Implications of Information Processing Theory on Persons Who Are Nonspeaking

An Honors Thesis (HONRS 499)

by

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ABSTRACT

The purpose of this thesis was to examine the relationship between information processing theory and augmentative/alternative communication. Literature on information processing theory and augmentative/alternative communication was reviewed. Results of the review revealed unique cognitive processing demands placed on the AAC user when using an aided communication system. This thesis will discuss these unique cognitive demands as related to the communicative process for persons who are nonspeaking.
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Chapter 1

Literature Review

Introduction

Few researchers in the field of speech-language pathology have addressed the link between information processing theory and augmentative and alternative communication (AAC). This area of inquiry appears significant because there are many components of information processing theory that are applicable to AAC. In order to explore this avenue of thought, it is necessary to understand the information processing theory itself.

This thesis will first discuss information processing theory—a theory that describes how information is manipulated in three interacting subsystems (i.e., sensory, short-term, and long-term memory). Information processing theory is central to the cognitive processes that are essential to everyday life. Mnemonic strategies, automaticity, and metacognition will be discussed within the information-processing context. This literature will serve as a basis to discuss cognitive processing strategies for persons who use AAC systems. A number of different areas will be discussed relating information processing theory to AAC. Special emphasis will be placed on the symbol learning process for populations of nonspeaking persons. Lastly, this thesis will address the cognitive processing demands and external factors (e.g., iconicity, naturalness of the intervention environment, the addition of a voice output system, and age) that nonspeaking populations experience when utilizing an AAC system.
Information Processing Theory

The theory of information processing developed as researchers were studying how information is acted on by children and adults (Berk, 2000). Researchers wanted to determine how information is detected, transformed, stored, accessed, and modified through the human cognitive system. They devised a cognitive system in which information is attended to and then manipulated as it flows through the mind (Berk, 2000). Baddeley (1999, p. 9) considers this system—"the probable psychological structure of human memory"—to be the information processing theory. This theory of information processing is central to discovering how children learn.

According to Baddeley (1999, p. 19) memory is "an array of interacting systems, each capable of encoding or registering information, storing it, and making it available by retrieval." Baddeley states that most psychologists would divide information processing theory into three subsystems that hold the information for periods of time: sensory memory, short-term memory, and long-term memory. The three subsystems will be discussed along with working memory, mnemonic strategies, automaticity, and metacognition to create a complete representation of the information processing theory. Figure 1 in Appendix A is provided to the reader to summarize the information processing memory system model proposed by Atkinson and Shiffrin (as cited in Baddeley, 1999, p. 10).

Sensory Memory

The sensory memory is the system where auditory or visual stimuli first enter the mind. Sensory memory consists of visual sensory memory and auditory sensory memory. An example of visual sensory memory is when you briefly look at an object, close your eyes, and in the following instant you are able to visualize that image. Visual sensory memory is often
accompanying by auditory sensory memory. The auditory sensory memory holds auditory stimuli we have just heard, allowing us to remember that stimuli for short time periods (Baddeley, 1999). These two divisions of sensory memory only hold the information long enough for the mind to give the stimuli attention. If attention is not given, the information is lost.

**Short-term Memory**

The next, and likely most crucial, aspect of information processing is short-term memory. Baddeley (1999) states that short-term memory is similar to sensory memory in that it is not one entity within itself. On the contrary, short-term memory consists of many components that manipulate auditory stimuli, visual stimuli, or both while the stimuli are being held. Information and ideas that would otherwise flow out of the processing system are held and later used for various purposes (Baddeley, 1999). One of those purposes is to solve problems, which utilizes the working memory that will be discussed later in this thesis.

Problem solving is not the only component of short-term memory. The short-term memory performs such functions as the rehearsal and coding of information flowing in from the sensory memory. Information can then be transferred into the long-term memory store. Short-term memory also deals with the retrieval of information from long-term memory. It may be necessary in some situations to retrieve information in order to complete a task. Short-term memory is the entity that decides what to do with information before it is sent to the permanent memory store (i.e., long-term memory).

Short-term memory is the element of our processing system that is the most crucial to everyday living. It functions to process language input from those we are interacting with in our environment. In addition, short-term memory also holds linguistic information from long-term
memory in order to understand and produce language. This is the subsystem that would hold onto a spoken sentence long enough for comprehension to occur.

In order to perform the aforementioned functions, there is a theory that short-term memory has a limited, fixed capacity (i.e., information held at a given time). The capacity of short-term memory can be assessed by digit span – the maximum number of sequenced digits that can be remembered. Digit span can give interventionists an idea of the capacity a person may have for retaining information in short-term memory.

Cognitive capacity should be assessed to produce strategies that are compatible to the person’s cognitive ability. Certain strategies may be utilized to augment the person’s current cognitive abilities so tasks do not use all of the available cognitive resources. Guttentag (1989) noted that the capacity of short-term memory and the resources available to access information through short-term memory become increasingly efficient with age. Part of this increase in capacity could be due to the increased efficiency in use of memory, or mnemonic, strategies (Guttentag, 1989). Implementing mnemonic strategies into intervention programs could more effectively complete cognitive tasks. Researchers have made it increasingly obvious that mnemonic strategies are important aspects to the efficiency of short-term memory. Mnemonic strategies will be discussed in further detail later in this thesis.

**Working Memory**

Another component of short-term memory is working memory. This is thought to be the aspect of memory that is used to solve problems. Solving arithmetic equations or analytical problems are examples of working memory (Baddeley, 1999). Three components of working memory, as proposed by Baddeley, include the central executive and its “slave” systems, the phonological loop and visuo-spatial sketchpad. The central executive is the theoretical system
that coordinates information flowing through the other two components and links the information to long-term memory. This component combines memory and processing for the working memory system. The two slave systems assist the central executive by freeing up some of the limited resources so more difficult tasks can be processed (Baddeley, 1999).

