Introduction

The most notable gift that humans possess is their ability to verbally communicate. Inability to speak can be the most catastrophic disability, since this deprives one of independence and human dignity. People with impaired/limited speech are described as being communicatively impaired, non-verbal or speechless. Without a reliable and consistent mode of self-expression, speechless persons become socially isolated (**Bhatnagar and Silverman, 1999).**

The communication is the essence of human life and all people have the right to communicate to the fullest extent possible. No individual should be denied this right, irrespective of the type and/or severity of communication, linguistic, social, cognitive, motor, sensory, perceptual and/or other disabilities they may present **(ASHA, 2005)**.

Disorders impairing a patient's communication abilities may involve voice, speech and language (**Miller et al., 1998; Rao, 1996).**

Lack of verbal communication is commonly found in persons with inborn conditions brain damaged motory handicapped (BDMH), Autism spectrum disorders (ASDs), dual sensory disorders, genetic syndromes e.g., Rett syndrome

(Shah et al., 2007), multiple disabilities (including hearing impairment) **(Romski and Sevcik, 2005)** and with acquired conditions as neurological conditions (stroke, traumatic brain injuries), degenerative conditions (Huntington's chorea, multiple sclerosis (MS), amyotrophic lateral sclerosis (ALS) and Parkinson's disease) and with oral-facial-neck malformations, many of them are also tracheostomized and ventilator-dependent (**Bhatnagar and Silverman, 1999)**.

Augmentative and alternative communication (AAC) is an umbrella term that encompasses the communication methods used to supplement or replace speech or writing for those with impairments in the production or comprehension of spoken or written language **(ASHA, 2005)**.

Augmentative and Alternative Communication can be used by individuals who are nonverbal, have poor speech intelligibility and/or limited verbal expression. Individuals who are unable to use verbal speech for all of their communication needs may require augmentative and alternative communication. There are a variety of congenital or acquired impairments that can cause individuals to be unable to speak or write without adaptive assistance. The most common congenital causes of such severe communication disorders include autism, BDMH, mental retardation and

developmental apraxia of speech. Acquired impairments that most often result in the need for AAC assistance include amytrophic lateral sclerosis, multiple sclerosis, traumatic brain injury, stroke and spinal cord injury **(Hoge and Newsome, 2002).**

Two types of individuals may benefit from the use of AAC systems: those with long-term communication impairments (e.g., dysarthria, aphasia, apraxia) and those with more temporary conditions (e.g., tracheostomy placement, intubation) **(Downey and Hurtig, 2003**).

People with deafness or hearing impairment are also said to be using sign language as an alternative method of communication. Blind or visually impaired people who use Braille or Moon and/or technology based on these systems may also be thought of as using a specialized form of augmentative and alternative communication **(Glennen and DeCoste, 1997).**

AAC is typically classified as involving aided or unaided communication **(Lloyd et al., 1997**). Unaided AAC systems are those that do not require an external tool and include facial expression, vocalizations, gestures and sign languages and systems **(Beukelman and Mirenda, 2005)**.

The benefits of gestures and pantomime are that they are always available to the user, usually understood by an educated listener and are efficient means of communicating **(Lloyd et al., 1990).**

An aided AAC is any device, either electronic or non-electronic, that is used to transmit or receive messages (**Beukelman and Mirenda, 2005)**. Such aids range from low-tech to high-tech, from communication books to speech generating devices **(Mirenda, 2003).**

It is important for AAC users to have a means to express wants and needs, to exchange information, develop social closeness with others and to engage in social etiquette routines. The goal of AAC is to use the most effective communication possible that may require a multimodal approach in order to be able to communicate for different purposes in a variety of contexts. The individual's full communication capabilities could include "any residual speech or vocalizations, gestures, signs and aided communication**" (ASHA, 1991).**

Aim of the Work

The aim of this work is to review the state-of-art communication options for non-verbal patients and to develop a new method that can be implemented as an AAC tool for the communicatively impaired subjects.

The Normal Communication Process

Communication entails an exchange or sharing of ideas between two parties **(Kotby, 1980).** Verbal communication is the highest level of communication processes. Other non-verbal messages are laughing, crying and facial expression. The complex symbolic human communicative ability (language) is specific to mankind. The human child is born with the structural pre-requisites for symbolic communication that needs the triggering of environmental stimulation.

