CONSISTENT VERSUS VARIED SYMBOL LOCATIONS ON SYMBOL IDENTIFICATION IN CHILDREN WITH CEREBRAL PALSY

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SEPTEMBER 2023

CERTIFICATE

This is to certify that this dissertation, entitled "**Consistent versus Varied symbol locations on symbol identification in children with Cerebral Palsy**" is a bonafide work submitted in part fulfillment for the degree of Master of Science (Speech Language Pathology) of the student Registration number P01II21S0014. 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 the award of any other Diploma or Degree.

Mysuru

September, 2023

Dr. M. Pushpavathi

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CERTIFICATE

This is to certify that the dissertation entitled "**Consistent versus varied symbol locations on symbol identification in children with Cerebral Palsy"** is a bonafide work submitted in part fulfillment for the degree of Master of Science (Speech-Language Pathology) of the student Registration number P01II21S0014. This has been carried out under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled "**Consistent versus varied symbol locations on symbol identification in children with Cerebral Palsy**" is the result of my own study under the guidance of Dr. Reuben Thomas Varghese, Scientist-B, Department of Speech-Language Sciences and Co-guidance of Dr. R. Rajasudhakar, Associate Professor, Department of Speech-Language Sciences at All India Institute of Speech and Hearing,Mysuru and has not been submitted earlier to any other university for the award of anyother Diploma or Degree.

Register No: P01II21S0014

Mysuru

September,2023

DEDICATED TO MY

PARENTS

&

HUSBAND

For All the love and support you guys have given me!

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"If you aim to be something you are not, you will always fail. Aim to be you. Aim to look and act and think like you. Aim to be the truest version of you. Embrace that youness. Endorse it. Love it. Work hard at it. And don't give a second thought when people mock it or redicule it. Most gossip is envy in disguise"

– Matt Haig, The Midnight Library

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CHAPTER I

INTRODUCTION

Cerebral palsy (CP) is a developmental disorder that affects different subsystems of one's body, including the motor, neurological, and speech systems. Children with CP exhibit abnormal muscle tone (which can influence their posture, movement, coordination and balance issues), reduced strength, loss of selective motor control, etc. Children with CP often evince a range of communication difficulties that includes speech and language domains. Thus, early intervention is crucial for children with CP. Early intervention involves the management of speech and language abilities by combining speech-language therapy and Alternative and augmentative communication (AAC). AAC systems can benefit both children and adults who face difficulty in communication. Studies have reported that children with CP often benefit from AAC, which aids them in overcoming both speech and language barriers (Drager et al., 2019).

Motor learning is defined as an individual's capacity to perform a motor skill that can induce a relatively permanent improvement in performance due to practice and experience (Magil, 2010). Rehabilitation professionals working with individuals with CP can apply the knowledge and information that is derived from motor learning principles to organize a program of treatment based on scientific evidence. Principles of motor learning have a major role in the identification and symbol access in the grid-based display organization of AAC devices. Further, the principles of motor learning can also be applied using AAC for the rehabilitation of children with CP.

AAC systems are crucial for people with CP who have difficulty communicating. AAC can help in improving communication for persons with CP. AAC

systems make it simpler for persons with CP to express their needs, thoughts, and feelings, which may improve their overall quality of life. When a person with CP finds it's difficult to communicate, AAC systems will act as an important mediator which will thus improve the confidence of the person and thus will also give more opportunities for them to communicate. In addition, children with CP also exhibit speech impairments that make communication exceedingly challenging in different situations. In such situations, AAC assist children with CP communicate their needs with their family, colleagues, and other people.

There are several elements that need to be taken into consideration while designing an AAC system to be functional and beneficial. AAC systems ought to be made in a way which can be customized to a person's unique needs. The grid organization of the AAC, which refers to how the symbols are grouped and presented on a device, is one such aspect that should be taken into account. In order to make the communication process more easy and less laborious, the grid should be well organized so that it becomes easy for the user to find the symbols easily and in a faster way. Symbols can be organized in different ways, and one important arrangement that is becoming popular nowadays is the location-based arrangement. In location-based arrangement, the change in the location of the symbols across sessions will have an effect on the user's speed and ease of communication. Studies have reported that when the symbols are organized in such a way that they will remain consistent and more organized across sessions will eventually improve the users speed and efficiency (Dukhovny & Zhou , 2016) . Symbols are located in two ways in the grid organization of AAC devices.

a. Consistent location: In consistent location, the location of the symbols will remain constant from the initial phase to the later stage of AAC training. For example, if the target symbol is a dog, the position of the dog will remain the same across sessions and trials (Figure 1.1).

Figure 1.1

Figure Depicting the Consistent Location Condition of 12 Symbols

b. Varied location: In the varied location of symbols, the location of the symbols will vary from the initial phase to the later stage of AAC training. Eg: If the target word is dog then the position of the dog will be varying across the sessions and trials (Figure 1.2).

Figure 1.2

Figure Depicting the Varied Location of 12 Symbols

Since AAC users have difficulties in dividing attention and suppressing attention to distractors, visual search is considered to be more distracting to them than to people who use natural speech (Wilkinson et al., 2014). When a symbol's meaning or position is thoroughly learned, then the need to pay attention to these symbols will be less (Wilkinson & Jagaroo, 2004). Few researchers have highlighted that consistent symbol location also plays a significant role in symbol identification success, similar to the effects made by graphic representations (e.g., Thistle & Wilkinson, 2013). Maintaining symbols in consistent locations in an AAC grid display will aid the formation of procedural memory. Through constant practice and repetition, an individual will be able to store the learned action in their procedural memory, which will thus help them in freeing up the cognitive load (Fitts & Posner, 1967). While introducing a AAC device for an individual with a limited set of vocabulary, the arrangement can be made in such a way that only the known symbols are visible whereas the other symbols are hidden in places which is already reserved, thus will further help them in their visuospatial learning. Designing an AAC system that will either cover the existing symbols or leave the cells in the array blank can support motor learning. In order to plan an effective intervention, a Speech-Language Pathologists (SLPs) should decide on an appropriate array size for the future and determine which symbols should be visible currently. SLPs also develop a plan for teaching additional vocabulary. By doing so, individuals can learn how to use the system effectively and efficiently over time.

Several studies have been done to assess the role of motor learning principles for children with CP, and they found that motor learning principles play a significant role in the rehabilitation of CP children (Burtner et al., 2014; Monteiro et al. (2010); Larsen et al., 2021). Using the motor learning principles in AAC, the child may be able

to develop their operational competence by lowering the cognitive demands, thus freeing up their internal resources which helps in improving their communication skills (Wilkinson & Jagaroo, 2004). Further, the engagement of procedural memory representations and the automaticity of responses may be supported by maintaining a constant symbol position. These elements will facilitate motor learning. Motor learning is an individual's capacity to perform a motor skill that can induce a relatively permanent improvement in performance due to practice and experience. Studies have reported that designing a display that supports motor learning may make communication easier by moving the symbol search from a visual examination which is time-consuming, to an action that is subconscious and automatic, using the consistent location arrays (Thistle et al., 2018). Thus, considering an AAC device that will facilitate the motor learning principle will be more beneficial for a child with CP than the traditional AAC systems.

1.1 Need of the study

Studies have indicated that consistent symbol location was useful for better identification skills in AAC devices for normal individuals. However, it was noticed that the majority of the studies were conducted in typically developing individuals and were not explored in persons with communication disorders, especially in children with CP. In addition, it was noticed that limited studies were done in the Indian context. Hence the present study is aimed at addressing these research gaps.

1.2 Objectives of the study

- To measure the response time and accuracy in symbol identification skills for children with cerebral palsy using consistent symbol location using Avaz AAC application.

- To measure the response time and accuracy in symbol identification skills for children with cerebral palsy using varied symbol locations using Avaz AAC application.

- To compare the response time and accuracy in symbol identification for children with cerebral palsy between consistent versus varied symbol locations using Avaz AAC application.

CHAPTER II

REVIEW OF LITERATURE

Cerebral palsy (CP) is defined as a physical impairment that is non-progressive in nature and will have a significant effect on the motor ability of an individual (Rosenbaum et al., 2006). The range of impairments varies across the affected individual and thus the characteristics that a person diagnosed with cerebral palsy exhibits will be more or less similar to another person diagnosed with cerebral palsy. Children with CP will exhibit a wide range of speech and language difficulties that will have a significant impact on their day-to-day life in varying degrees. To address the variety of challenges that children with CP confront, early intervention is therefore critically necessary. This means that part of early intervention will include the management of speech and language issues, which can be accomplished by integrating speech and language therapy with AAC.

