COMPARATIVE STUDY BETWEEN GRID-BASED AND VISUAL SCENE DISPLAY BASED AAC SYSTEMS IN CHILDREN WITH CEREBRAL PALSY

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University of Mysore

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August 2022

CERTIFICATE

This is to certify that this dissertation entitled "**Comparative Study between Grid-Based and Visual Scene Display Based AAC Systems in Children with Cerebral Palsy**" is a bonafide work submitted in part fulfilment for degree of Master of Science (Speech-Language Pathology) of the student Registration Number: **20SLP009**. This has been carried out under the guidance of the faculty of this institute and has not been submitted earlier to any other University for the award of any other diploma or degree.

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CERTIFICATE

This is to certify that the dissertation entitled "**Comparative Study between Grid-based and Visual Scene Display Based AAC Systems in Children with Cerebral Palsy**" has been prepared under my supervision and guidance. It is also being 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 the dissertation entitled "**Comparative Study between Grid-based and Visual Scene Display Based AAC Systems in Children with Cerebral Palsy**" is the result of my own study under the guidance of Dr. Ajish K Abraham, Professor of Electronics and Acoustics**,** Department of Electronics, All India Institute of Speech and Hearing, Mysore and co-guidance of Dr. Reuben Thomas Varghese, Scientist-B, Department of Speech Language Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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Abstract

Introduction

Children with developmental disabilities experience a range of communication deficits. Early intervention for their communication deficits involves traditional speech therapy as well as use of augmentative and alternative communication devices (AAC). AAC systems use different formats for display. The current study aims to compare two such systems, Visual Scene Display (VSD) system and Grid-based AAC system.

Need of the study

Studies have shown efficacy of VSD systems over other display systems of AAC. However, there are limited studies done in the Indian context. There is also a paucity of such studies on children with Cerebral Palsy (CP), who are having communication disorders. The current study therefore aims to develop and determine the efficacy of VSD system over Grid-based AAC system in the Indian context.

Method

The study employed 6 children with Cerebral Palsy (CP), in the age range of 5-12 years. The children were divided into two groups. Group I was evaluated and trained using the Grid-based AAC system and Group II was tested and trained using the VSD system. The outcome measure used was identification accuracy for the pictures displayed on screen in terms of number of correctly identified images. Three categories of vocabulary (fruits, food items and furniture) were chosen for the study. Ten pictures for each category were finalized after validation.

Results

In the pre-training condition, there was no significant difference in the identification accuracy scores for Group II (assessed with VSD system) compared to Group I (assessed with Grid-based AAC system), for all three categories. The scores were higher for Group II comparatively. In the post-training condition, a significant difference was obtained in the scores for categories of fruits and food items. This difference could be attributed to the factors such as contextual cues, presence of familiar background embedded within Indian context in VSD system. However, no significant difference was observed for furniture category.

Conclusion

The current study indicates efficacy of VSD systems over Grid-based AAC systems for certain categories of vocabulary. Similar studies shall be conducted with a larger sample size and across children with other communication disorders to draw conclusive inferences regarding the efficacy of VSD systems.

Chapter I

INTRODUCTION

The ability to communicate is essential for fulfilling day-to-day needs and having a satisfactory life. Communication can be achieved by verbal or non-verbal modes and is integral to development. This development of various communication modalities is often delayed or deviant in children with developmental disorders. Thus, they often experience communication disorders owing to the general developmental delay, which can significantly impact their day-to-day activities.

Cerebral Palsy (CP) is a developmental disorder affecting various sub-systems of the body, including the neurological, motor, and speech motor systems. As a result, children with CP often exhibit a range of communication deficits involving both language and speech domains. Their receptive and expressive language skills are often affected to varying degrees. Their speech skills, especially speech intelligibility, are also often affected due to the compromised motor system. Early intervention is imperative for children with developmental disorders such as CP. Such early intervention includes intervention for speech and language abilities, combining traditional speech therapy and augmentative and alternative communication (AAC) systems.

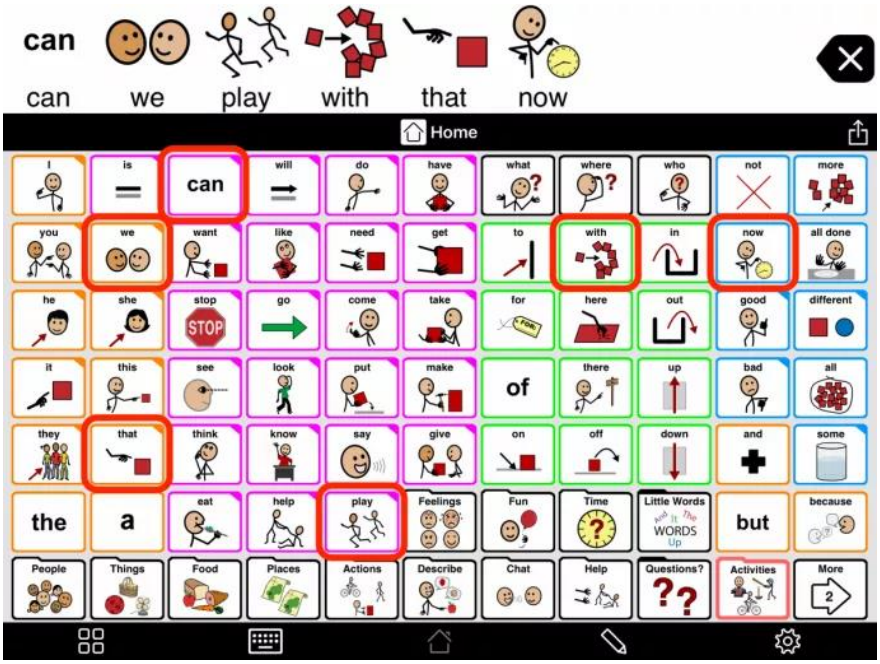
AAC systems are used with both children and adults experiencing communication deficits. AAC can be used either as a complete alternative to the verbal mode of expression or as a compensatory mechanism to enhance the intelligibility of messages. Broadly, AAC systems can be of two types, aided and unaided. Aided AAC systems refer to devices and physical systems, whereas unaided AAC systems (such as facial expressions and gestures) do not include physical devices. AAC systems include

low technology as well as high technology systems to aid in communication. Low technology options include using gestures, facial expressions, body language, and low-cost communication boards. High technology options include mobile apps and other technologically advanced devices. Depending on a child's skill set, appropriate AAC technology is chosen. Children, as well as family members, are trained to use these systems to aid in the development of communication skills.

The present study focuses on two systems of display used in AAC applications, Grid-based and Visual Scene Display (VSD) systems. Grid-based AAC systems (Figure 1.1) utilize a simple Grid-based display of different icons belonging to various categories and vocabulary.

Figure 1.1

Grid-based Display system (Charlene, 2014)



(Source : https://www.assistiveware.com/blog/progressive-language-in-proloquo2go)

On the other hand, a VSD based AAC system utilizes a contextually embedded display for the different vocabulary sets. The different vocabulary referents/ pictures

are embedded within the natural context or background in which they generally appear. A VSD (Figure 1.2) is a AAC system which helps in enabling, contextualizing and personalizing the support communication which helps in reducing the cognitive demands and makes learning easier. It also helps to support social interactions and will provide a platform for exchanging ideas.