The first slave system of working memory is the phonological, or articulatory, loop. The phonological loop is believed to be the area of memory where people take in stimuli they have just heard and say it over again in their mind using subvocal speech. This is the speech that makes up the running commentary in our minds (Baddeley, 1999). Many persons use subvocal speech when performing such tasks as reading or counting (i.e., we actually “say” the words in our mind). The phonological loop utilizes this rehearsal of stimuli (i.e., speech or text) to maintain a memory trace. This memory trace contains parts of the stimuli previously processed. The stimuli are being held until all of the parts have gone through the loop. This slave system of working memory is literally a loop where phonological information flows. Each piece of phonological information is recycled until the entire sequence is contained in working memory. Then the information previously processed flows back around to form the complete chunk of information to be processed for comprehension (Baddeley, 1999).

Baddeley (1999) has indicated that there is a debate over the phonological loop. Some question the efficiency of the components that make up the phonological loop and others question if the phonological loop actually exists. Baddeley reveals evidence for a phonological loop in the information processing system. This includes problems that result when participants are not allowed to rehearse each word in a sequence. In this instance, the words are not registered in the short-term memory store because individuals can no longer use subvocal speech to rehearse. Another obvious piece of evidence for the phonological loop is that persons can
remember short words more easily than longer words. The longer length requires the working memory to hold the stimuli for a greater period of time during rehearsal. This allows earlier words to fade out of the memory trace.

Baddeley (1999) further proposes that the phonological loop in working memory is a back-up process in language acquisition and comprehension. He believes this system maintains that information taken in will be properly comprehended and encoded. The idea behind this is that stimuli are held in the phonological loop until all parts are processed. This ensures that no information will be lost, allowing the person to process all parts of the information. Language acquisition is facilitated because the person is able to comprehend the stimuli they are receiving. If the phonological loop did not exist, part of the stimuli may be lost, resulting in only partial understanding of what was said.

The phonological loop of working memory works together with the second slave system of the central executive: the visuo-spatial sketch pad. Baddeley (1999) describes the visuo-spatial sketch pad as a system in which persons are able to manipulate images viewed and store them in the short-term memory. This is the type of task where a person is asked to do mental rotation exercises by twisting around a first image to make it look like a second. In order to perform that task, the person must retain the first mental image and twist it while viewing the second image.

Imagery as part of information processing is a debated topic. Marschark, Yuille, Richman, and Hunt (1987) reviewed literature in this area. These researchers found no evidence that imagery is one of the strategies used by short-term memory to store information in long-term memory for retrieval. They concluded that persons do not create an image in their mind to facilitate processing while learning words or symbols.
Some researchers take the opposite view as Marschark, et al. (1987). Brewer (as cited in Marschark, et al., 1987) believed that persons use images to store information more effectively in their memory. This extra strategy in storage then makes retrieval of that information easier. Studies on this issue create evidence for the use of imagery in memory. Participants in these studies confirm the use of images when encoding concrete information (i.e., words) into their memory. These persons are able to visualize the image of the stimuli (i.e., they hear the word "dog" and see the image of a dog in their minds). Additionally, the results of these studies show that the same individuals recall the concrete information much more readily than information about feelings or other abstract ideas. The abstract ideas do not allow for effective recall because the person is not able to create a mental image.

This visuo-spatial sketch pad and the phonological loop are entities that work together in order to solve problems in the working memory. The central executive coordinates this entire process to ensure that information is processed efficiently and effectively. When these components coordinate properly, problems are solved with little cognitive demand placed on the person.

**Long-term Memory**

The next subsystem of information processing is long-term memory. This is what many people think of as "memory." Long-term memory is where information is stored for longer periods of time. There are two types of long-term memory: episodic and semantic (Baddeley, 1999). When persons remember certain situations or events, they are using episodic memory. Semantic memory is more broad than episodic. It involves worldly knowledge such as word meanings and geographical locations. These types of memory enable persons to more efficiently process words and events in the long-term memory.
Baddeley (1999) discussed the idea that short-term and long-term memory are separate systems in information processing. Evidence for this separation is that stimuli in short-term memory are processed in terms of sounds (i.e., the phonological loop of the working memory), but stimuli in long-term memory is processed in terms of meaning. More evidence for this taxonomy is that new information cannot simply flow into the long-term memory. This information must first be processed in the short-term memory in a way that facilitates long-term learning (Baddeley, 1999).

In order for information to be processed so it becomes a part of the long-term memory, many persons use memory techniques called mnemonic strategies. These strategies help facilitate learning within the information processing system. They keep information in the short-term memory store or process it into long-term memory. Mnemonic strategies are clearly crucial to the learning process for all persons.

**Mnemonic Strategies**

People use mnemonic strategies such as rehearsal and chunking of information to help make information more salient while it is in the short-term memory store (Baddeley, 1999). These techniques allow visual and auditory stimuli to remain in the short-term memory for longer periods of time. The use of mnemonic strategies also allows stimuli to undergo the “deep” processing required for long-term learning (Baddeley, 1999).

Meadows (1998) noted that effective thinkers are able to utilize mnemonic strategies. These persons become proficient at the strategies they use by exhibiting a wide range of them. Effective thinkers not only have specialized memory strategies for specific tasks, but also more general strategies that can be applied to many different situations (Meadows, 1998).
Most persons do not realize the extensive use of mnemonic strategies in our everyday lives. The use of a rehearsal strategy is common when trying to place information into memory. For instance, persons use this strategy to remember phone numbers. The numbers are repeated either in their head or aloud to facilitate processing. This example also alludes to the use of vocalization as a mnemonic strategy. Many persons utilize vocalization by verbalizing the information they want to remember. When remembering information such as a phone number, other persons may use chunking. This mnemonic strategy separates stimuli into smaller parts for easier processing. People may chunk a telephone number or name by rehearsing the information in chunks, such as “765...233...9999.”