According to various studies, children's communication and language skills were undoubtedly enhanced when AAC devices were introduced at a young age. Symbols can be arranged in two different types of grid organization in high-tech AAC devices, namely varied and consistent symbol locations. However, in the recent past majority of the high-tech AAC devices is using varied symbol locations where the location of the symbols will keep on changing whenever a new word or symbol is added to a child’s vocabulary. Consistent symbol locations are a new advancement adding to the location-based grid organization. Recent research shows that compared to the varied symbol locations, consistent symbol locations are more effective for the development of language skills and aid in faster communication with the help of the principle termed Motor learning (Wilkinson & Jagaroo, 2004). It will be beneficial for language learning

and communication to advance more quickly if the AAC systems' composition is improved and the motor learning concept is used. As a result, it will aid in enhancing the quality of life for both CP patients and their caregivers.

The reviews of the studies are organized under the following headings:

2.1 Speech and language characteristics in Children with CP

2.2 Motor Learning in CP

2.3 AAC in children with CP

2.4 Effect of symbol location in the grid organization of High tech AAC devices

2.1 Speech and Language Characteristics in Children with CP

Children with CP will be having significant breakdowns in the communication process both as a receiver and sender of a message. They exhibit impairments in several areas such as motor, cognitive, sensory, etc., which will lead to a negative impact on communication. Impairment in cognitive skills will lead to delayed development of speech and language. Due to their motoric weakness, the clarity of speech will be significantly hindered and thus, the development of both spoken and written language. The presence of sensory impairment along with delay in speech and language development will also lead to problems in developing intrapersonal relationships and difficulty in perception of speech.

Since the production of speech depends on resonatory, respiratory, phonatory, and articulatory subsystems, any deficits in the functioning of these systems will lead to difficulty in the production of speech. Motor speech disorders such as cerebral palsy will disrupt the functioning of any or all of the system and so it will affect speech. These dysfunctions in subsystems will lead to difficulties such as breathing which is irregular

in nature, poor voice quality, difficulty in pitch variations, hyper nasality with or without nasal air emissions, etc. The disturbances that are faced by children with CP in terms of cognitive skills will lead to delays in both receptive and expressive language, which will affect the child's ability to produce spoken language. Along with this, motor weakness will have an impact on how children express themselves through speech, body language, gestures, and facial expressions, which can lessen their capacity to communicate effectively. Limited studies that are based on population data have looked at the prevalence and characteristics of language impairment in kids with cerebral palsy (CP) and it is reported that about 74% of children with CP experience language difficulties. Voorman et al. (2010) studied children with CP in the mean age range of 11 years who were administered Vineland Adaptive Behaviour Scales (Sparrow et al.,1984) and found communication impairment in about 74% of participants.

Holck et al. (2011) studied the narrative ability of children with CP who were verbal. A total of 10 participants with CP who speak the Swedish language were compared with typically developing children. Bus Story Test (BST) (Renfrew, 1997) was administered to both groups, and the findings revealed that children with CP had significant difficulty in narrative skills where they used less complex grammar and few subordinate clauses.

Mei et al. (2016) evaluated the language characteristics of children diagnosed with CP, where 84 children in the age range of 5-6 years who were born between the years of 2005-2007 were selected as the participants. In order to identify language impairment, standardized tests such as The Preschool Language Scale (Zimmerman et al., 2002), Communication and Symbolic Behaviour Scales-Developmental Profile Caregiver Questionnaire for non-verbals (Wetherby & Prizant, 2002), Peabody Picture

Vocabulary Test (Dunn & Dunn, 2007) and Columbia Mental Maturity Scale (Burgemeister et al.,1972) were administered. The results revealed that 61% have impairment in receptive or expressive language skills, Among the total participants, 24% were non-verbal, 44% had impairment for mixed receptive and expressive language skills, while isolated receptive and expressive impairments were seen in 7% and 5%, respectively. They also found that the participants had deficits in different domains of language such as syntax, morphology, and semantics. The study concluded that language abnormalities commonly affect both the receptive and expressive language domains and that isolated impairments are quite uncommon.

In continuation to their earlier study, Mei et al. (2020) conducted a study to observe the variables and characteristics that are associated with the speech delay that is shown by children with CP. As a part of the study, a total of 84 children in the age range of 4.11 to 6.6 years were selected as the participants. To differentially diagnose articulation, phonological, and motor speech disorders, a systematic assessment of oromotor and speech functions was conducted, and the results reveal that out of the 84 participants, 82% had speech production difficulties and delays in their development. The majority of the participants were verbal, whereas 20 were nonverbal. Among the verbal, speech difficulties such as dysarthria, articulation and phonological deficits, and childhood apraxia of speech were also found. The study also implies that there was a significant reduction in speech intelligibility for those participants with dysarthria and childhood apraxia of speech.

A longitudinal study of children with CP was conducted by Long et al. (2022) to observe the severity of speech impairment for 101 children in the age range of 4-10 years. To rate the speech severity Viking Speech Scale was used, and to determine the

extent to which the severity of speech changed across time was measured using the Bayesian mixed-effects ordinal logistic regression method. The results revealed that about 80% of children diagnosed with CP had speech difficulties. Along with this, significant limitations were found in language, cognition, and functional communication.

All these studies reported that, early speech and language difficulties are faced by children with cerebral palsy which will eventually hinder the communicative abilities of the child. These studies emphasize the value of early intervention by considering speech and language therapy for children who are young, which has been shown to significantly enhance the kids' communication, speech, and language skills. several studies have reported that along with speech and language therapy, thus there is a need for early introduction of AAC for children with significant limitations in speech and language skills.

2.2 Motor Learning in CP

Nieuwboer et al. (2009) defined motor learning as the process in which a new skill is learned and refined through repetitive practice. Rehabilitation professionals working with individuals with CP can apply the knowledge and information that is derived from motor learning to organize a program of treatment based on the scientific evidence from this area of expertise. Principles of motor learning play a major role in the identification and symbol access in the grid-based display organization of AAC devices. This can help in the better communicative success of both adult and child AAC users (Guadagnoli & Lee, 2004). The principles of motor learning can also be applied using AAC for the rehabilitation of clients with CP.

Monteiro et al. (2010) compared the motor learning skills in children with CP and children without any difficulties in posture and movement. In order to evaluate motor learning skills, a paradigm of maze tasks. The study was conducted in 4 stages where the initial stage was pretesting, the second stage was the acquisition phase, the third was the immediate transfer phase, and the final stage was the short-term and long-term transfer phases. Participants were seated in front of the computer and were instructed to follow the maze's drawing direction until they reach the exit of maze which was depicted as 'X'. The participants were instructed to complete the task as fast as they can and the task running time was measured. The results reveal that there was a significant decrease in task duration between the first and last acquisition trial for both normal children and children with CP, where the initial phase consisted of a high number of errors, inconsistent responses and there was a high requirement for attention while in the final phase, there was a significant reduction in errors with consistent response and less requirement of attention. In comparison with children without CP, the responses were better in children with cerebral palsy and thus it shows that motor learning is having an important role in children with CP.

Burtner et al (2014) studied the role of different feedback frequencies in the motor learning process in children who are typically developing and children with cerebral palsy. A total of 19 children with CP and 20 children with typical development were selected for the study. The task given was to learn a precise, synchronized movement of the upper limb with the aid of a small lever. Participants were divided into four groups, where children with CP and typically developing children were divided into two subgroups either with 62% feedback or with 100 % feedback. The experiment was conducted over 2 days where in day 1 which is the acquisition phase, the participants were trained with the motor task for 200 trials (in which the groups

received reduced feedback and complete feedback conditions) whereas on day 2 participants were tested in two different conditions namely no feedback retention test and with feedback reacquisition test. The accuracy and consistency of the movements were measured. The results revealed that both groups had significant improvements in both the accuracy and consistency of responses following the 200 trial session which is related to the acquisition phase. There was a significant improvement in the accuracy of movements by children who are typically developing who received 100% feedback in comparison with the same group who received 62% feedback. In the case of children with cerebral palsy, the type of responses for both feedback groups were much similar however the number of errors were less in 100% feedback group. This study reveals the importance of motor learning principles along with feedback to acquire a new skill.

Larsen et al. (2021) studied the role of activities that are based on motor learning principles on the functional abilities of adults with cerebral palsy. The participants were divided into two groups, namely the active group and the control group where the former group received a 12-week intervention program that was based on the principles of motor learning whereas the control group received standard care. For the active group, assessment was done under three conditions that are at the baseline, after the intervention program, and a follow-up assessment after one month, whereas for the control group, a baseline assessment and follow-up assessment were conducted. The outcome measures were Gross Motor Function Measure (GMFM) and neurological status. The results reveal that there was a significant improvement in terms of GMFM in the active group in comparison with the control group, while the results of the neurological examination did not reveal any obvious trends. The study lends credence to the idea that exercises based on motor learning theories could enhance gross motor function in persons with severe cerebral palsy.