Figure 1.2

Visual Scene Display system (Jennifer, 2017)

(Source: https://www.spectronics.com.au/blog/the-dynavox-t10-a-new-tablet-device-for-aac/)

VSDs are helpful for children as well as adults of different ages who have significant cognitive or linguistic limitations. In VSD (Figure 1.2), events can be captured and replayed instantly, which in turn gives more contextual information and support for interaction. It also enables communication partners to participate more actively in the communication process. It can represent a generic context (e.g. a living room or a bed room) or a personalized context (e.g. photo of the child doing an action).

The images/ videos, which are presented in VSDs will either be in a full form or integrated from different sources which will help in categorizing the entire image. For instance, in VSD, a digital photo of the birthday party in which an adult holding the birthday cake and the child blowing out the candles can be captured and viewed in the application. Using various aspects of the scene, the vocabulary respective to the event are fed into the scene and referred to as hotspots to represent the language concepts. For illustration purpose, each and every object represented in the picture will be linked to a speech output. For e.g., when candles are touched in the scene, the speech output may be given as “candles”; and selecting child's mouth will give a speech output message “blow the candles at the cake”. When the birthday cake is selected, a speech output “birthday cake” will be given.

The use of such a context-based display system has been reported to aid in better comprehension and learning. Studies have reported that VSDs aid in higher processing speed, development of conceptual knowledge, and development of social communication skills. (Kathryn et al., 2003; Light et al., 2004; Nelson et al., 1992; Wilkinson & Light, 2011; Wilkinson et al., 2012). However, limited studies are done in the paediatric population, especially in the Indian context. No VSD based system is available in any of the Indian languages. Hence, there is a pressing need for more such studies across the Indian population, assessing different communication domains. The present study aims to investigate whether such a difference exists in the ability to learn and identify vocabulary while using Grid-based and VSD based systems of AAC.

Objectives of the study

- To develop Grid-based and VSD AAC systems.
- To compare the identification accuracy (in terms of percentage of correctly identified images) in children with CP using Grid-based vs VSD-based AAC systems before training.
- To compare the identification accuracy (in terms of percentage of correctly identified images) in children with CP using Grid-based vs VSD based AAC systems after training.

Chapter II

REVIEW OF LITERATURE

Children with Cerebral Palsy (CP) often experience a range of speech and language issues that affect their daily activities to varying extents. The speech and language intervention framework for these children often includes using augmentative and alternative communication (AAC) devices, to facilitate their communication skills. Most of the existing AAC devices use a Grid-based system for displaying pictures belonging to various categories to help with receptive and expressive language skills in children with developmental delays. Visual scene display (VSD) systems are a relatively recent addition to the systems of AAC. Current studies indicate that VSD systems are more beneficial for the development of language skills as compared to the other existing systems. Improvement in the composition of the AAC systems and the use of facilitatory features such as the addition of contextual features in VSD systems will be beneficial for faster improvement of language learning and communication. Usage of these systems will improve the overall quality of life of children and all associated individuals, especially the nearest kin of the children.

2.1 Speech and language characteristics in children with CP

Owing to developmental delay and oro-motor weakness, children with CP experience varying degrees of speech and language delay. Mei et al. (2016) conducted a study to determine the frequency, range, and features of language impairment in a community sample of children with CP aged 5 to 6 years. 84 participants with CP were included in the study. Standardized measures of receptive and expressive language and non-verbal cognition were administered to all the participants. 61% of the participants indicated language impairment, 24% were non-verbal, and 44% had a co-occurring

receptive and expressive language impairment. 7% of participants had an isolated receptive language impairment, while 5% of participants had expressive language impairment. Deficits were observed across domains of semantics, syntax, and morphology. They also found that cognitive impairment and Gross Motor Function Classification System levels IV and V were associated with high rates of language impairment. The study concluded that language deficits affect both receptive and expressive language domains in a comorbid manner. Mei et al. (2020) extended their previous study to examine the frequency, characteristics, and factors associated with speech delay and disorder in a community sample of children with CP. The subjects were 84 children (37 females, 47 males) between the ages of 4.11 and 6.6 years. The researchers systematically evaluated speech and oro-motor function to differentially diagnose between articulation, phonological, and motor speech disorders. The results of the study revealed delayed or disordered speech production in 82% of the participants. Out of the 82%, 20 participants also had minimal verbal presentations. Out of the total verbal participants, 78% of participants were with dysarthria, 54% of participants were with articulation delay, 43% of participants were with phonological delay, and 17% of participants were with features of childhood apraxia of speech. Speech intelligibility was poorest in those with dysarthria and features of Childhood Apraxia of Speech (CAS). They also found the presence of language impairment and reduced quality of life (health-related). The study concluded that multiple levels of speech production, such as phonetic, cognitive-linguistic, neuromuscular execution, and high-level planning/programming, could be affected in children with CP (Mei et al., 2020). Long et al. (2022) conducted a study to examine speech impairment severity classification over time in a longitudinal cohort of children with CP for a total of 101 children between the ages of 4 and 10 years. Viking Speech Scale (VSS) was used to

rate speech severity using a four-level classification rating scale administered at 4, 6, 8, and 10 years of age. Bayesian mixed-effects ordinal logistic regression method was used to model the extent to which speech severity changed across time and to determine patterns of change across the age groups considered and classification rating group levels. The authors reported that over 80% of children diagnosed with CP exhibited speech deficits. Language, cognitive, and functional communication limitations were also found to be prevalent. Therefore, these studies indicate diverse, heterogeneous communication profiles among children with CP.

These studies indicate that early speech performance may influence later childhood speech abilities. Early intervention, speech therapy, in particular, should be initiated for young children with CP exhibiting speech and language impairments. Studies also strongly support the need for AAC intervention at the earliest, especially for children with more severe speech impairments. (Long et al., 2022)

2.2 AAC in children with CP

Communication is fundamental to a child's general physical and psychological health, especially in the early formative years. When this aspect of development is affected due to a communication disorder, various areas of their life could be affected, such as daily activities, expression of wants, desires, emotions, knowledge, interactions with peers, family and the community they belong to (Romski et al., 2015).

CP is a complex disorder with a heterogeneous exhibition of symptoms, increasing the risk of speech and language delays. Along with their general developmental delay, their motor deficits add to the communication difficulty (Smith & Hustad, 2015). Children diagnosed with CP thus often benefit from using AAC devices to overcome both language and communication deficits. (Light et al., 2012)

AAC approaches could include using manual signs or symbol systems or both to promote a 'total communication' approach, whereby all communicative modalities are used. High-tech and low-tech AAC systems are used in isolation or combination, especially for children with more severe communication issues (Clarke et al., 2017). Sreekumar (2014) conducted a study to determine the efficacy of the use of the Awaz app, a Grid-based AAC system. The study included a 7-year-old child with CP who was given 10 training sessions to improve requesting ability by pointing to desired pictures on the screen. The child showed an improvement in functional communication skills post 10 training sessions.

