

PERCEPTIONS OF WORKING MEMORY USE IN  
COMMUNICATION BY USERS OF AAC

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## ABSTRACT

Augmentative and alternative communication (AAC) is defined as “all forms of communication (other than oral speech)...used to express thoughts, needs, wants and ideas” (“Augmentative and Alternative Communication (AAC),” 2012). Working memory is a temporary cognitive process, which briefly maintains and manipulates information while it is being encoded as a part of long-term memory (Engle, Nations, & Cantor, 1990; “Introduction to Working Memory”, 2007). It has been suggested that based upon the unique skill set and needs of users of AAC systems, the design of these systems should reflect knowledge gleaned from the cognitive sciences (Light & Lindsay, 1991) with training and implementation of AAC incorporating an understanding of the cognitive processes impacting memory, learning, and visual processing (Light & Lindsay, 1991; Wilkinson & Jagaroo, 2004). This study sought to examine how users of AAC managed and perceived the cognitive load associated with working memory demands while communicating and what specific strategies and/or design features users of AAC perceived they used during conversation when using AAC. Results revealed an overall large amount of variability in participants’ responses. Length of symbol/word sequences, word prediction, seeing the message as it is being created, attention to the conversational topic, and attempting to remember what their conversational partner said appeared to be judged as having the highest degree of importance for the use of a speech generating device and success and message completion in conversation. Errors in conversational while using a speech generating device and stressors during the conversational process appeared to be most closely related to reported lack of time to create messages and the time it takes to create messages. Users of AAC did not report high frequency of active attention to the working memory processes and design features.

## DEDICATION

This dissertation is dedicated to the users of augmentative and alternative communication who gave of their time and efforts to participate in this study. The researcher truly appreciated the honesty of the input provided, the thought given to completing the survey questions, and the enthusiasm for contributing to a study focused on adult users of augmentative and alternative communication.

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## CHAPTER 1

### INTRODUCTION

Individuals who have difficulty with the development of speech frequently use augmentative and alternative communication (AAC) (Frost & McGowan, 2011). Augmentative and alternative communication is defined as “all forms of communication (other than oral speech)...used to express thoughts, needs, wants and ideas” (“Augmentative and Alternative Communication (AAC),” 2012, n.p.). Augmentative and alternative communication strategies cover a broad range of complexity (Maro & Tufte, 2005) and are often characterized by one or more of the following: eye contact, facial expressions, vocalizations, gestures, touch, body movements, pictures, sign language, writing, computers, keyboarding, graphic and orthographic symbols, and speech generating devices (SGD). Individuals may experience complex communication needs (CCN) necessitating access to AAC as a consequence of a disability or combination of disabilities involving impairments in sensory, motor, cognitive, or linguistic skills, such as Autism Spectrum Disorders, Apraxia, Aphasia, Cerebral Palsy, Traumatic Brain Injury, Amyotrophic Lateral Sclerosis (ALS), and some genetic disorders (ISAAC, 2011; Light & Drager, 2007; Thistle & Wilkinson, 2011, 2013).

Working memory is a temporary cognitive process, which briefly maintains and manipulates information while it is being encoded as a part of long-term memory (Engle, Nations, & Cantor, 1990; “Introduction to Working Memory”, 2007). Factors affecting working memory capacity are thought to be: age, number of informational chunks, linguistic skills, and familiarity of content (Daneman & Carpenter, 1980; “Introduction to Working Memory”, 2007). The stronger an individual’s working memory, the greater the

expected potential for learning, reasoning, language comprehension, reading, and problem solving (Engle, Nations, & Cantor, 1990; “Introduction to Working Memory”, 2007). Weaknesses in working memory can impact processing instructions, organizing information and learning multipart operations (Baddeley & Hitch, 1974; Buhner, Kroner, & Ziegler, 2008; Kyllonen & Christal, 1990; “Introduction to Working Memory”, 2007; Light & Lindsay, 1991).

Conversation when using AAC is a complicated process requiring attention to multiple motor, attention, and language tasks. Development of a conversational response can require the ability to remember the location and sequence of target symbols, while monitoring message development and completion (Thistle & Wilkinson, 2012, 2013; Wagner, Shaffer, & Swim, 2011). Users of AAC also often present varied motor, sensory and cognitive abilities, directly impacting rate and access methods (Light & Drager, 2002). These challenges can result in lengthy and time-consuming interactions as evidenced by the rate of conversation. Approximately 125-250 words per minute are used during ordinary communication, whereas users of AAC typically can only produce approximately 5-25 words per minute (Beukelman & Mirenda, 2005; Foulds, 1980).

Assessment of working memory as a research paradigm with individuals presenting complex communication needs (CCN) who use AAC requires management of variables such as response timing, cognitive abilities, motor effort, fatigue, and attentional demands. Higgenbotham and Bedrosian (1995) point out that individuals using AAC are heterogeneous. The common factor is the use of AAC, with users of AAC often presenting a high degree of variability in language skills, perception and physical condition, limiting the validity in assigning findings to a broader group of individuals

using AAC. While specific research in the area of working memory with users of AAC has been overall limited, the literature associated with AAC does provide us with a context for considering how AAC and working memory processes interact. Multiple authors have described the significant processing, attention, and memory demands the user of AAC engages to communicate (Light & Drager, 2002; Light, Parsons & Drager, 2002; Thistle & Wilkinson, 2011, 2013). Light and Lindsay (1991) in their discussion of cognitive science and AAC, suggested that the complexity of disorders users of AAC present has the potential to negatively impact sensory and working memory processes during the use of AAC. Fried-Oken and Light (2012) addressed the challenges that individuals using AAC face within the context of AAC and language learning, noting that to successfully maintain and manipulate content for storage and processing, multiple cognitive processes are involved, including attention, concentration, sequencing, as well as motor and sensory skills. Thistle and Wilkinson (2013) in their extensive discussion of working memory demands of AAC suggested that AAC places unique and multiple demands upon working memory processes. Specifically for the AAC user, working memory demands are associated with the following: recall of navigation systems and page associations, locating symbol targets and inhibiting of distraction related responses during message formulation. Oxley and Norris (2000), in their discussion of voice output communication aids and memory strategies, identified several factors influential to success, including capacity, attention, memory structure, and metamemory. Wagner, Shaffer, and Swim (2011) point out that children learning to use AAC systems with visual-graphic displays are impacted by multiple processes involving the language system and display medium, use of icon encoding, cues provided by color markers, the child's

knowledge of language and concepts, as well as working and episodic memory skills.

Understanding how working memory management strategies facilitate successful use of AAC from the perspective of the individual user is a focus of research that has not been pursued. This information potentially has impact upon future direct research investigating AAC and working memory, clinical interactions and system design. Putting this information in the context of the learning strategies and system design features thought to contribute to the learning process further assists with understanding and maximizing the role of working memory processes and associated components of attention, rehearsal, and perception within the scope of using AAC. Reflecting on the difficulty of testing and making generalizations regarding working memory processes within the heterogeneous population of AAC users also suggests that allowing AAC users to contribute to the discussion of working memory provides for more discerning contexts when working with individuals who rely on AAC to communicate.

#### *Rationale For Study*

As noted previously, the users of augmentative and alternative communication (AAC) represent a heterogeneous population (ISAAC, 2011). Some users of AAC, such as individuals with autism or delayed language development, incorporate use of a speech generating device (SGD) into the natural language learning process. Other users, such as those presenting traumatic brain injury, stroke or Amyotrophic Lateral Sclerosis (ALS), may begin to use AAC as part of a rehabilitative or compensatory process. Most individuals who use augmentative and alternative communication (AAC) face complicated communication and learning challenges, often associated with constraints imposed by suspected weaknesses in sensory and working memory, as well as the ability

to use strategies to facilitate memory skills (Light & Lindsay, 1991). Typical AAC users must attend to auditory cues, visual symbols, symbol activation, message building, pragmatic and linguistic demands within the context of social and environmental noise, as well as the natural time constraints imposed by interactive turn-taking. Additionally, the AAC user needs to recall symbols, locations, and sequences in order to communicate (Wagner, Shaffer, & Swim, 2012) within a presentation of the sensory, cognitive, language, and motor impairments that are not easily assessed and may not be stable across time and environments. These unique needs result in longer lag times between processing and responsive messaging, increasing the potential for information to be lost from working memory processes. It has been suggested that based upon the unique skill set and needs of users of AAC systems, the design of these systems should reflect knowledge gleaned from the cognitive sciences (Light & Lindsay, 1991) with training and implementation of AAC incorporating an understanding of the cognitive processes impacting memory, learning, and visual processing (Light & Lindsay, 1991; Wilkinson & Jagaroo, 2004).

The following research questions were addressed:

- a. How do users of AAC manage the cognitive load associated with working memory demands while maintaining attention to communication expectations necessary for conversational success?
- b. What specific strategies do individuals using AAC identify as those employed to track conversational comments, manage message formulation and recall the location of targets within their AAC system?

- c. What cognitive processes, learning strategies, and system design features do users of AAC report they employ during use of their current AAC system?

## CHAPTER 2

### REVIEW OF LITERATURE

While research in the area of working memory is abundant, research specifically addressing working memory performance with individuals using AAC is far more limited. To supplement and build on the research examining working memory performance and the use of AAC several additional areas of research and commentary will be addressed: the scope of AAC; models of working memory that may provide theoretical concepts relevant to the use of AAC; and the discussion of the importance of working memory for the use of AAC. Reviewing the scope of augmentative and alternative communication (AAC) provides a context for understanding the complexity of motor and cognitive tasks an individual using AAC is required to accomplish in order to successfully engage conversational interaction. Reviewing multiple models of working memory provides a context for understanding the complexity and application of the cognitive correlates when using working memory. Finally, reviewing the research and literature discussing the broad relationship between working memory and AAC provides connection between these two processes and background for discussing the responses AAC users provide to questions associated with the cognitive processes related to working memory when using AAC.

#### *Scope of Augmentative and Alternative Communication*

AAC is defined as “all forms of communication (other than oral speech) that are used to express thoughts, needs, wants and ideas” (American Speech-Language-Hearing Association, [ASHA], 2012, n.p.). AAC typically incorporates the use of multimodal strategies, such as: facial expressions or gestures, graphic symbols, eye movements,

signed language systems, computers, mobile tablets and/or dedicated speech generating devices (SGD) to communicate using letters, words, phrases, symbols, sentences, narratives or encoded messages (ASHA, 2012; Bedrosian, 1997). AAC may also be referred to as “aided AAC” (Thistle & Wilkinson, 2011, p 17), referring to use of tools that are not part of a person’s body, such as the oral cavity and articulators. Electronic AAC tools that utilize varied simple and complex language systems are often referred to as a speech-generating device (SGD). According to Matas, Mathy-Laikko, Beukelman and Legresley (1985) and the National Joint Committee for the Communication Needs of Persons With Severe Disabilities in 1991 (ASHA, 2012) it was estimated that over two million individuals in the United States are severely communicatively impaired. A subset of individuals with severe communication impairments may use AAC as their primary means of communicating.

Selecting an AAC system for an individual requires a systematic matching process or “AAC feature-matching process” (Glennon & DeCoste, 1997, p.170), as well as collaborative team assessments (Beukelman & Mirenda, 2005), whereby the individual’s competencies, communication needs and environmental characteristics are matched to the features of an AAC system. Considerations include analysis of motor skills, language, cognition, perception, and motivation. Symbol style, vocabulary needs, access modality, complexity of output, size and weight of the speech-generating device (SGD), degree of ease of integration into communication and social exchanges, and the user’s preference for the AAC system are also involved in deciding which type of AAC system is appropriate for an individual, (van der Meer, Sigafoos, O’Reilly, Lancioni, 2011). An AAC user may transition to more complex AAC system as his/her motor,

cognitive, and language skills develop. With the introduction of portable and lower-cost tablet devices, a user may employ multiple AAC systems simultaneously.

AAC ranges in technological complexity from no-tech/low-tech (e.g., signed communication/keyboard) to high-tech (e.g., tablet or integrated computer systems). Message activation displays can be static or dynamic. Static displays are stable and maintain a pattern of consistency. Variations in static displays are the result of replacing one display array for another based upon situational needs. Dynamic screen presentation provides the user of AAC with increased communication options for categorical, semantic, or syntactic associations and expansions, within a single system (Maro & Tufte, 2005). The categorical arrays within a dynamic system become increasingly narrow, offering the user access to more specific vocabulary. Voicing within an AAC system can be digitized (i.e., recorded human voice) or synthesized (i.e., computer-based voicing) with increasing variety of voicing characteristics emerging as computer technology and memory capacity has progressed (“Section 5: Types of AAC Devices,” 1999).

Some AAC systems use primarily prestored text that is retrieved as needed during a conversation. Faster rates of conversation are possible with pre-stored content (e.g., complete sentences, or even paragraphs, can be retrieved with a single activation. The efficiency of this type of AAC system in contextual conversation may be negatively impacted due to challenges that arise from attempting to predict and organize the specific utterances required for conversation (Todman & Rzepecka, 2003). Frequently someone other than the user establishes the vocabulary that is preprogrammed into a speech-generating device, restricting user input into message content. According to Yoder and Kraat (1983) the vocabulary available to the individual using AAC can impact the nature

and boundaries of communication. In retrieval-based AAC systems, selection of syntactic and morphologic form and language content are selected with an attempt to match the utterance to the situation. The message may be perceived as inappropriate by the listener, if the match is not highly specific, (Nelson, 1992).

Generative AAC systems, that allow for the user of AAC to create their own message within the conversation provide more opportunities for linguistic competency; yet may also present associated reduced rate of conversation and utterance length, more common use of yes/no response patterns, or more frequent partner-controlled speaking interactions may be (Todman & Rzepecka, 2003). Eulenberg (as cited in Todman & Rzepecka, 2003, p. 226) reported that users of AAC indicated that lengthy pauses prior to responses negatively impacted conversational pleasure and led to negative perceptions of intellectual and social abilities by others. Similarly, Todman and Lewins (1996) reported AAC conversational partners' ratings revealed a positive relationship between social effectiveness ratings and conversational rate. Within generative systems, strategies can be used to decrease frequency of motor movement, increase speed, and facilitate awareness of target location.

Encoding is a technique used to increase speed of message completion and allows the user of AAC to combine target sequences to produce both preprogrammed and novel messages. Targets used to encode messages can be colors, symbols, words, numbers, Morse code, and/or letters. Using numeric codes requires the user to enter one or more numbers in order for stored vocabulary words or phrases to be expressed. Use of letter codes, often referred to as abbreviation/expansion strategies, requires the user to enter a shortened pattern of a word or phrase and the AAC system translates the code into a word

or phrases (Glennon & DeCoste, 1997). Another form of encoding is that characterized by semantic encoding. Semantic encoding uses picture icons rather than numbers or letters to cue the user to use picture sequences for words or phrases. Some semantic encoding systems use icon prediction to narrow the choice of selectable targets during icon sequencing. The Unity® language system (“About the Unity Language, 2012) used within many Minspeak® (Baker, 1982) based AAC systems is an example of semantic and icon-sequencing encoding programs.

Word prediction is a strategy designed to reduce the number of keystrokes or target selections required to complete a word. A list of possible word choices is provided as the AAC user accesses a letter to spell a word. Each letter keyed into the system narrows the possible choices. Word prediction programs are often phonetically based and accommodate common spelling errors.

Selection techniques vary depending on an individual’s motor and sensory skills, most often falling into the categories of either direct selection or scanning. Directly touching the target with a finger, stylus, head pointer, eye gaze, or optical mouse would be considered direct selection. Scanning is an indirect access strategy requiring the user to activate one or more switches to move a cursor across, down or around a display array prior to target selection and relies on visual or auditory access to targets (Beukelman & Mirinda, 1998; Fager, Jakobs, Beukelman, Ternus, & Schley, 2012). Auditory scanning enables the individual to make a choice based on auditory prompts, with or without visual access, presented prior to switch activation (Hoffman, 1998).

There are multiple patterns of scanning, including circular, directed, linear, row-column, or block. Circular scanning is a simple scanning pattern where choices are

presented in a circle and are highlighted one at a time until the user pauses the scanning thereby choosing the item (Cumley, n.d.; University of Washington, 2000). Directed scanning involves multiple switches and provides increased control to the AAC user by permitting control of directionality prior to making a target selection. The marker or cursor moving in a line across each row of the display until the target is highlighted and the AAC user activates a switch to select a target characterizes linear scanning (Cumley, n.d.; University of Washington, 2000). Row-column scanning requires multiple activations by the AAC user. Each row on the communication board is highlighted individually until the user activates a switch. A second switch activation is required to target an item as the scanning progresses across each item linearly (i.e., column). Group-Row-Item scanning allows a group (e.g., top half vs bottom half) to be highlighted as the first selection, then each row in that selection is highlighted via another switch activation, followed by each item in the selected row being highlighted linearly until selected (Cumley, n.d.; University of Washington, 2000).

Many AAC systems utilize color-coding to facilitate recall. Storing content within logical groupings, such as color or semantics before encoding the content into long-term memory (LTM), appears to facilitate future retrieval from LTM (Dehn, 2008; Shiffrin & Atkinson, 1969; Tulving, 1962; Lange, Guttentag, & Nida, 1990; Melkman, Tversky, & Baratz, 1981; Schleepen & Jonkman, 2009). An example of color-coding is the Fitzgerald color-coding schema (Bishop, Rankin, & Mirenda, 1994), which places words together based upon grammatic categories. The user of AAC learns the location of symbols by applying color-coding, shape and grammatical meaning (Fitzgerald, 1949; Glennon & DeCoste, 1997). Color-coding has also been suggested as a means of

facilitating rate of object location (Wilkinson, Carlin, & Thistle, 2008), as well as a means of lessening the cognitive load associated with the tasks of using AAC (Wilkinson & Jangaroo, 2004). Utilization of these strategies enables the user to use coding schemas to access LTM for location of required icons/words/pictures used during communication. Encoding appears to follow a developmental trajectory into adolescence, therefore users of AAC below 7-9 years of age may need support for learning to use coding strategies for processing and recall (Bjorklund & de Marchena, 1984; Bjorklund & Jacobs, 1985; Ornstein, Baker-Ward, & Naus, 1988; Ornstein & Nause, 1978).

Another strategy for accessing vocabulary is the use of integrated picture scenes. It appears that when used with children, whereby the users accesses vocabulary targets from within the scenes, use of integrated scenes reduces working memory requirements, drawing more upon episodic memory (Drager & Light, 2010; Drager, et al., 2004; Drager, et al., 2003; Light et al., 2004). Integrated scenes have limited applicability for the use of grammatically organized, self-generated conceptual language that listeners often associate with competent communication.

### *Working Memory Models*

This section of the paper introduces the reader to several models of working memory. Working memory models address the functional processing and storage of information, at the same time active mental processing is competing for attention. The exercise of using augmentative and alternative communication (AAC) is a complex set of activities associated with language processing (i.e., attending to conversation, thinking about a conversational response, tracking topic changes) while completing multiple activities and processes (i.e., recalling target locations, self-cueing for linguistic

sufficiency to achieve communicative intent, message activation). There are multiple models of working memory: the multiple component model of Baddeley (1986, 2000, 2002, 2007) and Baddeley and Hitch (1974); Cowan's (1988, 2001, 2005) model focused upon memory activation; the model proposed by Ericsson and Kintsch (1995), which theorized about long-term working memory; the task-switching hypothesis proposed by Towse and Hitch (1995); and the unitary model of short-term memory supported by Chuah and Maybery (1999).

The multiple component model of working memory described and discussed by Baddeley (1986, 2000, 2002, 2007) is the model most frequently referred to in discussions and research related to working memory functioning. Baddeley and Hitch (1974) developed a model with three components, reflecting an expansion from the unitary model for short-term memory storage model proposed by Atkinson and Shiffrin (1968). Atkinson and Shiffrin (1968) described memory as being divided into "three structural components" (p. 90). The first component, the "sensory register" (p. 90), received sensory information, which was briefly maintained, decayed and was lost. The second component, the "short-term store" (p.90), maintained information for approximately 30 seconds, utilizing rehearsal processes to keep information available. This was considered to be an individual's "working memory" (p. 92). The sensory information coming into the sensory store was transferred to the auditory-verbal-linguistic short-term store. The final component, the "long-term store" (p. 91), was considered a more permanent reserve for information copied from the short-term store. The model introduced by Baddeley and Hitch (1974), which was further elaborated upon by Baddeley (1986, 2000, 2002, 2007) and Baddeley and Jarrold (2007) proposed

multiple components involved in the storage and processing of information. Primary to this working memory model is the “limited-capacity” (Baddeley, 2002, p. 86) central executive component. The central executive is thought to regulate cognitive tasks and attention, providing retrieval and integration of information (Baddeley, 1986, 2002). It also serves to manage subordinate systems--visuospatial sketchpad, phonological loop, and episodic buffer--through the encoding of information, distribution of tasks and integration of information. (Adams & Gathercole, 2000; Archibald & Gathercole, 2007; Baddeley, 1996, 1998; Baddeley & Jarrold, 2007; Baddeley & Logie, 1999; ”Introduction to Working Memory”, 2007; Levin, Thurman, & Kiepert, 2010; Light & Lindsay, 1991; Paas & Sweller, 2012; Spillers & Unsworth, 2011).

Baddeley (1986) indicated that these temporary subsystems coordinate information from auditory, visual, and spatial modalities into a single depiction of the event or content, involving the processes of attention and reflection. Responsibility for phonological verbal and auditory information reside within the phonological loop, while visual and spatially perceived information reside within the visuospatial sketchpad (Baddeley, 2002, 2007). Integrating data from the phonological loop and the visuospatial sketchpad with long-term memory is the episodic buffer (Baddeley, 2007).

The phonological loop is considered to be a temporary storage system for phonologic and verbal information. Information resides in the phonological loop for a very limited amount of time. Rehearsal is used to refresh the information to avoid decay (Baddeley, 1986; Baddeley & Hitch, 1974). The rehearsal component is characterized by subvocal repetition of content to support the refreshing and retention of information and facilitate language comprehension and acquisition. It has been suggested that subvocal

rehearsal is tied to articulatory skills, involving “subvocal articulation” (Larsson & Sandberg, 2008, p. 139) of auditory, picture and printed content. Memory span, which has been found to increase in capacity from age seven through adolescence, is thought to be related to the rate of subvocal rehearsal. Relevant to users of AAC is that rehearsal of phonological content, as it impacts working memory, appears to be more closely related to the central capacity to construct speech-motor programming, rather than the overt ability to use speech muscles to produce phonological patterns (Baddeley, 1998, 2002; Baddeley & Wilson, 1985; Caplan & Walters, 1995; Montgomery, 2003).

The visuo-spatial sketchpad is also a multicomponent system (Baddeley & Logie, 1999) managing the processing, manipulation, and recall of visual images, mental maps, and spatial content through storage and rehearsal. Additionally, it performs a role in spatial orientation and facilitates the solving of visuospatial problems. Rehearsal within the visuo-spatial sketchpad is less well understood than that suggested within the phonological loop (Adams & Gathercole, 2000; Archibald and Gathercole, 2007; Baddeley, 1998, 2002; Larsson and Sandberg, 2008; “Introduction to Working Memory”, 2007; van Daal, Verhoeven, van Leeuwe, & van Balkom, 2008; Levin, Thurman, & Kiepert, 2010; Montgomery, 2003).

Considering the significant multisensory integration and requirements of attention that are ongoing when using AAC, several additional theoretical models of working memory will be reviewed. The discussion of additional working memory models provides for a more comprehensive and integrated consideration of how working memory may be utilized and long-term memory accessed when using complex AAC systems. Analysis and review of these models enhances the understanding and background for the

discussion of the cognitive processes associated with working memory that contribute to successful use of AAC. These models of working memory are not as frequently referred to in the AAC literature as Baddeley's (1998, 2002, 2007) model, however the references to integration of sensory systems, attention management, and interaction between and retrieval from long-term memory processes have relevance to the considerations of the competing cognitive processes and attention requirements for successful use of AAC.

The first of these models to be considered is that of Cowan (1988, 2001, 2005), who proposed a working memory model focused upon memory activation and encoding of tactile-sensory, phonological and visual-spatial information. This model of working memory theorized that visual, auditory, and spatial representations in working memory were subsets of representations in long-term memory. Working memory is present at two levels: 1) activated components of long-term memories, or "activated memory" (Levin, Thurman, & Kiepert, 2010, p. 120), which is unlimited, and 2) a restricted target of attention, considered being consciously a part of the activated memory. Similar to Baddeley's (1998, 2002, 2007) model of working memory with a central executive component directing attention and having a limited capacity, the second element of Cowan's model was characterized by restricted capacity, focused upon attention, and networked between concurrently activated items, which are subsequently merged into long-term memory ("Introduction to Working Memory", 2007; Levin, Thurman, & Kiepert, 2010).

Another older model of working memory to be considered is that of Ericsson and Kintsch (1995), which theorized about working memory with a focus on long-term working memory. Ericson and Kintsch (1995) proposed a working memory model

comprised of bundling small informational chunks and then unbundling them for linkage through a retrieval process. The authors identified the temporary storage of information as being short-term working memory. Long-term working memory is a stronger storage process. Attention is required to focus on enough prompts to obtain information residing in long-term memory. It is the recovery cues in short-term working memory that enable necessary information in long-term memory to be accessed and used when an individual is engaged in activities of extreme skill, thereby increasing the overall capacity of working memory (Ericsson & Kintsch, 1995; "Introduction to Working Memory", 2007; Levin, Thurman, & Kiepert, 2010; Paas & Sweller, 2012).