The above studies highlight the importance of motor learning in the skill acquisition of an individual with cerebral palsy. However, there are few empirical research examining how children with cerebral palsy who use AAC develop their motor skills.

2.3 AAC and Children with CP

Cerebral palsy is majorly classified based on the motoric difficulties that are manifested by the patient, along with other conditions that are majorly associated with the motoric impairments. Along with this the participant also exhibits impairments in speech, language, and sensory skills, which will eventually lead to communication difficulties that is life life long. Previous literature has reported that about 30 to 80 % of children with CP exhibit communication impairment, affecting the quality of life of children with CP. As a part of an integrated intervention approach that aims at improving the communication skills of children with CP, AAC can also be introduced. A study was done by Hustad and Miles (2010) on preschool children with CP and they found that there was a need of AAC for about half of the children and they had tasks in their educational process that is related to AAC. When we adopt a wait-and-watch approach in the case of patients with CP, it will prevent them from accessing those tools that are alternatives to communication. Professionals have suggested that introducing AAC at an early age to children with CP will enhance their communication skills.

Guro et al. (2010) evaluated the prevalence of speech difficulties and to determine the usage of AAC by children with CP. A total of 564 were considered, where 270 children had normal speech, 90 children had speech that was slightly indistinct, obvious indistinct, and severe indistinct speech were found in 52 and 35 children, respectively. A total of 110 children were observed to have no speech. Among

these 197 children with speech difficulties were shown to benefit from AAC devices. It was found that the use of AAC, both low-tech and high-tech, for communicative requirements has benefited children with CP. People use a variety of extra communication methods in addition to the AAC system, including gestures and facial expressions.

Sreekumar (2014) evaluated the efficacy of the usage of the Avaz application in a child with CP. The participant was a seven-year-old child with spastic cerebral palsy with delayed speech and language skills. The child communicated her needs through simple vocalization and changes in facial expression. The main goals that were focused on during the therapy session include basic skills such as pointing, eye-hand coordination, and the act of communication such as requesting, greeting, etc., which were trained using the Avaz app. The child attended a total of 10 sessions of speech therapy and with the Avaz app, the child was trained about its usage and pointing to the correct pictures in the display according to the commands. The post-therapy evaluation revealed that there was significant improvement in the communication abilities of the child and also the child started using more conventional communication. An improvement in pointing skills and eye-hand coordination was also noted.

Smith et al. (2015) examined the perceptions of different parents and child risk factors associated with language intervention in children with cerebral palsy (CP). The study revealed that intervention services should focus on impairments, promote parental competence, and encourage and support parents in fostering their child's learning and overall development. Therefore, it is crucial to introduce AAC systems as part of early intervention to facilitate speech and language skills and promote successful communication. Incorporating AAC in intervention is essential to support and develop

a child's full range of communication skills in children with CP (Clarke & Price, 2012; Pennington, 2008). Introducing AAC to children with CP at an early age could be challenging but is also necessary to facilitate the development of communication and language skills (Geytenbeek, 2011). From these studies, it is shown that it becomes crucial to include AAC systems in early intervention in order to develop speech and language abilities and encourage effective communication.

Avagyan et al. (2021) have conducted a systematic review of the efficacy of AAC devices on communication interventions in children with CP. The review followed the Cochrane Collaboration guidelines and the databases from where the information was collected include PubMed, Embase, Pedro, Cochrane Central Register of Controlled Trials, etc. They reviewed the articles which evaluated the efficacy of AAC devices in children with CP. Among the total articles searched, nine articles met the selection criteria. The number of participants ranged from 4-215 in the studies. The studies used different AAC intervention strategies that are aided and unaided. Among the nine studies, two studies compared AAC with no AAC and no speech therapy, whereas in one study comparison between two different AAC devices were done, while in another, they compared the use of the same AAC devices in two different populations namely the control group and the experimental group with patients. The outcome of the study reveals that almost all studies in the review exhibited an improvement in speech and language skills (receptive and expressive) in children with cerebral palsy. Out of the total nine studies, seven studies showed improvement in communication skills with quantifiable evidence. In those studies, which made a comparison between AAC and speech therapy or no therapy, an improvement in communication in AAC intervention strategies that is having quantifiable evidence with a moderate to long-term effect was observed. Thus in general, this systematic review provided moderate-quality evidence

showing that AAC therapies have demonstrated medium and long-term efficacy in enhancing verbal communication of CP patients.

2.4 Effect of Symbol Location in the Grid Organization of High tech AAC devices

Individuals with cerebral palsy (CP) frequently face serious communication difficulties. They could be able to communicate and express themselves more clearly with the use of augmentative and alternative communication (AAC) technology. In augmentative and alternative communication (AAC), the function of symbol location refers to the positioning of symbols on a communication aid, such as a communication board or speech-generating device. An AAC system's usefulness for people with communication difficulties can be significantly impacted by the placement of symbols on it.

Wilkinson et al. (2015) studied the neural correlates that are associated with visual search tasks in college students. A total of 18 participants without any disability were selected for the study. The test was done in two conditions, stable arrangement and unpredictable arrangement of line drawings. Where in a stable arrangement the line drawings remain the same throughout the trials while in an unpredictable the arrangement of line drawings will be varied across the trials. A joystick with a response button was used to create responses during both the sample and the response period. Participants sat on their backs in the magnet while holding the joystick box on their torsos and operating the joystick with their right hands. Stimuli used in the study were line drawings of animals. Where 20 of the line drawings are in stable condition and the other 20 are in an unpredictable condition. A pre-training phase was given before the experimental condition where participants were given total blocks of 40 trials which were divided into stable and variable conditions equally. The testing was done either

on the same day or a few days after the pre-training phase. A total of two experimental conditions were conducted with stable and unpredictable conditions separately, with 20 trials for each condition while the imaging was acquired in the run. Responses were quantified in two means both behavioural and neurological, where in behavioural accuracy and the latency of the responses was measured and in neurological the amount of activation of brain areas in each condition was found out using fMRI. The results of the study reveal that in stable condition the response time and accuracy were better in stable conditions than in unpredictable conditions, whereas the fMRI study reveals a statistically significant difference in the amount of activation between the two conditions, with greater activation of stable conditions in comparison to the unpredictable condition in areas such as in motor cortex, bilateral cerebellar regions, primary visual cortex, etc. Thus the study reveals that the responses in stable conditions are better than those in unpredictable conditions, majorly in areas that support the long-term memory and spatial system, cortical and subcortical structures that support motor learning, and in the dorsal visual pathway. The ease of finding and choosing AAC symbols is related to motor learning, as well as the anticipation of motor demands necessary for responding, according to the observed rise in activity in cortical and subcortical motor regions (including the motor cortex, postcentral gyrus, putamen, and cerebellum) during the stable condition, compared to the unpredictable condition.

Dukhovny and Zhou (2016) conducted a study on adults without disabilities in which they compared the effect of size-centered conditions versus location-centered conditions in the symbol identification abilities using AAC devices. A total of 20 adult participants without disabilities were considered for the study. The study was done in two conditions, namely size-centered and location-centered. A total of six highly frequent words were selected for the study. For each condition, a training session was

done before testing in the two conditions where in size-centered, the sizes of the six icons are large, and in location-centered condition, the sizes of the six icons remain small and consistent across sessions, whereas the other symbols are hidden. The training phase in each condition is followed by the testing phase, where the participant will be introduced to 34 symbols along with the six learned symbols. The auditory stimulus which is pre-recorded will be presented and the participants will be instructed to locate the stimulus. A total of 24 trials where each of six symbols will have four trials will be given. Participants' responses were recorded through two apps namely Avaz and Alexicom. The responses will be quantified based on the accuracy and response time of the participant to locate the symbol. The findings of the study reveal that there was a significant improvement in accuracy and a reduction in response time in the location-centered condition in comparison with the size-centered condition. Additionally, findings show that, at least in tasks carried out with individuals without disabilities, location-centered design when compared to Speech Generating device grids that rely on large beginning icons followed by a gradual drop in icon size, seems to lead to improved vocabulary location.