Guro et al. (2010) conducted a study in Norway to determine the prevalence of speech deficits and to investigate the use of AAC systems in children with CP. Out of the 270 children included in the study, 90 had normal speech, 90 were found to have slightly indistinct speech, 52 had indistinct speech, 35 had very indistinct speech, and 110 children were found to have no speech. The study also indicated that speech problems were most commonly found in children with the dyskinetic type of CP. Out of the 197 children with speech problems, only 106 children were found to be using an AAC system. Children diagnosed with CP have benefited from the use of AAC, both low tech as well as high tech, for communicative needs. In addition to the AAC system, individuals also employ a range of additional modes for communication, such as facial expressions and gestures. A review study on the use of AAC systems in children with CP conducted by Clarke et al. (2016) point out that a total communication approach is often used wherein all modalities of communication are employed, and high-tech and low-tech AAC systems are utilized by children with severe motor impairments. The risk of being unable to meet all required communication needs using speech is more in children with CP owing to the combination of impairments involving the domains of

both motor and communication. Smith & Hustad (2015) conducted a study wherein they examined the different parent's perceptions and child risk factors associated with language intervention in children with CP. The study indicated that intervention services focus on these impairments, promoting parental competence, and encouraging and supporting parents in fostering their child's learning and overall development. Therefore, it becomes utmost important to introduce AAC systems as a 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; Trinka et al., 2008). Introducing AAC to children with CP at an early age could be challenging but also necessary to facilitate the development of communication and language skills (Geytenbeek, 2011).

2.3 Display systems in AAC

Display features such as layout, organization, representation, etc. have an impact on the overall effectiveness of an AAC system. Over the years, a number of display systems of AAC have been developed, each with advantages and limitations of their own. Studies (For e.g.: Thistle & Wilkinson, 2015) suggest that the type of display can have an impact on the visual cognitive processing abilities.

Grid-based display in which AAC symbols are arranged in row-column grids, has been widely used in AAC systems. Each individual cell within the grid contain an AAC symbol. Variety of symbols related to a given topic are presented in the grids. The symbols are arranged in the grid category wise or event based. For example, a page of items related to people or food, a page of items related to a trip (event-based). The symbols in each page are designed to support emerging sentence structure. These

systems have shown to facilitate aspects of communication such as initiating requests, developing comprehension abilities, reducing challenging behaviors, and promoting overall engagement. (Ganz et al., 2012; Romski et al., 2010; Walker & Snell, 2013).

On the other hand, VSD systems are a relatively new addition. VSD systems take advantage of natural context and motivating events of life. (Blackstone, 2004). Audio and video output can also be given when needed with the help of "hotspots" embedded within the scene. Studies have indicated that such systems can be especially helpful for language development in children who are in early stages of symbolic development. (Light et al., 2019)

2.4 Relevance of VSD systems in AAC intervention

VSDs typically are digital photos with the benefit of context to facilitate understanding and support conversations, social interactions, learning, and general communication activities such as play, storytelling, and participation. Often beginners of communication with varying skill levels benefit a lot from using VSD systems since they provide the advantage of context. These systems can be used for various set-ups such as birthday parties, holidays, and day-to-day activities.

Studies indicate that VSDs tap into the context-based and event-based learning mechanisms that underlie the learning of a language (Babb et al., 2019; Kathryn et al., 2003; Light et al., 2004; Wilkinson & Light, 2011). Studies also indicate that such contextually loaded environments provide a diverse range of experiences which support the growth of a child's repertoire of conceptual knowledge (Keampffer, 2013; Nelson et al., 1992; Vivian et al., 2012).

Studies (For e.g.: Wagner et al., 2012) on visual cognitive processing of photographs show that the processing speed for recognizing the natural elements within

these scenes and judging overall context and constituent elements improve when naturalistic scenes are used. Such studies indicate that the naturalistic scenes within these photographs preserve the conceptual and visual relationships between the elements, as experienced in the real world, which might provide the necessary cues for predicting the elements. These studies have also indicated that specific elements within these scenes, especially human figures, aid in improved processing abilities (Wilkinson et al., 2012).

2.5 Comparison between VSD and Grid-based AAC systems in persons with communication disorders

Comparison studies between VSD and Grid-based AAC systems are currently scarce in number. Few studies in the area indicate the efficacy of VSD based AAC systems.

Studies indicate that the number of conversational turns is more when individuals use VSD based AAC systems than Grid-based AAC systems. Brock et al. (2017) conducted a study wherein they tried to compare the number of conversational turns taken by individuals with aphasia during conversations with a partner while using a Grid-based AAC system and a VSD based AAC system. They found that the number of conversational turns was higher when participants used a VSD-based system. Patients were also found to demonstrate more conceptually complex utterances, fewer frustration signals and unsuccessful navigation attempts while using VSD systems. Such studies have found that VSD based systems have more semantic associations (Dietz et al., 2007; Hux et al., 2010).

Another study by Thiessen et al. (2019) tried to compare the speed and accuracy of determining the themes portrayed in Grid-based systems and VSD systems. The

study recruited 13 adults diagnosed with traumatic brain injury and 13 adults with no diagnosed pathological condition. They viewed the displayed content on both systems and made decisions regarding the themes and the central idea depicted. The study found that both groups could identify the themes more accurately and rapidly with VSD systems than with Grid-based systems.

Although the studies mentioned above indicate relative efficacy of VSD systems compared to Grid-based AAC systems with an adult population, there are not many studies to prove the same in young children, which signals the need for such studies in the pediatric population as well.

2.6 Research gaps

Several studies have indicated the need for using AAC systems for children with CP and the relevance of VSD systems in facilitating the improvement of communication skills. However, there is a lack of substantial research in the area, particularly in the Indian context. Studies have indicated the importance of a context in facilitating communication skills, especially for beginning language learners, but there are not many studies to investigate the same. Moreover, there are not many studies on the impact of VSD systems in children with CP in the Indian context. Therefore, the present study aims to investigate the relevance of VSD systems, in improving communication in children with CP, in Indian context.

Chapter III

METHOD

3.1 Study Design

Between-group design was used to compare the effects of Grid-based and visual scene display (VSD) based AAC systems.

3.2 Participants

Six children in the age range of 5-12 years (mean age of children included: 5.9 years), diagnosed by a neurologist with a CP disorder, were chosen as participants.

The children were further divided into two groups consisting of three participants each. Participants were assigned to each group on a random basis. The first group (Group I) was assessed and provided intervention using the Grid-based AAC system, while the second group (Group II) was assessed and provided intervention with the VSD based AAC system. The demographic details were taken in the format given in Appendix III.

3.2.1 Inclusion criteria (for both groups)

The participants were selected based on the following inclusion criteria:

- The child's vision should be adequate or corrected.
- The child should have the ability to operate the touch screen of the laptop.
- The child's receptive language age should be in the age range of 2.4 to 2.6 years (Level X) and expressive language in the age range of 1.10 to 2.0 (Level VIII) (Assessment done using Assesment Checklist for Speech-Language Skills (Swapna et al., 2010)).
- The child's primary language of exposure at home should be Kannada.

3.2.2 Exclusion criteria (for both groups)

- Those who have attended AAC therapy before.
- Those who have any associated cognitive or psychological impairments.

3.3 Procedure

The study was conducted in four phases:

3.3.1 Phase 1: Stimuli development

Phase I involved developing and validating the stimuli to be administered and the VSD system to be used. Three lexical categories such as food items, fruits and furniture were chosen for the study. Images for VSD and Grid for all the three categories were organised in this phase. The PicSyms for the Grid-based system were chosen from the freely available images on the internet. PicSyms are line-drawn graphic symbols created using Boardmaker™ software. Images for VSD were captured by the researcher using Nikon D5300 digital single lens camera. The photos were taken within the natural context in which the items are most likely to be found/ exist. The parameters of lighting, colour, size of object, depth of photography, and focus on the object of interest were kept in check while taking the photographs.