Several studies have proven that as children get older, increased sophistication and efficiency of mnemonic strategy use leads to better recall (Best & Ornstein, 1986). Studies have also shown that younger children can be taught the mnemonic strategies of older children in order to facilitate recall (Best & Ornstein, 1986; Cox, Ornstein, Naus, Maxfield, & Zimler, 1989).

Best & Ornstein (1986) studied the hypothesis that mnemonic strategies can be taught to young children. The researchers found that children’s recall increases when given experience in categorizing items. Categorizing is a mnemonic strategy that many younger children do not yet utilize. Third graders were first asked to sort highly associated items (i.e., doll, stroller, bottle). As a result of this experience, the children were then able to sort a set of low-associated items (i.e., ball, fork, hammer) more semantically. Participants who were first given experience in sorting were then able to utilize their sorting strategies with the second set of items that are generally more difficult to categorize. These children were noted to have better recall, especially of the low-associated items. They were also able to give good instructions to first graders on
how to organize information semantically. This study proves that when given prior experience with a task, younger children can come up with their own strategies. The children gained knowledge about the usage of the strategies and were then able to teach the strategies to younger children. Better recall was noted because these strategies led to more efficient information storage in the short-term memory.

Cox, Ornstein, Naus, Maxfield, & Zimler, (1989) also tested the hypothesis that younger children can be taught to use mnemonic strategies typical of older children. In addition, these researchers questioned whether younger children were able to handle two strategies at once. In the first experiment, 3rd graders demonstrated better rehearsal and recall when given an active rehearsal strategy to sort low-associated items semantically. The second experiment showed that sorting of related items facilitated active rehearsal for these 3rd graders. The results illustrate that young children can use two mnemonic strategies – active rehearsal and categorical sorting – at the same time. The researchers concluded that a structured teaching method including active rehearsal and sorting would lead to better recall.

Another study conducted by Ornstein, Stone, Medlin, and Naus (1985) highlighted the idea that children may need to retrieve information from long-term memory to facilitate the active rehearsal strategy in the short-term memory. The researchers hypothesized that the use of active rehearsal strategies leads to an increase in recall as children get older. This hypothesis was formed from the theory that young children may lack the efficient retrieval ability they need in order to rehearse. The results of the two experiments in this study showed that second graders improved their recall performance when given an active rehearsal strategy, the opportunity to see all items presented, and extra time to rehearse. Control groups not given these three strategies had recall abilities far below those of the children who utilized the strategies. It appears that
when the children were given mnemonic strategies they lacked, they did not need to use the retrieval process to facilitate recall. Young children must increase their efficiency of using strategies for recall. This will then allow them to utilize retrieval more efficiently.

Salthouse and Saults conducted a study focusing on dual-task costs that also provides evidence for the effectiveness of mnemonic strategies (as cited in Guttentag, 1989). These researchers noted that when younger children are asked to perform two tasks at the same time (i.e., remembering a sequence of words while tapping their fingers), they have a difficult time doing so. These limitations are due not only to a lack of available resources, but also because children are not able to use strategies effectively. Older children, on the other hand, use effective strategies to encode and retrieve the information. This allows them to perform both tasks simultaneously.

Beyond implementing mnemonic strategies, the efficiency of short-term memory can also be affected by automaticity. As individuals practice a task and become familiar with the process, that task becomes automatic.

**Automaticity**

Automaticity is theoretically believed to make processing more efficient in the short-term memory. Nearly any task performed repeatedly will result in automaticity. Repeated motor movements allow the task to become second nature to the person. When a task is automatic, it does not require as many cognitive resources during processing. This allows resources to be available for other tasks or stimuli that are not automatic.

The basic theory of automaticity is easy to understand when applied to everyday situations. For instance, when first learning to drive a car, a person uses a lot of cognitive resources to concentrate on this new task. Any interruptions or additional cognitive demands can
become too much to handle. Gradually the person becomes more comfortable with driving because they have done so repeatedly. The person is then able to listen to the radio or talk with friends while driving. The cognitive processes involved in driving the car have become automatic for that person. Most every daily activity, from riding a bicycle to typing on a keyboard, has become an automatic part of our cognitions.

Samuels and LaBerge proposed a model of automatic information processing in reading (as cited in Samuels, 1994). The central component of this model is that as children get older they are able to become fluent readers because the process of decoding the text becomes automatic. New readers must struggle with the cognitive demands of decoding the written words and then comprehending them. Automaticity frees up much of the available cognitive resources and allows them to be used to comprehend the text. The main concepts of this model apply to any cognitive task. When individuals are first learning a task, many of their resources are spent on one part of the task, leaving the rest incomplete. As each of those parts is mastered, they become more automatic and allow other parts of the task to be mastered.

Automaticity is essential to efficient information processing and is a part of our everyday lives. Another crucial aspect of this cognitive process is metacognition, which will be discussed next.

Metacognition

Several psychological theorists, including Piaget and Vygotsky, agree that metacognition is central to the development of cognition (Meadows, 1998). Metacognition is defined as the behavior of thinking about thinking. According to Meadows, these behaviors include the awareness of cognitive operations in order to evaluate them. In addition, metacognitive behaviors include awareness of personal capabilities required to perform the task and
orchestrating thought to solve problems. Metacognition first allows a person to define the task or problem at hand and think about what knowledge they will need to solve the task. The person also utilizes metacognition to devise a plan for solving the task and ensure that the solution to the task is correct (Meadows).

Metacognition is an integral part of the cognitive tasks persons face everyday. It is important to many areas supported by cognitive development, including language. In order for children to learn tasks, they must first be able to understand the processes behind those activities. Utilizing metacognition creates a link to information processing. As children become more proficient at tasks they use less cognitive resources. They are able to think about the task, including the steps needed to complete the task.