Thistle et al. (2018) conducted a study to understand the influence of consistent symbol location in motor learning in preschool children who doesn't have any disability. A total of 24 subjects participated in the study, and they were divided into two consecutive groups, where one group was tested with the consistent symbol location. In contrast, the other group was tested with the variable symbol location; the symbols were arranged on a 29.2 cm tablet. Participants were instructed to look at the target stimuli, which were printed in a binder, and then to locate the target symbol on the tablet screen. In consistent location conditions, the location of the symbols remained constant across all the sessions and trials. In contrast, in the variable condition, the

location of the symbols was changed across each trial and session. A total of five sessions were conducted, wherein each session, a total of nine trials were given. The time the participant took to locate the symbol after seeing the target stimuli was measured using the MTS-III software. The results revealed that all the consistent location participants had a significant improvement in response time from the fifth session when compared to the first session. During the first session, both groups had an average response time of six seconds, which was reduced to three seconds in consistent symbol location conditions. In contrast, participants in the variable group exhibited less improvement in the fifth session than in the first session with an average response time of six seconds in comparison with the consistent symbol location condition. The results revealed that consistent symbol location was more effective than varied symbol locations in AAC.

Thus, from the above studies it can be inferred that Augmentative and alternative communication (AAC) systems are designed to help individuals with communication impairments express themselves more effectively. These systems often rely on visual symbols to represent words, phrases, or concepts. One important factor that can affect the usability and effectiveness of an AAC system is the consistency of symbol location. When symbols are consistently located in the same place across different screens or contexts, users can learn to associate the symbol with its location, reducing the cognitive load required to search, locate and select the symbol.

Consistent symbol locations can also improve motor learning, as users become more familiar with the system and develop muscle memory for selecting frequently used symbols. This can lead to faster and more accurate communication, as users can anticipate the location of the symbol they need and select it more quickly. In contrast,

variable symbol locations can increase the cognitive load required to search, locate and select symbols, as users must constantly scan different parts of the screen or system to find the symbol they need.

In addition to improving communication efficiency, consistent symbol locations can also enhance social interactions and reduce social stigma. When users can communicate more quickly and accurately, they may feel more confident and empowered in social situations. Additionally, consistent symbol locations can make it easier for communication partners to understand the user's message, reducing the need for clarification or repetition.

Overall, the use of consistent symbol locations in AAC systems can offer significant advantages over variable symbol locations. AAC designers and practitioners should prioritize consistency in symbol location to improve the usability and effectiveness of these systems, and to enhance the communication experiences of users.

2.5 Research Gaps

The studies mentioned above show that consistent symbol location is important for the AAC system since it can improve communicative efficiency of AAC users. The neurotypical population, which includes adults, toddlers, and adolescents without any disabilities, is where the effectiveness of consistent symbols is evaluated most extensively**.** However, a majority of studies were done in neurotypical individuals, while the exploration in persons with communication disorders, especially with CP is very limited. In addition, limited studies has been done in the Indian context. This observation emphasises the need for additional study on augmentative and alternative communication (AAC) systems for people with communication difficulties, particularly in children with CP. Hence, this present study aims to explore the

effectiveness of consistent symbol location in AAC systems for children with CP in Indian context. This study will provide valuable insights into how AAC systems can be optimized for individuals with CP and other communication disorders, particularly in a cultural context that has not been extensively studied.

CHAPTER III

METHOD

The aim of the present study was to evaluate the effect of consistent versus varied symbol location in children with cerebral palsy using Avaz AAC application.

3.1 Research Design

Between-group design was used to compare the effects of consistent and varied symbol location using Avaz AAC application.

3.2 Ethical Considerations

The study was carried out while adhering to the AIISH ethical committee guidelines for Bio behavioural 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 A).

3.3 Participants

20 Kannada-speaking children with spastic CP (11 Males and 9 Females), in the age range of 5-12 years (*Mean age: 7 years*) who were diagnosed by a neurologist were chosen as participants. The participants were selected from special schools in Karnataka and from the Department of Clinical services, All India Institute of Speech & Hearing, Mysore. The children were further divided into two groups and each group consisted of 10 participants. Participants were randomly assigned to each group. The first group (Group I) was assessed and trained for consistent symbol location, while the second

group (Group II) was assessed and trained using varied symbol locations. The demographic details were taken in the format given in Appendix A.

Table 3.1 below includes details of children with CP, including the chronological age, receptive language age and intellectual quotient (IQ) score.

Table 3.1

Details of the participants in Group I and Group II

GROUP I				GROUP II			
Sr No	Age(yrs)	RLA(yrs)	IQ score	Sr No	Age(yrs)	RLA(yrs)	IQ score
1	6.5	4.1-4.6	71	1	7.4	4.7-5.0	70
2	8.2	5.7-6.0	75	2	25.2	3.7-4.0	78
3	5	4.7-5.0	80	3	6.2	3.0-3.6	71
4	5.5	5.1-5.6	83	4	7.3	5.7-6.0	76
5	8.7	3.0-3.6	71	5	6	4.7-5.0	80
6	6.2	4.1-4.6	70	6	8.3	> 5.7-6.0	82
7	9.3	> 5.7-6.0	81	7	5.3	3.7-4.0	74
8	11	> 5.7-6.0	79	8	6.5	5.7-6.0	78
9	5.2	3.7-4.0	70	9	6.1	5.7-6.0	89
10	12.1	>5.7-6.0	85	10	5.7	4.7-5.0	73

Note. ‘Yrs’ represent ‘Years’

3.3.1 Inclusion Criteria (for both groups)

The participants were selected based on the following inclusion criteria:

- Participants with spastic cerebral palsy.
- Participants should be native Kannada speakers.
- Receptive Language Age (RLA) should be above three years (Assessment was done using Checklist for Speech-Language Skills, ACSLS; Swapna et al., 2010).
- Participant's vision should be adequate or corrected.
- Participants should be able to point to symbols on the tablet screen and should not have any dexterity issues.
- Participants with borderline intellectual functioning (ICD 10 classification) were also considered for the study.

3.3.2 Exclusion Criteria (for both groups)

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

- Participants who had attended AAC therapy before.
- Participants who have any associated behavioural impairments.

3.4 Materials

A total of 15 symbols were selected from three categories which included action verbs, familiar objects, and animals as shown in table 3.2. From each category, a total of five items were selected and material was formed and arranged in consistent and varied location arrangement in a 24 grid system with 6x4 rows in the Avaz application (Version 6.6.4). Figure 3.1 and 3.2 depicts the consistent and varied symbol location in Avaz.

Table 3.2

Selected Categories for the Study

Sr. No.	Categories	Items in each category
1	Familiar objects	Chappal
		Cup
		Dress
		Chair
		Brush
2	Animals	Monkey
		Cow
		Dog
		Elephant
		Cat
3	Action verbs	Brushing
		Eating
		Sleeping
		Crying
		Playing
	Total	15

Figure 3.1

The Consistent Symbol Location of 15 Picture Symbols

Figure 3.2

The Varied Symbol Location of 15 Picture Symbols

3.5 Pre-assessment Measures

In order to select participants for the study, the student researcher conducted an assessment of the child's language skills using the Assessment Checklist for Speech-Language Skills (Swapna et al., 2010) assessment tool. AAC assessment protocol kit was administered (Saxena & Manjula, 2005) before finalising the participants for the study. Detailed evaluation of all other skills required for the study were documented, and children who fulfilled the inclusion criteria were chosen. Initially, pre-assessment testing was done on checking participant's accuracy and pointing abilities. Only those participants who could correctly point to 15 grid symbols were taken in the present study.

3.6 Clinical Conditions

The training was given in two conditions, namely the consistent location condition and the varied location condition. In consistent grid location conditions, a total of 24 grid arrangements were taken, out of which 15 symbols had consistent locations in the Avaz AAC application within each trial and were stable across sessions. In varied location conditions, a total of 24 grid arrangements were taken in which the location of the 15 symbols was shuffled across different grids in the Avaz AAC application within each trial and was different across all sessions.

3.7 Clinical Procedure

Sessions were carried out in a quiet room, and participants were seated along with the caretaker, where the experimenter gave clear instructions about the procedure. A total of five sessions were carried out with both groups, wherein each session was given a total of five trials. Stimulus were presented through auditory mode, which was

pre-recorded by a native Kannada female speaker on the computer. Each of the stimuli was presented one after the other. The participant's task was to listen to the auditory stimulus, and were instructed to point to the symbols in the Avaz AAC application as soon as possible. Figure 3.3 and 3.4 depicts the measurement of accuracy and response time of the target symbol using a consistent and Varied symbol location arrangement.