The final working memory model to be considered is the unitary model of short-term memory of Chuah and Maybery (1999). The authors support a unitary model of short-term memory, rather than a working memory model with unique verbal and visual-spatial subsystems. Examining their proposal, the authors assessed verbal and spatial span development associated with short-term memory with 60 children evenly divided across the age spans of 5-6, 8-9 and 11-12 years of age. Verbal and spatial spans were identified as the criterion tasks with articulation rate, tapping rate, verbal speed of search and spatial speed of search utilized as the predictor tasks. Results revealed improved performance on all measures for age groups 5-6 years to 8-9 years and 8-9 years to 11-12 years, with articulation rate, tapping rate, and speed of search impacting age-associated increases in verbal span and spatial span performance. It was found that articulation rate or tapping did not show a developmental association independent of speed of search. Additionally, articulation rate made similar contributions to verbal span and spatial span. The authors judged that the research results were similar to "speed of processing" (p. 25)

and unitary models of working memory, suggesting that verbal and spatial spans seem to be dependent upon similar sources of development. They noted that age did not appear to be a major contributor to recall in the absence of other contributing resources. The authors concluded that short-term recall was represented more by a unitary system rather than separate verbal and visuospatial systems as described in the more traditional working memory model describing discrete subsystems.

These various models of working memory have been presented to provide a context for processing the research related to working memory and AAC and to enrich understanding of the cognitive processes associated with AAC addressed in the survey. The multiple theories of working memory functioning maintain several consistent factors: working memory capacity is limited; time and complexity of content is significant to the amount of information that can be retained; managing content within chunks can extend overall capacity; distractions contribute to content decay; and utilization of some form of reactivation or rehearsal can be used to prevent content decay (Baddeley, 2000; Barrouillet, Portrat, & Camos, 2011; Cowan, 1988, 1999; Cowan, Rouders, Blume, & Saults, 2012).

#### *Working Memory and Alternative and Augmentative Communication (AAC)*

The next section of this paper reviews two aspects of the literature: 1) that discussing the cognitive; and 2) working memory processes engaged within the context of using AAC and research related to the discussion of AAC use and working memory related processes. Examination of how researchers within the field of AAC perceive working memory and cognitive processes interacting during successful use of AAC provides a background for discerning the strength of the relationship between AAC and

working memory processes.

### *Using AAC and Cognitive Processes*

Light and Lindsay (1991) provided a discussion of cognitive science as it relates to the use and architecture of AAC systems, specifically within the scope of how AAC users “learn, remember, and communicate with others” (p. 187). They suggested that multiple forms of sensory information input and “recoding” (p. 187) characterize the first step in cognitive processing. Sensory memory is thought to have limited duration and variable capacity (Averbach & Coriell, 1961; Broadbent, 1958; Cowan, 1988, 1995; Crowder, 1982; Crowder & Morton, 1969; Rostron, 1974; Sperling, 1960). Light and Lindsay (1991) noted that there is limited information available regarding how well users of AAC access and process sensory information. They proposed that awareness of working memory content was greater than that of basic sensory information and that working memory capacity also appeared to have a much greater impact overall upon cognitive capacity. Light and Lindsay (1991) point to several factors associated with AAC use that have the potential to be stressors upon working memory: maintaining attention to an intended message; processing symbols, words or pictures that have already been accessed within the message formulation process; limited vocabulary experience; inability to use writing to facilitate recall; the time required to practice access to achieve automaticity; changes in device development and programming; and the use of encoding techniques such as Morse Code or Unity® which require the AAC user to retain the code in addition to maintenance of the formulation process and progress within the message generation activity (Prentke-Romich Company, 2012). Strategies suggested for managing these stressors to working memory within the AAC process include: the

development of “automaticity” (p.189) (e.g., overlearning), organizing and scaffolding displays of content to be recalled (e.g., letter or word associations to trigger recall), and utilization of aids to recall (e.g., visual display of message progression) (Light & Lindsay 1991; Wagner & Jackson, 2006).

Thistle and Wilkinson (2011, 2013) provided comprehensive reviews of the working memory demands when using aided AAC for individuals with developmental disabilities. The authors indicated that the use of augmentative and alternative communication places significant demands on attention for the processing of cognitive and sensory information. To successfully use AAC, the individual accesses short-term memory (STM) functioning when engaged in choice-making from an array of symbols, needing to remember what symbols have been looked at to make the correct choice. The user also engages long-term memory (LTM) by having to recall symbols accessed in the past and where on the AAC system the symbol is located. For users, this can require recalling page, category, and symbol location simultaneously and sequentially while message formulation is ongoing (Thistle & Wilkinson, 2011, 2013). Thistle and Wilkinson (2013) suggest that attention shifting and active processing associated with working memory are required when individuals create syntactically correct messages through the recall of symbol locations, device navigation, self-monitoring and self-correction of accurate message formulation, responding and making choices in response to predictive cues. These activities require working memory to integrate the activities of STM and LTM for communicative success. Thistle and Wilkinson (2013) suggested that difficulties with working memory could impact users of aided AAC with symbol selection and location or symbol sequencing when working across multiple displays.

### *Research of Working Memory with Users of AAC*

Introducing the concept of phonological working memory and complex communication needs (CCN), Larsson and Sandberg (2008) point to the body of literature suggesting that phonological awareness was highly predictive of literacy success and that multiple studies have demonstrated reduced memory ability for verbal content with nonverbal individuals. While children with CCN appear to develop sound awareness and phonological structure, they do not seem to be able to transfer these skills to phonological processing of printed or pictorial content to the same degree as those without CCN. Phonological working memory has been the focus of two studies (Larson & Sandberg, 2008; Taibo et al., 2010) with children presenting complex communication needs. The results of these two studies inconsistently identified specific weaknesses in phonological working memory. Overall, the studies do suggest that phonological memory processing in children with CCN is different from that of children presenting normal speech-language development. Additionally, the concept of subvocal rehearsal contributes to the discussion of phonological memory and has been the focus of several studies with individuals presenting CCN or part of a larger study looking at phonological working memory (Sandberg & Hjelmquist, 1996, 1997; Foley & Pollatsek, 1999; Larson & Sandberg, 2008; Murray & Goldbart, 2011). Subvocal rehearsal appears to have an impact on the storage or processing of phonological content (Larsson & Sandberg, 2008) or to be related at some level to working memory processes (Sandberg & Hjelmquist 1996, 1997; Murray & Goldbart, 2011).

A weakness in overall phonological memory processes were suggested by Larsson and Sandberg (2008) who compared memory performance of children with

complex communication needs (CCN) and cerebral palsy with that of children presenting typical speech-language development. The authors examined whether the inability to articulate speech sounds directly impacted subvocalization and memory capacity of individuals presenting complex communication needs using AAC, hypothesizing that in the absence of overt articulation skills children presenting CCN and cerebral palsy would exhibit difficulty constructing and storing phonological content within the phonological loop, resulting in weaker phonological memory. Performance on visuospatial tasks was expected to be similar between the two groups. The children in the study using AAC employed Bliss symbols to communicate which the authors considered to be a task dependent primarily upon visual memory skills. Bliss symbols or “Blissymbolics” (Blissymbolics Communication International, 2016, n.p.) refers to a symbolic language system that is composed of over 5,000 symbols. The symbols are semantically based and can be combined in many ways to create new words, as well as syntactic and grammatical structures (“Blissymbolics Communication International”, 2012, 2016). The subjects were matched comparatively by gender, as well as mental and linguistic age measurements. The children with CCN and cerebral palsy responded through direct selection or partner-assisted scanning with extra time allowed for task completion. Utilizing tasks designed to measure phonological short term memory, visuospatial short term memory, phonological working memory and visuo-spatial working memory, results revealed that children without disabilities exhibited stronger performance on all measures, with the exception of the phonological working memory test. Within their discussion, the authors suggested that poorer performance on the phonological short term memory test reflected impaired articulation ability resulting in diminished ability to build and store

phonological units, which then faded more easily and impacted phonological short term memory. The one measure that individuals with CCN showed significantly better performance was the measure assessing phonological working memory. The authors suggested that this difference may have been a consequence of, when controlling for linguistic age, the children in the typical comparative group were younger and not accustomed to the digit names. Another possible suggestion was that the children presenting CCN had difficulty with storing phonological content associated with short-term memory, yet, when adding a processing component within the working memory task, children with CCN could compensate for weaknesses in storage. The authors suggested that these results supported their hypothesis that children with CCN exhibited reduced function of the phonological loop. The suggestion was that the absence of overt articulation skills negatively impacted the ability to construct and store phonological representations. The authors did not detect stronger visuo-spatial skills in the children using AAC, negating the hypothesis that locating symbols within a communication display would foster improved visuo-spatial memory skills. Use of a symbol system for communication did not appear to transfer to better performance on spatial and visual working memory or short-term memory assessments for children with CCN. Overall, the authors suggested the variations in memory performance evidenced by the children with CCN invite discussion that memory difficulties for individuals within this population indicate a more broad weakness in phonological memory functioning, rather than specific weaknesses in phonological working memory.

Taibo et al. (2010) researched the impact of working memory and phonological skills upon literacy performance in adults 16-34 years of age with cerebral palsy

presenting CCN and using AAC. One of their hypotheses was that individuals using AAC presenting higher working memory capacity would show stronger reading and spelling skills than those presenting lower working memory capacity. The authors formally and informally attempted to measure vocabulary knowledge, language comprehension and grammar/syntactical structure for each participant within the study. For the purposes of the study, each participant was assigned to one of two groups: low working memory capacity or high working memory capacity using a measure of digit span recall and accommodating for fatigue experienced by the AAC users by removing time restrictions during formal assessment. Results revealed statistically significant stronger reading and spelling skills for individuals using AAC exhibiting high working memory skills. These strengths were only significant for reading words, spelling picture names and knowing orthographic patterns. The authors suggested that once the knowledge of orthographic patterns was developed and the acquisition of a visual sight word vocabulary was established, working memory aided reading performance, thereby allowing for easier ability to visually recognize written words. There existed the possibility that stronger working memory provided for improved abilities to store phonological information and maintain visual orthographic representation, therefore providing more resources for processing linguistic content.

It has been suggested that working memory in individuals presenting CCN is compromised by impaired subvocal rehearsal related to their presentation of impaired articulation rate and/or production. Murray and Goldbart (2011) explored subvocal rehearsal by examining the impact of input mode and word classes on subvocal rehearsal with children presenting cerebral palsy (CP) and those without CP. Results revealed that

mode on input did not have a significant difference in their use of subvocal rehearsal, although it appeared the children without disabilities utilized a larger variety of working memory strategies during the tasks. The authors reported that this resulted from possible differences in phonological working memory for the children with CP. In a series of studies investigating phonological ability with young children using AAC, Dalhgren, Samberg and Hjelmquist (1996, 1997) showed that children using AAC exhibited difficulty with the synthesis of phonemes and the analysis of word length, although when children using AAC developed the ability to read, they showed improved performance on measures of memory, sound identification and word length. Foley and Pollatsek (1999) showed that adults presenting anarthria and dysarthria were able to exhibit patterns of recall, demonstrating that, while the ability to overtly articulate sounds was beneficial to phonological memory encoding, it was not a necessary skill.

*Motor Performance When Using AAC and Working Memory and Working Memory Processes*

The final area of literature to be reviewed for the purposes of this study is examination of the demands upon attention and memory related to motor learning and complexity reflecting the complex motor actions and attending skills associated with direct selection or scanning activities for users of AAC. The motor activity associated with AAC is not a naturally learned activity and is not modeled frequently by others during the learning process. Motor skills and knowledge, which are learned more inherently or “biologically” (Paas and Sweller, 2012, p. 40) and through collective learning processes permit the opportunity for reduced stress upon the cognitive load associated with working memory activities. Wassenberg, et al. (2005) found that within a

population of normally developing 5 and 6-year-old children working memory was positively related to motor performance. Sasisikaren, Smith, Sadagopan, & Weber-Fox (2010) point to research in the area of higher level motor skill acquisition suggesting that, when learning new motor skills, adults and children experience “neural noise” (522) and increased inconsistency in motor movements. In terms of attentional control, Redick, Calvo, Gay, & Engle (2011) referred to the “executive attention account” (p. 321) of working memory capacity theory proffered by Engle and Kane (2004) and Kane, Conway, Hambrick, & Engle (2007) proposing individuals with higher working memory capacity have a better ability to control attention during episodes where the individual experiences significant task interference. Redick et al. (2011) point out that individual differences in working memory capacity impact information that is kept current and used for processing, whereas Unsworth and Spillers (2010) found that individuals with higher working memory capacity were able to recollect content with increased speed, efficiency, and correctness.

Scanning, as a selection strategy when using AAC, has inconsistently been found to place more demands upon memory skills than direct selection most likely due to the impact of time required for scanning and the dependency upon long-term memory associated with scanning activities. Individuals using scanning in a time efficient manner must have in long-term memory a location for each meaningful symbol and develop automaticity over time with practice. This enables the user of AAC to focus on message development rather than the activities of selection (Horn & Jones, 1996; Mizuko, Reichle, Ratcliff, & Esser, 1994; Wagner & Jackson, 2006). Adopting a “developmental resource-allocation perspective” Wagner and Jackson (2006, p. 115) investigated the cognitive

demands of visual linear scanning and direct selection between normally developing kindergarten, first, and third grade children. Their findings suggested that scanning demanded more from the children cognitively than did direct selection. They described these cognitive demands to be associated with holding content in working memory for longer periods of time while waiting for the cursor to move across symbols prior to selection, lack of automaticity during scanning, and individual motivation. Mizuko and Esser (1991) researched differences between direct selection and linear-sequential scanning related to short-term visual memory, with four year-old children presenting no disabilities. No significant differences in memory skills were found related to selection strategy. Mizuko et al. (1994) continued investigating short-term visual memory differences with four-year old children without disabilities using direct selection and row-column scanning, varying the size of the AAC symbol designs. Results revealed improved recall within the direct selection condition when the array size was larger, suggesting that row-column scanning may have been more taxing of the cognitive skills involved in AAC symbol selection for normally developing children.

## *Summary*

Working memory is most often described as a system with limited capacity, providing a strategy for temporarily maintaining information while completing additional processing and transfer of information to and from long-term memory. Working memory is considered to impact an individual's cognitive development within the areas of reasoning, reading, language and vocabulary development and academic development (Baddeley, 1986; Conway et al., 2005; Riding, Grimley, Dahrae, & Banner, 2003; Unsworth, 2007; Unsworth & Engle, 2007). A significant component of this process is attention to task, and research indicates that individuals described as presenting high working memory capacity are able to direct attention to task with greater success and suppression of interrupters to the memory process (Redick & Engle, 2006; Redick, Heitz, & Engle, 2007). Successful communication while using a complex AAC system is a task which appears to rely on working memory significantly for task completion due the involved processes that are part of communicating with AAC. These processes include: attention to task, use of long-term memory for target location and recall, management of complex and atypical motor movements, managing and attending to the conversational experience using nontypical communication strategies, and a background of language learning that may be delayed, poorly modeled and unconventional.

Communication competence for individuals using AAC should include consideration of what communication strategies will be utilized and what messages will be communicated within the context of the situation (Nelson, 1992; Todman & Rzepecka, 2003). Bedrosian, Hoag, and McCoy (2002) suggested that the atmosphere of social

engagement where the focus is more upon enjoying a positive interaction and developing relationships is a situation when the time involved in message generation may be of higher consideration. Conversational rate, reduced pause times, increased conversational spontaneity of communication, and length of the AAC generated utterance have been found to be positively associated with children's attitudes regarding communicative competence and engagement (Beck, Kingsbury, Neff, & Dennis, 2000; Todman, 2000). Within the context of conversation, partners understand that individuals using AAC are required to make decisions regarding pause time and message type. A study of aided conversations using "whole-utterance" (Todman and Rzepecka, 2003, p. 233) raters agreed that conversations characterized by shorter pause times provided increased communication competence. They did note, however, that different AAC users achieved different ratings of communication competence, suggesting that varying degrees of experience with AAC can create differences in rater's opinions of competence outside of the scope of pause time in isolation (Todman and Rzepecka, 2003). Light (1989) indicated that communication competency for individuals using AAC was based upon knowledge, judgment, and skill in four specific areas: linguistic, operational, social and strategic. Linguistic and operational competencies are associated with use of tools, while social and strategic are related to knowledge and judgment of use. Light (1989) proposed that these four communication competencies were interrelated and individuals using AAC must synthesize and master each skill set in order to achieve communication competency.

It is apparent that achieving communication competency is a difficult and long-term process for the users of AAC, with multiple factors impacting communicative

success. While no specific reference to working memory was cited when specifically discussing communication competency, it would seem that achieving communication competency could not exist without significant dependency upon working memory skills as reflected in the literature related to the cognitive processes involved with using AAC. Consistent and competent use of high-tech AAC systems requires integration of linguistic, social, motor, and sensory systems while using an atypical communication strategy. Designers of AAC systems and language programs, as well as therapists working with users of AAC have developed strategies and design features to facilitate increased learning, language complexity and competency. These strategies include color-coding, encoding, predictive vocabulary, partner-assist, and categorical strategies. The user of AAC works to develop automaticity with their systems, however, they are continually expected to process and express the linguistic features of their native language, while simultaneously accessing the symbols, vocabulary and semantic components unique to their AAC system. Essentially, the individual may be processing and encoding two language systems within a restricted time span to maintain social-effectiveness in conversations. Developing a degree of automaticity and use of design and learning strategies would appear to significantly reduce this cognitive load and decrease stress on working memory. It is suspected, however, that working memory is also significantly involved in the use of complex AAC (Light & Lindsay, 1991; Thistle & Wilkinson, 2011, 2013). It is challenging to complete effective and transferrable studies attempting to determine the relationship between working memory and AAC use as a consequence of the unique communication characteristics associated with complex AAC, the heterogeneity of the population of AAC users, and the atypical language development

process and skills that users of AAC may represent. It is within the context of these difficulties and the extreme amount of attention to task to be communicatively successful that this study has evolved.

## CHAPTER 3

### RESEARCH METHODS

This study utilized a qualitative methodology. Improved understanding of the role of working memory when using augmentative and alternative communication (AAC) can be achieved through investigation of the cognitive processes users of AAC engage in the conversational process. Two qualitative methodologies were utilized to collect data from adult users of complex AAC: A brief structured biographical survey, with additional survey items of Likert-like questions, and a less structured personal follow-up of open-ended questions. These methodologies were employed as a means for developing insight into the concepts of working memory that impact successful use of AAC within the conversational process.

In order to obtain data that would reflect a high degree of accuracy, participants were adult and older-teen users of AAC. Focusing on this restricted population set reflected some of the characteristics of “purposeful sampling” (Light, Singer, & Willett, 1990, p. 53) or “criterion-based selection” (LeCompte & Preissle, 1993, p. 69) that Maxwell (2005) referred to as a means of selecting specific individuals from which to gather information. It was expected that adult and older-teen users of AAC would provide responses characterized by a higher degree of accuracy of recall, and ability to comprehend survey questions.

To achieve validity of the process, the questions and selected response sets would be evaluated prior to administration by three professors from Temple University. These individuals represented a significant collective research experience in working memory, education, learning and cognition. Additionally, a fourth reviewer was a university-based

program director and instructional professional with substantial research, teaching and consulting experience in the field of AAC and intellectual disabilities. Study participants were solicited via Internet, AAC-related resources, as well as referrals from individual speech-language therapists, device consultants, and other professionals in the field of AAC. All participants were presented with multiple response options to choose from in order to complete the survey. From the population of survey participants, a smaller group of participants were solicited to respond to three open-ended questions, examining content areas from the survey with greater depth. It was expected that at least ten respondents would be solicited from the larger population group as surveys were completed and returned until at least ten follow-up surveys had been received. Once at least ten completed follow-up surveys were returned, survey respondents were no longer asked if they would be interested in completing the follow-up questions.

#### *Role of the Researcher*

The researcher in this study had responsibility to establish biases, beliefs or expectations, and values as a preface to the study. This researcher had been a practicing Speech-Language Pathologist for 34 years, specifically working in the field of Assistive Technology (AT) and Augmentative and Alternative Communication (AAC) for approximately 14 years. Personal professional experience included working within the public schools, university settings, physician's office, hospitals, and private practice. The researcher presented on implementation of AT and AAC at national and international conventions, conferences, professional organizations, and community agencies, instructed undergraduate and graduate students, and consulted with families and AAC users. At the time of the study the researcher was a speech-language pathologist (SLP)

and AT/AAC consultant within private practice. The researcher was a member of American Speech-Language-Hearing Association (ASHA), Council for Exceptional Children (CEC), and International Society for Augmentative and Alternative Communication (ISAAC). The researcher was licensed to practice speech-language pathology in Maryland, Delaware and Pennsylvania. The researcher believed that the experiences in the field of AAC contributed to the development of an awareness and conceptual basis for the skills and expectations users of AAC face when using an AAC system for communication. Additionally, the researcher was aware of her personal preferences for specific AAC systems and made all possible efforts to be objective and recognize personal biases during data collection and analysis. The researcher was aware of the importance of considering the opinions and ideas of other professionals and researchers as a means to further understand study participants.

### *Participants*

In order to collect purposeful data, participants for this study met several criteria. Participation was based upon convenience and criterion sampling procedures (Patton & Cochran, 2002). Criteria established for participant sampling included:

- Use of current high-tech AAC system for a minimum of two years
- High-tech AAC was defined as dedicated AAC systems, integrated AAC systems, and use of communication apps on tablets that permitted some generative language responses.
- Residence within family home, group home, rehabilitation facility, or independent-living environment.

- Ability to complete survey and interview with independently generated responses. Family members or an assistant were able to code responses.
- Within the age range of 16 years and above.

Individuals for participation were solicited through professional and special interest Internet-based resources, contacts enabled via AAC device manufacturer representatives and those obtained from the researcher's professional peer community. Some users of AAC utilize caregiver support when using AAC during conversational interactions. To obtain a representation of the participants' degree of individualized responses, each participant was asked if they responded to the survey themselves or with the support of another individual. The total subject pool was expected to be between 20-35. This number was expected to be small (i.e., 15-30 participants) based upon AAC users' physical access to the Internet, access to literacy, and ability to self-nominate for study participation.

#### *Date Collection*

Prior to completion of all data collection, consent was obtained from all participants (See Appendix C). All responses were reported in a confidential manner to protect the identity of the participants. A protocol of surveys and follow-up, open-ended questions were employed to collect data. The aim of the surveys and interviews was to identify cognitive processes related to working memory impacting conversational success when using AAC. Two question protocols were developed for this study. The first was a 28-question survey (Appendix B). The second was a three, open-ended question, follow-up questionnaire (Appendix A) completed by the researcher with at least ten participants.

These participants were selected on a sequential basis as they completed the survey and agreed to complete the follow-up questionnaire.

### *Survey*

The survey responses were collected via multiple methods based upon participant preference. The options presented to potential participants included: e-mail, Smartphone or computer conferencing options (e.g., FaceTime or Skype), on-line survey access (i.e., Survey Monkey), personal meeting, or telephone. When responses were obtained through Internet and/or telephone conferencing, the researcher sent to the participant a printed copy of the survey and answer options prior to contact. The opportunity to engage self-administered surveys reduced the chance of interviewer bias (“Questionnaire Design and Analyzing the Data Using SPSS”, n.d.). The survey contained questions related to demographics, strategies used to maintain communication effectiveness, communication competency, AAC design features, message formulation, and behaviors or activities associated with cognitive processes reflecting working memory activity. The open-ended questions focused upon: factors impacting communication breakdown, and the processing demands associated with the use of AAC to communicate. The primary intent of the survey was to obtain data from adult users of AAC that informed content reflecting the cognitive processes associated with working memory employed when using AAC during conversation.

### *Interview*

The purpose of the follow-up questions (Appendix A) were to provide an opportunity for AAC users to respond with increased measure to selected items from the

survey, to provide any comments or suggestions surrounding the survey content, as well as the use of AAC success relative to design. These are factors that provided knowledge for clinicians, designers of AAC systems and future researchers working with users of AAC and working memory skills. The interview was conducted via Smartphone, telephone, Internet video conferencing options (e.g., FaceTime or Skype) or e-mail.

#### *Documentation of AAC Use*

At the beginning of the question survey, all participants responded to questions providing biographical content (Appendix B). This content provided information regarding: specific AAC system used, length of time current AAC system had been used, use of facilitator during survey completion, age introduced to AAC, age and sex of participant, educational history, and current residential setting.

#### *Participation Incentive*

Participants in the study were provided with a financial incentive of a \$25.00 Amazon Gift Card or Visa/MasterCard Gift Card for completing and returning the survey.

#### *Validation Strategies*

There are multiple validation strategies that can be applied to qualitative research. This researcher approached the present study from perspectives of being trustworthy, authentic and credible (Creswell & Miller, 2000). Trustworthiness was demonstrated by performing in a credible, transferable, dependable, and confirmable manner during data collection. Credibility was demonstrated through the careful collection of data, awareness and familiarity with the population of participants, purposeful sampling, and review of survey questions and response options by researchers, instructors and

consultants in the content areas of working memory and AAC. Transferability was demonstrated by providing accurate reflection of the reported participant characteristics and conditions. Dependability was demonstrated by concise description of the research process, including design and planning, data collection and evaluation of the inquiry process. Confirmable manner was reflected by the researcher's use of a "data-oriented" (Shenton, 2004, p 72) approach to data collection and analysis resulting in an objective reflection of the participants' responses independent of the researcher's opinions.