Three speech-language pathologists, experienced in the field of AAC, validated the images for VSD. Parents of three children who were AAC users also validated the images. Validation was based on clarity, relevance, colour and iconicity parameters (Appendix II). A four-point Likert scale was used to rate. The rating system was as follows: '1' - Not satisfactory, '2' - Satisfactory, '3' - Good, '4' - Very good. The parameters used to validate the images were adapted from Manual for Non-Fluent Aphasia Therapy in Kannada (Goswami et al., 2012). The photos that received a rating of '3' and '4' were chosen for the study. 10 images were finalised for each category after validation.

3.3.2 Phase 2: Stimuli administration in the pre-training condition

In order 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 Skill (Swapna et al., 2010) assessment tool. Detailed evaluation of all other developmental skills was conducted and documented. AAC assessment protocol kit was administered (Tanushree & Manjula, 2005) before finalising the participants for the study. Children who fit into the inclusion criteria were chosen for the study.

The purpose and procedure of the study were explained to all participants. Written consent (Appendix I) was obtained from them at the beginning of the study. Pre-training assessment of identification accuracy (Appendix IV) in terms of the percentage of correctly identified images was done for the three categories (fruits, food items and furniture) for both groups. Four images were presented at a time on the laptop screen, and participants were asked to point toward the said image. Trial test items were administered initially to ensure that the participants understood the task.

3.3.3 Phase 3: Conducting training sessions

The student researcher provided two therapy sessions (Figure 3.1) per week for the participants in both groups. A total of 20 online therapy sessions were provided during the course of the study. Each therapy session spanned 45 minutes. The participant was seated across the laptop screen along with the parent. Both the groups were provided therapy using similar activities as appropriate for their age, using the respective AAC systems. The child and parent were seated in front of the laptop screen for all the activities. Outcome measurements (Appendix IV) were made after 20 therapy sessions in terms of the percentage of correctly identified images (Figure 3.2). Test-retest reliability measurement was done after a gap of 5 days. All sessions were

conducted online, keeping in mind the current covid protocols. The sessions were conducted using either zoom or google meet video calling platforms.

Figure 3.1

Photo depicting online training session using the VSD system

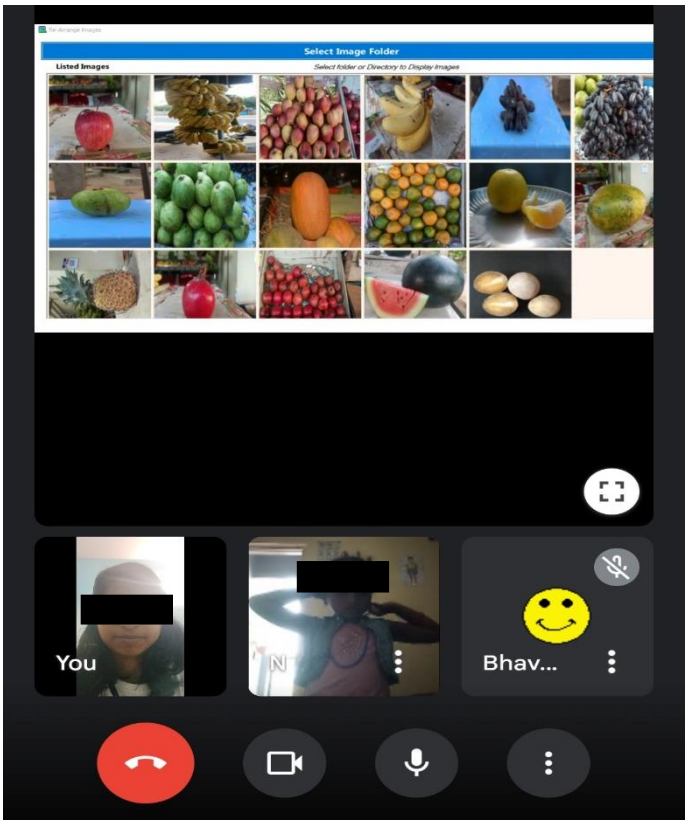
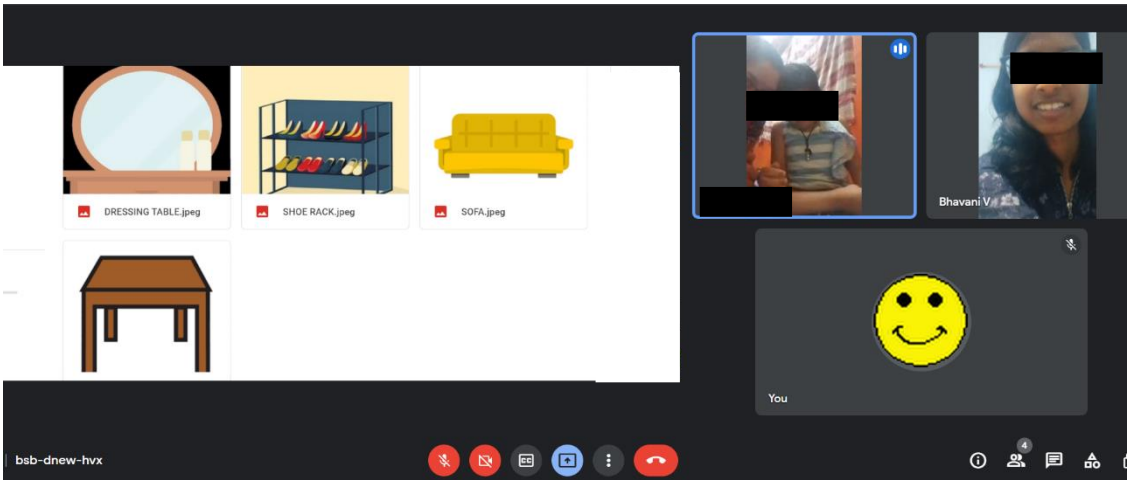


Figure 3.2

Photo depicting measurement of post-training identification accuracy scores using the Grid-based system



3.3.4 Phase 4: Analysis

The groups were compared using the outcome measure of identification accuracy. The percentage of correctly identified images was measured for all the three lexical categories for both the groups in pre-training and post-training conditions. Statistical analysis was done using Statistical Package for Social Science (SPSS) software version 20. Descriptive statistics were done to obtain the mean, standard deviation, and median scores. Normality was checked using Shapiro wilks test of normality. Since the sample did not follow assumptions of normality at 0.05 level of significance ($p < 0.05$), non-parametric test, the Mann-Whitney test, was done to determine if a significant difference exists between the identification accuracy scores of the two groups. The test-retest reliability was established by calculating the Cronbach's alpha values for the identification accuracy scores.

Chapter IV

RESULTS

Studies done in the past have indicated the importance of contextual cues in learning and the benefit of using Visual Scene Display (VSD) systems in language learning. The present study aimed to assess this advantage of VSD systems and bridge the lacuna by conducting the study in an Indian context in children with Cerebral Palsy (CP).