Figure 3.3

Photo Depicting Measurement of Accuracy and Response time of Target Symbols using Consistent Symbol Location

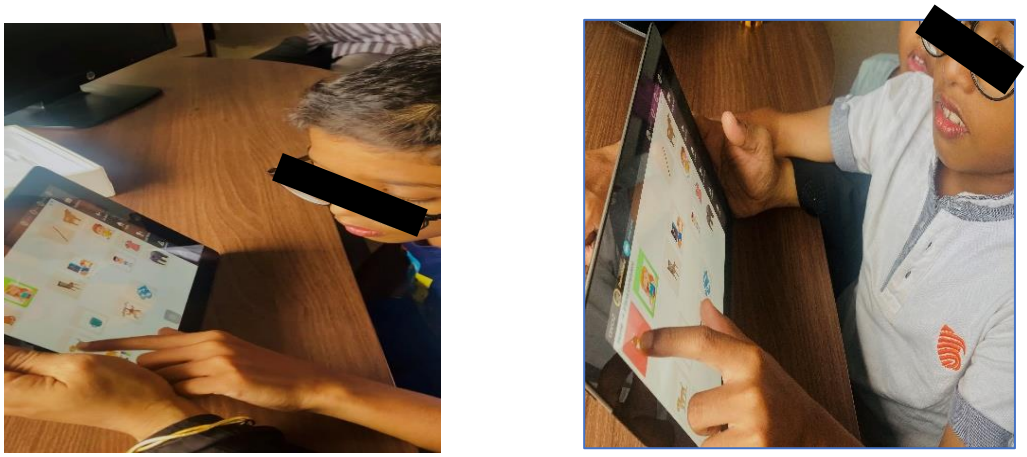
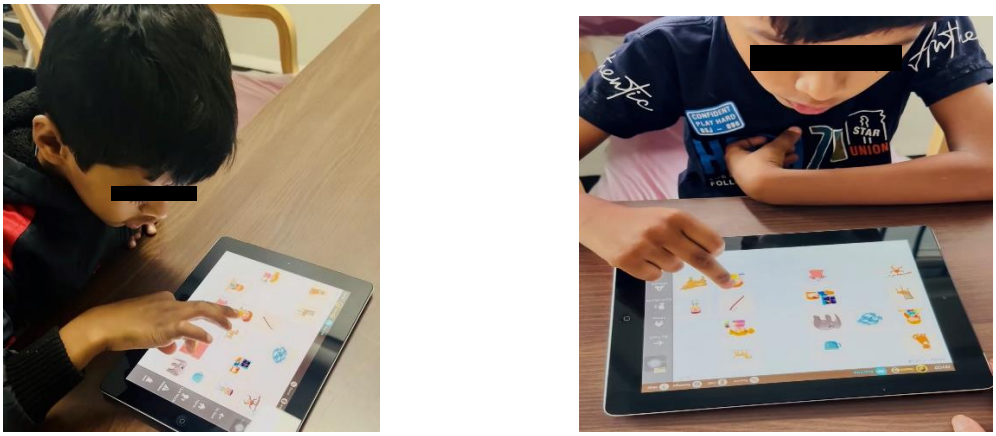


Figure 3.4

Photo Depicting Measurement of Accuracy and Response time of Target Symbols using Varied Symbol Location



3.7 Test-retest reliability

Test-retest reliability was measured by following the same procedure on 20 % of the participants using all the stimuli two weeks later in both groups to determine whether the procedure carried out in measuring both response time and accuracy between the tasks and groups of children with CP were reliable.

3.8 Analysis of the Outcome Measures

The outcome measures like 'accuracy' and 'response time' for the target symbol identification were measured for consistent and varied symbol location arrangement to examine the transparency. In the present study, the response time for identifying the desired symbols was calculated in seconds, and identification accuracy in terms of frequency of 'Accurate responses' and 'No responses' for both Group I and Group II. The response time for identifying the target symbol was measured in seconds, which is the time taken to identify all the symbols in the display grid. Average time taken for the five sessions were computed. In accuracy measures, a score of '1' was given for the correct identification of symbols, and a score of '0' was given for no response or incorrect response and average responses for the five sessions were computed. The raw score obtained from the two group participants were tabulated and subjected to statistical analysis using the SPSS software (Statistical Package for the Social Science package, version 26.0) to compare the performance of both groups. To analyze the data, the following statistical measures were used:

a) Mean, Median, and Standard Deviation (SD) to measure the response time and identification accuracy scores for consistent and varied symbol location arrangement.

b) Shapiro-Wilk test of normality to check the normality distribution of the data and Mann Whitney sign rank test to analyze the significant difference of response time and identification accuracy for consistent and varied symbol location between two groups of participants.

c) Cronbach's alpha test was used to assess the test-retest reliability of the obtained scores.

CHAPTER-IV

RESULTS

The current study aimed to evaluate the effect of consistent symbol location versus varied location in the symbol identification skills of children with CP. A total of 20 children with CP participated in the study and were split into two groups. 10 children with CP were present in Group I, who were presented with consistent symbol location, and Group II consisted of 10 other CP children with varied symbol location arrangements. All the participants were instructed to identify the particular symbol arranged in different symbol locations in the Avaz AAC application. Response time and accuracy of the responses were noted. Further, using SPSS software (version 26.0), the results ofthe identification task administered to the participants were analyzed in various aspects.

The findings of the present study are as follows:

4.1 Measurement of Accuracy and Response Time in Symbol Identification Skills for Children with Cerebral Palsy using Consistent Symbol Location in Avaz AAC Application

Mean response time duration and accuracy scores for identifying the different symbol categories of animals, common objects, and action verbs were computed for group I. Mean, Median and Standard Deviation (SD) were computed for the group and are tabulated in Table 4.1.

Table 4.1

Mean, Median, and Standard Deviation (SD) of Identification Accuracy Scores and Response Time for Group I

	Group I		
	Mean	SD	Median
Accuracy (In Percentage)	89.90	12.84	91.00
Response Time (In Seconds)	23.64	7.06	23.70

4.2 Measurement of Accuracy and Response Time in Symbol Identification Skills for Children with Cerebral Palsy using Varied Symbol Locations in Avaz AAC Application

Mean response time duration and accuracy scores for Identifying the different symbol categories of animals, common objects, and action verbs were computed for group II. The participants were presented with symbols whose position varies across trials and sessions. The Mean, Median, and Standard Deviation (SD) were calculated for the group and are tabulated in Table 4.2.

Table 4.2

Mean, Median, and Standard Deviation (SD) of Identification Accuracy scores and Response Time for Group II

	Group II		
	Mean	SD	Median
Accuracy (In Percentage)	79.90	14.40	79.00
Response Time (In Seconds)	59.17	9.32	57.40

4.3 Comparison of the Response Time and Accuracy in Symbol Identification for Children with Cerebral Palsy using Varied Versus Consistent Symbol Locations in Avaz AAC Application

Response time and accuracy calculations were made to compare participants' responses in the two symbol location conditions. First, the Shapiro-Wilk test of normality was done tocheck the normality distribution of the data. The result of the Shapiro-Wilk test revealed that the data did not follow a normal distribution. Hence, non-parametric Mann-Whitney U test was administered to compare both groups' response time and identification accuracy between the consistent and varied symbol location conditions. The results of the Mann-Whitney U test are tabulated in Table 4.3

Table 4.3

Results of the Mann-Whitney test for Response Time and Identification Accuracy between Consistent and Varied Symbol

Consistent Vs. Varied	|Z|	*p*-value	Effect size
Response Time	3.78	< .001	0.84
Accuracy	3.45	< .001	0.77

The results of the Mann-Whitney U test indicated a statistically significant difference on response time and identification accuracy between consistent and variable symbol locations. The effect size results revealed a moderate effect on response time and identification accuracy between the consistent and varied locations. The mean score value with standard deviation obtained by both response time and identification accuracy for consistent and varied symbol locations are represented in figure 4.4 and 4.5

Figure 4.4

Bar graph with Standard Error bar (SD) Representing Mean Response Time Obtained for Consistent and Varied Symbol Location Conditions