The researcher provided interpretive validity by interpreting the data and developing conclusions that realistically reflected the participants' responses such that the interpretation of data was useful, contextual, well documented and authentically reported (Altheide & Johnson, 1994; Hale, 1993; Wakkary, 2008). Several additional specific strategies to assure validity were employed during this research. One strategy was to clarify or provide comment regarding this researcher's previous professional experiences and biases that might have impacted the investigative process, questions, observations or interpretations. Additionally, the survey questions, as well as the follow-up questions, were reviewed by professionals actively engaged in research, instruction and consulting in the fields of AAC, learning, cognitive development, and working memory as a means of considering the validity of the questions being directly related to content associated with working memory and AAC. Two data sources, survey and follow-up questions, were employed as means of collecting data. The surveys were available to the participants in multiple ways to provide participants options for responding as accurately as possible with respect to their individual motor and communication needs (Creswell, 2003; Ghrayeb, Damadaran, & Vohra, 2011). Data characterized by noted deviations

from the response pool obtained was identified during data analysis as an additional strategy of improving validity (Patton & Cochran, 2002). To facilitate content validity the questions on the survey were selected based upon their direct relationship to the research questions and the components of working memory. Ambiguous and leading questions were eliminated from the survey. To facilitate internal validity a neutral response option was provided to encourage participants to respond should they truly feel they did not have an opinion (Hill, 2009). It was assumed that all respondents would not answer some questions. Survey questions characterized by 25% or more respondents not coding at least a single answer were to be omitted from the final data analysis. Individual items with missing data were coded as No Response in final data reporting. It was also recognized that the survey was voluntary and may represent only a subset of the total population of AAC users. Respondents were characterized by several common features: access to avenues for solicitation, possibility of assistance to complete the survey, receptive language skills adequate for processing survey questions, opportunity to return mail, return phone or internet contact, access to the Internet, and motivation to contribute to the research endeavor. Additionally, the financial incentive may have encouraged participation by some individuals who would not have participated without such incentive.

### *Data Analysis*

The statistical methodology typifying analysis of quantitative data, which is characterized by clear and unequivocal numerical data, was not employed for data analysis within the current study. Qualitative data, obtained within the current study, was exemplified by less straightforward data analysis, requiring the use of analytic strategies

accommodating the irregular data obtained from surveys. There were three data analysis processes reflecting three different data collection strategies: single answer survey questions, Likert-like items and more in-depth follow-up questions. Analysis of demographic data and responses to Likert-like questions enabled the researcher to examine associations between respondent characteristics and content directly related to the primary research question: What cognitive processes associated with working memory users of complex AAC engaged when productively employing AAC in the conversational process? The data were archived in hard and digital copies. Follow-up question responses were recorded, transcribed and saved in hard and digital copies. Each survey was coded numerically for identification to maintain anonymity. Likert-like items were employed as a means of obtaining data regarding the degree to which participants agreed or disagreed with the significance of some items. Additionally, the data collected regarding specific skills within follow-up questions allowed for a more broad measurement of AAC skills, strategies and components of working memory. Descriptive statistics were utilized to code all demographic data. Average or mean scores for the following categories were described within nominal scales: age, years using AAC system, selection and access strategies, how survey was completed, educational level, and estimate of typical length of utterance. Likert scales were used most often to measure opinions, choices, and preferences. The questions within this survey that were measured by Likert-like items included content related to: factors associated with communication success, reading abilities, strategies for communicating, self-evaluation of communication skills, strategies for creating messages, skills associated with working memory, and degree of success when communicating (Dickinson, 2013; Gliem & Gliem,

2003; Gob, McCollin, & Ramalhoto, 2007; Hall, “How to Use the Likert Scale in Statistical Analysis”, 2012; Marston, 2009).

It was proposed that use of the Likert-scale format for questions with multiple possible answers or response sets would increase the potential for responses from study participants. The increased likelihood of participants responding to items could subsequently increase the reliability and validity of the overall measure. Survey questions in Likert-scale format are ordinal data. The data were evaluated as continuous data. Data analysis resulted in descriptive statistics presenting frequency distributions, median, mode, and summative information represented through the use of ordinary bar charts. The interquartile range was examined as a measure of variability surrounding the median, outliers or missing data. Use of the mean was not applied respecting the lack of equal distance measures between Likert-scale responses. Frequency distributions would demonstrate which skills or strategies were used more often and to what degree these variations occur. (Dickinson, 2013; Gliem & Gliem, 2003; Gob, McCollin, & Ramalhoto, 2007; Hall, n.d.; Hill, 2009; “How to Use the Likert Scale in Statistical Analysis”, 2011; Marston, 2009).

## CHAPTER 4

### RESULTS

**Survey.** Results of the survey were obtained from 27 participants. Participants were self-selecting in response to solicitation via social networking (i.e., Facebook, listserv participation), e-mail solicitation by augmentative and alternative communication (AAC) device representatives following e-mail contact from the researcher, e-mail solicitation by AAC language development company officer and e-mail solicitation by the researcher to adult users of AAC. Each respondent was provided with the survey in the format of their choosing, which included: e-mail, United States Postal Service, online survey access, or personal interview via Skype. The three follow-up questions were solicited of 11 respondents who completed and returned the survey. Respondents to complete the follow-up questions were solicited by the researcher directly as surveys were returned. Solicitations were ongoing until at least ten follow-up questionnaires were returned. Gift cards were provided to the participants upon completion and return of the original survey.

Biographical information about the respondent was the focus of the initial section of the survey, including content such as sex, speech-generating device (SGD) used, education and literacy. Respondents were 70.3% male (n=19) and 25.9% female (n=7). Response to this question was unclear on the returned survey for a single participant. Educational levels ranged from General Equivalency Diploma (GED) completion to Graduate or Law School. Speech generating devices (SGDs) reportedly employed by the participants included: Accent™ series (Prentke-Romich Company) 37% (n=10), ECO™ and ECO™2 (Prentke-Romich Company) 25.9% (n=7), Maestro™ (Tobii Dynavox)

7.4% (n=2), Proloquo2Go app (AssistiveWare®) on an iPad 7.4% (n=2), EZ Keys (words+) 7.4% (n=2), Assistive Express app (assistive apps) on an iPad 3.7% (n=1), C-Series (tobiidynavox) 3.7% (n=1), unspecified tobiidynavox AAC device 3.7% (n=1), Xpress™ (tobiidynavox) 3.7% (n=1), iPad Mini with unspecified language system 3.7% (n=1), and TouchChat HD app on unspecified tobiidynavox AAC device 3.7% (n=1). Two participants reported use of multiple AAC systems as part of their communication strategy.

Most participants completed the survey independently (77.7%, n=21). Fewer participants used the support and assistance of an aide, partner or family member (22%, n=6). Access strategies reported included: direct select (81.4%, n=22) and scanning (14.8%, n=4). A single participant (3.7%) reported use of two access strategies, direct selection and scanning. All participants, with the exception of a single individual, who did not respond to the question, reported range of utterance to be six or more words.

Surveyed literacy activities revealed participants to engage in a high level of reading and writing activities overall: 96.2% (n=26) read and wrote e-mail correspondence; 92.5% (n=25) read articles via the Internet; 81.4% (n=22) read a newspaper; 88.8% (n=24) wrote papers for presentations; 74% (n=20) read content for their employment; and 74% (n=20) wrote content for their employment.

The remaining parts of the survey probed the respondents' perception of behaviors or skills judged to be associated with working memory behaviors and strategies, as well as design features built into SGDs to support ease of accessibility and speed of message generation. To collect the above information, five primary questions related to message development when using an SGD were probed. Within each primary question

there were multiple sub-factors for the respondents to evaluate using a five-point Likert-like scale (i.e., Not Important, Somewhat Important, Important, Very Important, Necessary). Within each question set there were some participants who did not respond to all sub-factors. Omissions were considered within the descriptive statistics of median, mode and interquartile range.

The final aspect of data collection was three follow-up questions provided to eleven participants. These questions surveyed difficulties related to conversation and message creation when using a speech-generating device and management of the processing demands as perceived by the users of AAC. The questions provided the participants the opportunity to express personal observations and feelings without the constraints of a rating scale.

*When Having a Conversation, How Often Do You Experience the Following When Communicating With Your Speech-Generating Device?*

The first primary question addressed three sub-factors experienced when communicating with an SGD, using a Likert-like scale of: 1=Never, 2=Seldom, 3=Sometimes, 4=Most of the Time, 5=Always. The majority of respondents judged the sub-factors *successfully communicate your message and create a message that reflects what you want to say* as “most of the time” or “always”. Responses to the factor *get distracted when creating a message* demonstrated more variability than the previous two sub-factors, however, very few participants overall, judged that they became distracted “most of the time” or “always” when creating a message. Please refer to Figure 1 for a summary and Figures 2-4 for specific findings, median, mode and interquartile range values.

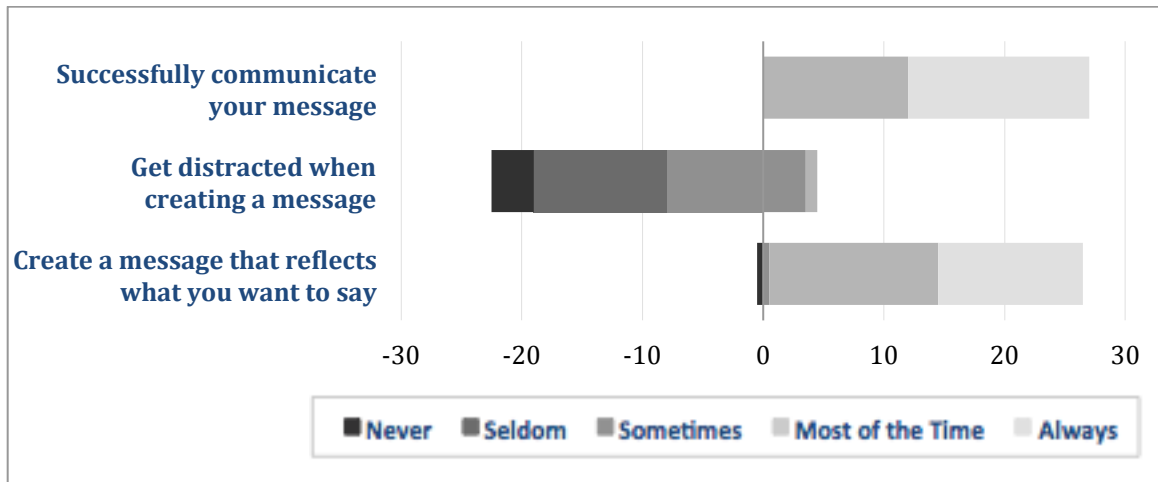


Figure 1. When having a conversation, how often do you experience these when communicating with your speech-generating device?

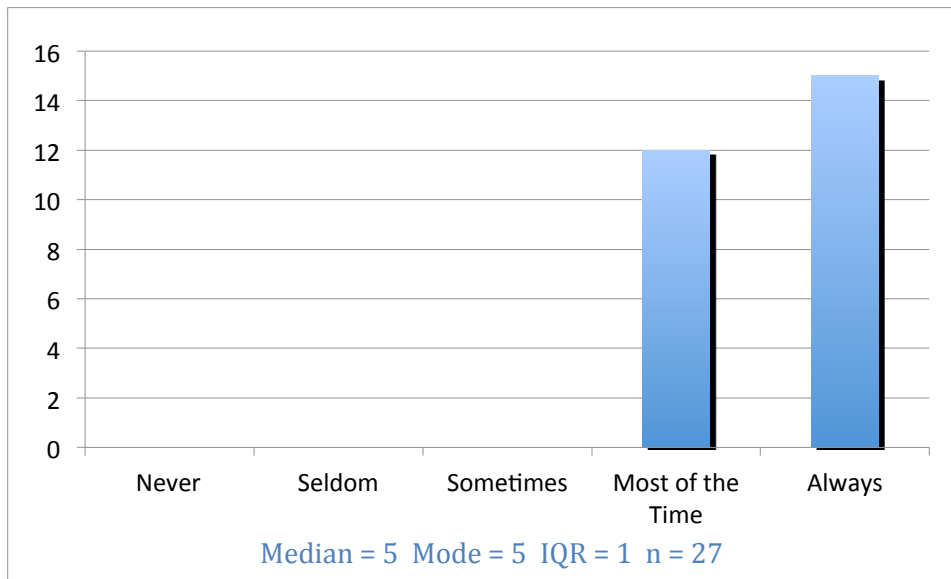


Figure 2. Successfully communicate your message

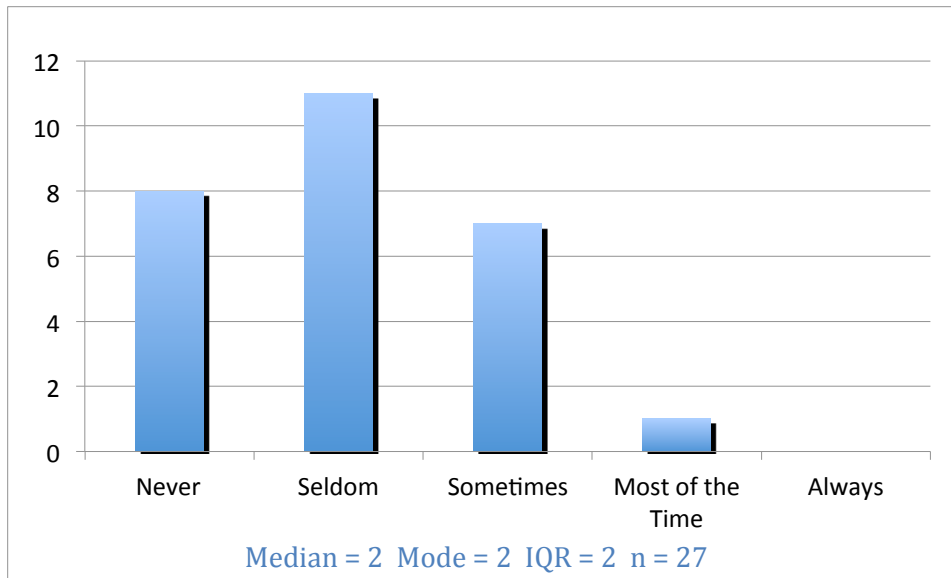


Figure 3. Get distracted when creating a message

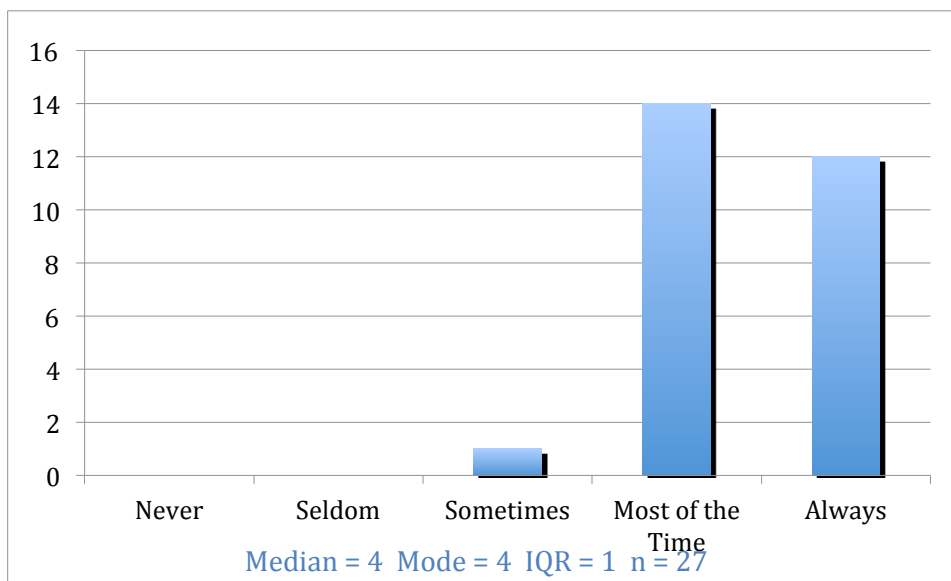


Figure 4. Create a message that reflects what you want to say

*How Important Is Each of the Following For Using Your Speech-Generating Device*

The second broader question asked the users of SGDs to evaluate the importance of multiple factors “*for using your speech-generating device*” (Figure 5), using a Likert-like scale of: 1=Not Important, 2=Somewhat Important, 3=Important, 4=Very Important, 5=Necessary to evaluate each sub-factor. Several factors revealed response patterns with

no dominant pattern. These factors included: use of auditory feedback while creating message, using categories and pages, memorizing symbol/page sequences, using motor pattern sequences, recognizing connection between symbols, being able to break a symbol sequence into smaller pieces, and combining new symbols with prestored phrases. The single factor exhibiting a dominant response pattern was length of symbol/word sequence, which was judged by few respondents as “not important” or “somewhat important”. Please refer to Figure 5 for a summary and Figures 6-13 for specific findings, median, mode and interquartile range values.

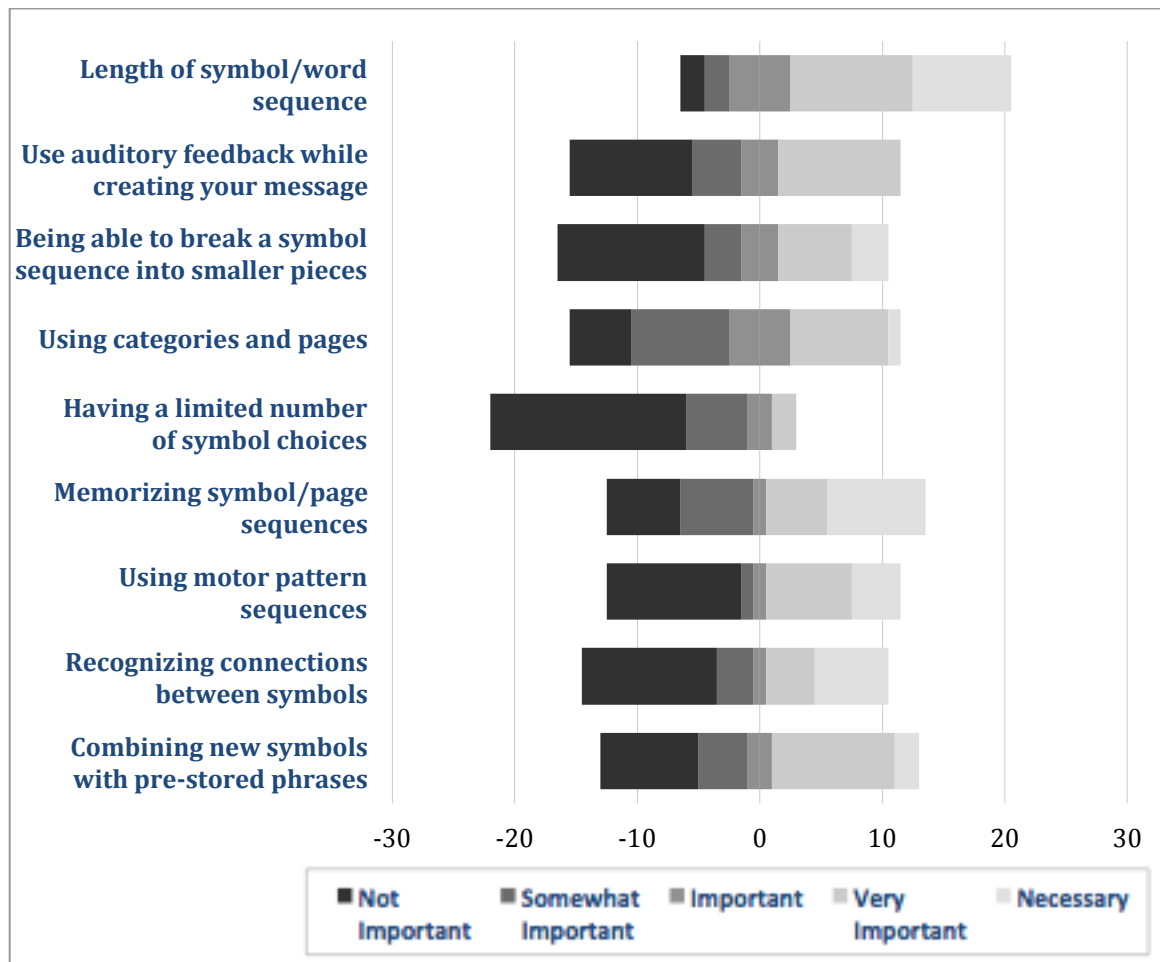


Figure 5. How important is each of these for using your speech-generating device?