**Summary**

Information processing theory describes how persons process information. The first subsystem of this theory is sensory memory, where stimuli enters the mind. Stimuli that has been attended to then flows into the second subsystem, short-term memory. Short-term memory is essential to processing because it holds the stimuli so it is comprehended. A crucial component of short-term memory is working memory. This system solves problems utilizing the phonological loop and the visuo-spatial sketch pad. The last subsystem of information processing theory is long-term memory. This is the storage subsystem for information that has been processed. To facilitate the processing of stimuli in these subsystems, persons utilize mnemonic strategies, automaticity, and metacognition.

The purpose of this thesis is to address the link between the processing of information and AAC. Before this connection can be discussed, however, a thorough explanation of the theory, processes, and intervention relating to AAC must be made.
**AAC**

Augmentative and alternative communication (AAC) is a fairly new specialization in the field of speech-language pathology. Over the past two decades, AAC has grown to encompass the communicative needs of persons who are nonspeaking. These are persons whose disabilities do not allow them to use the spoken mode of communication. The American Speech-Language Hearing Association (ASHA) defines AAC as “an area of clinical practice that attempts to compensate either temporarily or permanently for the impairment and disability patterns of individuals with severe and expressive communication disorders” (ASHA, 1991, p. 10). AAC consists of symbols (i.e., representations of concepts or objects) utilized to meet the communication needs and wants of persons who are nonspeaking. According to ASHA (as cited in Beukelman and Mirenda, 1992, p. 3), AAC interventions should “utilize the individual’s full communication capabilities, including any residual speech or vocalizations, gestures, signs, and aided communication.”

AAC Users are representative of various ages and populations of persons with disabilities. Persons who use AAC have the common need to communicate with their environments through a mode other than speech. These are persons with developmental disorders such as autism, specific language impairment, or mental retardation. AAC Users also include those who have congenital disorders (i.e., cerebral palsy) and acquired disorders (i.e., multiple sclerosis, stroke) that limit their ability to communicate.

**AAC Systems**

AAC systems are made up of two types: unaided and aided. Unaided communication is the most natural type of AAC and is where persons use their own bodies to communicate. For example, a person might use unaided communication techniques such as manual signing or
gesturing. Aided communication is the AAC system where an individual uses some sort of external device to formulate responses. Examples of aided communication include miniature objects, communication boards, and electronic communication boards (Fuller, Lloyd, & Stratton, 1997).

For populations of nonspeaking persons, communication is not the effortless symbolic process as it is for most humans. These persons must have an alternative way to communicate their needs and wants because they are not able to utilize speech. AAC systems have emerged as a way to compensate for these communication limitations. The core of any communication process is the ability to represent messages and concepts in alternative ways. Many persons do this by gesturing while speaking or giving thumbs up for a job well done (Beukelman & Mirenda, 1992). Based on this premise, AAC interventionists use symbols as the communication mode for persons who are nonspeaking.

Symbols represent certain concepts or objects the AAC user can communicate about. More specifically, ASHA states that symbols are used for the “visual, auditory, and/or tactile representation of conventional concepts” (as cited in Beukelman & Mirenda, 1992, p. 3). According to ASHA, the symbols in AAC are used for those populations of persons “for whom gestural, speech, and/or written communication is temporarily or permanently inadequate to meet all of their communication needs” (as cited in Beukelman & Mirenda, 1992, p. 4). Symbols are designed for use with various communication systems (e.g., communication boards, electronic communication devices). AAC utilizes these symbols as an integral part of communication interactions.
Several characteristics allow facilitators to choose the symbols that work the best for each AAC User. One such characteristic is the degree of iconicity of the symbol. Iconicity refers to how closely the symbol resembles its referent (i.e., the object or idea represented by the symbol) (Fuller, Lloyd, Stratton, 1997). According to Koul and Lloyd (1998), symbols lie along a continuum of iconicity. At one end they can be opaque. A symbol that is opaque has little visual relationship to its referent. Opaque symbols include synthetic speech output and arbitrary logographs such as Premack Symbols. In the Premack symbol set, a meaning is arbitrarily assigned to the shapes (Fuller, Lloyd, Stratton, 1997). Symbols at the other end of the continuum of iconicity are easy to assign a meaning to and are considered to be transparent. Examples of transparent symbols include real objects, photographs, and Picture Communication Symbols (PCS). In the middle of this continuum lie translucent symbols. Reichle, York, and Sigafoos define translucent symbols as those symbols whose meaning is easy to guess without having extra information available (as cited in Fuller, Lloyd, & Stratton, 1997). Translucent symbols encompass partially picture-based symbols such as Blissymbolics and DynaSym.

The degree of iconicity can have a significant impact on the AAC User. Symbols that demonstrate a greater degree of iconicity (i.e., transparent symbols) are easier to learn because there is greater resemblance to the referent. For instance, symbols based on pictures (i.e., Picture Communication Symbols) lead to more efficient learning than symbols based on line drawings (i.e., Blissymbolics).

When choosing the appropriate AAC system, Lloyd, Fuller, and Arvidson (1997) indicate that interventionists must consider other symbol characteristics beyond degree of iconicity. The complexity of the symbol must also be taken into account. Facilitators must look at the sophistication of each symbol, including the background and the number of semantic elements
Implications of (i.e., the intricacy of the lines of symbols). Symbols can be complex if the background contains other figures instead of simply being white. For instance, it would be more difficult for an AAC User to see and learn a symbol on a background that is distracting, such as a checkerboard. A background that consists of only one color and no objects would make the task of symbol learning much easier. The complexity of can also increase with symbol sets such as Blissymbolics when there are more line strokes added to the drawing. Because Bliss symbols are made of black and white lines, more lines (i.e., strokes) produce a greater number of semantic elements and greater complexity.