The present study aimed to investigate and compare the identification accuracy for pictures displayed on screen in two formats, visual scene display and Grid-based. Six children with CP in the age range of 5-12 years were recruited for the study. They were divided into two groups of three children each. Both groups received 20 online therapy sessions. Grid-based AAC system was used with Group I whereas Visual Scene Display AAC system was used with Group II. Identification accuracy scores were measured for three categories of fruits, food items, furniture.

Results of the study are compiled across the objectives as given below:

4.1 Development of Grid-based and VSD based AAC systems

Images for VSD and Grid for all the three lexical categories such as food items, fruits and furniture, were collected. Based on the feedback (Appendix V) during validation by 3 SLPs, images pertaining to bed (furniture), chiku and pineapple (fruits) were modified. Grid-based and the VSD system to be used for the study were developed using ASP web framework application (https://docs.microsoft.com/en-us/aspnet/overview). The validated images (Appendix VI), as given in Table 4.1, were uploaded into the Grid-based/ VSD system using the upload button in the ASP web framework application. The images were positioned at an appropriate place on the

screen, using left, right, top and bottom movement feature of the ASP web framework.

Table 4.1

Validated images chosen for the study

Sl. no.	Category		
	Fruits	**Food items**	**Furniture**
1.	Apple	Biscuit	Bed
2.	Banana	Chapati	Cupboard
3.	Chiku	Chips	Chair
4.	Grapes	Dal	Bench
5.	Guava	Idli	Dining table
6.	Orange	Milk	Dressing table
7.	Papaya	Rice	Book shelf
8.	Pineapple	Vada	Shoe rack
9.	Pomegranate	Dosa	Sofa
10.	Watermelon	Bread	Table

4.2 Comparison of identification accuracy in children with Cerebral Palsy while using Grid-based and VSD based AAC systems before training (AAC based therapy)

4.2.1 For the category of fruits

The identification accuracy was measured for the category of fruits for both the groups before initiating AAC based therapy. Table 4.2 indicates the mean, standard deviation and median values of pre-therapy identification scores for both the groups.

Table 4.2

The Mean, Standard Deviation, and Median values of pre-therapy identification scores for Group I and Group II for the category of fruits

Group	N	Mean	Std. deviation	Median	Percentage of correctly identified images
Group I	3	5.00	2.00	5.00	50%
Group II	3	6.67	1.1	6.00	66.67%

Results indicate that the identification scores were higher for Group II participants (who were tested with the VSD based AAC system). The Mann-Whitney U test was employed to determine whether the difference in identification scores is significant. The statistical analysis indicates that no significant difference exists between the two groups (/z/ = 1.107, $p > .05$).

4.2.2 For the category of food items

The identification accuracy was measured for the category of food items for both the groups before commencing AAC based therapy. The pre-therapy identification scores for both the groups are depicted in Table 4.3.

Table 4.3

The Mean, Standard Deviation, and Median values of pre-therapy identification scores for Group I and Group II for the category of food items

Group	N	Mean	Std. deviation	Median	Percentage of correctly identified images
Group I	3	4.33	1.528	4.00	43.33%
Group II	3	7.00	2.646	8.00	70%

Results show that the identification scores were higher for children who were tested with the VSD based AAC system (Group II). The Mann-Whitney U test was employed to determine if a statistically significant difference exists between the scores of the two groups. The statistical analysis indicates that no significant difference exists between the two groups (/z/ = 1.328, $p > .05$).

4.2.3 For the category of furniture

The identification accuracy was measured for the category of furniture for both the groups before initiation of AAC based therapy. Table 4.4 indicates the pre-therapy identification scores for Group I and II, for the category of furniture.

Table 4.4

The Mean, Standard Deviation, and Median values of pre-therapy identification scores for Group I and Group II for the category of furniture

Group	N	Mean	Std. deviation	Median	Percentage of correctly identified images
Group I	3	2.33	1.528	2.00	23.33%
Group II	3	3.67	1.528	4.00	36.67%

Identification scores were higher for children who were tested with the VSD based AAC system (Group II). The Mann-Whitney U test was employed to determine whether the difference between the scores of the two groups is significant. Results show no significant difference exists between the two groups (/z/ = 1.124, $p > .05$).

4.3 Comparison of identification accuracy in children with Cerebral Palsy while using Grid-based and VSD based AAC systems after training

4.3.1 For the category of fruits

The identification accuracy was measured for the category of fruits for groups I and II after Grid-based and VSD based therapy (Table 4.5).

Table 4.5

The Mean, Standard Deviation, and Median values of post-therapy identification scores for Group I and Group II for the category of fruits

Group	N	Mean	Std. deviation	Median	Percentage of correctly identified images
Group I	3	7.00	1.00	7.00	70%
Group II	3	9.67	0.577	10.00	96.67%

The results point out that identification scores were higher for children who were tested with the VSD based AAC system (Group II). The Mann-Whitney U test was employed to test the significance of the difference between the scores of the two groups. The statistical analysis shows a significant difference exists between the two groups (/z/ = 1.993, $p < .05$).

4.3.2 For the category of food items

The identification accuracy was measured for the category of food items after training using Grid-based and AAC based systems respectively, for Group I and Group II. Table 4.6 shows the post-therapy identification scores.

Table 4.6

The Mean, Standard Deviation, and Median values of post-therapy identification scores for Group I and Group II for the category of food items

Group	N	Mean	Std. deviation	Median	Percentage of correctly identified images
Group I	3	6.33	1.55	7.00	63.33%
Group II	3	9.33	1.155	10.00	93.33%

Results indicate that the identification scores were higher for children who were tested with the VSD based AAC system (Group II). The significance of the difference in scores was tested with Mann-Whitney U test. Results showed that a significant difference exists between the two groups (/z/ = 2.023, $p < .05$).

4.3.3 For the category of furniture

The identification accuracy was measured for the category of furniture after AAC based therapy. Table 4.7 indicates the mean, standard deviation and median values of post-therapy identification scores for both the groups for the category of furniture.

Table 4.7

The Mean, Standard Deviation, and Median values of post-therapy identification scores for Group I and Group II for the category of furniture

Group	N	Mean	Std. deviation	Median	Percentage of correctly identified images
Group I	3	6.00	1.00	6.00	60.00%
Group II	3	6.00	1.732	5.00	60.00%

Identification scores were equal in terms of mean score for children who were tested with the VSD based and Grid-based AAC system.

4.4 Comparison of identification accuracy in children with cerebral palsy while using Grid-based AAC system in pre-training vs post-training conditions.

The identification accuracy was measured for all the three categories (fruits, food items and furniture) before and after training using Grid-based AAC system. Table 4.8 indicates the mean, standard deviation and median values of pre-training and post-training identification scores for Group I.

Table 4.8

The Mean, Standard Deviation, and Median values of pre-therapy and post-therapy identification scores for Group I

Condition	N	Mean	Std. deviation	Median	Percentage of correctly identified images
Pre-training	3	11.67	5.033	11.00	38.88%
Post-training	3	17.33	2.309	18.00	57.77%

Results revealed that participants showed better identification scores in post-training condition. No significant difference was observed when Wilcoxon Signed Ranks test was employed. (/z/=0.604, p>0.05).

4.5 Comparison of the identification accuracy in children with cerebral palsy while using VSD based AAC system in pre-training vs post-training conditions

The identification accuracy was measured for all the three categories before and after training using VSD AAC system. Table 4.9 indicates the mean, standard deviation and median values of pre-therapy and post-therapy identification scores.