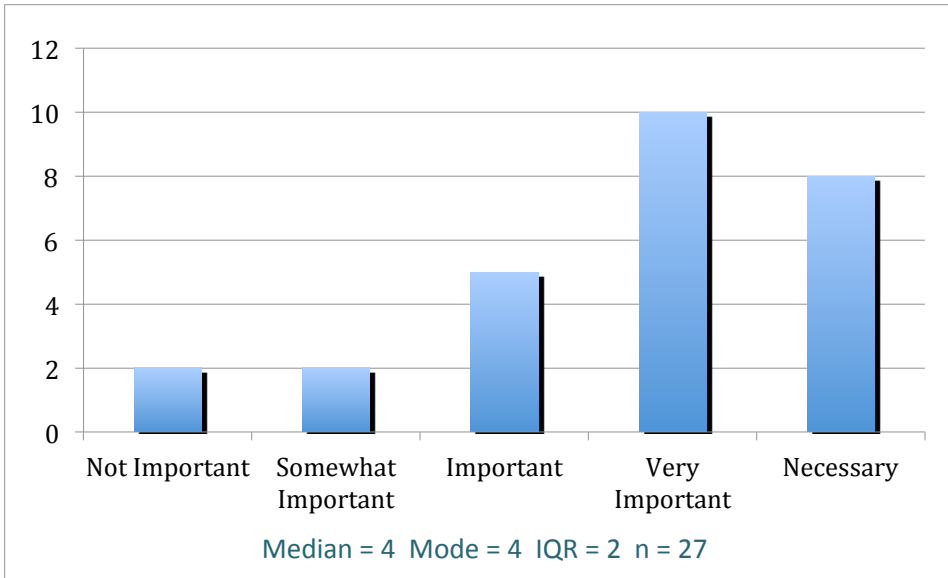


Figure 6. Length of symbol/word sequence

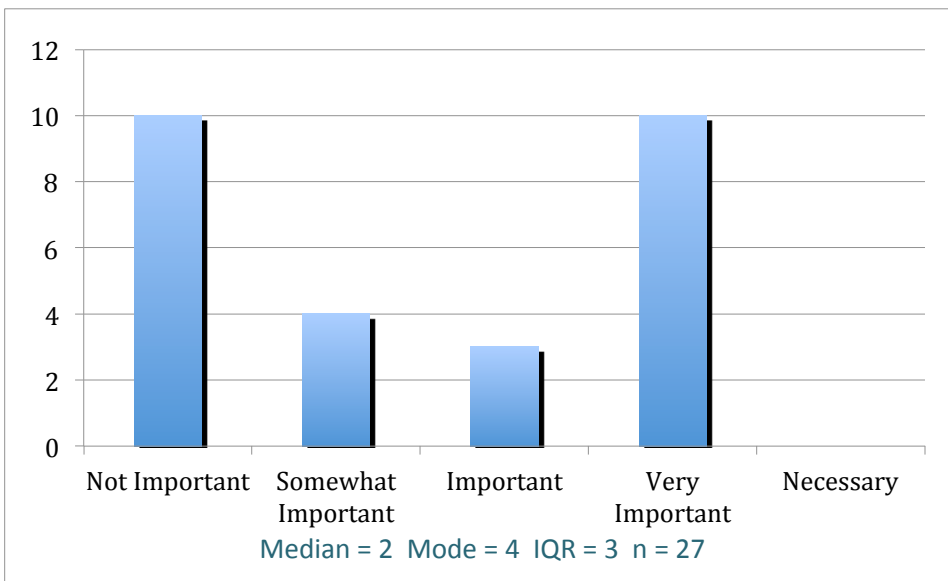


Figure 7. Use auditory feedback while creating your message

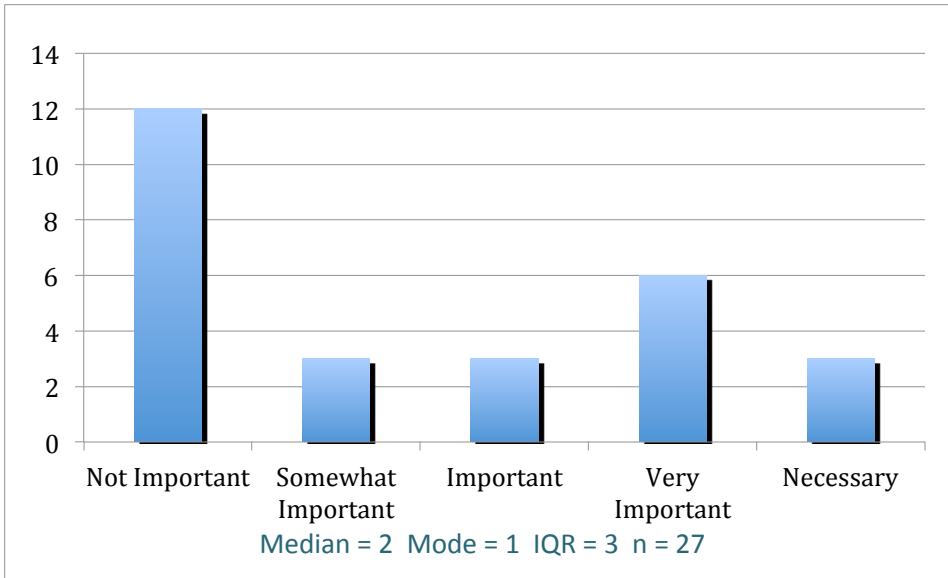


Figure 8. Being able to break a symbol sequence into smaller pieces

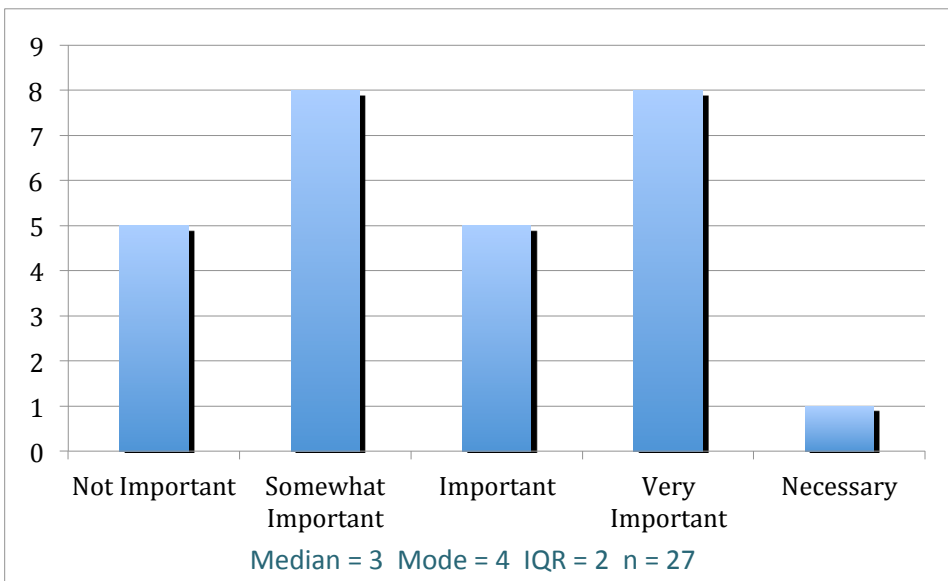


Figure 9. Using categories and pages

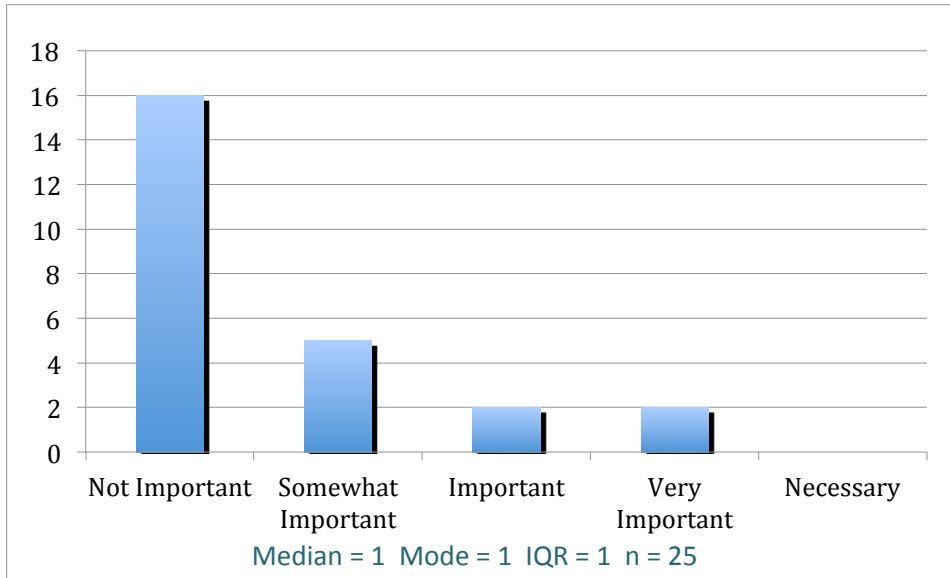


Figure 10. Having a limited number of symbol choices

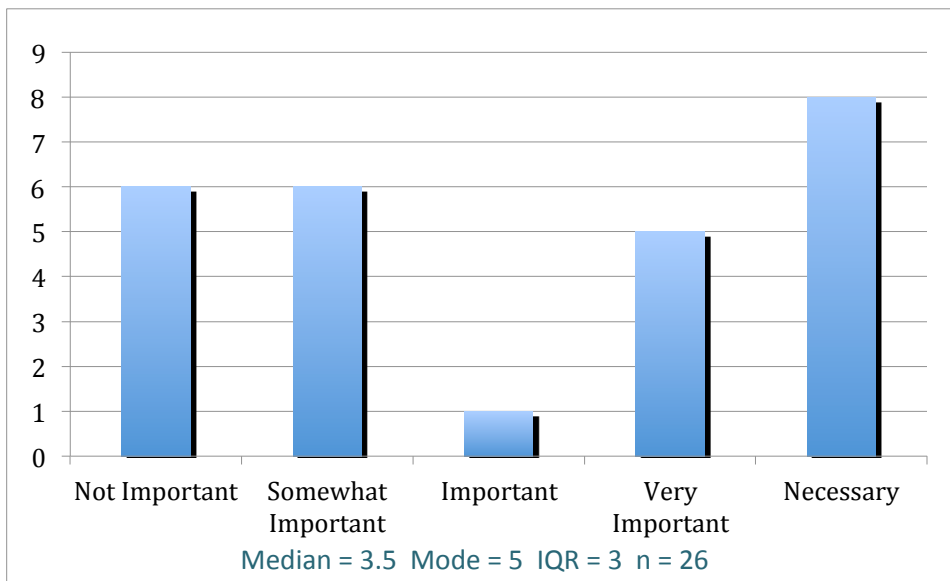


Figure 11. Memorizing symbol/page sequences

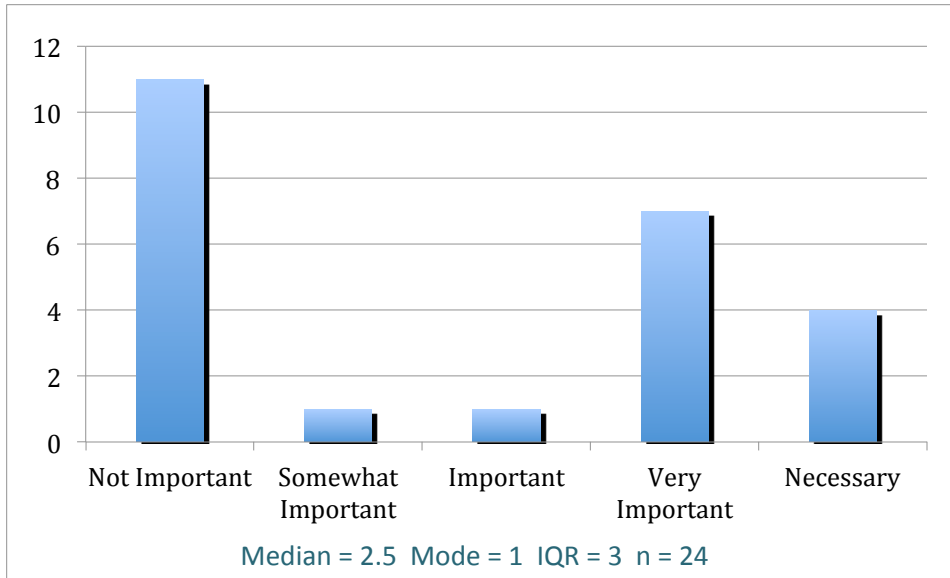


Figure 12. Using motor pattern sequences

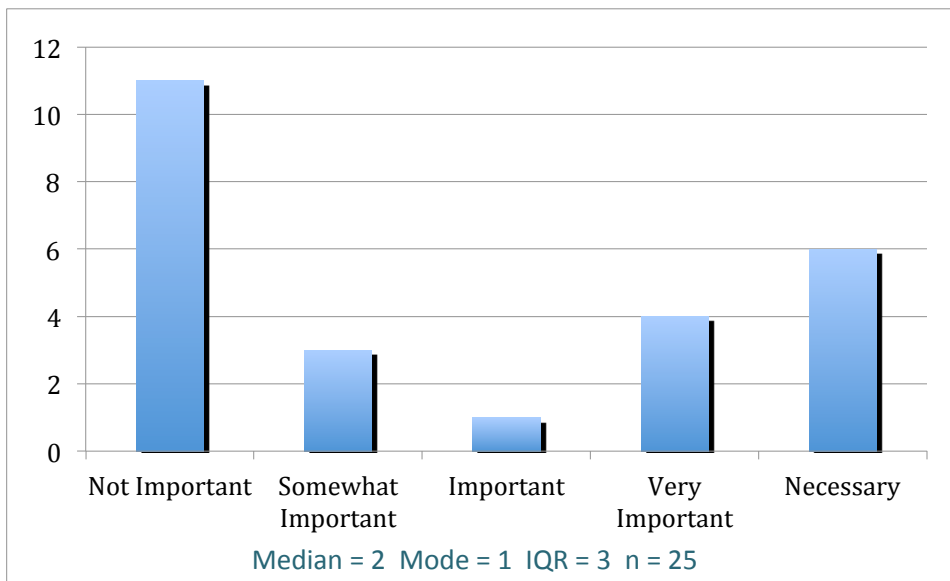


Figure 13. Recognizing connections between symbols

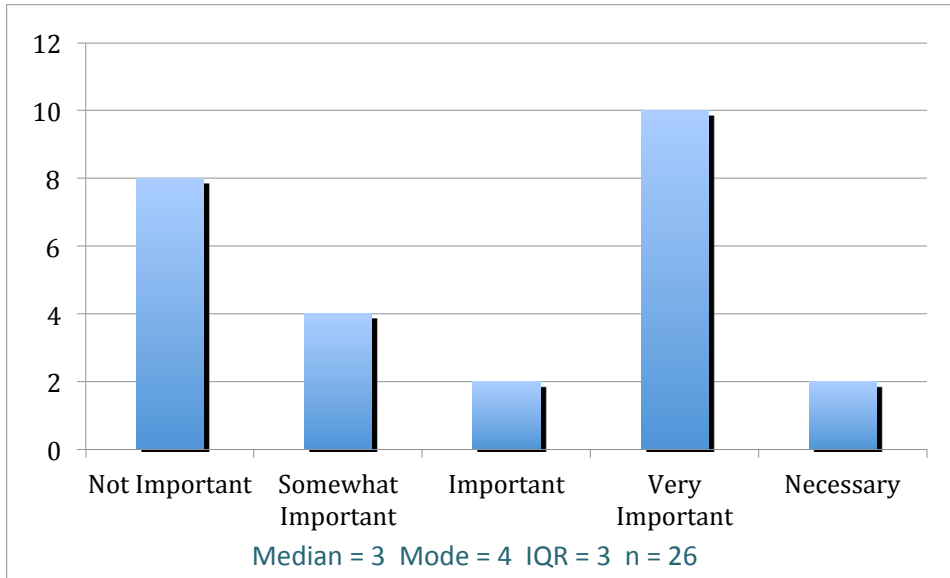


Figure 14 Combining new symbols with pre-stored phrases

*How important Is Each of the Following for Completing a Message Using Your Speech-Generating Device*

The next primary question addressed the importance of 13 sub-factors using a Likert-like scale of: 1=Not Important, 2=Somewhat Important, 3=Important, 4=Very Important, 5=Necessary. Multiple sub-factors evaluated were characterized by variable response patterns as evidenced by scattered rating responses. These factors included: color coding of targets, category associations, looking at the symbols on my AAC system, using motor movement, picture cues, keeping my messages short, breaking the message into small pieces, and relying on frequently used symbols. Sub-factors judged as being “very important” or “necessary” by a large number of respondents included: using word prediction, and seeing the message as I am creating it. The sub-factor use of icon prediction was characterized by a variable response pattern, however, there was a noticeable split in evaluation of importance primarily between “not important” and “very important”. Please refer to Figure 15 for a summary and Figures 16-28 for specific findings, median, mode and interquartile range values.

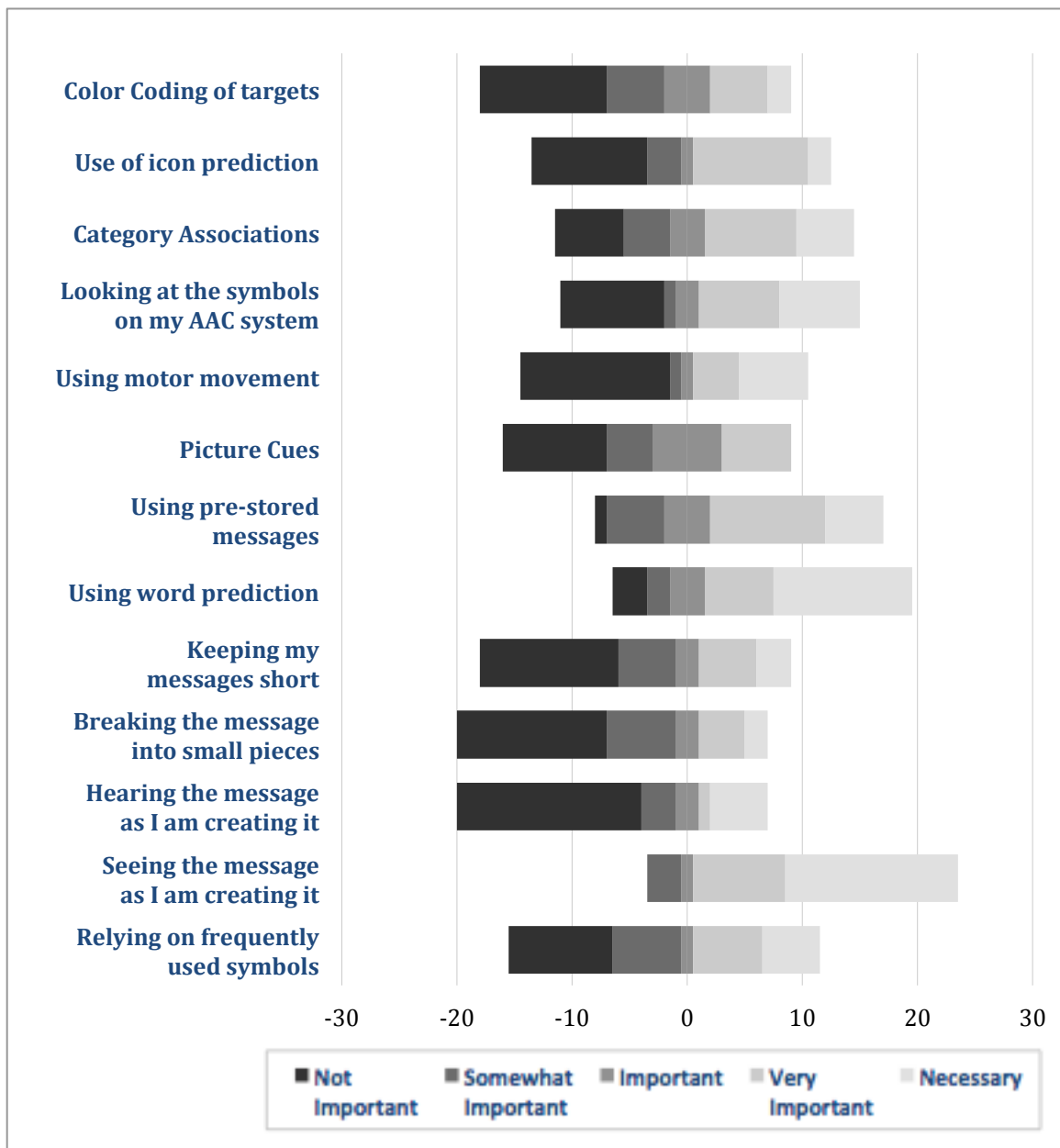


Figure 15. How important is each of these for completing a message using your speech-generating device?