The perceptual distinctness, or the degree the symbol is different from other symbols, is another characteristic to consider. Symbols are complex in perceptual distinctness if the AAC User has a difficult time differentiating between them. Many referents have symbols that appear to be the same or closely resemble each other. Those symbols are not perceptually distinct. For example, symbols that represent a horse and a cow may not look different enough that the AAC User is able to easily distinguish and learn them.

When selecting symbols, the size of the symbol and its degree of ambiguity, or the number of concepts it represents, are also important. A symbol’s size should depend on the needs of the AAC User. Symbols for AAC Users should be not too small or too large. AAC Users with visual impairments will need larger symbols to accommodate their needs. The main goal is that the user is able to see the symbol and fit as many symbols on the communication board as possible (Fuller, Lloyd, Stratton, 1997). The degree of ambiguity of a symbol is another consideration when selecting symbols. Symbols that are high in ambiguity have multiple meanings (i.e., the same symbol is utilized for the concepts “food”, “eat”, “dinner”, etc.). A higher degree of ambiguity may fit the needs of some AAC Users. High
ambiguity of symbols enables the user to create more novel utterances with less symbols. This, in turn, allows the user to fully utilize limited space on the communication board. Other users may have higher cognitive processing demands that require the use of symbols with less ambiguity (i.e., one symbol is used to represent each concept).

The symbols used in AAC essentially belong to a variety of sets or systems. These symbol sets are collections of similar types of symbols that can be expanded to meet the needs of the particular AAC User (Fuller & Lloyd, 1997). Symbol sets can be differentiated by fitting them into the unaided and aided communication categories. Unaided communication symbol sets are those found in American Sign Language, fingerspelling, gestures, and so on. Aided communication consists of such symbol sets as photographs and pictures, graphic symbols, and synthetic speech.

Aided communication symbol sets are frequently arranged on an array to make several symbols available for the user. Symbol arrays are typically placed in a notebook, a communication board, or electronic device. Many times the notebooks have a page for each environmental concept or situation the AAC User will encounter. The user can then turn to the page and be ready to communicate in each situation. Communication boards range from a simple piece of cardboard with photographs attached to more complex electronic communication boards. Electronic communication boards are central to many current AAC intervention programs. These boards consist of any array of symbols chosen to fit the AAC User's communication needs. The user is able to select the symbol(s) to convey a message through voice output.

While these electronic communication systems compensate well for the AAC User's limited communication abilities, there are drawbacks. The rate of communication for the
Implications of AAC Users is very slow. Mathy-Laikko, West, and Jones found that the average AAC User’s words per minute is between 2.3 and 8.2 (as cited in Higginbotham, Scally, Lundy, & Kowarsky). Newer synthetic speech systems have been created to increase comprehension in order to remedy this problem.

Many professionals involved in AAC intervention suggest that systems such as communication boards are not the ultimate solution to meeting the communication deficits of nonspeaking populations. The goal of AAC intervention is to provide these individuals with a way to more efficiently and effectively engage in an array of interactions (Beukelman and Mirenda, 1992). Light (1988) specified that these interactions should be utilized to fulfill four specific communication purposes for the AAC User: the communication of needs and wants, information transfer, social closeness, and social etiquette. The purpose of AAC intervention is to allow persons who are nonspeaking to communicate as effectively as those persons in the speaking population.

**AAC Intervention**

The most crucial aspect of AAC intervention is for persons to learn and retain the symbols being taught. In order to facilitate this process, interventionists have begun to utilize message encoding. Symbols are chosen according to the individual user’s needs and capabilities (Beukelman & Mirenda). The symbols are then paired together into a symbol set so the messages are encoded through sequential order (Beukelman & Mirenda). Encoding symbols in sequential order provides many persons with the organization needed to remember the symbols during a communicative interaction.

Beyond the encoding of symbols, there are other areas within AAC intervention that must be addressed. Assessment for AAC is a thorough process that focuses on the skills of the
potential AAC User and any potential communication partners (Light, Roberts, Dimarco, & Greiner, 1998). Persons who are nonspeaking are assessed in many ways to determine the best intervention. This involves assessing the whole person, including any environmental or cognitive limitations that may present themselves.

Light (1988) described three domains that enable the AAC user to develop a wide range of skills to make communication more effective. These domains should be assessed and included in the intervention process. The first of these is the linguistic domain. This domain deals with the receptive and expressive language skills of the communicative partners in the person's environment. The partners must be able to understand the AAC User's message and also communicate effectively in return. The second domain leading to effective communication is social. The social domain necessitates that AAC intervention addresses the sociolinguistic and sociorelational skills related to communicative interactions. Interventionists must take into consideration the varied communication environments the AAC User will encounter and what skills are needed to successfully communicate in those environments. To complete the AAC intervention, Light mentioned the strategic domain. In order to overcome any excess demands from the other domains, the strategic domain deals with the use of certain strategies by the AAC user. The AAC User may need to compensate for problems with the language skills of their communicative partner or in their communicative environments.

These three domains must be addressed in AAC intervention. However, there is much more to the intervention process itself. Currently there are several theoretical intervention techniques to facilitate the learning of symbols for persons who are nonspeaking. Existing AAC interventions were devised to be implemented as the basis of therapy or simply as a means to augment it. These theoretical techniques focus on the thorough assessment and intervention of
persons who are nonspeaking. The method of teaching persons who are nonspeaking has long
been a debated topic. Many researchers struggle with finding all the necessary parts to this
equation. Light (1988) mentioned the importance of the actual interactions involving AAC
Users, noting that little research had been completed in this area. She reasoned for a
macroanalytic approach to intervention with persons who are nonspeaking. With this type of
methodology, the facilitator must look at all of the factors surrounding the AAC user and the
interaction itself.