Table 4.9

The Mean, Standard Deviation, and Median values of pre-therapy and post-therapy identification scores for Group II

Condition	N	Mean	Std. deviation	Median	Percentage of correctly identified images
Pre-Training	3	17.33	2.889	19.00	57.77%
Post-training	3	25.00	2.646	24.00	83.33%

The descriptive scores revealed better identification accuracy in the participants post VSD training. Wilcoxon Signed Ranks test was employed to determine if a statistically significant difference exists between the scores of the two groups. No significant difference was noticed between the two groups (/z/=1.633, $p>0.05$).

To summarize the above results, a statistically significant difference was observed in the identification scores in the post-training condition for the categories of fruits, and food items. No statistical difference was observed in the identification scores for the category of furniture in the post-training condition. No significant difference was observed between the identification scores for all categories in the pre-training condition. However, the scores of Group II was comparatively higher than Group I. Similarly, no significant difference between the pre-training and post-training

identification accuracy scores was observed but the scores improved after the training sessions for all the categories.

Chapter V

DISCUSSION

Several studies done in the western context have indicated the superiority of Visual Scene Display (VSD) based AAC systems over other systems in aiding language development and learning. There is a paucity of such studies in the Indian context. The current study thus aimed to determine if VSD systems have an advantage over Grid-based AAC systems in terms of identification skills in children with Cerebral Palsy (CP). Grid-based and VSD system required for the study, was developed in the first phase. Field testing was then conducted with six children with CP, dividing them into two groups of three each. Group I received training with the Grid-based system and Group II received training with the VSD system. A total of 20 sessions of Grid-based AAC therapy and VSD based AAC therapy were provided respectively to Group I and Group II. The identification accuracy was measured in terms of percentage of correctly identified images for both the groups.

5.1 Selection of Participants

The rationale for choosing Cerebral Palsy (CP) participants in the present study was the following: -

Firstly, the prevalence of CP in India ranges from 2.08 to 3.88 live births (Chauhan et al., 2019). Though motor impairment is a defining feature of CP, difficulties with communication are also a vital feature of this disorder, which hinders the persons affected with CP in their day-to-day activities as well as their quality of life (QoL). To facilitate communication in this population, speech and language therapy using AAC devices/ systems/ modes are usually the preferred mode by Speech-Language Pathologists (SLPs), especially for persons with CP having severe expressive

communication deficits. Secondly, studies have reported that AAC benefits children with CP, especially those in their early years and rehabilitated early (Cress & Marvin, 2003; Romski & Sevcik, 1993). In the present study, the mean age of the participants was 5.9 years, and they were first-time AAC users. Thirdly, the majority of clients availing AAC therapy services in the researcher's institute were from this population. These factors lead the researcher to choose the CP population.

However, in the present study, only six children participated (3 trained using VSD and 3 trained using Grid-based display systems), which is less than previous studies (Kathryn et al., 2003). The reduced number is due to the inability of the parents to make the child attend the 20 online training sessions.

Earlier studies using VSD investigated the naming accuracy and reaction time for the VSD images during a face-to-face therapy or diagnostic session. In the present study, the participants (both Group I & II) were trained for 20 sessions in the online mode. Further, since the study involved training the participants in VSD as well as Grid-based systems for Group II and Group I respectively through online sessions (due to the COVID pandemic), the sample size was limited to 6 to prevent attrition by the researcher.

5.2 Selection of Outcome measures

Holyfield et al. (2019), while analyzing the benefit of VSD based AAC against low tech isolated symbol based AAC, the time of gaze to the symbol was taken into consideration. The present study could not use this factor as an outcome measure, as it requires an eye tracking equipment to measure the gaze time. In several previous studies, reaction time and naming accuracy were measured whereas in the present study, only identification accuracy was measured. The participants in the present study

had an expressive vocabulary of fewer than 50 words, so they were not able to name/ pronounce words. For measurement of reaction time, the participant shall respond by pressing a button. For pressing the button immediately to measure reaction time, participants had difficulties due to motor weakness. However, all participants were able to point to pictures in both VSD and Grid-based systems correctly.

5.3 Development of Grid-based and VSD based AAC systems

VSD system, which was used for the study, was developed using ASP web framework application. The images used for building the system were relevant to the Indian context. The images were carefully selected after validation by experienced speech language pathologists as well as parents of AAC users. Light et al. (2019) opined that it is crucial to develop empirically driven guidelines for the design of VSD. This will lead to more benefit when VSDs are used by children with developmental disabilities. Using the ASP web framework application, it was feasible to position the images at an appropriate place on the screen. These factors might have contributed to the higher score of VSD trained participants compared to Grid-based, in pre-training and post-training phase. Moreover, another highlight of the developed Grid-based and VSD based system is that it can be used in offline mode. This will be an added advantage for Indian users in rural areas where there is difficulty in getting linked to the internet.

5.4 Improvement in identification accuracy after AAC based therapy using VSD system

The results indicate a significantly higher identification accuracy score for the categories of fruits and food items in the post-training condition for those who received AAC based therapy using VSD system. This is in accordance with past studies, which suggest better processing speed for recognizing natural elements and judging overall

context when naturalistic scenes are used in photographs. Studies have shown that such scenes take advantage of the event-based learning mechanisms underlying language learning. (Kathryn et al., 2003; Light et al., 2004; Wilkinson & Light, 2011; Wilkinson et al., 2012). It was also observed in the current study that there were more instances of children obtaining ceiling scores for each category suggesting faster learning of vocabulary with VSD system.

The higher scores for Group II could also be due to higher levels of engagement with VSD as evidenced by Holyfield et al. (2018) in their study comparing high-tech Visual Scene Displays and low-tech isolated picture symbols. O'Neill et al. (2019) suggested better visual attention to meaningful elements within Visual Scene Displays which could be another reason for higher scores for Group II in the current study. The higher level of engagement could be a factor in improving the comprehension abilities. Previous studies (Holyfield et al., 2019; O'Neill et al., 2019) thus indicate more significant improvement in language skills when VSD based AAC systems are used, attributable to more contextual cues within VSD systems and more resemblance to the corresponding real object. Wilkinson et al. (2012) suggested in their study, higher levels of joint attention when using VSD system. The authors also suggested that VSD systems also lower the processing load, which is especially important for efficient learning in children. The significant improvement in identification scores in the present study is attributable to all the above factors reported in the previous studies.

Parents of children in Group II (trained with the VSD system) also reported more instances of generalization of identification skills in other environments beyond the training environment. Previous studies by Wilkinson et al. (2012) have indicated improvement in social communication skills, such as more turn-taking for communication, which was also reflected in the present study.

Also, the current study included VSD images taken in an Indian context. This might have also had a beneficial effect on their episodic memory and thus reduction in processing load as previously suggested in study by Zangari et al. (2009).

However, for the category of furniture, no significant difference in scores was observed in the post-training period. The groups had similar identification scores for the category of furniture. This result might be attributed to the lack of exposure of the participants within the age range specified in the study to the variety of furniture in day-to-day life. However, the group of furniture was included in the study considering the feasibility of collecting photographs. Also, as the furniture are generally available in the household, it was assumed that the participants may be familiar with the furniture types. Another possible reason is that people were not included in the photographs incorporated in the VSD. Light et al. (2019) suggested that if people are included, it leads to better visual processing. People were not included in the present study considering the fact that the child's attention may focus more on people rather than the object.

