conditions. The results revealed faster response time and greater identification accuracy score in corner arrangement compared to closed set arrangement in children with DS on the communication board.

6.1 Clinical implications

- The findings of the above study can help in understanding the effect of spatial arrangement (closed set versus corner) in terms of response time accuracy for identifying the target symbols in a communication board in children with DS.
- The findings of the study can also help engineers/technologists/ SLPs in designing AAC devices and communication boards for persons with DS.

6.2 Limitations of the study

- The present study considered only two spatial arrangement conditions, closed set and corner.
- The present study included only 16 picture symbols to evaluate symbol identification skills.
- The present study included only the DS population.

6.3 Future directions

Further studies can be done to investigate other cues in AAC system design such as the internal color and background color to evaluate its effect on symbol selection . In addition, studies can also be done with different clinical conditions, different languages, and different age groups.

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APPENDIX I

CONSENT FORM

All India Institute of Speech and Hearing, Naimisham Campus, Manasagangothri, Mysore – 570006.

Dissertation on

"CLOSED SET VERSUS CORNER SPATIAL ARRANGEMENT IN THE SYMBOL IDENTIFICATION SKILLS OF CHILDREN WITH DOWN SYNDROME"

Information to the caregiver

I, pursuing my dissertation titled - "**CLOSED SET VERSUS CORNER SPATIAL ARRANGEMENT IN THE SYMBOL IDENTIFICATION SKILLS OF CHILDREN WITH DOWN SYNDROME**" under the guidance of Mr. Reuben Thomas Varghese (Speech Language Pathologist, Dept. of Clinical Services, AIISH Mysore). The study aims to evaluate whether changes in the spatial arrangement of symbols (closed set versus corner) influence the symbol identification skills in children with Down syndrome using a communication board. We need to collect data from 20 children diagnosed with Down Syndrome of age 6-12 years. We assure you that this data will be kept confidential. There is no influence or pressure of any kind by us or the investigating institute to your participation and the research procedure is different from routine medical or therapeutic care activities. There is no risk involved to the participants but your cooperation in the study will go a long way in helping us understand and it will, thus assist in the assessment and treatment of these individuals.

Informed Consent

I have been informed about the aims, objectives, and procedure of the study. I understand that I have a right to refuse participation as a participant or withdraw my consent at any time.

I (caretaker of), ____, the undersigned, give my consent to be a participant in this investigation/study.

Signature of participant
(Name and Address)

____
____
____

Signature of the investigator
Date