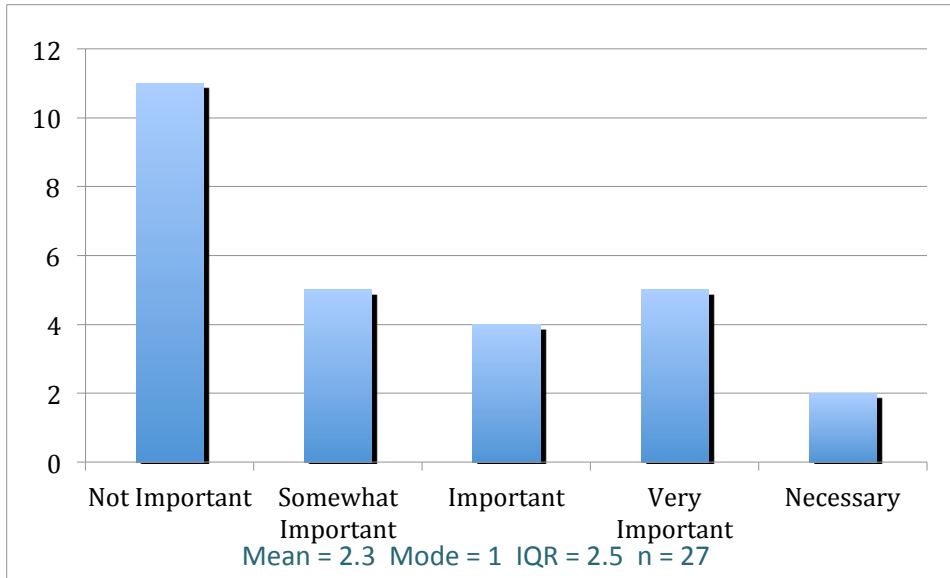


Figure 16. Color-coding of targets

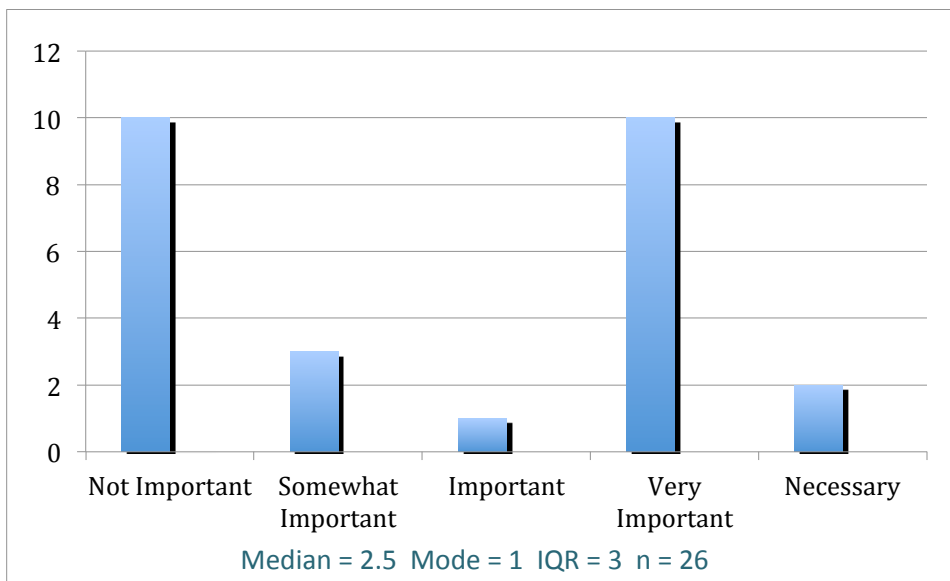


Figure 17. Use of icon prediction

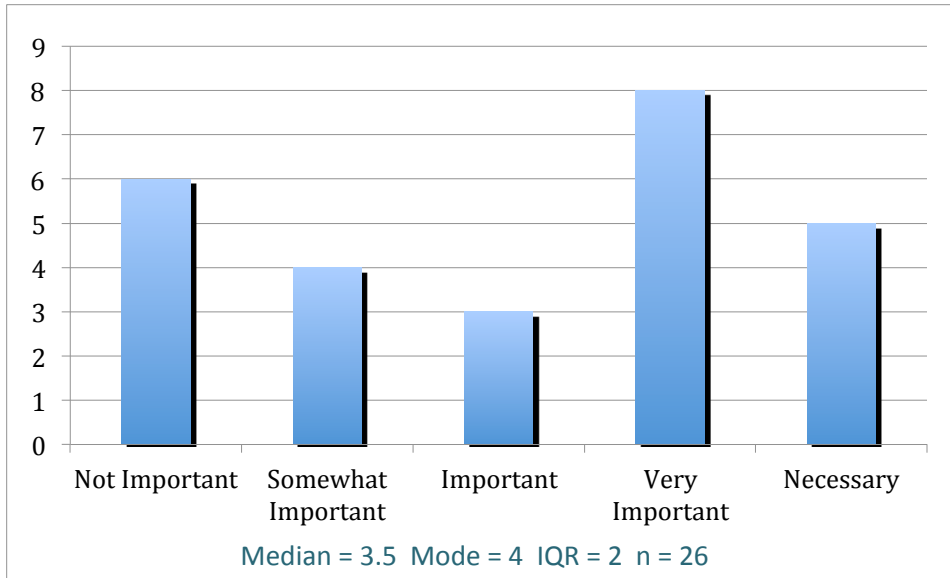


Figure 18. Category associations

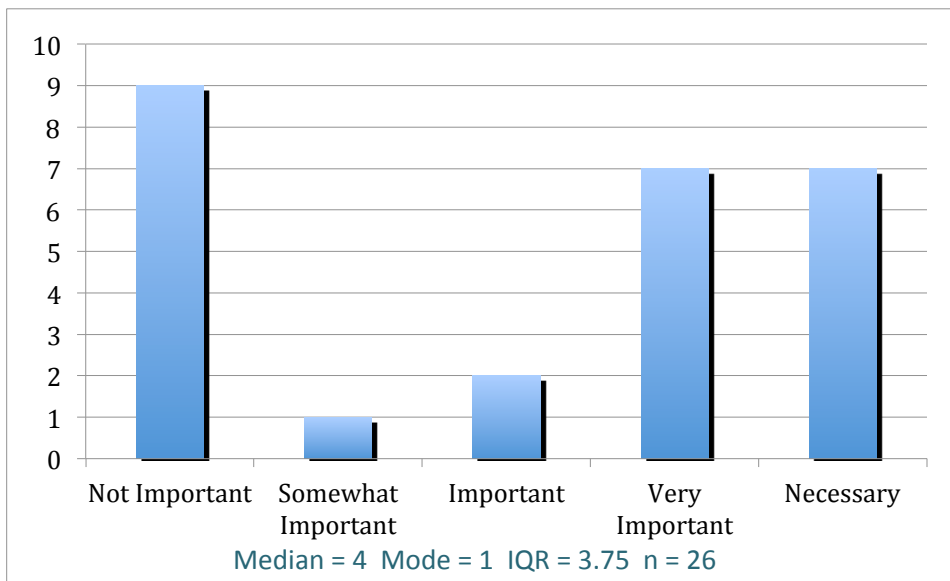


Figure 19. Looking at the symbols on my AAC system

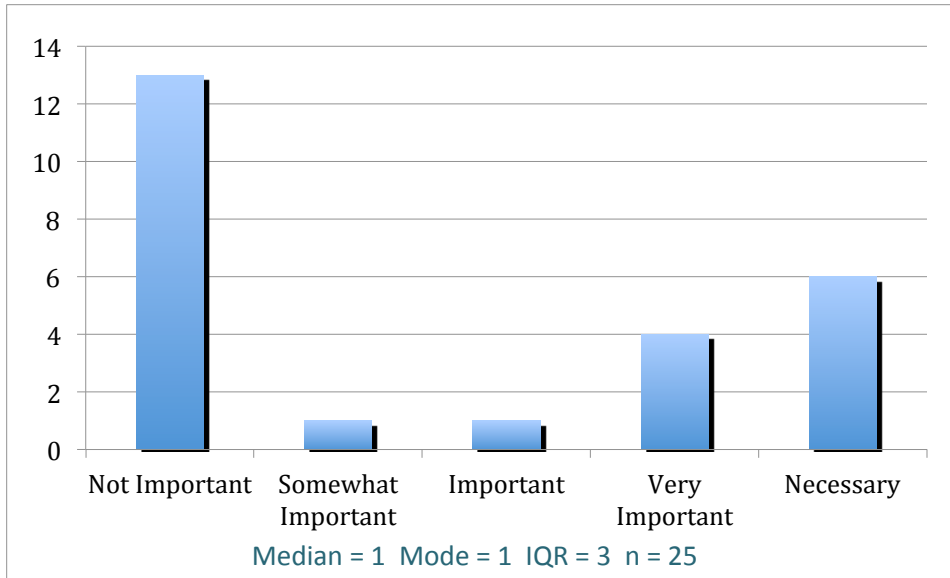


Figure 20. Using motor movement

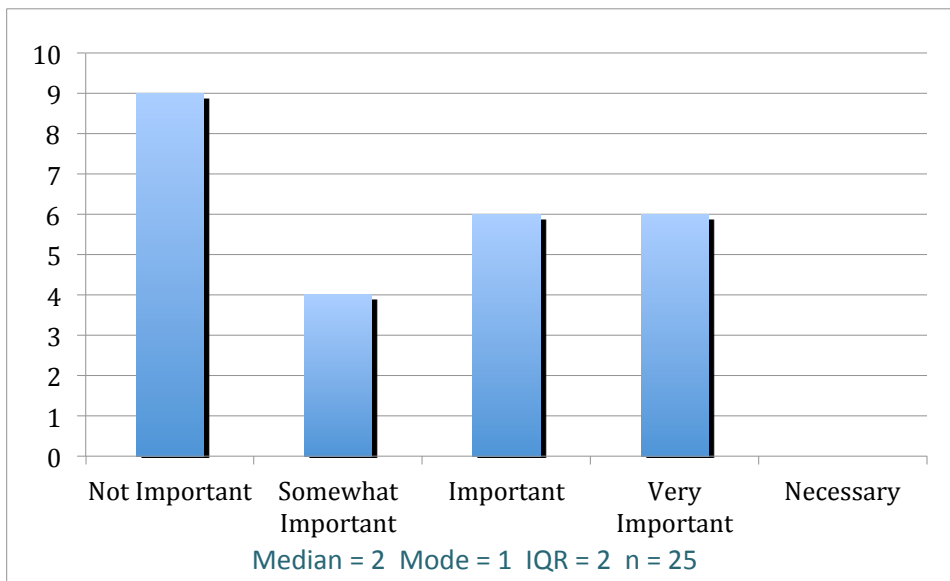


Figure 21. Picture Cues

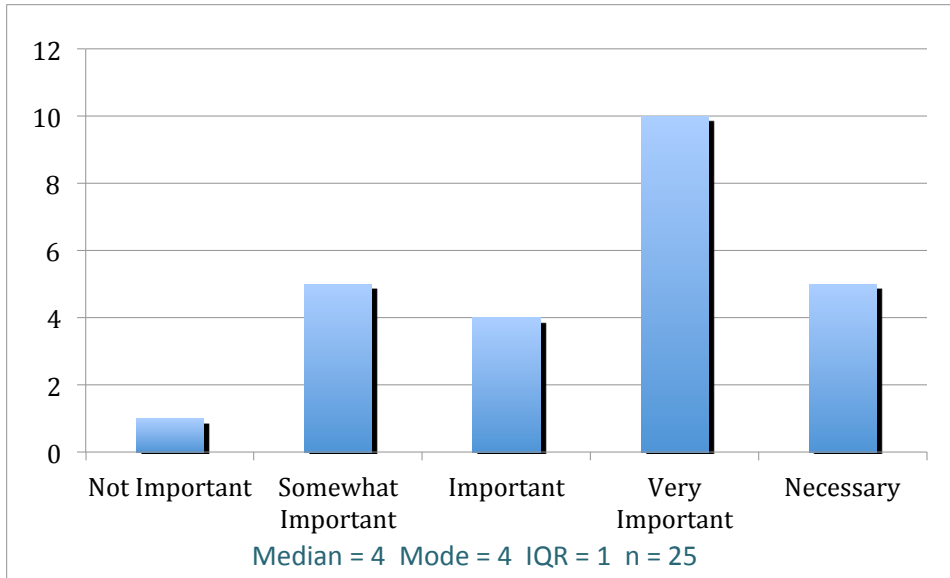


Figure 22. Using pre-stored messages

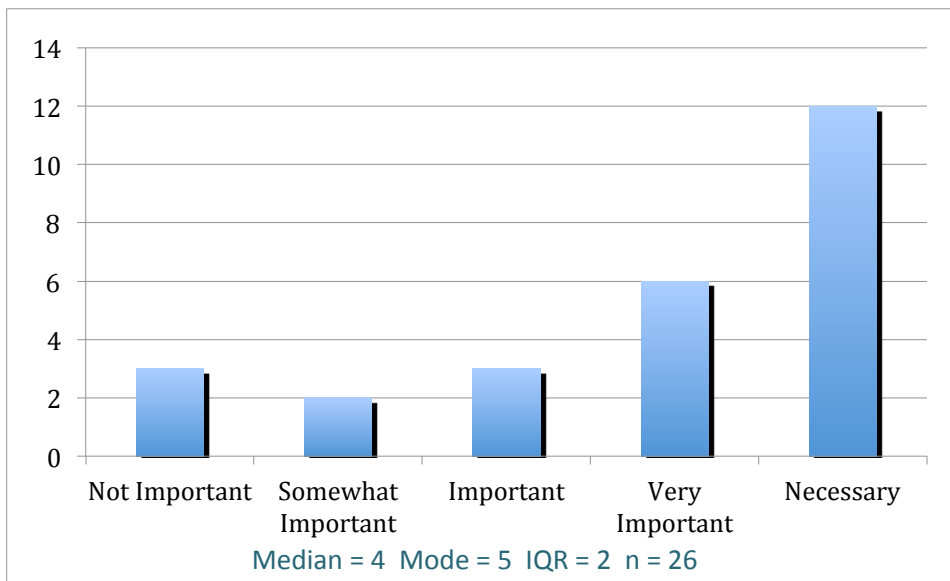


Figure 23. Using word prediction

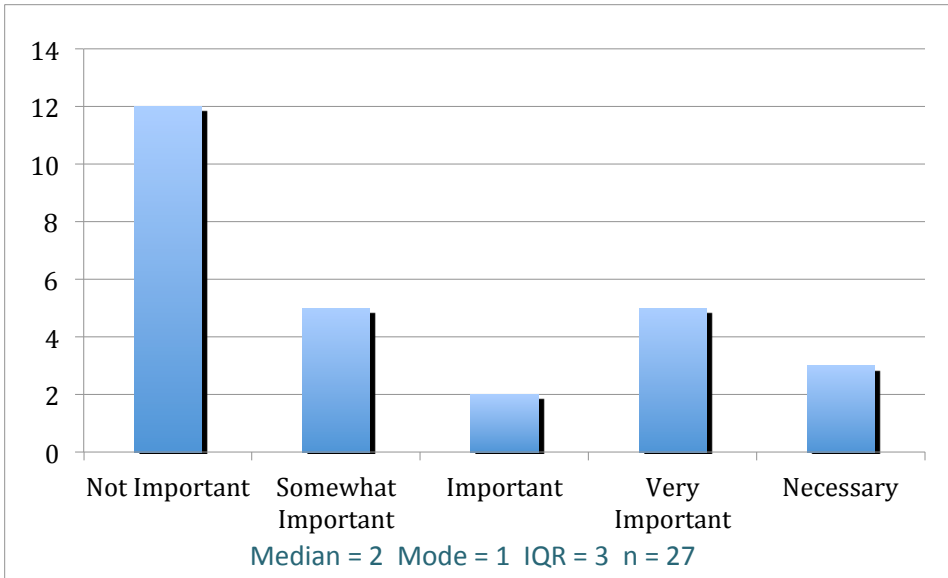


Figure 24. Keeping my messages short

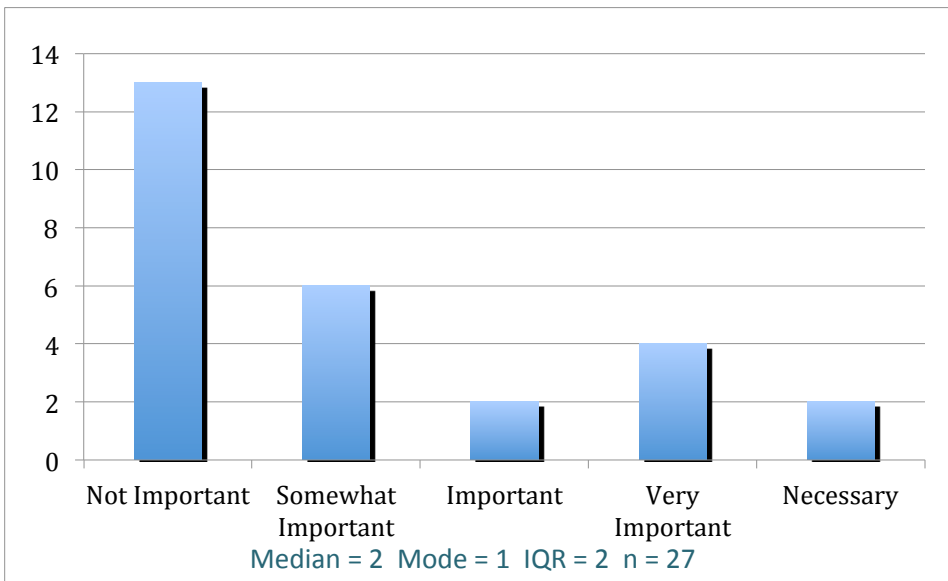


Figure 25. Breaking the message into small pieces

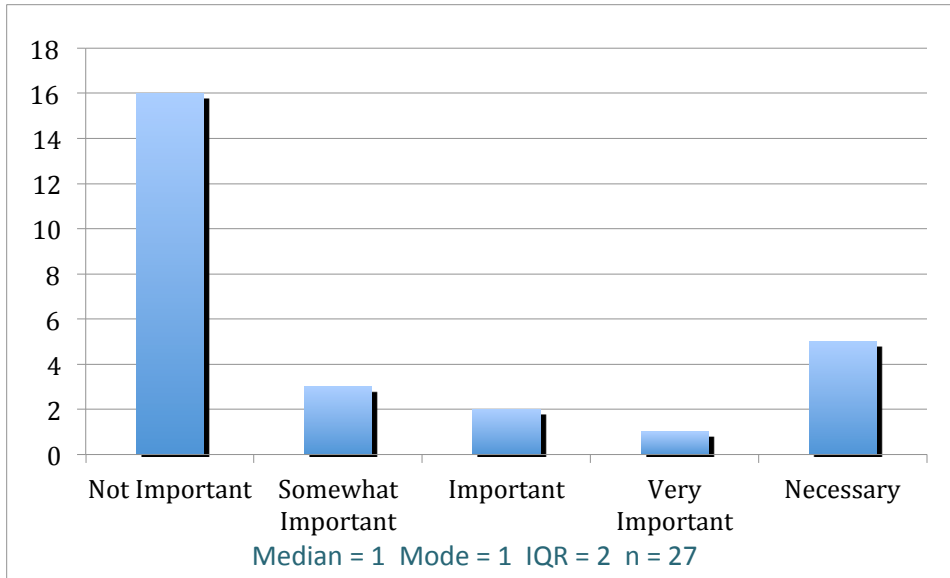


Figure 26. Hearing the message as I am creating it

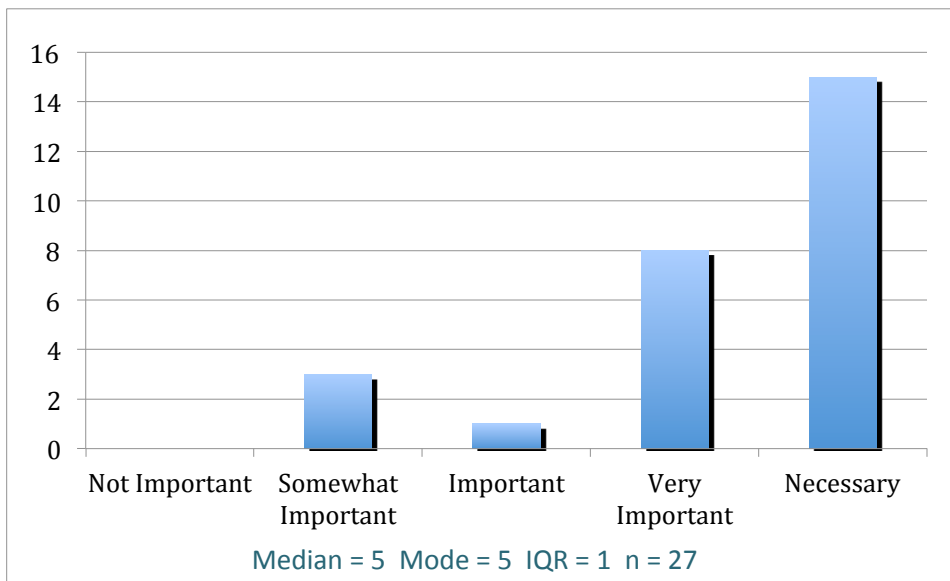


Figure 27. Seeing the message as I am creating it

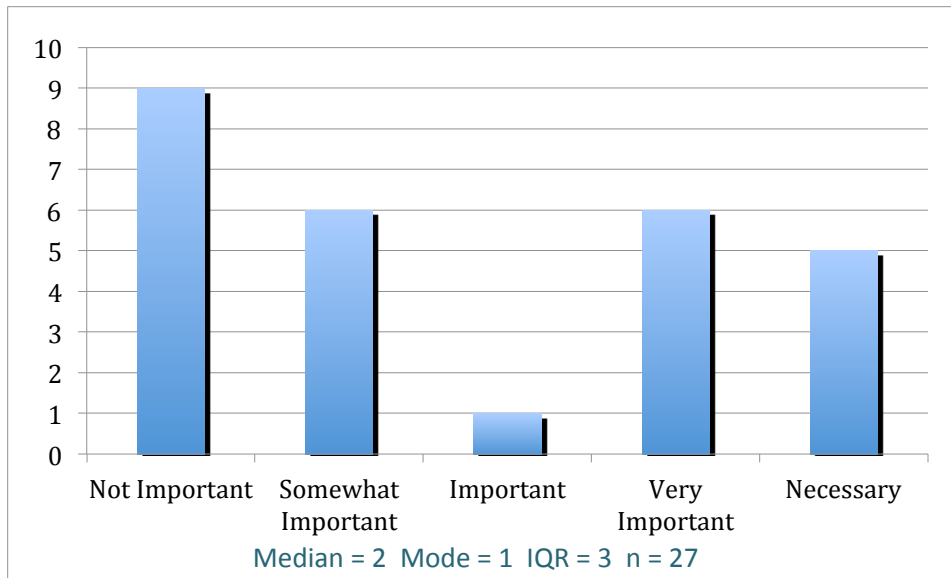


Figure 28. Relying on frequently used symbols

*When Having a Conversation How Often Does Each of the Following Contribute to Errors When Developing Messages on Your Speech-Generating Device*

There were 18 sub-factors evaluated within this broader question using a Likert-like scale of: 1=Never, 2=Seldom, 3=Sometimes, 4=Most of the Time, 5=Always. Several sub-factors were characterized by no strong specific pattern to respondent evaluations of the factors impact upon errors. These included: not having the vocabulary/symbols I need, pre-programmed phrase does not match the conversational topic, getting frustrated, and changes in conversational topic. There were several sub-factors that were judged by a majority of respondents as having limited impact upon errors in message development as evidenced by few responses within the categories of “most of the time” or “always”. These sub-factors included: forgetting message content, forgetting where I was in developing a message, forgetting what the conversation is about, difficulty paying attention, motor problems, forgetting symbol locations, layout of my display, difficulty processing what is going on in the conversation, not understanding the

conversational topic, grammar mistakes, not having the vocabulary/symbols I need, distractions around me, interruptions, and my partner does not give me enough time to communicate. Continuing to explore the sub-factors with limited impact upon errors when developing messages on an SGD, there were several factors, already noted, that were characterized by a high frequency of “never” and/or “seldom” evaluations by respondents. These factors included: forgetting message content, forgetting where I was in developing a message, forgetting what the conversation is about, difficulty paying attention, forgetting symbol locations, layout of my display, difficulty processing what is going on in the conversation, not understanding the conversational topic, grammar mistakes, and getting frustrated. Finally, the sub-factor judged by the respondents to have a positive impact upon error production when developing messages on an SGD, as evidenced by a higher rate of “sometimes”, “most of the time”, and/or “always” ratings. This factor included: the time it takes to create a message. Please refer to Figure 29 for a summary and Figures 30-47 for specific findings, median, mode and interquartile range values.

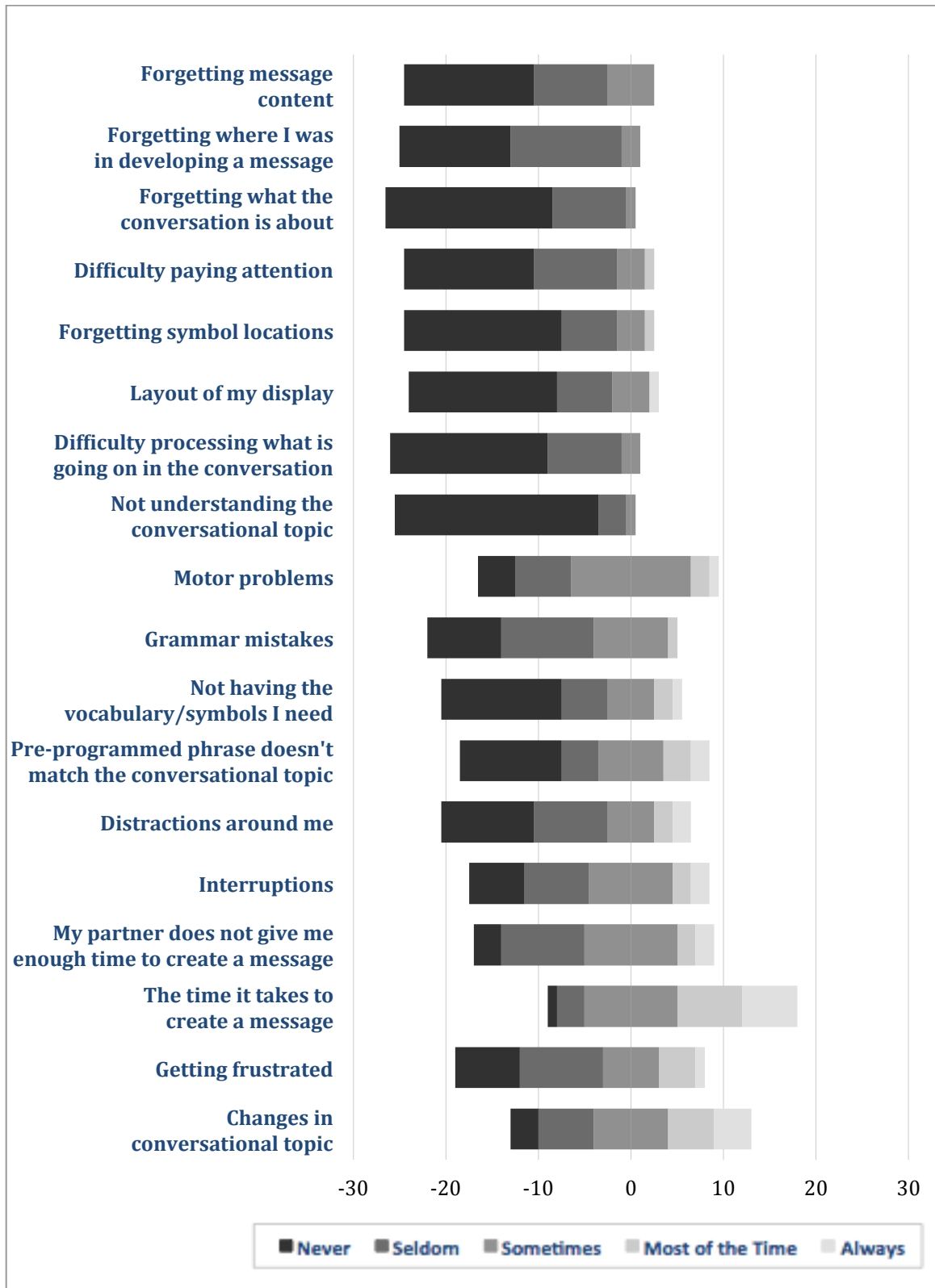


Figure 29. When you are having a conversation how often does this contribute to errors when developing messages on your speech-generating device?