Communication involves several physiological processes namely; respiration, phonation, resonance, articulation and symbolization. Voice, speech and language are the components of communication. The main process of communication is language, spoken or written (**Kotby, 1977).**

Language is an arbitrary symbolic system that pairs sounds and signs to meanings **(Kotby, 1980).**

Kotby (1980) reported that verbal communication or language is a complex function and its development requires:

- Integration of intellectual brain abilities
- Normal sensory channels
- Intact psyche and stimulating environment

So disruption of any or a number of systems can impair its development.

Language comprises the following three major aspects: form, content and function **(Lahey, 1988)**. Each of these components is distinct but interrelated.

1. Form of Language:
   a. *Phonology* is the sound system of a language and the rules that govern the sound combinations.
   b. *Morphology* is the rules governing the order and the construction of phonemes in the word.
   c. *Syntax* is the rules governing the order and combination of words in sentences.
2. Content of Language:
   a. *Semantics* is the system that governs the meanings of words and sentences.
3. Function of Language:
   a. *Pragmatics* is the system that combines the above language components in functional and socially appropriate communication **(ASHA, 1993)**.

The American Speech – Language and Hearing Association (ASHA) (1982) has defined language as a

complex and dynamic system of conventional symbols that is used in various modes for thought and communication. Human language holds that:

- Language evolves within specific historical, social and cultural contexts.
- Language, as a rule-governed behavior, is described by at least five parameters: phonologic, morphologic, syntactic, semantic and pragmatic.
- Language learning and use are determined by the interaction of biological, cognitive, psychosocial and environmental factors.
- Effective use of language for communication requires a broad understanding of human interaction including such associated factors as nonverbal cues, motivation and sociocultural roles **(ASHA, 1982)**

Speech is defined as acoustic vibrations from patterns of movement of speech organs as lips, tongue, jaw, palate and pharynx. The specific sound components of speech are formed as a result of the action of the articulators on the primary laryngeal sound waves resulting from phonation **(Lawrence and Raymond, 1982).** It involves the coordinated motor activity of muscles involved in respiration, phonation,

resonance and articulation. The entire system is modulated by central and peripheral innervations, including with cranial nerves V, IX, X, XI, and XII, as well as with the phrenic and intercostal nerves. Respiratory muscles, specifically the muscles associated with expiration, must generate enough air pressure to provide adequate breath support to make speech audible. The diaphragm is the main muscle of expiration, however, the abdominal and intercostal muscles help to control the force and length of exhalation for speech. Phonatory muscles of the larynx generate vibratory energy during vocal fold approximation to produce sound. Vocal pitch and intensity are modified by subglottic air pressure, tension of the vocal fold and position of the larynx. Articulatory muscles within the pharynx, mouth and nose form the tone of the sound (resonance of the speech). By altering the shape of the vocal tract, we are capable of producing a tremendous range of sounds. Sound waves are transformed by the auditory system to neural input for the speaker and the listener. The outer ear detects sound-pressure waves in the air and converts them into mechanical vibrations in the middle and inner ear. The cochlea then transforms these mechanical vibrations into vibrations in fluid, which act on the nerve endings of the eighth cranial

nerve. Thus, the process of communication begins and ends in the brain **(Lohscheller and Eysholdt, 2008).**

Voice is the complex, dynamic product of vocal fold vibration that allows us to vocalize (i.e., make sound) and verbalize (i.e., produce language through speech) **(Justice, 2006).**

The prerequisites of normal voice production are:

1. Full range of movement of the vocal folds in vertical and lateral dimensions.
2. Presence of a pliable layered structure with ability to change biomechanical properties of superficial layer of mucosa (epithelium and superficial layer of lamina propria) on the deeper more firm structure (thyroarytenoid muscle) of the vocal fold appropriate to pitch, loudness and phonatory task.
3. Optimal coaptation of the vocal folds' edges
4. Optimal phonatory adductory force.
5. Optimal expiratory support to guarantee optimal air flow across the glottis.
6. Optimal timing between the phonatory adduction of the vocal folds and phonatory exhalation.
7. Optimal tuning of the laryngeal muscles (internal and external) to adjust the vocal fold length, mass and tension necessary for the intended vocal duties **(Kotby, 1986).**