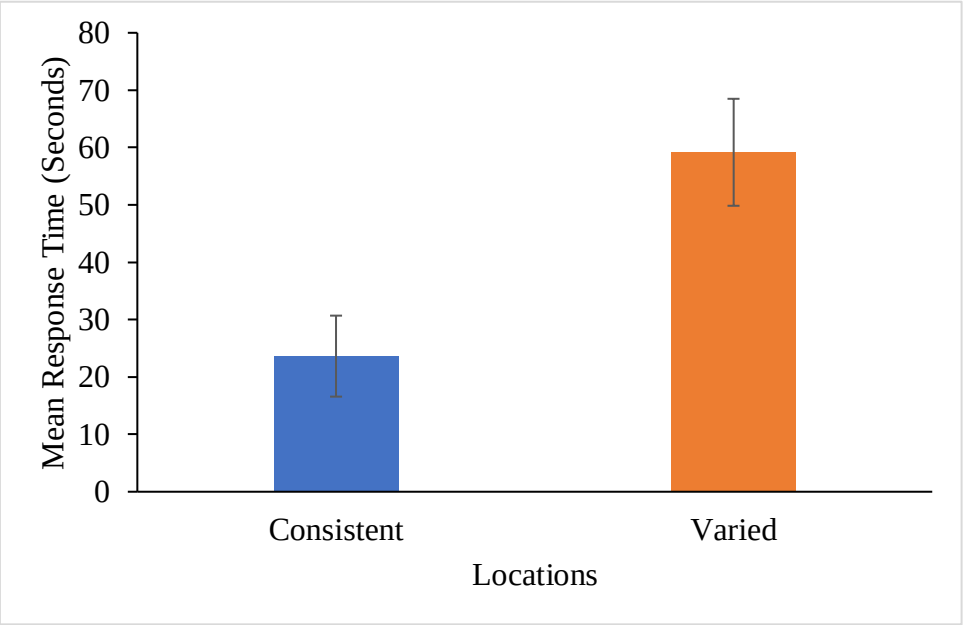
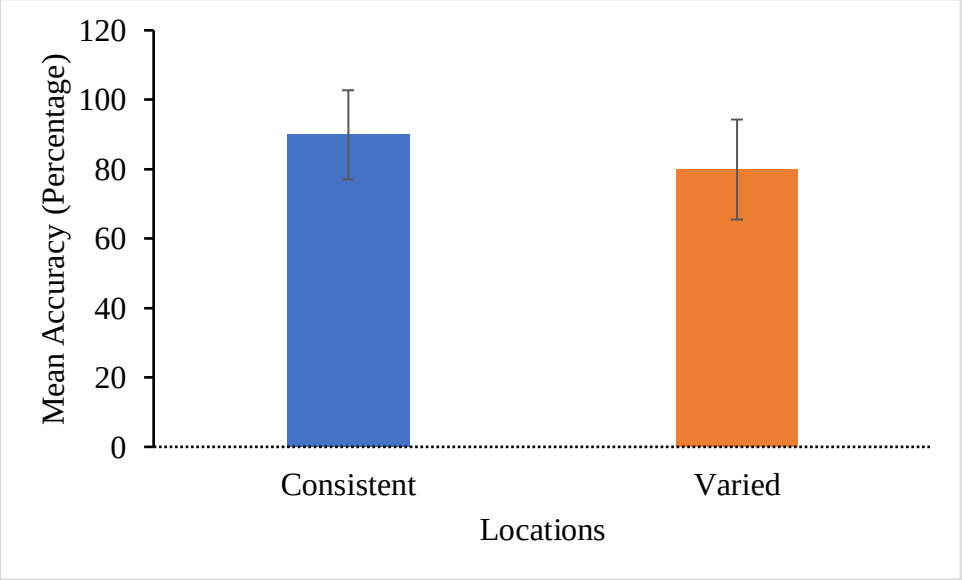


Figure 4.5

Bar graph with Standard Error bar (SD) Representing Mean Identification Accuracy Obtained for Consistent and Varied Symbol Location Conditions



As a result, it is clear from the findings mentioned above that the consistent symbol location condition produced better outcomes than the varied symbol location condition regarding both response time and identification accuracy. Between the two groups, the results were statistically significant, which means response time was significantly lesser for group I (consistent) and further the accuracy scores were also significantly higher for group I (Consistent).

4.1 Results of Test-retest Reliability

Test-retest reliability was measured using Cronbach's alpha test after the gap of two weeks by following the same procedure on 20% of the participants (four children with CP) using consistent and varied symbol location conditions. The test results revealed that α=.64 and α =.89 for accuracy and response time, respectively, indicating good internal consistency for accuracy and response time.

To summarize, upon visual inspection of the graph as well as when comparing the mean and median values, there was a marked difference between the response time and identification score in the symbol identification skills when the symbols were arranged into a consistent symbol location condition than a varied symbol location on Avaz Application for CP children. Further, the Mann-Whitney U test was done to check for the statistical difference. The Mann-Whitney U test results revealed a statistically significant difference in the response time and identification score between both groups' consistent and varied symbol location conditions.

CHAPTER V

DISCUSSION

Studies have been done in evaluating the efficacy of consistent symbol location in comparison with the varied symbol location, where they reported that even neurotypical adults and children find difficulty in locating symbols when they are in varied symbol locations. Research states that consistent symbol location, which aids the motor learning process, is much easier to identify, with lesser cognitive and attentional demands. Incorporating consistent symbol location in AAC systems will benefit persons with communication difficulties. Although several studies indicate the importance of the consistent location of symbols for effective communication, there are few such positioning systems in disordered populations and in the Indian context. Therefore, this study aimed to evaluate the efficacy of consistent symbol location in comparison with that of the varied symbol location by administering it on children with cerebral palsy.

The study was a between-group comparison, where both groups consisted of 10 children each. Group 1 had a consistent symbol location, whereas Group 2 had a varied symbol location. Participants were presented with 15 symbols in two different symbol organizations in the Avaz Application and were instructed to point to the symbols as fast as possible. The auditory stimulus was presented via laptop, which a female speaker pre-recorded. The responses were accounted in terms of response time which is calculated in seconds using a stopwatch, and accuracy, which is calculated based on a scoring of 1 for accurate response and 0 for inaccurate response. A total of five sessions were given to each participant, where each session had a total of five trials. The study was conducted in children with CP who is in the age range of 5-12, who haven't attended any AAC therapy before.

5.1 Response Time between the Consistent and Varied Symbol Location Condition

The response time was compared for the two groups. The present study's findings revealed that Group I, who were presented with consistent symbol locations, performed better than Group II, who were presented with varied symbol locations. The above results show a statistically significant difference between both groups. The results suggest that after training, Group I exhibited a significant decline in the amount of time taken to identify the symbols presented across sessions, whereas in Group II, the amount of time required to identify the symbols remained unchanged across the sessions. This study's findings align with those of previous investigations. (Dukhovny & Zhou, 2016; Thistle et al., 2018).

5.1.1 Reasons for Better Response Time in Consistent Symbol Location Group

In order to make the visual search for a symbol effective, the presence of effective visual cues plays a major role. The visual search process is more difficult and distracting to AAC users, especially for those who have disabilities, in comparison with those who use natural speech as a form of communication. Persons with disabilities will be exhibiting difficulties in dividing their attention while doing such visual search tasks in an AAC device. Further, they will be having difficulty in resisting distractors while communicating using an AAC device which is in consensus with the previous study done by Wilkinson et al. in 2014. Several researchers stated that when the location of a symbol is well known and learned, then the need to divide the attention to each symbol will be reduced (Jagaroo & Wilkinson, 2004). When the symbols are consistent, then the location of the symbols will be well learned, and thus the difficulty in dividing attention will be reduced. In addition, when the placement of a symbol is consistent, the mental representation of the symbols will be soldiered and thus aid in establishing

procedural memory. When a procedural memory is created, the action fades from the explicit memory (Fitts & Posner, 1967), allowing the person to concentrate on other cognitive activities. Once procedural memory is established, the need for attention to visual search tasks to locate a symbol is reduced, eventually reducing the individual's cognitive load, making the communication process more easy and reliable. In a varied symbol location where each symbol varies across sessions, there is a need for learning the visuospatial arrangement repeatedly, making the visual search and symbol identification process more hectic. Thus, the users will need less time to locate the target symbol. (Dukhovny & Gahl, 2014).

Motor learning is a person's ability to improve their performance permanently due to continuous practice. When training was given in a consistent symbol location, the participants demonstrated motor learning due to their experience in symbol identification. (Thistle et al., 2018). When an AAC display is given in such a way , it will further facilitate the motor learning process. The symbol identification process will be easier since the visual search, a time-consuming process that requires our conscious attention throughout, will change to an automated subconscious action and thus facilitating faster responses. Participants anticipate the symbol location in consistent conditions due to their experience, whereas such anticipation will be absent in varied conditions. Further, Wilkinson et al. (2015) stated that neural substrates have increased involvement during visual search for the target in consistent location conditions. Compared with the varied condition, the activation for cortical areas involved in the motor learning process is more for the consistent condition, (Hardwick et al., 2013). Due to the formation of procedural memory about the symbol configuration in the consistent location condition, increased activation of the hippocampal memory system was also observed.