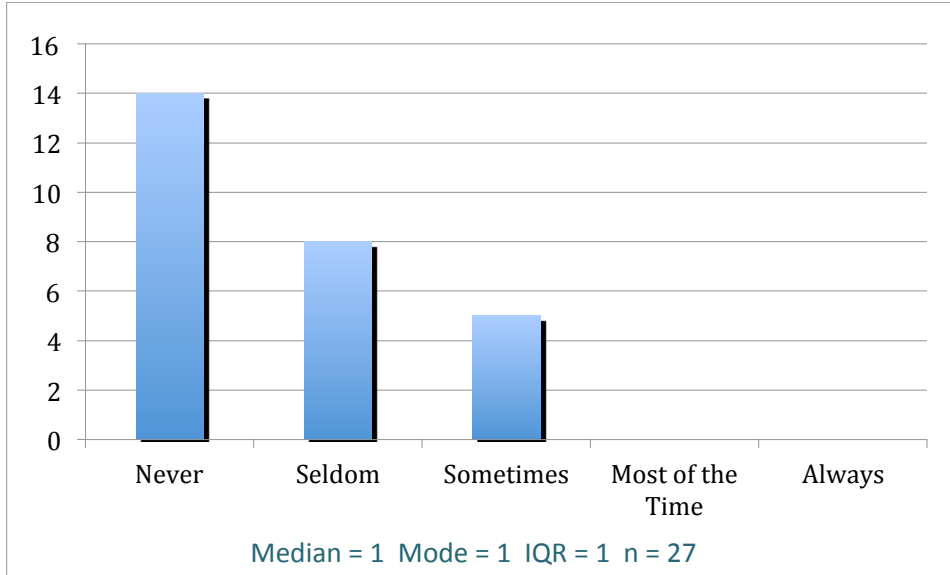


Figure 30. Forgetting message content

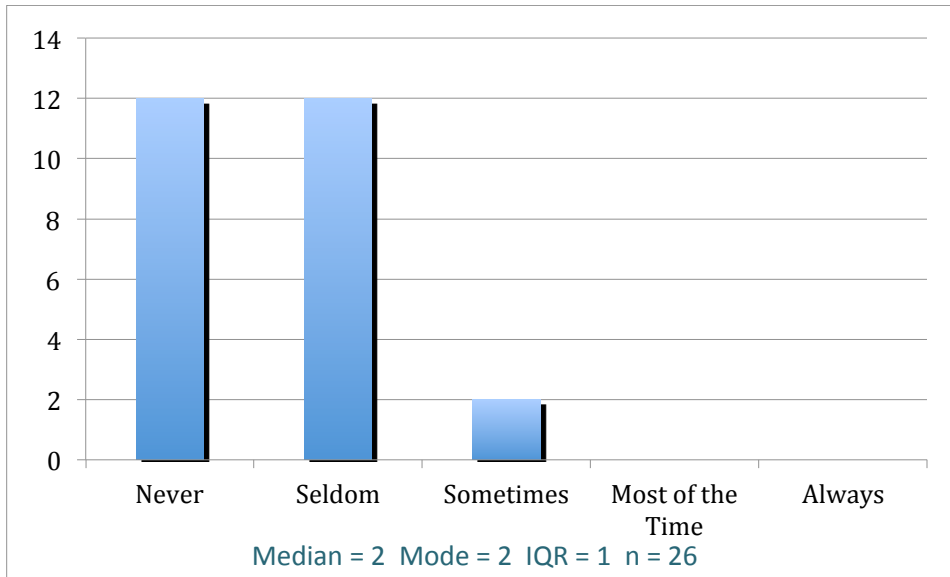


Figure 31. Forgetting where I was in developing a message

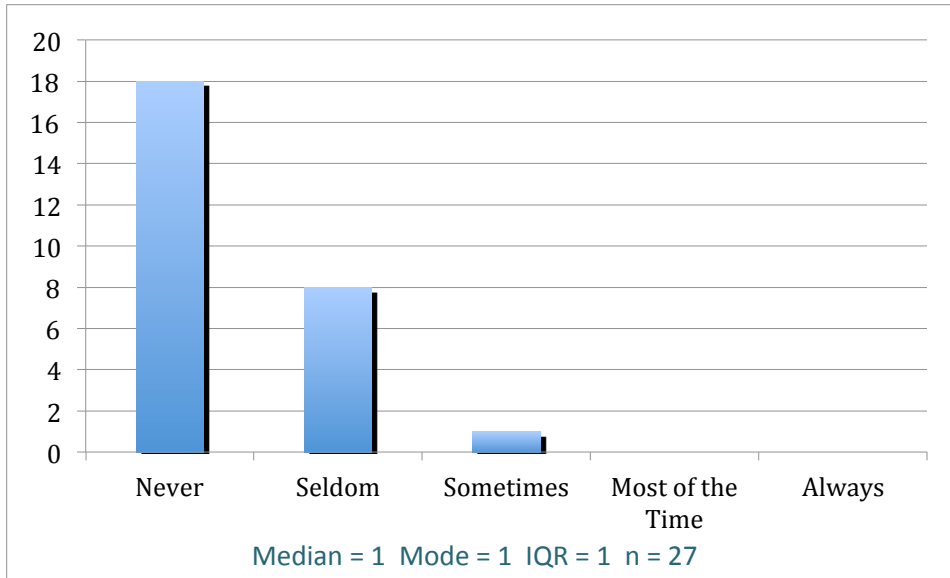


Figure 32. Forgetting what the conversation is about

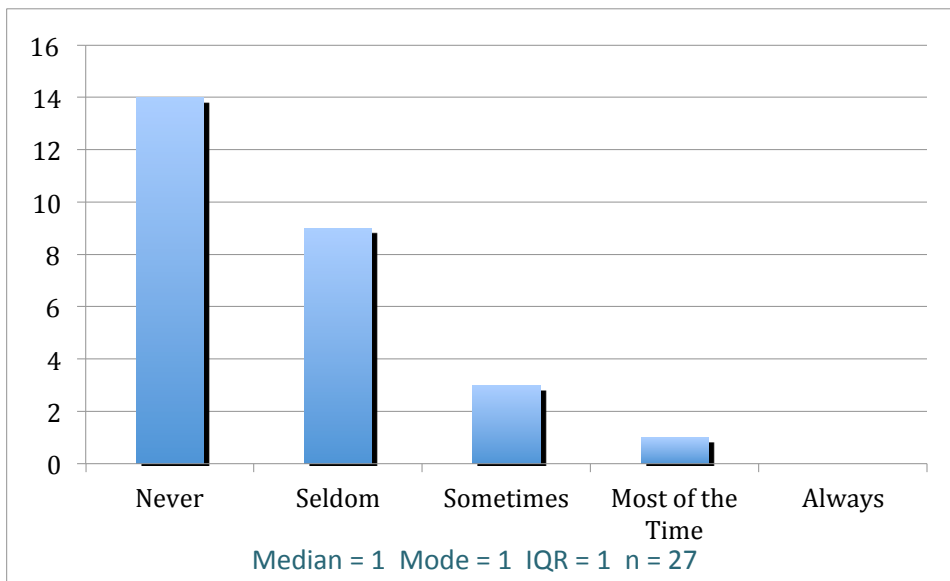


Figure 33. Difficulty paying attention

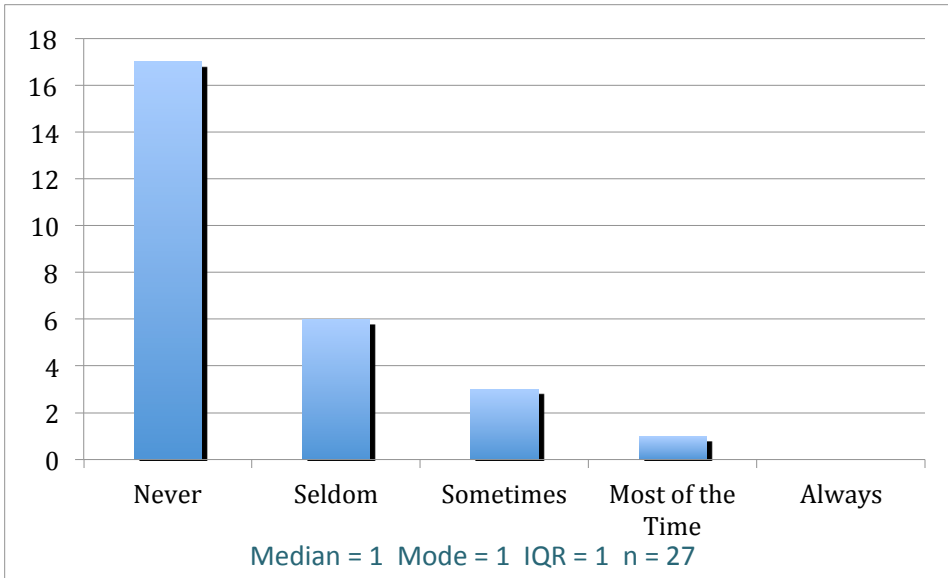


Figure 34. Forgetting symbol locations

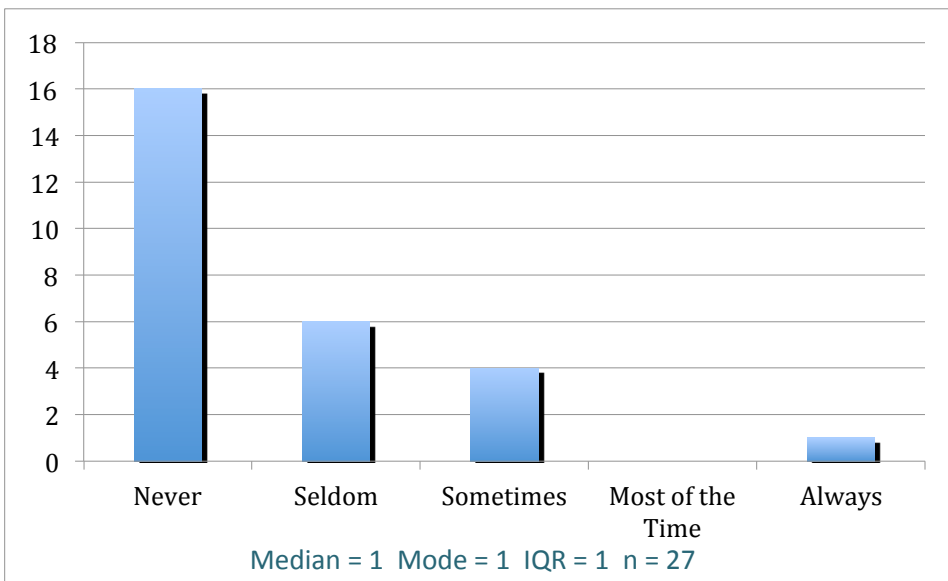


Figure 35. Layout of my display

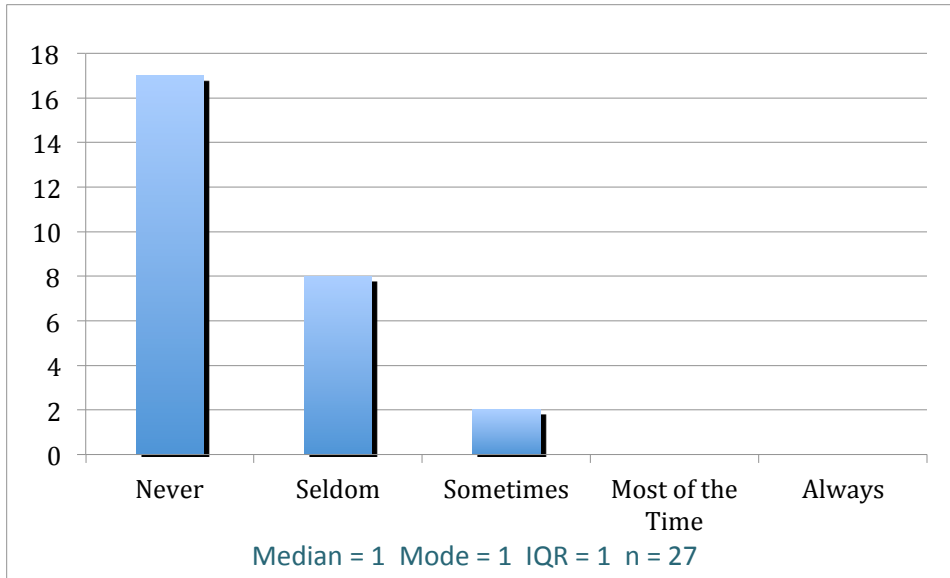


Figure 36. Difficulty processing what is going on in the conversation

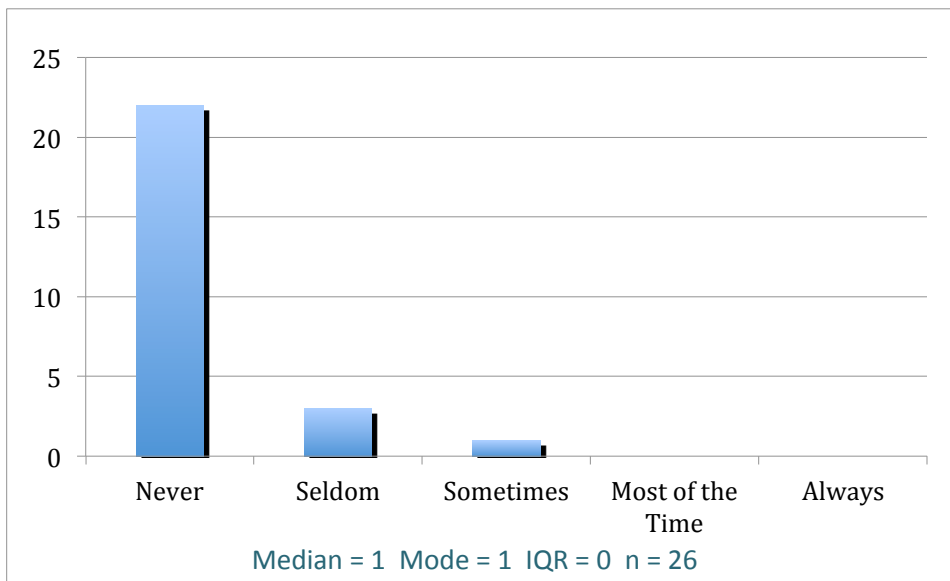


Figure 37. Not understanding the conversational topic

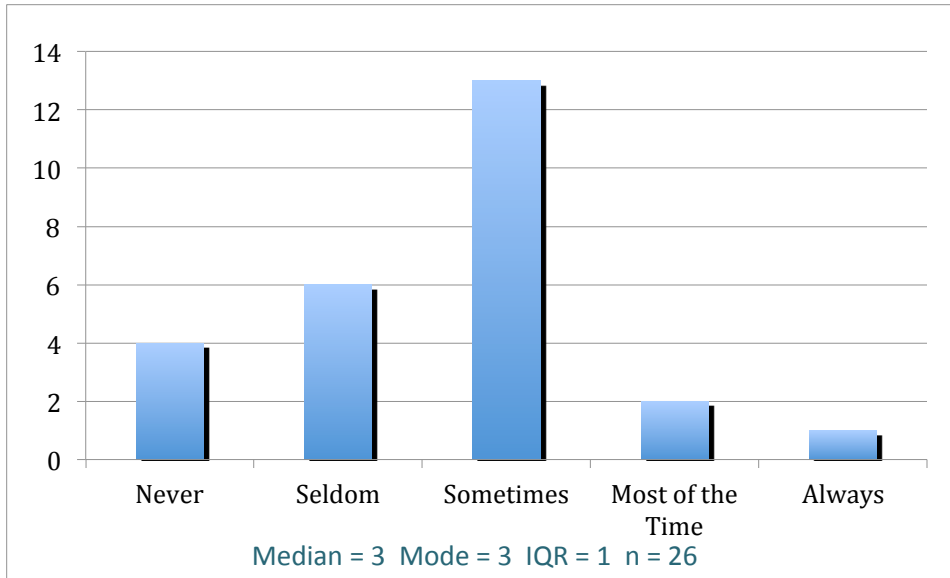


Figure 38. Motor problems

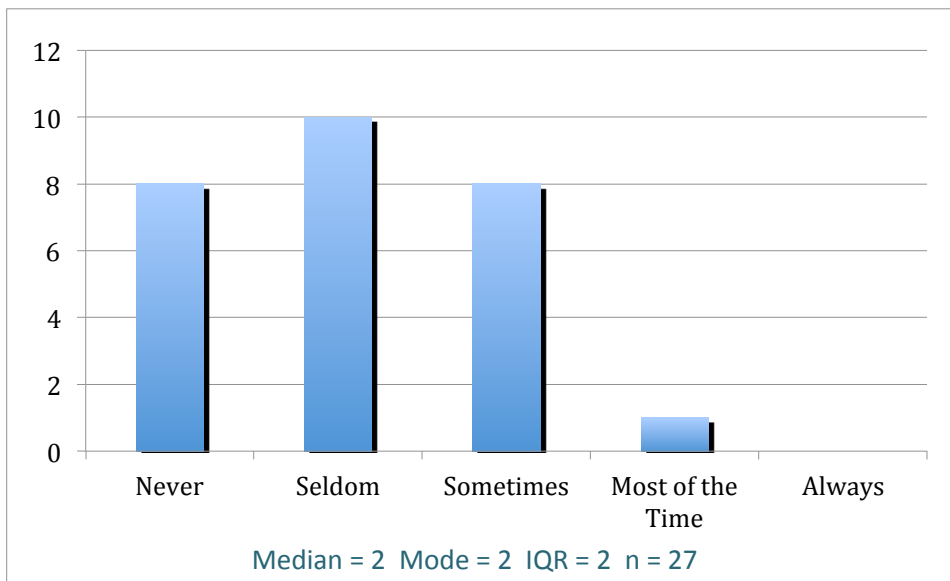


Figure 39. Grammar mistakes

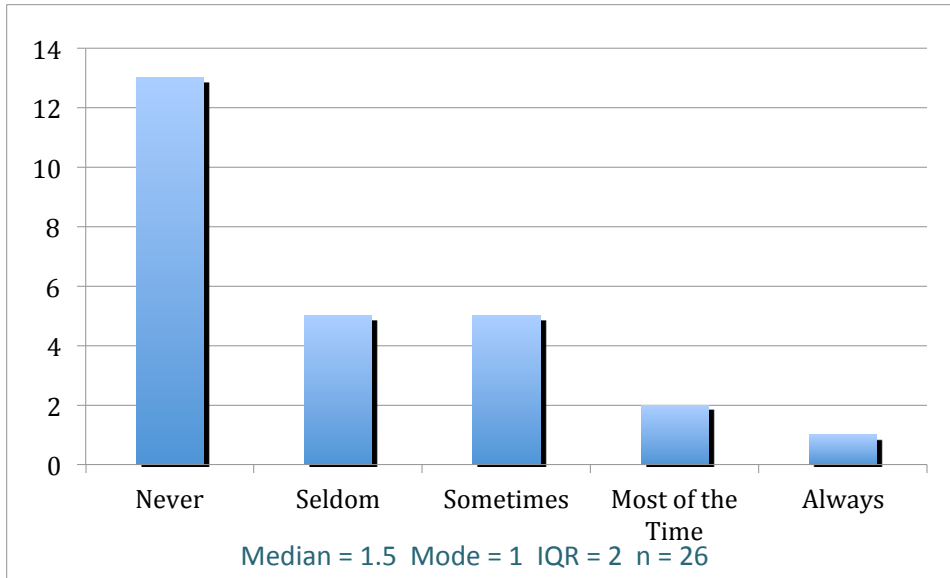


Figure 40. Not having the vocabulary/symbols I need

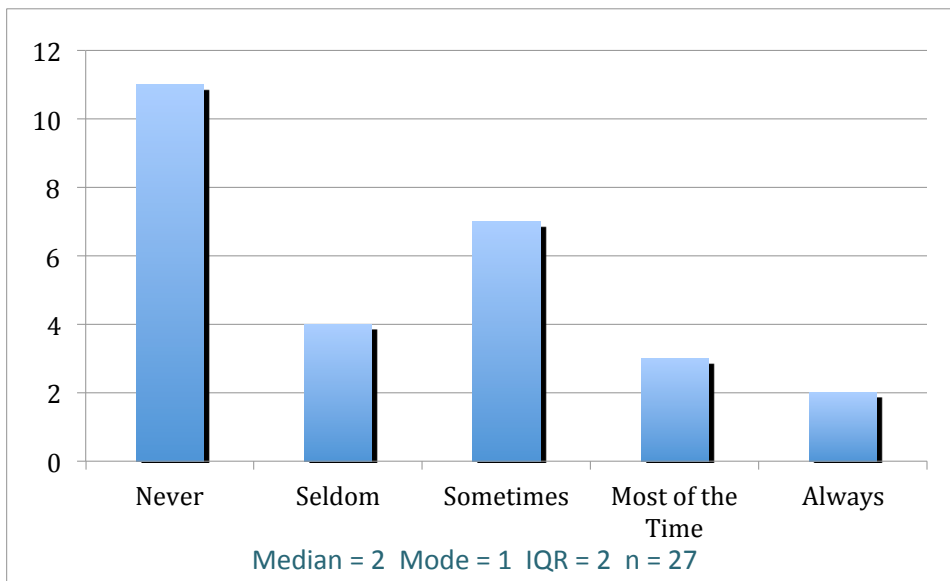


Figure 41. Pre-programmed phrase does not match the conversational topic

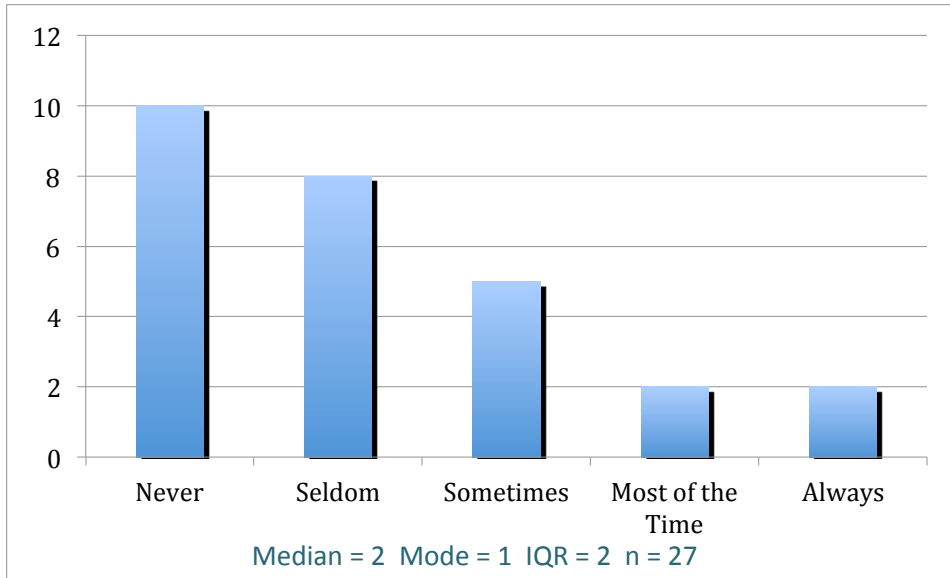


Figure 42. Distractions around me

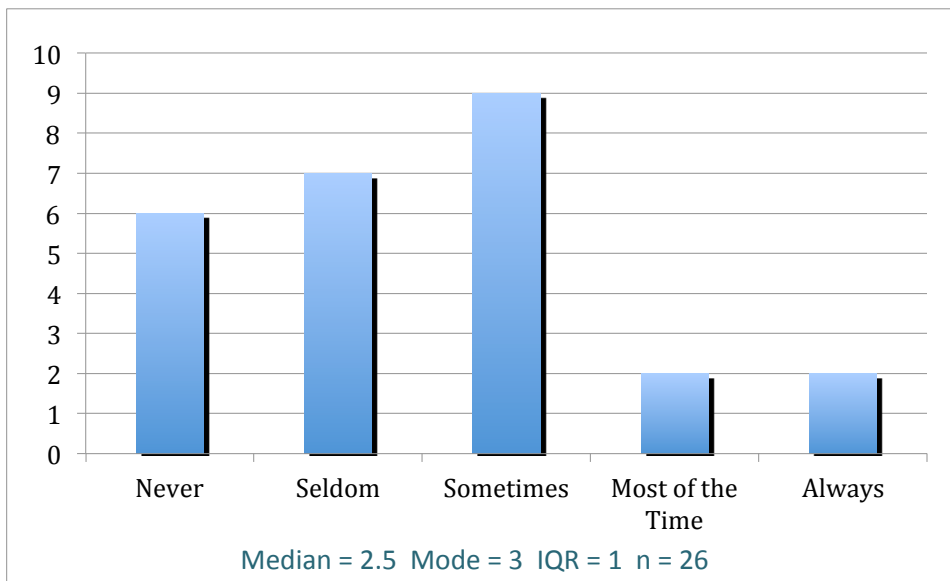


Figure 43. Interruptions

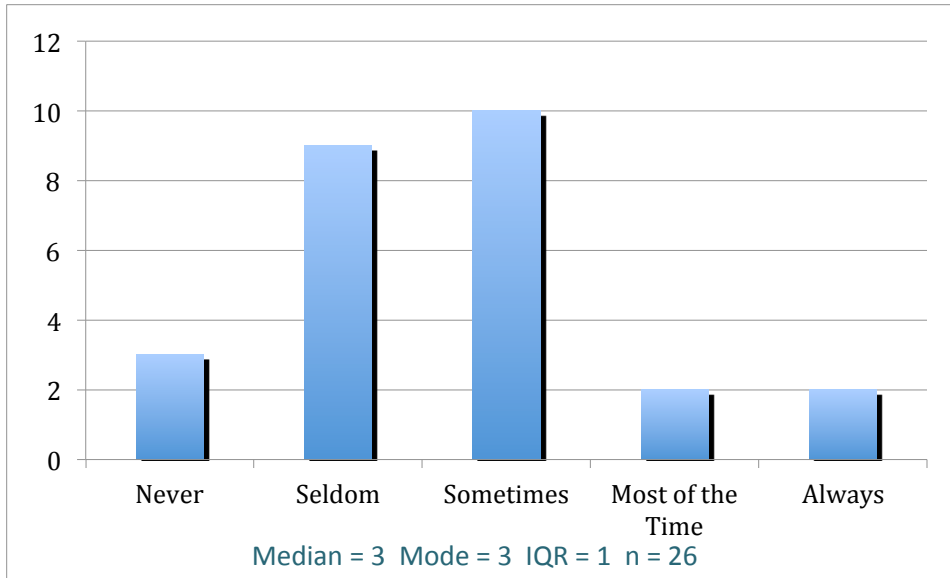


Figure 44. My partner does not give me enough time to create a message

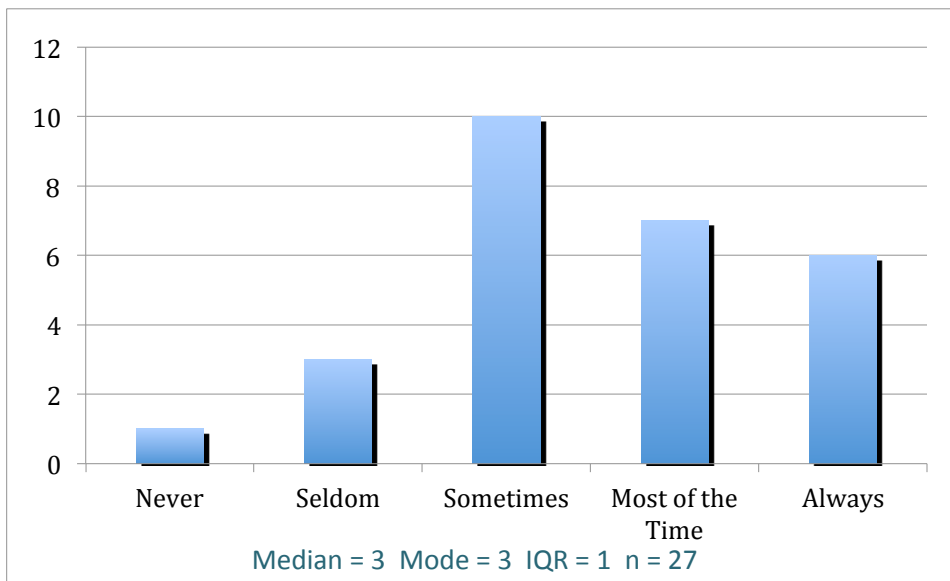


Figure 45. The time it takes to create a message

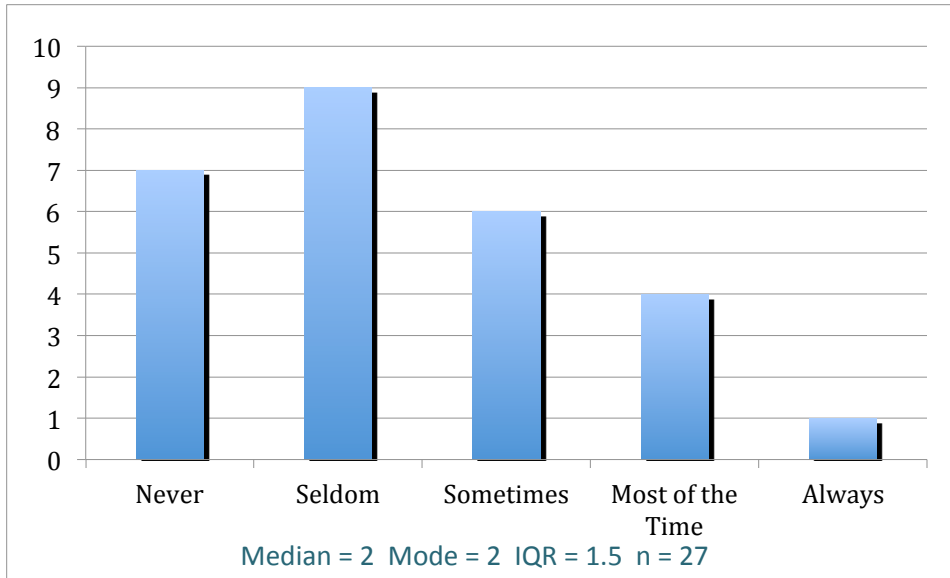


Figure 46. Getting frustrated

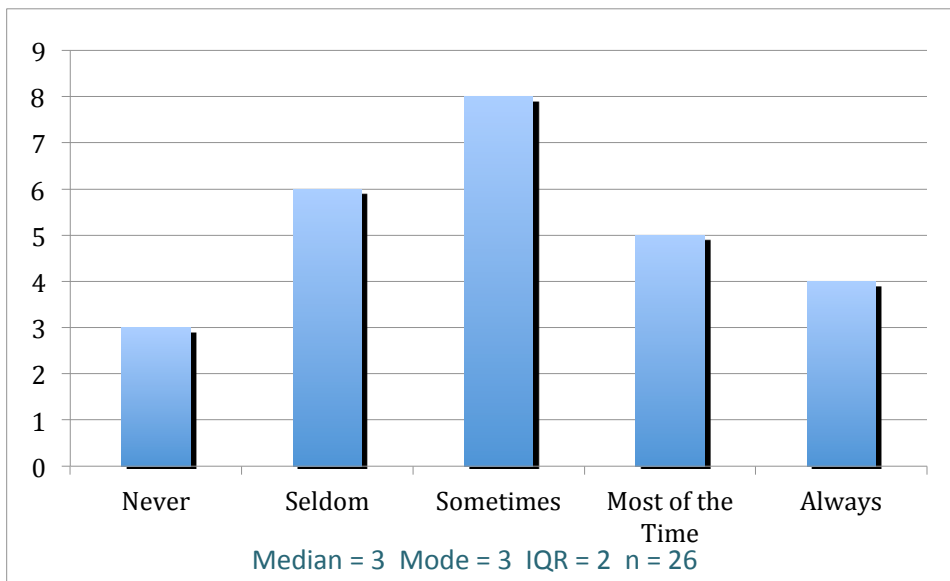


Figure 47. Changes in conversational topic

*When Having a Conversation, How Often Does Each of the Following Contribute to Success When Using Your Speech-Generating Device?*

There were eight sub-factors considered within this broader question.

Respondents evaluated the sub-factors using a Likert-like scale of: 1=Never, 2=Seldom, 3=Sometimes, 4=Most of the Time, 5=Always. The following factors were judged by a large number of participants to have the strongest positive effect upon success when using an SGD, as evidenced by frequency of respondents evaluating the factor as “most of the time” and “always” or a very limited response pattern of “never” and/or “seldom”. These factors included: paying attention to the conversational topic and planning the message before I start creating the message. The respondents identified all other sub-factors as having variable contribution to the success of conversation when using an SGD, as evidenced by no strong characteristic patterning to responses. These factors were: repeating what I want to say to myself several times, “seeing” the message in my head before I start creating the message, interruptions, silently repeating part of what was said to me to remember the topic, remembering what the other person said, and using commonly used expressions. Please refer to Figure 48 for a summary and Figures 49-56 for specific findings, median, mode and interquartile range values.