Most methodologies suggested by researchers center on aiding the needs of the person
who is no nonspeaking and helping the person to communicate effectively. The AAC Input
Framework (AACIF) and System for Augmenting Language (SAL) are two frameworks that
have proven to be effective. As these frameworks are discussed, note that there is little reference
to the information processing capabilities of the populations being served.

The AACIF is a relatively new framework that focuses on the input processes that occur
while training for symbol acquisition (Wood, Lasker, Siegal-Causey, Beukelman, & Ball, 1998).
Previously, much of the focus in AAC was on increasing the quality of the users’ expressive
communication. AACIF takes a different approach by integrating four components to augment
the comprehension of the AAC users (Wood, et al., 1998).

The first component of AACIF is augmenting the message (Wood, et al.). This
component addresses the communicative partner’s enhancement of the meaning and salience of
the message. The partner provides additional resources to the user so stimuli can be processed
more effectively (Wood, et al.). Pictures, photographs, gestures, and other materials at the user’s
capability level are utilized (e.g., while asking a child with comprehension difficulties if they
would like to eat, the partner augments the verbal message with a gesture mimicking eating).
Implications of AACIF's second component is mapping language and symbols (Wood, et. al., 1998). The goal of this component is to facilitate the encoding of symbols to their referents. The communicative partner assists in building of a connection between the symbol and the event or item associated with it. Scaffolding is provided to give the extra support the user might need to learn the symbols.

The third component of AACIF is augmenting message retention (Wood, et. al., 1998). This component's purpose is to ensure the maintenance of the symbols being learned. The communication partner gives the user a concrete illustration of the symbol to facilitate better recall (e.g., the user is given a "remnant book" that includes objects that are important to the user so that they may recall past events).

Developing a pool of response options is the fourth and final component of AACIF. In this component the user is given several options of what to communicate about so that they may improve their expressive communication abilities (Wood, et. al., 1998).

The AACIF framework is a thorough method to enhance the comprehension of most any AAC User. Another framework currently used with persons who are nonspeaking is the System for Augmenting Language (SAL). This framework is most often utilized with individuals with mental retardation as a way to augment their language (Sevcik, Romski, Watkins, & Deffebach, 1995). SAL is derived of several components designed to facilitate the communication abilities of the AAC User. These components include a speech-output communication device, symbol vocabulary, and monitoring system. SAL also includes specific teaching procedures in which the partner provides symbol input and encourages communication attempts. The theory behind SAL is that AAC Users can benefit from the addition of spoken input during graphic symbol
Implications of learning (Sevcik, et. al., 1995). Sevcik and colleagues noted that this intervention technique may be especially helpful to individuals with beginning symbol achievement patterns.

The ideas that comprise the techniques for symbol learning are also central to symbol retention. The focus must be on making sure that the AAC user generalizes the symbols they have been taught to their surrounding environments (i.e., home, school, etc.). While these techniques discuss many factors of the AAC intervention process, the underlying question of what other demands are present exists. By integrating the theory of information processing and the concepts behind AAC, this question may be easily answered.
Information Processing and AAC

There is little research to date on how the information processing theory relates to the use of augmentative and alternative communication for persons who are nonspeaking. Current research tells us that many persons demonstrate cognitive limitations that ultimately affect the processing of auditory and visual stimuli. Research also tells us that AAC Users have unique communication challenges during interactions. By examining the cognitive limitations and communicative challenges of AAC Users, we may be able to provide more effective intervention strategies from a cognitive science perspective.

Processing Demands

Much of the research on information processing has dealt with discovering what cognitive demands are present while interacting with the environment. A lack of available cognitive resources can place limits on the encoding of auditory or visual information. These limitations consequently impact the learnability of a given task. Some persons who are nonspeaking may have difficulty with reading while other persons may have difficulty learning a particular symbol and its referent.

Persons who are nonspeaking have unique cognitive skills and increased cognitive demands compared to the typical communicator. These persons must learn to manage and augment the communication skills they possess. The young child who is beginning AAC intervention will have different cognitive challenges than the adult who has used AAC techniques for many years. For example, the young child who is nonspeaking is participating in the language learning process in addition to learning to use an aided communication system. In contrast, the adult has already developed language so additional cognitive processing demands are only placed on him when using an aided communication system. The service provider (i.e.,
speech-language pathologist) must be aware of these factors because cognitive demand issues for the AAC User and the AAC partner must be considered during the intervention process.

When observing an interaction between an AAC User and partner it is easy to note these cognitive demands. For a typical AAC User, these demands exist not only in the production of communication, but also in the reception of input from the communicative partner. These persons must hold input for much longer than most communicators must. For example, auditory input received during a communicative interaction is held in short-term memory long enough to process the stimuli and then create a response. Most of us take this task for granted because we are able to devise a response in less than a second. However, the rate of communication for AAC Users is very slow. They must hold the input they receive in short-term memory, and then formulate a response. Often the AAC User is responding by selecting the symbol(s) needed to communicate their reply. This process involves accessing their memory for a particular referent and the associated symbol(s). The AAC User must then search for the designated symbol(s) placed on the communication board. The location of the symbol(s) is usually arranged in a specific array that can often place additional processing demands on the AAC User.

Additionally, the AAC User has further cognitive demands placed on him. For example, it may be difficult for some AAC Users to utilize motor movements when selecting symbols. As a result, the AAC User is required to retain the original auditory stimulus from the AAC partner. The AAC User must also formulate a response to the original auditory stimulus. This creates a situation where they have to hold stimuli for even longer periods of time until the motor acts are completed.

Current research has discovered other cognitive processing problems that surface in
special populations. Lahey & Bloom (1994) noted that children with language learning disabilities tend to have problems with comprehension, inferencing, and reasoning because of a limited capacity model. This creates the inability to construct and/or hold the mental model of the language they use to communicate. The theory is that this mental model contributes to automaticity and ease in language processing for persons who do not have a language delay. These persons are able to construct a mental model of the linguistic aspects of their responses. When persons become more adept at the construction of the mental models, the process becomes automatic. This allows resources to remain available for other linguistic and cognitive tasks. However, some children with disabilities often have difficulty developing mental models. As a result, these children have significant difficulty using language during communicative interactions. Lahey and Bloom (1994) explained the need to address this limited capacity issue in language assessment and intervention.