5.5 Comparison of identification accuracy between Grid-based and VSD system before AAC based therapy

In the pre-training condition, no significant difference was obtained for all three categories, but a comparatively higher score was obtained with the VSD system in all the three categories. The non-significance might be attributable to the small sample size. Light et al. (2019) reported that VSD images with familiar people and daily activities will lead to better visual attention. However, in the present study the images used did not have either familiar people or depiction of daily activities in both the conditions (Grid-based and VSD systems). The non-significance may also be due to the

fact that the participants in both the groups were never exposed to AAC based therapy. As they were using both the systems for the first time, significant difference might not have occurred, though the scores were higher for VSD. Higher scores for VSD may be because of the factors such as: -better processing speed for recognizing natural elements, higher levels of engagement with VSD, and more visual attention to meaningful elements within VSD.

Chapter VI

SUMMARY AND CONCLUSION

Children with Cerebral Palsy (CP) and other communication disorders require AAC systems to augment and support their language learning and, in some instances, to completely substitute for spoken language. Different aspects of display on AAC systems, such as the icon number, colour, and iconicity, can all impact the AAC system's effectiveness (Thistle & Wilkinson, 2017). The present study inspected one such aspect, i.e., the display system, focusing on Grid-based and visual scene display (VSD) systems of AAC.

The study involved two groups of participants with three children with CP in each group. The study was conducted in four phases. The first phase involved the development and validation of the stimuli. VSD images and PicSyms for the Grid-based system were organized, and the VSD system was developed. The second phase involved assessing the identification accuracy of the images for both groups before training. The third phase involved field testing of the VSD and Grid-based systems in children with CP in the age range of 5-12 years. Twenty online therapy sessions were then provided for both groups of participants. Group I was trained using the Grid-based AAC system, and Group II was trained using the VSD based AAC system. Three categories of vocabulary i.e., fruits, food items, and furniture, each having ten items were chosen for training. The identification scores were obtained for both groups at the end of the training period. Statistical analysis was done to determine if there was a significant difference in the identification scores between the groups for all the categories of vocabulary chosen. Results revealed a statistically significant difference in scores for the categories of food items and fruits post-intervention. The scores for the other category and the total score obtained did not have a statistically significant

difference. However, a comparatively higher score was obtained for the children in Group II (tested and trained using VSD system) for all categories.

6.1 Clinical implications

- Present study has established the positive impact of VSD based AACs compared to Grid-based AACs, in children with CP. Thus, the study can lead to development of indigenized VSD based AACs with images relevant to the Indian context.
- Availability of such VSD based AACs for Indian population will help children with developmental disabilities to have effective communication and to maximize learning.
- Development of indigenize VSD based AACs will help the children to have their visual attention driven toward the major concepts which emerge in early language development.

6.2 Limitations of the study

- The present study involved a small sample size of 6 children. Larger sample size could have increased the validity of results obtained and a higher probability of a significant difference in identification scores. The sample size could not be increased in the present study due to limitations in time.
- A single measure of language abilities, identification accuracy, was analyzed. Other measures such as reaction rate could have given a more detailed description of language and learning abilities. The present study could not incorporate the same due to limitations in time and resources.

- The present study included a small vocabulary for training. The language learning can therefore be attributed to repetitive use of the vocabulary throughout the 20 training sessions.
- A total of 20 training sessions were provided for all the patients. The possibility of a practice effect obscuring the accuracy of the scores measured, therefore cannot be neglected.
- The current study was conducted through online mode due to current covid protocols. The effectiveness of the training sessions might have been better if offline training sessions were conducted.
- The VSD images utilised in the current study did not involve human figures. Several studies have indicated that the performance is enhanced when the images have people or action in the images.

6.3 Future directions

Future studies can be done utilizing different measures of assessment, along with identification accuracy. Studies can also be done in children with communication disorders other than Cerebral Palsy. A larger sample size and lesser number of training sessions can be employed to improve the accuracy of the results obtained. Similar studies can be conducted in other languages and with children of different age ranges.

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APPENDIX I

Consent form

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

Dissertation on

"COMPARATIVE STUDY BETWEEN GRID-BASED AND VISUAL SCENE DISPLAY BASED AAC SYSTEMS IN CHILDREN WITH CEREBRAL PALSY"

You are invited to participate in the study titled "Comparative Study between Grid-Based and Visual Scene Display Based AAC Systems in Children with Cerebral Palsy". This study is conducted by Ms. Bhavani Venkatachalam, a postgraduate student of the All India Institute of Speech and Hearing, under the guidance of Dr.Ajish K Abraham, Professor of Electronics and Acoustics, All India Institute of Speech and Hearing, Mysoreand Co-guidance of Dr. Reuben Thomas Varghese, Scientist-B, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysore.

The study aims to develop and conduct a pilot study to determine the effectiveness of Visual Scene Display system against grid display systems of augmentative and alternative communication (AAC). Participants and caregivers will be interviewed to obtain demographic details and necessary information prior to confirming eligibility for the study. Once eligible, the Visual Scene Display system/ Grid Display system will be presented via tele-mode and the responses will be recorded for further reference. Further, 20 training sessions will be conducted and an assessment of the responses will be recorded again after 20 sessions. Two online sessions will be conducted per week and each session will be conducted for 45 minutes duration.

The identity of the participant will not be revealed at any time, the information and videos will be maintained confidential. The data obtained will not be disclosed, and the access will be limited to individuals who are working on the project. 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 foregoing information, or it has been read to me in the language I understand. I have had the opportunity to ask questions about it, and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate in this study.

I, _____, consent to be participant of this investigation/study/program.

Name, Email ID, age, and address of the participant Name of the investigator

Consent form (online)

INFORMED CONSENT FORM

You are invited to participate
in the study titled "**Comparative Study between Grid-Based and Visual Scene Display Based AAC
Systems in Children with Cerebral Palsy**".

This study is conducted by Ms. Bhavani
Venkatachalam, a postgraduate student of the All India Institute of Speech and
Hearing, under the guidance of Dr.
Ajish K Abraham, Professor of Electronics and Acoustics, All India
Institute of Speech and Hearing, Mysore and Co-guidance of Dr. Reuben Thomas Varghese,
Scientist, Department
of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysore.

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a pilot study to determine the effectiveness of Visual Scene Display system
against grid display system of augmentative and alternative communication
(AAC). Participants and caregivers will be interviewed to obtain demographic
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revealed at any time, the information and videos will be maintained
confidential. The data obtained will not be disclosed, and the access will be
limited to individuals who are working on the project. 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.

Contact number *

Your answer

Date *

Date

dd-mm-yyyy

I give my consent to participate for this investigation *

- ◯ Yes
- ◯ No

Submit

Clear form

APPENDIX II

Visual scene – validation form

Name: **SLP/ Parent**

Definition of parameters

1. **Clarity:** Whether the overall clarity of the image is appropriate in terms of both focus and contrast?
2. **Relevance:** Whether the image is culturally and ethically acceptable?
3. **Color:** Is the image appropriate in terms of colour?
4. **Iconicity:** Does the image appear to be recognizable and representational?