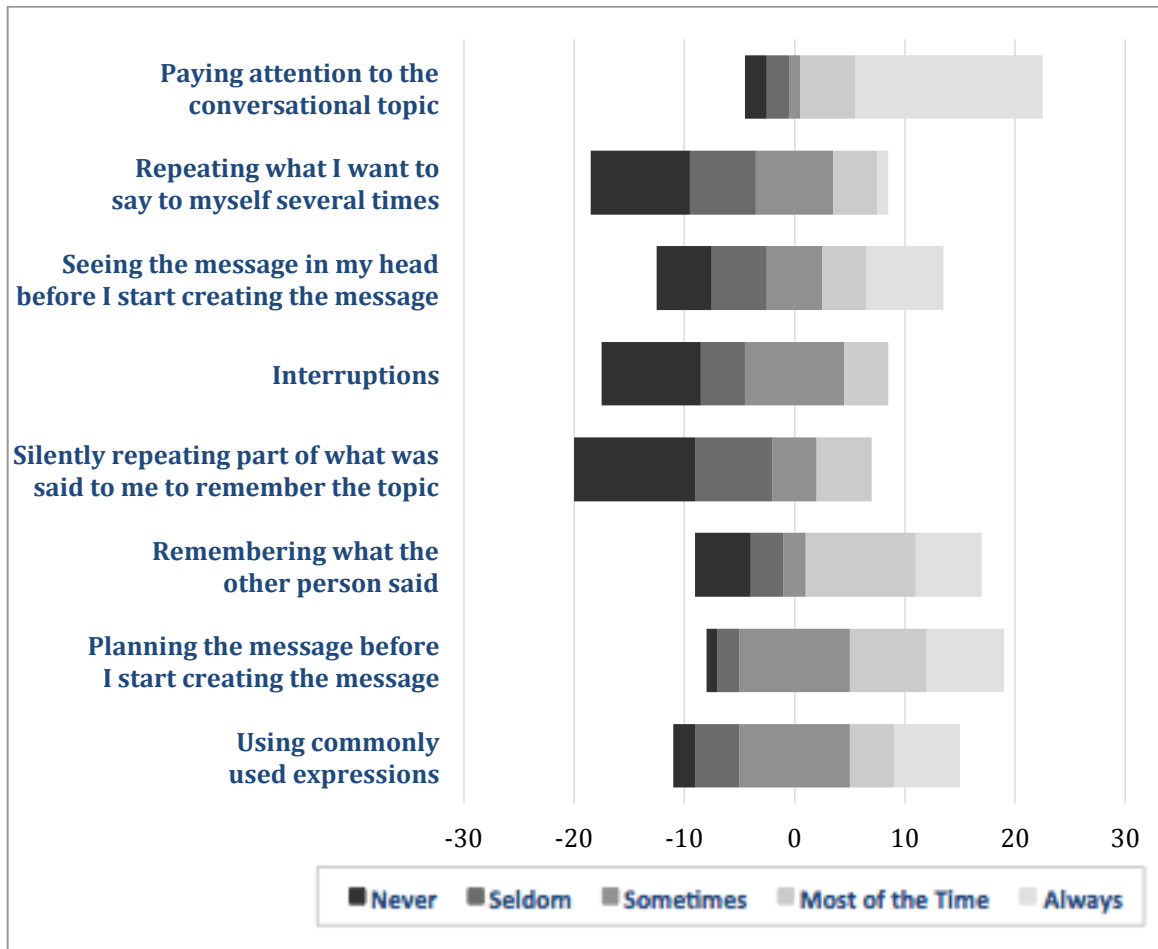


Figure 48. When having a conversation, how often does this contribute to success when using your speech-generating device?

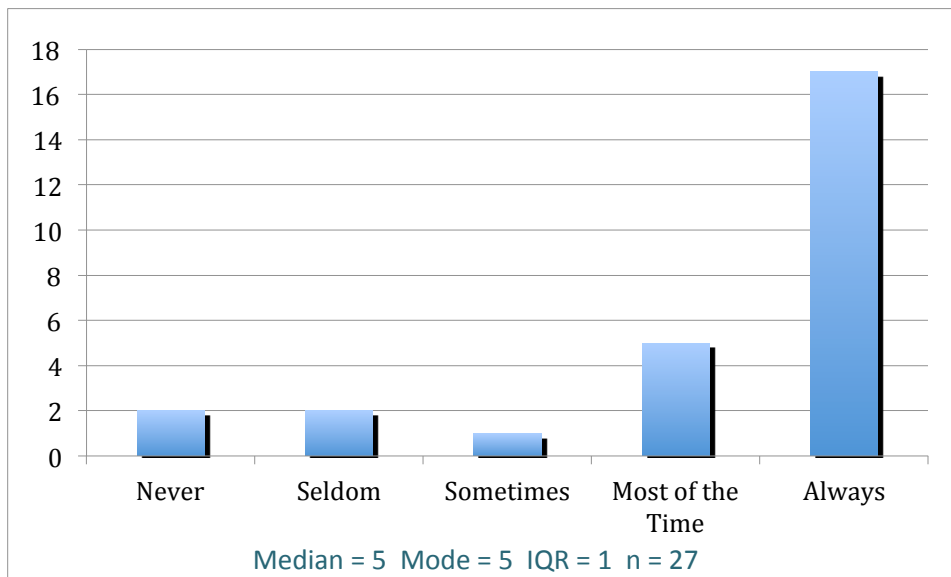


Figure 49. Paying attention to the conversational topic

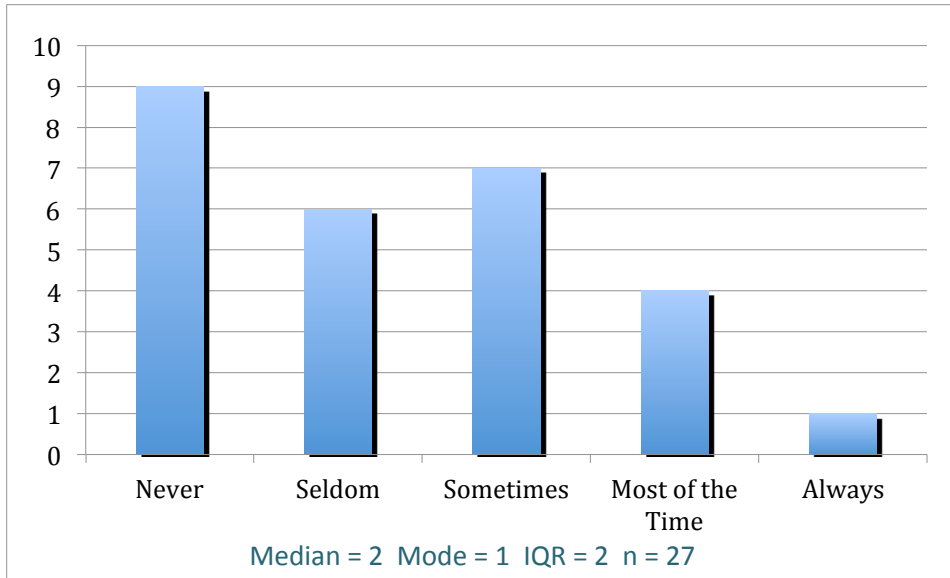


Figure 50. Repeating what I want to say to myself several times

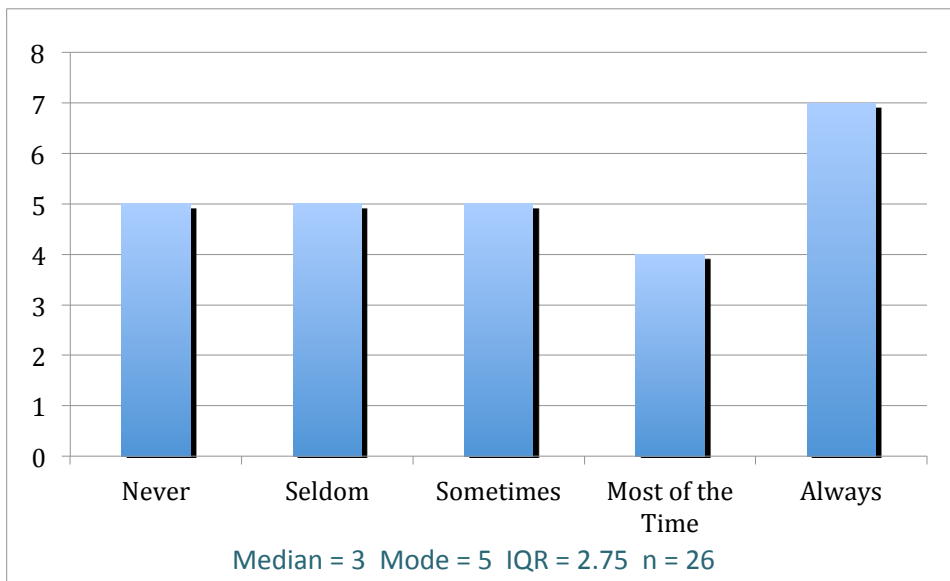


Figure 51. "Seeing" the message in my head before I start creating the message



Figure 52. Interruptions

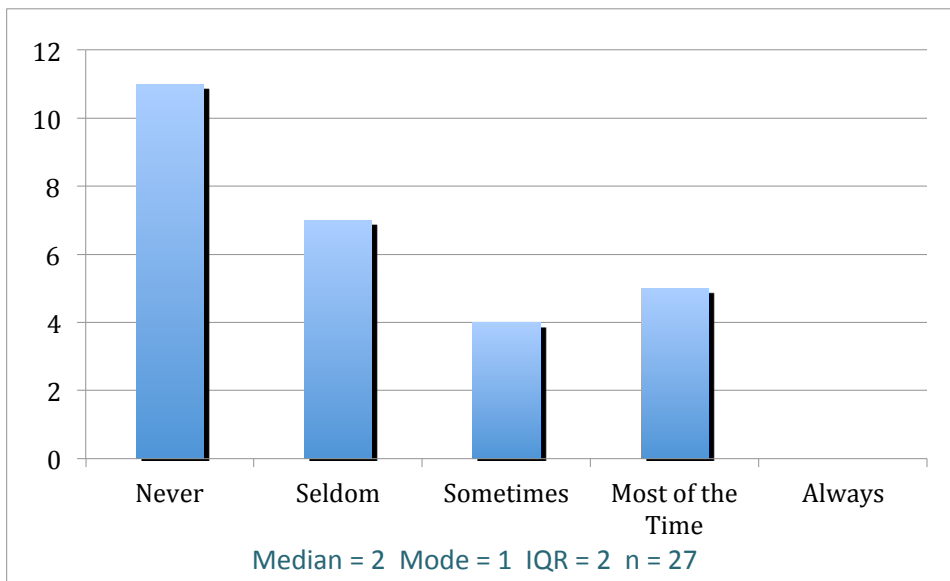


Figure 53. Silently repeating part of what was said to me to remember the topic

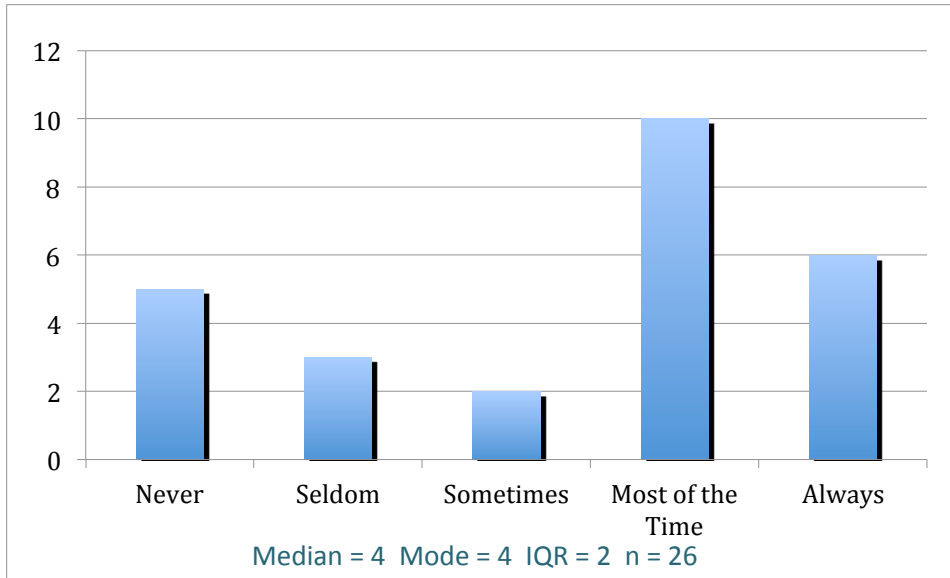


Figure 54. Remembering what the other person said

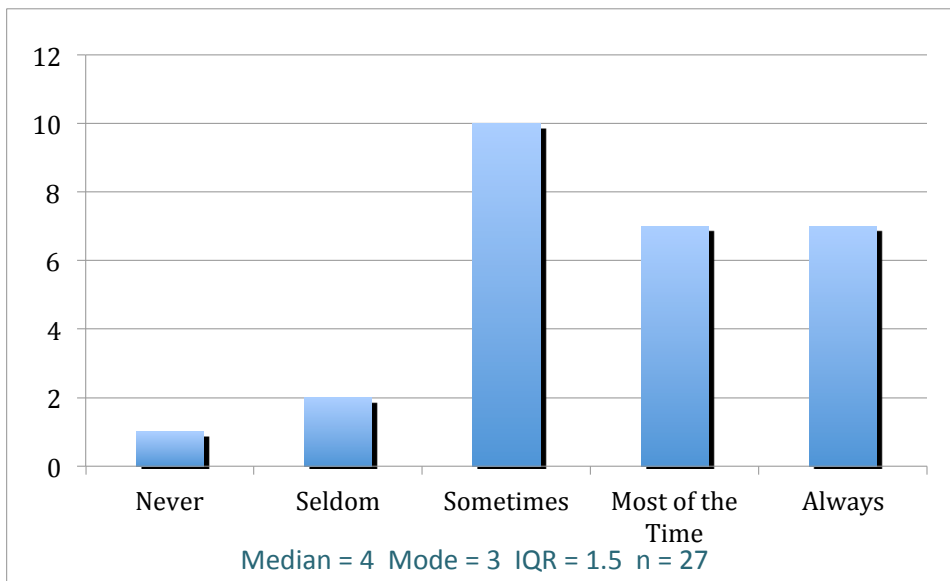


Figure 55. Planning the message before I start creating the message

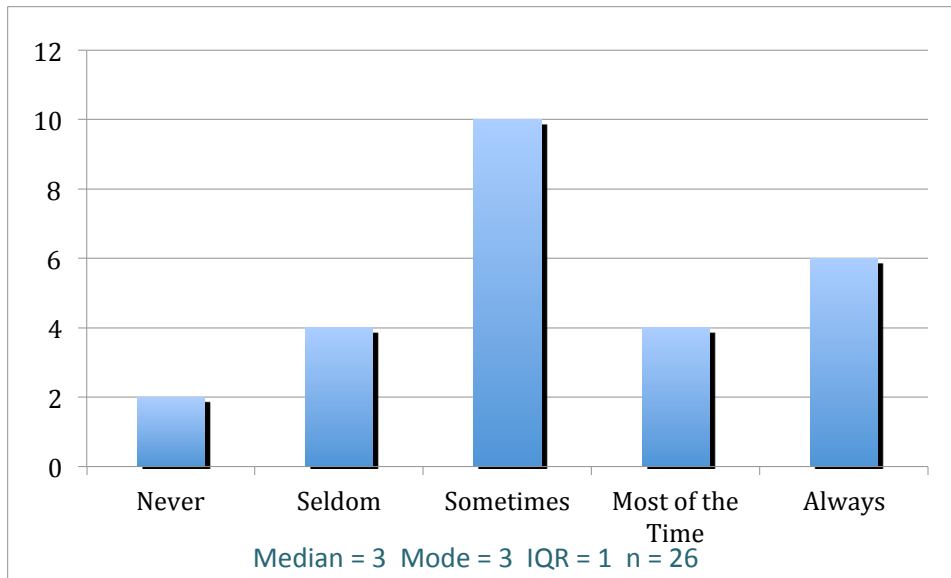


Figure 56. Using commonly used expressions

*What is Most Difficult About Creating Messages When Using AAC?*

The first follow-up question revealed that the primary concern for most participants (63.6%) was the time it takes to formulate messages. Specific difficulties associated with time, included: frustration over the time it takes to respond in conversation, time given by conversational partner to formulate response, responding fast enough to keep listener's attention, time to formulate message is not fast enough to actively participate in a conversation. Feelings reported by the participants, included: frustration, desire for Augmentative and Alternative Communication (AAC) system that allows for faster message development, partners and professionals not giving the AAC user time to formulate a message, conversational partners do not like to wait, frustration and fatigue when responding, maintaining listener's attention. One respondent reported that within the conversation he would remind the listener that it takes time to respond using an AAC system. The remaining participants reported additional individualized

difficulties which included: remembering icon location, control of motor coordination difficulties impacting message creation, message window too small impacting the ability to remember what the individual was writing and the length of content, difficulty using preferred access strategy (i.e., mouse) if not at a table, and word prediction which did not meet the needs of the communicator. Feelings expressed within responses included: frustration with poor motor control, and dislike of having to use shorter phrases to communicate.

*How Do You Manage the Processing Demands of Conversation While Formulating Messages On Your Communication SGD*

The second follow-up question revealed responses that were overall more individualized than the previous question, but without a consistent pattern being evidenced. Two threads expressed by 2-3 participants were writing, review and rewriting or following up later with the conversational partner and using pre-stored phrases to respond quickly. Review of remaining responses revealed the following feedback to the question: using individual personality to get time to say things, recognizing that individuals who do not give users of AAC time to respond do the same thing to individuals who do not use AAC to communicate, reciting thoughts to self before beginning entering text as a means of focusing on the task, asking communication partner to refrain from speaking, limiting environmental distractions (i.e., television, noise), being patient, listening while typing message recognizing that some of conversation may be missed, keeping message concise, using word prediction, not using device in ongoing conversation and preparing content in advance for targeted activities (e.g., transit, telephone calls).

*What Is the Most Difficult Task When Participating in Conversation when Using an SGD*

The third follow-up question once again revealed that rate of generating utterances in conversation was a major concern for most of the participants. Specifically, participants responded with comments to reflect this difficulty such as: finding icons quick enough to keep up with conversation, conversational topics change so quickly impacting the user of an SGD before they can reply with their device on the current topic, simply keeping up with the conversation, being quick enough to respond so the conversational partner does not have a long time to wait, the time it takes to compose a thought, and difficulty typing fast enough to participate in the conversation. Additional difficulties reported were related to conversational partner behavior and included the following: getting conversational partners attention and being patient while user creates a message even if they are unfamiliar with AAC and getting conversational partners to stop talking so the user of an SGD can speak. Feelings expressed by the users of AAC included: fear of looking stupid or senile, finding themselves becoming withdrawn to avoid the stress of conversation, letting inappropriate or hurtful comments pass because the user of the SGD was out of sync with the conversation, and finding themselves yelling or hitting someone to get the attention of the conversational partner to understand the user of the SGD wanted to say something. A single participant noted that use of prestored phrases, such as “I want to say something,” was helpful within the conversation.

With respect to the varied speech-generating devices used within the study, the researcher pursued further informal analysis of responses between two subsets of users:

- 1) Those individuals who used devices manufactured by Prentke-Romich, Co. (PRC), and
- 2) Those users who used a variety of other devices manufactured by Prentke-Romich, Co.

This arbitrary decision of how to divide the device sets was based upon the number of participants in the study who used devices manufactured by PRC (n=17) and those participants who used other types of devices including dedicated systems and apps on tablets (n=10). This analysis revealed several interesting patterns of responses, which will be discussed, however, the numbers in each group and the arbitrary division of device type categories contribute to the limitations of these findings.

Of the five primary questions within the larger survey, only two questions revealed noted differences in the response patterns within some items. These questions were: How important is each of the following for using your speech-generating device, and How important is each of the following for completing a message using your speech-generating device. With respect to the first question, four factors were observed to have response patterns showing noted differences between the two categories of devices types: Memorizing symbol/page sequences was characterized by a high frequency of “very important” or “necessary” by users of PRC devices, but never “not important”, whereas users of other device types revealed a higher frequency of “not important” or “somewhat important; using motor pattern sequences was characterized by a high frequency of “not important” or “somewhat important” by users of other device types, and a more scattered response pattern among users of PRC devices with a tendency towards the responses of “very important” or “necessary”; recognizing connections between symbols was characterized by a high frequency of “not important” by users of other device types and a more scattered response pattern by users of PRC devices; and combining new symbols with pre-stored phrases was characterized by a scattered response pattern overall for both device types, yet a higher frequency of “not important” by users of other device types and

a higher frequency of “very important” by users of PRC devices. Please refer to Figures 57-60 for a review of these analyses.

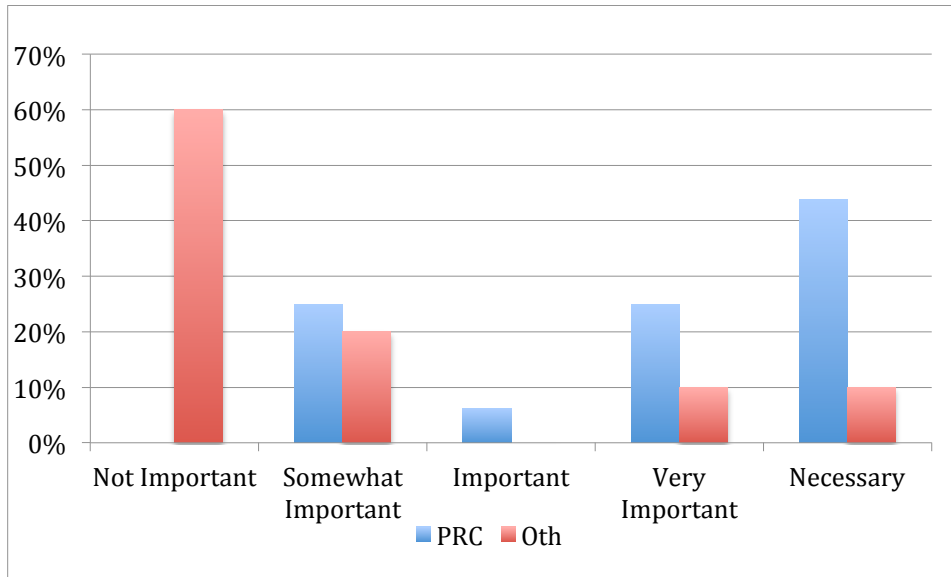


Figure 57. Memorizing symbol/page sequences

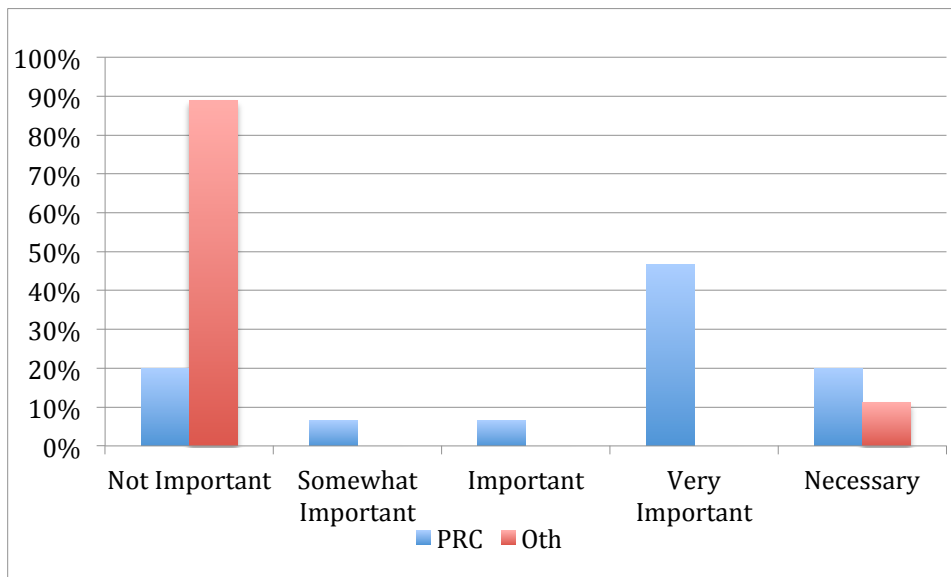


Figure 58. Using motor pattern sequences

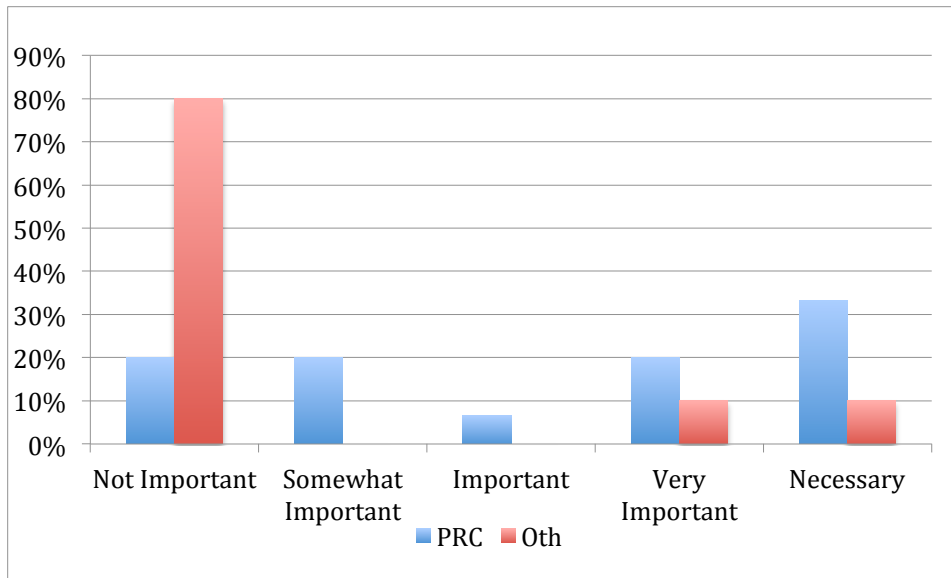


Figure 59. Recognizing connections between symbols

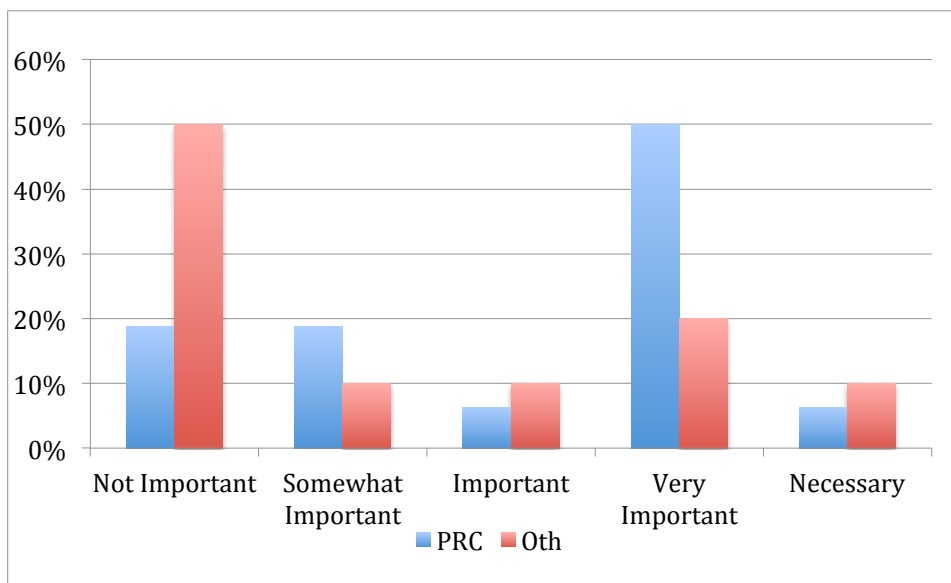


Figure 60. Combining new symbols with pre-stored phrases

With respect to the second question, four factors were observed to have response patterns showing noted differences between the two categories: Use of icon prediction was characterized by a higher frequency of “not important” for users of other device types and a higher frequency of “very important” by users of PRC devices; and three additional factors revealed similar response patterns: looking at symbols on my AAC

system, using motor movement, and picture cues were characterized by scattered response pattern overall by users of PRC devices and a higher frequency of “not important” by users of other device types. Please refer to Figures 61-64 for review of these analyses.