The theory of a limited cognitive capacity for those with language disorders can easily be applied to persons who are nonspeaking. There are many common processing characteristics for children who are language learning disabled as well as those children who are nonspeaking. An impaired neurological system can present auditory processing deficits for persons who are nonspeaking. Additionally, some of these children may have difficulty processing auditory information because of reduced environmental exposure. When assessing persons who are nonspeaking, we must keep in mind these unique cognitive demands. It is important for persons to be able to construct a mental model of the linguistic utterance they will communicate. Recall that persons who are nonspeaking must hold auditory stimuli for longer periods of time in order to formulate their response. Additional cognitive demands emerge with the inability to construct a mental model. When the person is not able to construct a mental model of a linguistic
utterance, tasks such as processing auditory stimuli and formulating a response may not be able to utilize a strategy of automaticity. Therefore, even more cognitive demands are placed on the AAC User.

The cognitive demands of an AAC User must be thoroughly assessed before deciding an intervention strategy. Current research on intervention has begun to focus on the cognitive demands of young children. Kangas and Lloyd (1988) indicated that many professionals did not provide AAC intervention to children who are nonspeaking if they demonstrated significant cognitive delays. It was previously thought that those individuals with significant cognitive delays could not improve their communication skills through the use of AAC. Kangas & Lloyd (1988) also noted that different cognitive skills are sometimes utilized when AAC Users learn graphic symbols. For example, some children who use AAC systems may not have the capacity to use extensive productive language. However, this is not to suggest that these same children do not have the ability to recognize graphic symbols. Moreover, researchers have indicated that various interventions are beneficial even though the cognitive prerequisites are not firmly established.

The cognitive demands discussed in this section directly affect communicative interactions of AAC Users. The effects of these cognitive demands on the AAC User are further compounded by several factors that affect the learning and retention of AAC symbols. Next, this thesis will discuss these factors, including degree of iconicity, naturalness of the environment, addition of a voice output system, and age of the AAC User.

Factors Affecting Symbol Learning and Retention

Interventionists must address the factors affecting symbol learning and retention so intervention can be tailored to the individual AAC User. AAC intervention is not as simple as
choosing a communication board and symbols. Interventionists must also consider a number of factors that ultimately will impact the communicative interaction between the AAC User and partner. The factors that affect symbol learning and retention are numerous. They include the iconicity of the symbol set, the naturalness of the environment, the addition of a voice output in the symbol-learning process, and the age of the AAC User. All of these factors influence the cognitive demands of the AAC User. Additionally, the AAC User who may demonstrate pre-existing cognitive deficits will need special consideration. Interventionists must gain knowledge of the person's specific communication needs during assessment. Those needs include examining the AAC User's cognitive and linguistic capabilities, in addition to the information processing demands placed on the user while receiving and responding to auditory stimuli. All of these considerations will contribute to an effective intervention program.

**iconicity.**

Iconicity is a conceptual continuum describing the ease of symbol recognition. Many persons judge the degree of iconicity based on "guessability." Symbols may be high or low in guessability (Beukelman & Mirenda, 1992). The degree of iconicity of symbols used in AAC intervention can determine the ease of learning for populations of persons who are nonspeaking. Researchers agree that no certain degree of iconicity will be the best for every AAC User. These researchers note that determining the degree of iconicity is dependent upon the individual person. Some persons who are nonspeaking will best utilize symbols high in iconicity while others will be able to utilize symbols with a lesser degree of guessability. The guessability of the symbols depends on which will best meet the AAC User's communication needs.

Interventionists must also consider the continuum of iconicity in perspective of the AAC
User's information processing abilities. These abilities must be assessed to determine what degree of iconicity will reduce the cognitive demands of the person who is nonspeaking. Some AAC Users may be able to handle opaque symbols (i.e., low in guessability). Other persons may have little cognitive resources available and will need to use transparent symbols (i.e., high in guessability). The transparency of the symbols allows the AAC User to utilize less of their limited cognitive resources when formulating a response.

Several studies have tested which degree of iconicity is the best for persons who are nonspeaking. These studies focus on which symbol sets lead to faster learning and better recall for specific populations. In particular, these studies have focused on the two most frequently used symbol sets: Rebus and Blissymbolics. Rebus symbols are black and white line drawings that are a less abstract representation of the word or object. They are classified into concrete symbols, relational symbols, and abstract symbols (Burroughs, Albritton, Eaton, & Montague, 1990). Bliss symbols are “black and white line geometric shapes and/or combinations of those shapes” that represent objects and words. These symbols are iconic and abstract (Ecklund & Reichle, 1987). Two studies detailing which of these symbol sets facilitates effective learning and recall will now be discussed.

In the first study, Ecklund and Reichle (1987) examined the ability of normal preschool children to recall logographs from Blissymbolics and Rebus sets. These researchers were testing the hypothesis that Bliss symbols have an advantage in learning over Rebus because of their flexibility in syntax. The Bliss symbols have flexible syntax because they can be combined to form infinite meanings and phrases with only slight changes in a few lines. Other researchers disagree with these findings and believe Rebus symbols to be easier to learn. These researchers found that Rebus symbols and other more iconic line drawn symbols were actually easier to learn
in the early stages of an AAC intervention program. In these experiments the complexity of the Blissymbolic syntax appeared to be its downfall.