5.2 Identification Accuracy between the Consistent and Varied Symbol Location Condition

The accuracy of responses between two groups was compared based on how correctly and accurately a participant located the symbol. The above results revealed significant difference between both groups, with the consistent groups showing better accuracy scores compared to varied group. There was an improvement in the accuracy of responses in each session for both groups, where the improvement in the consistent group was more pronounced than that of the varied group.

5.2.1 Reasons for better Accuracy in Consistent Symbol Location Group

For selecting the correct symbol, the user may move his or her hand to the general vicinity of the target icon and stay over the screen for one last visual scan of the region. In addition, during this time, users tend to make selection errors by touching icons that resemble those near the icon, which affects the accuracy of response due to their confusion in locating the exact symbol. Once the consistent symbol locations are introduced, the selection process becomes more automated, and the need for an extensive visual scan in order to differentiate between the symbols will be reduced and thus improving the accuracy of responses. This is in consensus with the study conducted by Dukhovny and Thistle (2018).

Dukhovny and Thistle (2018) pointed out that the motor learning process is important for speech-generating devices. When a user is given a consistent symbol location, motor learning takes place due to repeated practice and experience. Once the motor sequences and the organization of the symbols become familiar, the users will develop self-correction, which helps them overcome the difficulty they might exhibit due to the confusion created by symbols in general vicinity and appearance. Further, the users

tend to less rely on explicit instruction. Instead, they will start relying more on the internal feedback they are getting (Zwicker & Harris, 2009). Another reason for better accuracy is that once a person continues to repeatedly practice a behaviour or movement, due to the formation of motor schema, the particular movement becomes more autonomous, and there will be no need to pay conscious attention to perform the task (Schmidt,1975). Once the user reaches this stage, the user can stop focusing on the symbol images and start moving through the grid organization with smooth motions that are not hampered by visual search (uninterrupted by additional symbols). In addition, Wilkinson et al. (2015) stated that there is a greater activation of the dorsal visual stream, which is majorly involved in processing where things occur in a space. They found that in consistent symbol location, there was increased activation of this pathway, and it seems that greater dorsal activation is related to how easily or quickly you can find AAC signals on stable grid displays.

To summarize, the differences obtained in response time in consistent symbol location, identification accuracy, as well as the supporting studies, were discussed above. The present study found significant findings with possible explanations that are in line with previous research. The study explains the importance of consistent symbol location, which helps in making the process of communication much easier and thus gives an insight into the considerations that should be taken while designing an AAC devices.

CHAPTER VI

SUMMARY AND CONCLUSIONS

AAC has a major role in the effective communication of children with CP. It will help them in a way that will lessen their frustration at being unable to express themselves clearly, assist them in expressing what they are feeling, enhance social engagement, and ultimately improve inclusion. They become more self-reliant as a result, supporting their cognitive abilities' growth. These children's communication breakdowns can be overcome by adopting AAC devices, which improves their life participation and, in turn, their quality of life. Different spatial arrangements of symbols in AAC devices have a significant influence the communicative effectiveness. One such spatial arrangement is termed as the consistent and varied symbol locations. Previous research indicates that consistent symbol location has a major role in effective communication. Training in a consistent symbol location will make the symbols more familiar to the individual and thus, the symbols can become more predictable. The visual search process becomes less hectic once the symbols are located in familiar positions. The user can identify the symbol more easily and quickly, making their communication process quicker and more accurate. Consistent symbol location reduces the cognitive load seen, especially in children with communicative difficulties, by making the action more automated through procedural memory. Similar to procedural memory development, the motor learning process also develops. The motor learning ability makes the process of symbol selection easier since the movements are more automated, and hence children with cerebral palsy will have a significant improvement in the pattern of their responses. However, there is a lack of availability of such consistent symbol location systems in AAC devices. Additionally, relatively few

research has been conducted to assess the effectiveness of the consistent symbol location; the earlier studies were conducted in the typically normal population and the Western context. As a result, the present study highlights the importance of consistent symbol location over the varied by comparing the identification accuracy and response time between two groups of participants.

The aim of the present study was to compare between consistent versus varied location condition in the symbol identification skills using Avaz application, 20 children diagnosed with spastic cerebral palsy in the age range of 5-12 were selected for the study. A total of three categories were selected, which included: Common objects, Animals, and Action verbs. From each category, a total of five symbols were selected, and thus a total of 15 symbols were formed. The efficacy of the symbol location was tested by introducing the two groups to different conditions. In group I, a consistent symbol location was introduced where the location of the symbols remained the same across the sessions. In contrast, in group II, varied symbol locations were introduced, and the location of the symbols changed across all sessions and trials. Testing was done for a total of five sessions, where a total of five trials were given in each session. The participants were instructed to point to the symbols as soon as possible once they heard the auditory stimulus.

The identification task was analyzed based on response time and identification accuracy. Response time was measured in seconds using a stopwatch, and accuracy was measured based on correct and incorrect responses. The participant's responses were subjected to statistical analysis using SPSS (version 26.0). The results revealed a statistically significant difference between the two groups, indicating that Group I is better than Group II in terms of accuracy and response time.

6.1 Implications of the study

- The present study establishes knowledge about the efficacy of consistent symbol location over varied symbol location. These findings can help in developing better AAC display systems for children with communication disorders, especially in children with CP.
- The consistent symbol locations in AAC can be incorporated by SLPs during AAC therapy sessions for faster response time and better accuracy while identifying picture symbols for communication by utilizing the motor learning principles.

6.2 Limitations of the study:

- The sample size taken into account for the present study was less. The validity of the results might have improved with a larger sample size.
- Two participant groups were chosen for the current study to participate in the two presentation conditions (consistent and varied symbol location). The results, however, would have been more accurate if the same group of participants had been chosen to carry out both conditions after a certain period.
- The results can be more reliable if the number of sessions and trials were increased.

6.3 Future directions

A similar study can be replicated with other disordered populations in different languages with more number of samples to determine the efficacy of consistent symbol location in other AAC users.

REFERENCES

Avagyan, A., Mkrtchyan, H., Shafa, F. A., Mathew, J. A., & Petrosyan, T. (2021). Effectiveness and Determinant Variables of Augmentative and Alternative Communication Interventions in Cerebral Palsy Patients with Communication Deficit: a Systematic Review. *CoDAS*, *33*(5), e20200244. https://doi.org/10.1590/2317-1782/20202020244

Burgemeister, B. B., Blum, L. H., & Lorge, I. (1972). Columbia mental maturity scale. *(No Title)*.

Burtner, P. A., Leinwand, R., Sullivan, K. J., Goh, H. T., & Kantak, S. S. (2014). Motor learning in children with hemiplegic cerebral palsy: feedback effects on skill acquisition. *Developmental medicine and child neurology*, *56*(3), 259–266. https://doi.org/10.1111/dmcn.12364

Clarke, M., & Price, K. (2012). Augmentative and alternative communication for children with cerebral palsy. *Paediatrics and Child Health (United Kingdom)*, *22*(9), 367–371. https://doi.org/10.1016/j.paed.2012.03.002

Drager, K. D. R., Light, J., Currall, J., Muttiah, N., Smith, V., Kreis, D., Nilam-Hall, A., Parratt, D., Schuessler, K., Shermetta, K., & Wiscount, J. (2019a). AAC technologies with visual scene displays and "just in time" programming and symbolic communication turns expressed by students with severe disabilities. *Journal of Intellectual & Developmental Disability*, *44*(3), 321–336. https://doi.org/10.3109/13668250.2017.1326585

Dukhovny, E., & Gahl, S. (2014). Manual motor-plan similarity affects lexical recall on a speech-generating device: Implications for AAC users. *Journal of communication disorders*, *48*, 52-60.

Dukhovny, E., & Zhou, Y. (2016). Effects of icon size and location on speed and accuracy of SGD access. *Augmentative and Alternative Communication*, *32*(4), 241–248. https://doi.org/10.1080/07434618.2016.1236835

Dunn, L. M., & Dunn, D. M. (2007). *PPVT-4: Peabody picture vocabulary test*. Pearson Assessments.

Fitts P. M. & Posner M. I. (1967). *Human performance*. Brooks/Cole Pub.

Geytenbeek, J. (2011). Prevalence of speech and communication disorders in children with CP. *Developmental Medicine & Child Neurology*, *53*(1), 10-11.

Guadagnoli, M. A., & Lee, T. D. (2004). Challenge point: a framework for conceptualizing the effects of various practice conditions in motor learning. *Journal of motor behavior*, *36*(2), 212-224.