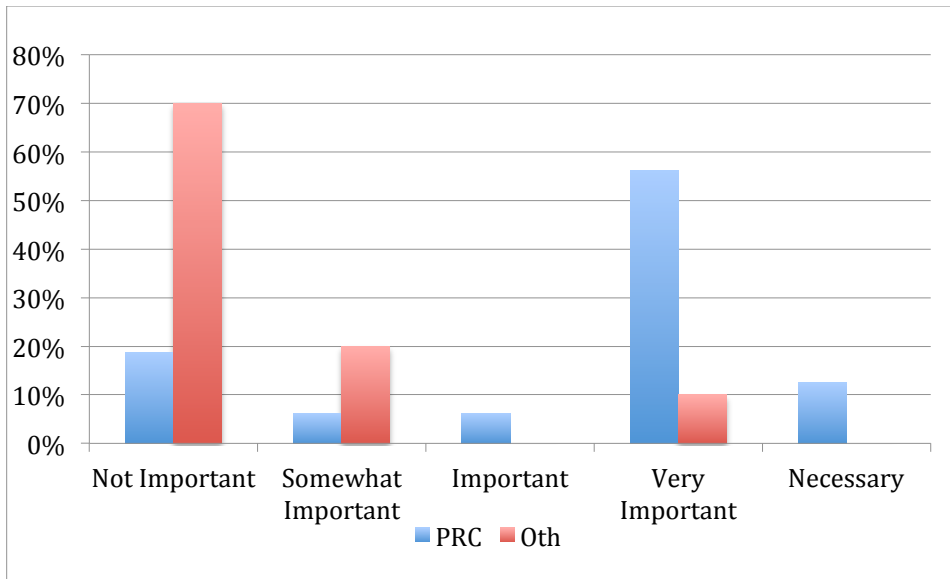


Figure 61. Use of icon prediction

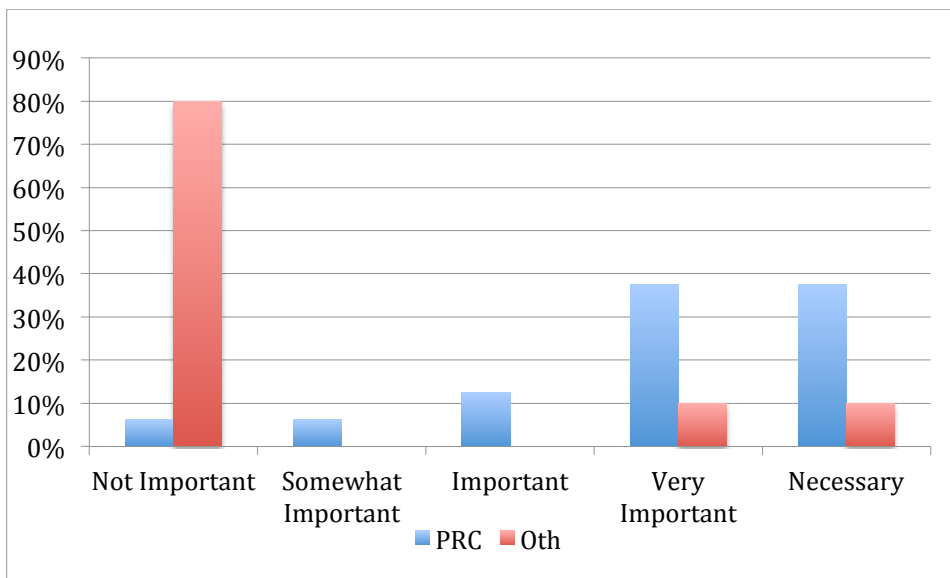


Figure 62. Looking at the symbols on my AAC system

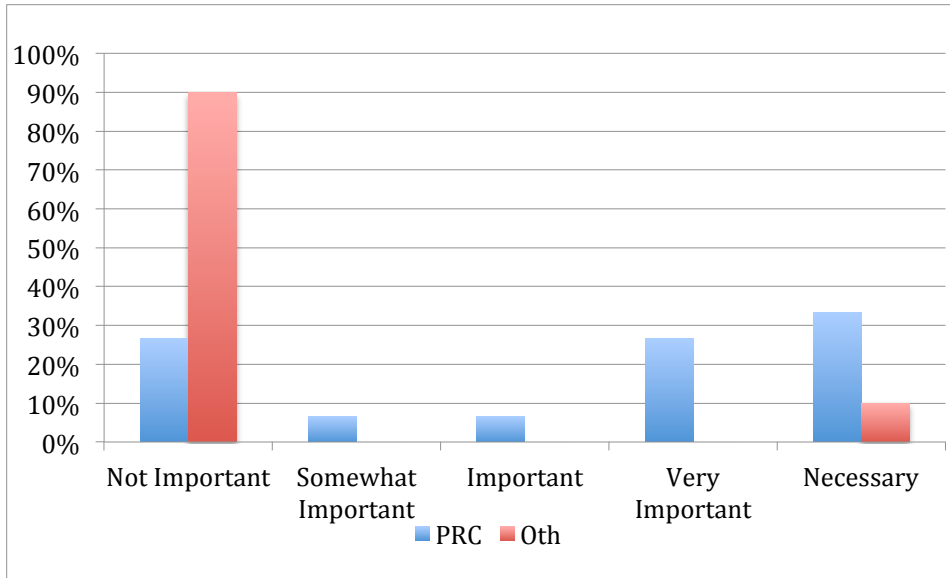


Figure 63. Using motor movement

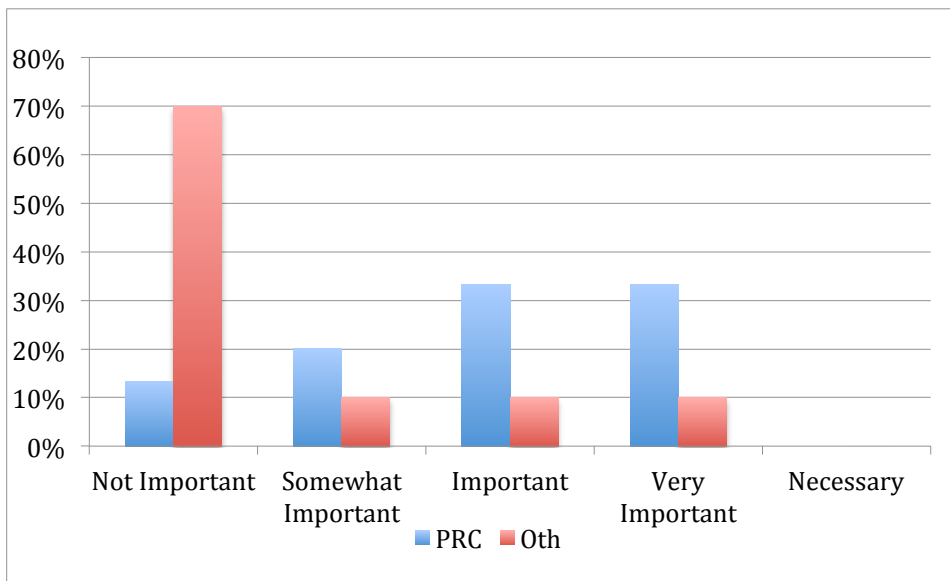


Figure 64. Picture Cues

## CHAPTER 5

### DISCUSSION

This study was completed to increase the understanding of how users of Augmentative and Alternative Communication (AAC) perceive the management of working memory and processing demands when using a speech-generating device (SGD) and what strategies or design features they find useful as a means of facilitating these skills. Within the Discussion section, the term speech-generating device refers to a dedicated communication system or app based tool on a tablet and reflects the primary component of AAC. While AAC is often more complex than a single SGD, for the purposes of this study AAC and SGD terms are often used interchangeably. This study revealed a large degree of variability among the factors surveyed related to judged importance during communication when using a speech-generating device. For most participants, the single factor judged as not being important when using an SGD for communication was the length of the symbol/word sequence. It appeared that most respondents were engaged in creating messages that reflected their intent, however, use of strategies associated with working memory and processing or design features, such as categorical and symbol meaning scaffolding, integrating generative and pre-stored vocabulary, recalling symbol or page sequencing, use of motor patterns, chunking of message content, and use of auditory feedback were not characterized by consistently strong patterns of response across the respondents, resulting in a large degree of self-reported variability overall.

The results of this study have significance for enhancing the meaning of research in the area of working memory and processing when using AAC and the discussion of

design features of AAC specific to increasing speed and accuracy of message formulation by giving voice to the users of AAC and how they perceive management of the processing demands of AAC with respect to use of the design features. Conversational activity when using AAC includes the challenges associated with typical expectations for language processing, organization of expressive form and content, and the pragmatic interaction overlaid with the challenges associated with the complex motor, sensory and cognitive presentations of individuals using AAC and the limitations of communicating using nontypical tools and strategies representing variations in linguistic structure, symbolization, and message development, as well as interruptions and extensions to the time necessary to complete a conversation (Beukelman & Mirenda, 2005; Light & Drager, 2002; Light, Parsons, & Drager, 2002; Thistle & Wilkinson, 2011, 2012, 2013; Wagner, Shaffer, & Swim, 2011). Observing the user of AAC easily reveals the complexity of factors impacting communication when using AAC. Communication using an AAC system is often motorically complex, time consuming, challenging to the typical give and take of conversational turn taking and topic switching, and is simply different in form and function than oral communication. The developers of speech-generating devices have attempted to reduce the stress of communicating by incorporating strategies and design features to increase speed and symbol location, while reducing processing demands via color-coding, encoding strategies, icon and word prediction, linguistic organization and categorical scaffolding.

### *Biographical Data*

Within the biographical data, it was noted that there were patterns to the makeup of the respondents: most participants were male; participants reported high levels of

education, ranging from high school equivalency through graduate and law school; types of SGDs reported were varied with all respondents using systems that permitted them to communicate independently; most surveys were completed without assistance; direct selection was the access strategy most often used; all respondents who answered the question reported range of utterance to typically be six or more words and a large percentage of respondents reported engaging literacy for a variety of activities, such as reading and writing e-mails, reading articles, newspapers, and employment content, as well as writing for their employment.

*Factors Impacting Completing Messages, Errors in Message, and Conversational Success*

When considering what factors were important for using a speech-generating device (SGD) and completing a message, it appeared that the length of symbol/word sequence, word prediction, and seeing the message as it was being created were judged to be of most importance to the participants. Most participants judged the factors of having a limited number of symbol choices and hearing the message as I am creating it to have the least amount of importance for message completion and use of a SGD. Within the communication process, users of SGDs have competing content for auditory attention, ongoing conversation and auditory feedback from their device. They may be choosing to focus on conversational partners comments more and relying on other monitoring strategies during message formulation rather than auditory feedback. Managing simultaneous auditory messages has the potential to create stress upon cognitive processing and compete for information processing within the phonological loop as described by Baddeley (1986) and Baddeley & Hitch (1974), allowing for limited

capacity to use repetition or rehearsal to retain information while creating messages using a SGD. This finding seems to be consistent with the unitary model of working memory (Chuah & Maybery, 1999) of more integrated visual-spatial and verbal subsystems contributing to short-term recall. For users of AAC, this model may mean that access to visual and spatial short-term recall is more integrated, perhaps increasing the strength of short-term recall during the complex activities and processing required for successful use of complex AAC. The automaticity that users of SGDs develop may be supporting the integration of attentional processing so automatically as not being perceived by users of AAC to the degree that it that they can report on the use of the strategy.

Errors in message creation have the potential to contribute to frustration, miscommunication, and possible reduction in the totality of message content for the user of AAC. Each of these has relevance for success in conversation and the user's overall sense of participation and materiality to conversational contribution. The single factor, which respondents judged to contribute most to errors during message production with a speech-generating device, was related to the time needed to create a message. Rather than be related to working memory overload, participant responses appeared to indicate that the length of time necessary to create a message was disruptive to the conversational flow and their participation in the conversation. Interestingly, for this question, it was the factors that were judged as not contributing to errors that were notable. These factors included: forgetting or having difficulty processing message content, conversational topic or content organization during message development, difficulty paying attention or attending to distractions or interruptions, or difficulty recalling AAC system symbol locations or layout. Motor issues were judged to intermittently contribute to errors during

message formulation reflecting the inconsistency of motor movements and motor organization that many users of AAC deal with as part of their overall disability presentation. It appeared that users of AAC did not judge their abilities to engage factors characteristic of the linguistic, attentional, and organizational processes associated with working memory to significantly impact error performance when using their SGD to create messages in conversation. The users of speech-generating devices may rely on the long-term memory processes necessary to recall AAC system organization through a more integrated process, more closely related to the working memory model of Ericson and Kintsch (1995) or Cowan (1988, 2001, 2005) rather than the attentional and rehearsal processes associated with the multicomponent, limited capacity models of Baddeley (1986, 2002, 2007) or Baddeley and Hitch (1974). Use of complex aided communication or AAC could be considered a very complex skill with dependencies upon motor memory, sensory processing, and cognitive processing related to the development and use of the language and conversational pragmatics. Access to long-term memory seems necessary for successful integration of these skills. When using AAC, short-term working memory cues may be activated via motor planning, symbol sequencing, and linguistic planning.

Consideration of conversational success when using a speech-generating device revealed that attending to the conversational topic and remembering what conversational partners said was important to most users of AAC. Maintaining simultaneous attention to conversational topic and content while accessing an SGD reinforces the working memory capacity theory (Engle & Kane, 2004; Kane et al., 2007). This theory suggested that higher working memory capacity might mean a stronger ability to control attention during episodes of significant task interference. The complex attention, sensory, motor,

linguistic and visual demands interacting during the use of AAC in conversation would appear to characterize an ongoing form of task interference within the conversational setting. It was noted that interruptions were considered by the participants to have limited impact upon conversational success. Users of AAC in this study, much like conversational partners without impairments, seem to be intent upon getting their intended message across regardless of interruptions experienced.

The open-ended questions were provided to a more limited sample of respondents, limiting generalizability. There were, however, very strong consistencies among the respondents related to message development that reflected findings within the larger survey. The time needed to compose a message when using an SGD, maintain listener's attention, and be in touch with the current conversational topic were the primary concerns reported by the users of AAC in this study. The concerns with time elements in conversation and message development also lead to a significant amount of personal frustration and worry related to conversational partner interactions. Managing the processing demands associated with message development revealed a variable reporting pattern among the limited sample of respondents to the open-ended questions, again reflecting the variability in the larger survey of the reported importance of active use of strategies of working memory and processing for success in conversation and message development. Some users of AAC did report the use of several strategies known to facilitate working memory success such as: limiting distractions, asking partners to refrain from speaking, reciting thoughts to self before answering and using the cueing support of word prediction.

Overall, the users of AAC in this study did not specifically focus upon strategies

for facilitating recall or dependency upon use of the design features and tools built into speech-generating devices. It is suggested they may not be aware of using these features as a consequence of long-term use of AAC. The therapists working with the users of AAC may incorporate these strategies into therapy in ways that the user of a speech generating device begins to automatically apply them without direct thought, much like the “automaticity” (p. 189) that Light and Lindsay (1991) suggest as a strategy to manage stressors to working memory. The learning and overlearning that goes into becoming a proficient user of AAC may directly impact the user’s ability to deal with the working memory demands of using AAC. Recall of symbol/word locations have become automatic as a consequence of practice and transfer to long-term memory. The strategies for learning, rate enhancement, and recall developed by the designers of AAC systems and reinforced within the context of AAC training may have become so automatic to the users of AAC that they no longer focus upon them.

It does appear that the users of AAC recognized the importance of attention and time to manage the use of AAC. The importance of attention within most working memory models, whether multi-component or unitary, is reinforced by the reports of the users of AAC in this study for success within conversation. Researchers in the field of AAC (Light & Lindsay, 1991; Thistle & Wilkinson, 2011, 2013) have suggested that the skills associated with cognitive processing are important for the management of working memory demands when using AAC. Users of AAC reported the importance of time, attention, focus on content, visual processing, and the use of features to reduce time used to create messages such as pre-stored messages and word prediction as most important to message development and communication success. The users of AAC in this study did

report that visualization of messages supported successful message formulation, which is one of the strategies researchers have suggested as supporting the management of working memory stressors (Light & Lindsay, 1991; Wagner & Jackson, 2006).

Within the context of conversational success and processing when using AAC, the open-ended questions provided information that supported the importance of conversational partners respecting the time required to use AAC successfully, the importance of topic maintenance, and the significance of continuing to develop design features of AAC systems that enhance speed, organization and decrease stressors to motor movement. In order for the users of AAC to be most empowered in conversation, the community of therapists and conversational partners should continue to reinforce the concepts of social networks fostered by Blackstone (2005) as a means of creating environments which are socially engaging and diverse as a means of supporting and strengthening the conversational power of users of AAC. Based upon dynamic systems of relationships between individuals in varied environments, the term *social networks* refers to the community of relationships that decrease isolation and encourage social participation (Blackstone, 2005). Blackstone (2005) reported the application of social networks reinforced participation in life, encouraged meaning that is co-created by the individuals involved in the interaction (Baxter, 2004; Higgenbotham, Blackstone, Berg, & Wilkins, 2009) and was dependent upon communication as the basis for the initiation, development, and continuation of relationships in society (Albrecht & Adelman, 1987). The concept of social networks has been suggested as a necessary part of the therapeutic process for the speech/language pathologist working with the individual using AAC (Beukelman and Mirenda, 1998).

### *Limitations of the Study*

The most significant limitations of this study were the small sample size, the self-selection of subjects for participation, the multiple types of speech-generating devices used, and the use of survey data rather than quantitative, test-based data to gather information related to working memory performance. The focus of the study was upon the perceptions of working memory activities by the users of AAC, thereby limiting the need for actual formal assessment of working memory performance.

While the sample size for this study was judged to be small, participants in this study and the results to the survey questions supported the position that, while individuals who use AAC are a heterogeneous group of individuals who have in common the use of an SGD (Higginbotham & Bedrosian, 1995), there were some commonalities to language usage, conversational frustrations and AAC system feature access and preferences. The users of AAC in this study were often well educated and literate with the potential for lengthy sentence development. They judged their communication attempts to be successful. They were frustrated by the time it takes to participate in a conversation and were well aware that conversational partners can lose interest and may have negative perceptions of their conversational and intellectual abilities (Beukelman & Mirenda, 2005, Todman & Lewins, 1996; Todman & Rzepecka, 2003).

### *Considerations for Future Research*

In view of the findings of this study there are several areas of research that should be considered to further engage consideration of working memory processes within the use of high-tech AAC. These include: direct assessment of working memory skills with adult users of AAC providing extended time to complete the task; self-analysis of

cognitive processes used during assessment of working memory skills by users of AAC to further develop insight into the strategies employed; continued comparison of visual and auditory memory skills with users of AAC; and continued sampling of working memory processes and use of design features among users of similar AAC systems, particularly as individuals are becoming proficient users. Within this discussion of future research, there needs to be the continued opportunity for the population of users of AAC to directly contribute to the design of AAC systems, to provide input into features impacting organizational and linguistic structures, and as suggested by other researchers (Wilkinson, O'Neill & McIlvane, 2014) to encourage more direct research with users of AAC.

Direct sampling of the users of AAC as to what features they find most useful for conversational success will support the growing awareness that for a single individual to achieve communication competency in multiple environments they may benefit from the use of multiple AAC systems. The users of AAC, specifically those using varied speech-generating devices, have much to contribute to the discussion of the cognitive processes involved in working memory to support learning, attention management to support working memory, and the features of AAC systems that enhance the functioning of working memory.

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## APPENDIX A

### EXTENDED FOLLOW-UP INTERVIEW

1. What is most difficult about creating messages when using AAC?
2. How do you manage the processing demands of conversation while formulating messages on your communication SGD?
3. What is the most difficult task when participating in conversation when using a SGD?

## APPENDIX B

### SURVEY

Thank you for agreeing to complete this survey.

Working memory is typically identified as the active mental manipulation and processing of information prior to storing that information in long-term memory. Working memory is temporary, typically no more than 10-15 seconds. Working memory uses information from long-term memory to make sense of new information being processed. Because information in working memory stays active for only a short time, information can be quickly lost.

To further understand the role of working memory when using a speech-generating device, we are attempting to gather information directly from you and other users of speech-generating devices (SGD). This information should assist therapists and developers of SGD to better support communication for individuals using SGD.

---

Date: \_\_\_\_\_

1. Sex

\_\_\_\_\_ Male  
\_\_\_\_\_ Female

2. Age: \_\_\_\_\_

3. Education Level

\_\_\_\_\_ High School  
\_\_\_\_\_ College  
\_\_\_\_\_ Graduate School

4. AAC System Used: \_\_\_\_\_

5. Length of Time Using Speech-Generating Device:

\_\_\_\_\_

6. How was this survey completed:

\_\_\_\_\_ Independently  
\_\_\_\_\_ With Assistance  
Who Assisted You?

\_\_\_\_\_ Parent  
\_\_\_\_\_ Spouse/Partner  
\_\_\_\_\_ Friend  
\_\_\_\_\_ Aide/Assistant

7. What is your access method?

\_\_\_\_\_ Direct Selection  
\_\_\_\_\_ Scanning

8. What is the range of words you typically use in most messages communicated with your AAC system?

\_\_\_\_\_ 1-3 words  
\_\_\_\_\_ 4-6 words  
\_\_\_\_\_ 6 or more words

9. What reading and writing activities are you able to do?

\_\_\_\_\_ Read e-mail  
\_\_\_\_\_ Write e-mail  
\_\_\_\_\_ Read articles on the internet  
\_\_\_\_\_ Read the newspaper  
\_\_\_\_\_ Write papers or presentations  
\_\_\_\_\_ Read for my job  
\_\_\_\_\_ Write for my job

10. When having a conversation, how often do you experience the following when communicating with your speech-generating device?

	<b>Always</b>	<b>Most of the Time</b>	<b>Sometimes</b>	<b>Seldom</b>	<b>Never</b>
Successfully communicate your message					
Get distracted when creating a message					
Create a message that reflects what you want to say					

11. How important was each of the following for using your speech-generating device?

	<b>Necessary</b>	<b>Very Important</b>	<b>Important</b>	<b>Somewhat Important</b>	<b>Not Important</b>
Length of symbol/word sequence					
Use auditory feedback while creating your message					
Being able to break a symbol sequence into smaller pieces					
Using categories and pages					
Having a limited number of symbol choices					
Memorizing symbol/page sequences					
Using motor pattern sequences					
Recognizing connections between symbols					
Combining new symbols with pre-stored phrases					

12. How important is each of the following for completing a message using your speech-generating device?

	<b>Necessary</b>	<b>Very Important</b>	<b>Important</b>	<b>Somewhat Important</b>	<b>Not Important</b>
Color coding of targets					
Use of icon prediction					
Category associations					
Looking at the symbols on my AAC system					
Using motor movement patterns					
Picture cues					
Using pre-stored messages					
Using word prediction					
Keeping my messages short					
Breaking the message into small pieces					
Hearing the message as I am creating it					
Seeing the message as I am creating it					
Relying on frequently used symbols					

13. When you are having a conversation how often do each of the following contribute to errors when developing messages on your speech-generating device?

	<b>Always</b>	<b>Most of the Time</b>	<b>Sometimes</b>	<b>Seldom</b>	<b>Never</b>
Forgetting message content					
Forgetting where I was in developing a message					
Forgetting what the conversation is about					
Difficulty paying attention					
Forgetting symbol locations					
Layout of my display					
Difficulty processing what is going on in the conversation					
Not understanding the conversational topic					
Motor problems					
Grammar mistakes					
Not having the vocabulary/symbols I need					
Pre-programmed phrase do not match the conversational topic					
Distractions around me					
Interruptions					
My partner does not give me enough time to create a message					
The time it takes to create a message					
Getting frustrated					
Changes in conversational topic					

14. When having a conversation, how often do each of the following to success when using your speech-generating device?

	<b>Always</b>	<b>Most of the Time</b>	<b>Sometimes</b>	<b>Seldom</b>	<b>Never</b>
Paying attention to the conversational topic					
Repeating what I want to say to myself several times					
“Seeing” the message in my head before I start creating the message					
Interruptions					
Silently repeating part of what was said to me to remember the topic					
Remembering what the other person said					
Planning the message before I start creating the message					
Using commonly used expressions					