Communication Disorders

A communication disorder is impairment in the ability to receive, send, process and comprehend concepts or verbal, nonverbal and graphic symbol systems. It may be evident in the processes of language, speech and voice. It ranges in severity from mild to profound. It may be developmental or acquired. A communication disorder may result in a primary disability or it may be secondary to other disabilities **(ASHA, 1993).**

This communicative ability may be either arrested or disrupted due to different reasons. Disruption maybe in:

1. Voice: dysphonia (organic, non-organic and MAPLs) or aphonia.
2. Speech: fluency disorders (stuttering, cluttering), nasality (open), motor speech disorders (dysarthia, apraxia).
3. Language:

   i. Delayed language disorder (DLD) **(Kotby, 1980)**

   - Sensory deprivation:
     - - Hearing impairment.
     - - Visual impairment.
   - Brain damage:
     - Diffuse brain damage (Mental Retardation) (MR).

- Brain Damage Motory Handicapped Child (BDMH).
- Minimal Brain Damage (Attention Deficit Hyperactive Disorder) (ADHD).

- Psychiatric Disturbance:
  - - Autism Spectrum Disorders (ASD)
  - - Childhood schizophrenia
  - - Selective mutism
- Specific Language Impairment **(Paul, 2001).**
- Environment deprivation **(Kotby, 1980).**

ii. Dysphasia

Voice Disorders:

Voice change is a common symptom of laryngeal disease. Other symptoms include respiratory distress, cough with variable forms of expectoration, dysphagia and/or pain related to the larynx **(Kotby, 1995).**

Common vocal symptoms that a specialist will see are:

1. Dysphonia (literally, difficult phonation): This may be broadly defined as a perceptually audible change of a patient's habitual voice, as self-judged or judged by his listeners. Dysphonic voice may be also described as a voice that fails to

meet a patient's vocal demands, personality, age, size or gender.

2. Aphonia: this reflects an inability to phonate. The patient is capable only of producing a type of whisper.

3. Phonasthenia: this may be defined as voice fatigue. It may be referred to as a "dysphonia" that is felt in the neck and throat rather than heard by the patients and their listeners. It may be broadly described by the patient as a status in which voice is not coping with the demands of daily life. The patient may experience:

- Sense of dryness and/or sourness of the throat.
- Tenderness in the throat and neck around the larynx.
- Frequent need to clear the throat.
- Sensation of sticky secretions (mucous) in the throat that is difficult to swallow, although swallowing of food and drinks not impaired.
- Inability to continue (speaking) during vocally stressful situation.
- In some cases change of voice after much or stressful speaking.

4. Dysodia: this is defined as a change or failure of some aspects of the singing voice, although the speaking voice is intact **(Kotby, 1995).**

Kotby (1995) classified voice disorders by etiology into 3 main groups:

1. Organic voice disorders
2. Non-organic (functional) voice disorders
3. Minimal associated pathological lesions(MAPLs)

Organic voice disorders:

The organic class includes the disorders of voice in which there are detectable morphological changes in the vocal apparatus, usually the vocal folds.

Causes of organic voice disorders:

1. Congenital malformation
   - Sulcus glottides
   - Congenital laryngeal webbing
   - Cri-du-chat syndrome
   - Congenital laryngeal cysts and laryngoceles
   - Congenital laryngeal stridor (laryngeomalacia)
2. Traumatic conditions

A. Mechanical trauma

- Blunt physical trauma
- Sharp, cut wounds and stabs
- Vocal trauma from vocal fold collision against each other.

B. Physical trauma
   - Thermal (burns)
   - Chemical (caustics)
   - Irradiation

3. Inflammatory causes:
   - Acute laryngitis
   - Chronic laryngitis
4. Laryngeal allergy
5. Laryngeal tumours

a) Benign:
   - Papilloma
   - Others

b) Dysplasia

c) Malignant
   - Carcinoma
   - Others

6. Neurological disorders of larynx
7. Endocrinopathies:
   - Thyroid gland dysfunction
   - Parathyroid gland dysfunction
   - Pituitary gland dysfunction
   - Gonadal dysfunction
   - Virilizing anabolic drugs