Rating Scale

- **0- Not satisfactory**
- **1- Satisfactory**
- **2- Good**
- **3- Very good**

Please circle the most appropriate rating

Sl. No	IMAGE	CLARITY	RELEVANCE	COLOR	ICONICITY
		FRUITS			
1.	Apple	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
2.	Banana	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
3.	Chiku	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
4.	Grapes	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
5.	Guava	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
6.	Orange	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
7.	Papaya	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
8.	Pineapple	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
9.	Pomegranate	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
10.	Watermelon	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
		FOOD ITEMS			
1.	Biscuit	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
2.	Chapati	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
3.	Chips	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
4.	Daal	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
5.	Idli	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
6.	Milk	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3

7.	**Rice**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
8.	**Vada**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
9.	**Dosa**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
10.	**Bread**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
FURNITURE					
1.	**Bed**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
2.	**Cupboard**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
3.	**Chair**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
4.	**Bench**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
5.	**Dining table**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
6.	**Dressing table**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
7.	**Book shelf**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
8.	**Shoe rack**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
9.	**Sofa**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**
10.	**Table**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**	**0 1 2 3**

APPENDIX III

Demographic Details

Sr No.:

Date:

Name:

Age/ Gender:

Diagnosis:

Results on ACSLS

RLA:

ELA:

AAC assessment protocol details:

APPENDIX IV

Identification accuracy checklist

Sl. No.	**Category 1**	**Response accuracy**	**Category 2**	**Response accuracy**	**Category 3**	**Response accuracy**
	Fruits		**Food items**		**Furniture**	
1	Apple /se:bu:/		Biscuit (biskittu)		Bed /ha:sige:/	
2	Banana /ba:lehannu/		Chapati /ʧapa:ti/		Cupboard /bi:ru:/	
3	Chiku /ʧiku:/		Chips /ʧips/		Chair /kurchi:/	
4	Grapes /dra:kshi:galu:/		Dal /da:l/		Bench /benʧ/	
5	Guava /si:be:hannu:/		Idli /idli:/		Dining table /u:tadamej iu/	
6	Orange /kittale:/		Milk /ha:lu:/		Dressing table /alanka:ri ka: me:ju:/	
7	Papaya /pappa:yi/		Rice /akki:/		Book shelf /pustakad akapa:tu:/	

8	Pineapple /ananas/		Vada /vada:/		Shoe rack /ʧappali: gudu/	
9	Pomegranate /da:limbe:/		Dosa /dosa:/		Sofa /sofa:/	
10	Watermelon /kallangadi:/		Bread /bred/		Table /tebal/	

APPENDIX V

Stimulus Validation Report

Ten Visual Scene images were captured for each of the three categories i.e. fruits, food items, and furniture. The images were validated by three speech language pathologists with a minimum of three years of expertise in the field of AAC and three parents of children who have used AAC for at least six months. The images which received a rating of good or excellent were finalised for the study (0-Not satisfactory, 1-Satisfactory, 2-Good, 3-Excellent). The images which received a lower rating were modified based on the suggestions given by the validators as indicated in the table below.

Sr. No.	Categories	Suggestions
1.	Fruits	Chiku - Modify depth of field (shallow depth of field is needed to increase the focus) Pineapple - Modify depth of field (shallow depth of field is needed to increase the focus)
2.	Food items	Excellent
3.	Furniture	Bed - Modify depth of field

APPENDIX VI

Visual Scene Image Dataset

1. Fruits

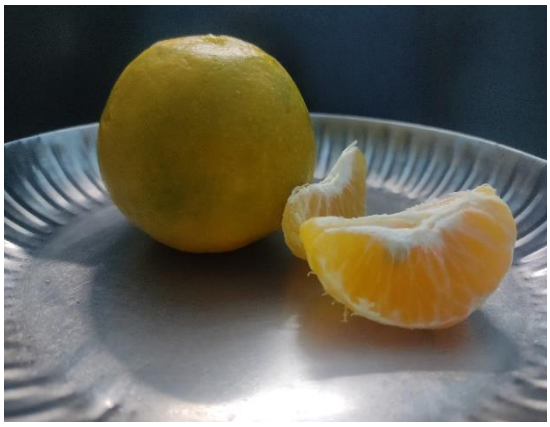
Apple

Banana

Chiku

Grapes

Guava

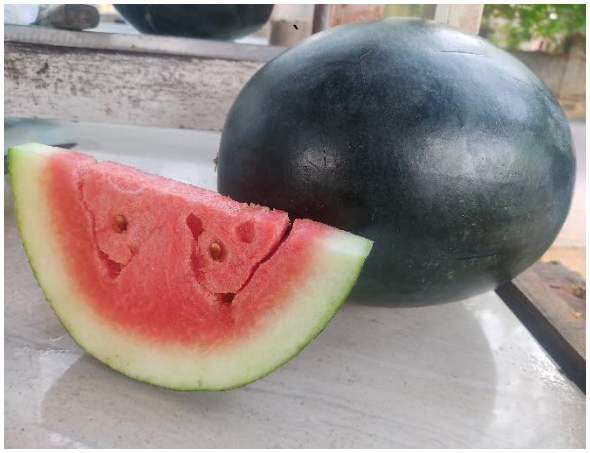


Orange

Papaya

Pineapple

Pomegranate



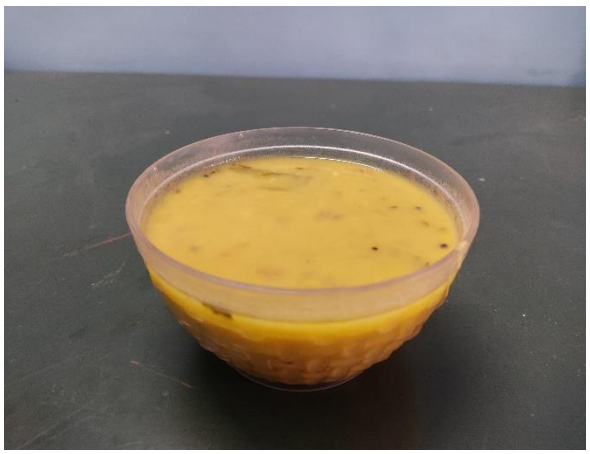
Watermelon

2. Food items

Biscuit

Chapati

Chips



Dal

Idli

Milk

Rice

Vada

Dosa

Bread

3. Furniture

Bed

Chair

Cupboard

Dressing-table

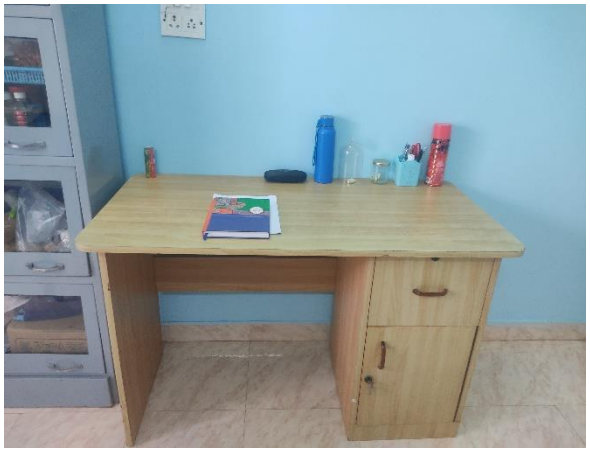
Bench

Dining-table

Book-shelf

Shoe-rack

Sofa



Table