Guro, A., R., M. T., & Torstein, V. (2010). Prevalence of Speech Problems and the Use of Augmentative and Alternative Communication in Children With Cerebral Palsy: A Registry-Based Study in Norway. *Perspectives on Augmentative and Alternative Communication*, *19*(1), 12–20. https://doi.org/10.1044/aac19.1.12

Hardwick, R. M., Rottschy, C., Miall, R. C., & Eickhoff, S. B. (2013). A quantitative meta-analysis and review of motor learning in the human brain. *Neuroimage*, *67*, 283-297.

HOLCK, P., DAHLGREN SANDBERG, A. and NETTELBLADT, U., 2011, Narrative ability in children with cerebral palsy. Research in Developmental Disabilities, 32, 262–270.

Hüche Larsen, H., Frisk, R. F., Willerslev-Olsen, M., & Nielsen, J. B. (2021). Motor-learning based activities may improve functional ability in adults with severe cerebral palsy: A controlled pilot study. *NeuroRehabilitation*, *48*(3), 273–283. https://doi.org/10.3233/NRE-201581

Hustad, K. C., & Miles, L. K. (2010). Alignment between Augmentative and Alternative Communication Needs and School-Based Speech-Language Services Provided to Young Children with Cerebral Palsy. *Early childhood services (San Diego, Calif.)*, *4*(3), 129–140.

Long, H. L., Mahr, T. J., Natzke, P., Rathouz, P. J., &Hustad, K. C. (2022). Longitudinal change in speech classification between 4 and 10 years in children with cerebral palsy. *Developmental Medicine and Child Neurology*, *November 2021*, 1–10. https://doi.org/10.1111/dmcn.15198

Magill, R., & Anderson, D. I. (2010). *Motor learning and control*. New York: McGraw-Hill Publishing.

Mei, C., Reilly, S., Bickerton, M., Mensah, F., Turner, S., Kumaranayagam, D., Pennington, L., Reddihough, D., & Morgan, A. T. (2020). Speech in children with cerebral palsy. *Developmental Medicine and Child Neurology*, *62*(12), 1374–1382. https://doi.org/10.1111/dmcn.14592

Mei, C., Reilly, S., Reddihough, D., Mensah, F., Pennington, L., & Morgan, A. (2016). Language outcomes of children with cerebral palsy aged 5 years and 6 years: A

population-based study. *Developmental Medicine and Child Neurology*, *58*(6), 605–611. https://doi.org/10.1111/dmcn.12957

Monteiro, C. B. D. M., Jakabi, C. M., Palma, G. C. D. S., Torriani-Pasin, C., & Meira Junior, C. D. M. (2010). Motor learning in children with cerebral palsy. *Journal of Human Growth and Development*, *20*(2), 250-262.

Nieuwboer, A., Rochester, L., Müncks, L., & Swinnen, S. P. (2009). Motor learning in Parkinson's disease: limitations and potential for rehabilitation. *Parkinsonism & related disorders*, *15 Suppl 3*, S53–S58. https://doi.org/10.1016/S1353-8020(09)70781-3

Pennington, L. (2008). Cerebral palsy and communication. *Paediatrics and Child Health*, *18*(9), 405-409.

Renfrew, C. (1997). The bus story. *Bicester, England: Winslow.*

Rosenbaum, P., Paneth, N., Leviton, A., Goldstein, M., & Martin, B. (2006). A report: the definition and classification of cerebral palsy/P. *Rosenbaum, N. Paneth, A. Leviton, M. Goldstein, D. Damiano, B. Dan, B. Jacobsson.Text: unmediated//Developmental Medicine and Child Neurology P*, 8-14.

Saxena, T., & Manjula, R. (2005). Assessment Guide & Kit for Clients who require Augmentative and Alternative Communication Rehabilitation.

Schmidt, R. A. . (1975). A schema theory of discrete motor skill learning. *Psychological Review*, *82*(4), 225.

Smith, A. L., &Hustad, K. C. (2015). AAC and Early Intervention for Children with Cerebral Palsy: Parent Perceptions and Child Risk Factors. *AAC: Augmentative*

and Alternative Communication, *31*(4), 336–350. https://doi.org/10.3109/07434618.2015.1084373

Sparrow, S. S., Balla, D., & Cicchetti, D. V. (1984). 1984: The vineland adaptive behavior scales: interview edition, survey form. Circle Pines, MN: American Guidance Service.

Sreekumar, S. (2014). Using AVAZ to Enhance Communicative Abilities of a Child with Cerebral Palsy. *Disability, CBR & Inclusive Development*, *25*(1), 95. https://doi.org/10.5463/dcid.v1i1.289

Swapna, N., Jayaram, M., Prema, K. S., & Geetha, Y. V. (2010). Development of intervention module for preschool children with communication disorders (Unpublished Project). AIISH Research Fund, All India Institute of Speech and Hearing, Mysore.

Thistle, J. J., & Wilkinson, K. M. (2013). Working Memory Demands of Aided Augmentative and Alternative Communication for Individuals with Developmental Disabilities. *Augmentative and Alternative Communication*, *29*(3), 235–245. https://doi.org/10.3109/07434618.2013.815800

Thistle, J. J., Holmes, S. A., Horn, M. M., & Reum, A. M. (2018). Consistent Symbol Location Affects Motor Learning in Preschoolers Without Disabilities: Implications for Designing Augmentative and Alternative Communication Displays. *American Journal of Speech-Language Pathology*, *27*(3), 1010–1017. https://doi.org/10.1044/2018_AJSLP-17-0129

Voorman, J. M., Dallmeijer, A. J., Van Eck, M., Schuengel, C., & Becher, J. G. (2010). Social functioning and communication in children with cerebral palsy:

association with disease characteristics and personal and environmental factors. *Developmental medicine and child neurology*, *52*(5), 441–447. https://doi.org/10.1111/j.1469-8749.2009.03399

Wetherby, A. M., & Prizant, B. M. (2002). *Communication and symbolic behavior scales: Developmental profile*. Paul H Brookes Publishing Co..

Wilkinson, K. M., & Jagaroo, V. (2004). Contributions of Principles of Visual Cognitive Science to AAC System Display Design. *Augmentative and Alternative Communication*, *20*(3), 123–136. https://doi.org/10.1080/07434610410001699717

Wilkinson, K. M., Dennis, N. A., Webb, C. E., Therrien, M., Stradtman, M., Farmer, J., ... & Zeuner, C. (2015). Neural activity associated with visual search for line drawings on AAC displays: An exploration of the use of fMRI. *Augmentative and Alternative Communication*, *31*(4), 310-324.

Wilkinson, K. M., O'Neill, T., & McIlvane, W. J. (2014). Eye-Tracking Measures Reveal How Changes in the Design of Aided AAC Displays Influence the Efficiency of Locating Symbols by School-Age Children Without Disabilities. *Journal of Speech, Language, and Hearing Research*, *57*(2), 455–466. https://doi.org/10.1044/2013_JSLHR-L-12-0159

Zimmerman, I. L., Steiner, V. G., & Pond, R. E. (2002). Preschool Language Scale. 4th edn Harcourt Assessment: San Antonio.

Zwicker, J. G., & Harris, S. R. (2009). A reflection on motor learning theory in pediatric occupational therapy practice. *Canadian Journal of Occupational Therapy*, *76*(1), 29-37

APPENDIX I

CONSENT FORM

All India Institue of speech and Hearing,

Naimisham Campus, Manasagangothri, Mysore

Dissertation on

"Consistent versus Varied symbol location

In the symbol identification for children with cerebral palsy"

You are invited to participate in the study titled Consistent versus varied symbol location in the symbol identification for children with cerebral palsy ". This study is conducted by Ms Irfana Thahani, a postgraduate student of the All India Institute of Speech and Hearing, under the guidance of Dr. Reuben Thomas Varghese, Scientist, Department of Speech-Language Sciences and Co-guidance of Dr R. Rajasudhakar, Associate Professor, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysore. The study aims to compare the effect of consistent and varied symbol location in the symbol identification skills of children with cerebral palsy using Avaz AAC application. Participants and caregivers will be interviewed to obtain demographic details and necessary information prior to confirming eligibility for the study. Once eligible, the icons will be presented in consistent or varied location to the participant, and the responses will be recorded for further reference. The identity of the participant will not be revealed at any time, and the information and videos will be maintained confidential. The data obtained will not be disclosed, and access will be limited to individuals working on the study. Participation in this study is voluntary. You can refuse to participate or withdraw at any point in the study without penalty or loss of benefits to which you are otherwise entitled. The procedures of the study are non-invasive, and no risks are associated.

Informed consent

I have read the preceding information or read it to me in the language I understand. I have had the opportunity to ask questions about it, and any questions I have asked have been answered to my satisfaction.

I, _____ , give consent on behalf of my child to be a participant of this investigation/study/program.