Ecklund and Reichle (1987) studied 32 preschool children to see if any differences in recall existed between Bliss symbols and Rebus symbols. 16 children were taught Bliss symbols and 16 were taught the Rebus symbols. Each group was exposed to 15 symbols in a flip binder. For recall, the children were shown a stimulus page with several symbols on it. When the researcher named each symbol, the children were to point to the associated symbol and name the symbol. Ecklund and Reichle found that normal preschool children recalled more Rebus than Bliss symbols. The researchers concluded that while the Blissymbol system does have flexibility, most children might not have the means to utilize this system completely. These children may find it difficult to develop the complex syntactic structures associated with Blissymbolics. However, it was noted that the differences in recall, though significant statistically, might not be significant clinically. The researchers hypothesized that although Rebus appears to be easier to learn in the beginning, this should not be the deciding factor for its use in intervention. The implication was that teaching Blissymbols may be more effective in the long run because of it’s flexibility in syntax.

Another study compared language delayed preschool children’s acquisition of Rebus versus Blissymbolics (Burroughs, Albritton, Eaton, & Montague, 1990). The researchers’ premise for testing this population is that previous research had noted that intervention with this population was functional nature. In this experiment, 13 children were assigned to each group. The first group was given Bliss symbols first, and then Rebus symbols. Children in the second group were tested with Rebus symbols first followed by Bliss symbols. The symbols were presented in a flip-page binder with 15 symbols to a page. To test the children’s recall of the
symbols, they were shown the symbol and asked to name its referent. The results of this study showed again that the Rebus symbol system was easier to identify in the beginning of training than Bliss symbols (Burroughs, et. al., 1990). However, more improvement was shown with the Bliss symbols from pre-test to posttest. The researchers stated that the Bliss symbol system might be the better system for more effective and efficient intervention (Burroughs, et. al., 1990).

When determining the appropriate symbol set for each AAC user, it is essential to determine which symbols on the continuum of iconicity best suit the user’s needs. For some AAC users, symbols high in iconicity (i.e., photographs or icons) may be the best fit. Other users may have enough cognitive abilities to use such systems as Blissymbolics, which allow for greater flexibility for future communication interactions. Besides iconicity, there are other important factors affecting symbol learning and retention. The next section will discuss the naturalness of the intervention environment.

naturalistic intervention.

An important factor relating to the learnability and retention of the symbol set is the environment where the communication interaction takes place. Most interventionists in the area of speech-language pathology now advocate the use of more naturalistic interventions. These are interventions in which communicative interactions are not artificially set up or fabricated. The intervention (e.g., the symbol learning process) is conducted in contexts that are natural to the individual child (Reed, 1994). For example, an interventionist would go to the child’s home and teach the child to associate symbols to their referents through play. Not only is the home environment natural to the child, but learning through play is something children do every day.

The basic premise of the naturalistic approach is that a natural learning environment not
only increases symbol retention, but also facilitates generalization of symbols to other contexts. Several researchers have noted that generalization has been observed when the intervention context closely resembles that of the contexts in the child's everyday life (Zangari and Kangas, 1997). One of the primary purposes of any intervention, including AAC, is to achieve generalization. Zangari and Kangas (1997) discussed the need to direct AAC interventions towards the person's future interaction environments. These environments differ for each person and can range from the classroom to the job site. Zangari and Kangas (1997) also noted that techniques and symbol types could be applied to different contexts or environments in order to facilitate effective symbol learning and retention. When the symbol learning process takes place in these environments, it increases the person's ability to utilize those symbols in each context. In addition, the person is able to expand their use of the AAC system to other environments.

The positive effects of naturalistic intervention extend beyond symbol learning, retention, and generalization. Learning in a natural environment also leads to the reduction of cognitive demands. The level of comfort associated with familiar surroundings or situations allows the AAC User to focus all cognitive resources on the task at hand. Additionally, cognitive demands are reduced because persons learn to utilize their AAC systems in various environments. The process of using the AAC system becomes automatic to the user, allowing the person to encounter a new environment without exhausting all of their cognitive resources. In contrast, a sterile, clinic setting does not prepare the user for the real-life communication situations they will encounter. A person who receives intervention through this method will not have the cognitive resources available to adapt to each environment. Assessment and intervention in the AAC User's natural environments allow the interventionist to determine the cognitive demands that emerge from each situation. This allows the interventionist to select the appropriate symbol
array that will be facilitative for each communicative environment.

voice output system.

Another factor affecting the learnability and retention of symbols is the use of a voice output system (VOCA). VOCA is an added communication aid on many communication boards that allows the AAC User to vocalize their output. The AAC User presses the symbols and the response is synthetically vocalized through the system. Researchers have stated that this speech technology may help with the emergence of receptive and expressive language skills because of the consistency of the signal. A consistent signal output allows the listener to comprehend speech more easily (Romski, & Sevcik, 1993). While human speech varies due to individual quality differences, the consistency of the VOCA allows the AAC User to process speech more effectively. When the VOCA results in more effective symbol learning, the cognitive demands of the AAC User have been reduced. In addition, the consistency of the VOCA system allows additional cognitive resources to remain available in order to formulate a response.

According to Schlosser, Belfiore, Nigam, Blischak, & Hetzroni (1995), there is little research on the correlation between the addition of this auditory stimuli and the consequent learning of symbols. In order to test this hypothesis, the researchers conducted a study with adults who have severe mental retardation. For this experiment, the participants were told to point to a certain symbol while given a model of how to do so. The participants then had 4 seconds to respond correctly. When the participants touched the symbol key, the target word was presented through the voice output. The researchers found that the addition of the VOCA auditory stimuli led to more efficient symbol learning (i.e., a fewer number of sessions were needed for each set). However, the researchers stated that there is no concrete evidence at the
present time as to the effects of VOCA on symbol retention. Furthermore, there seemed to be a lack of maintenance of the symbols learned throughout the study. Schlosser, et al. (1995) also concluded that auditory stimuli might have been reinforcing to the individuals during the symbol learning process. The researchers hypothesized that this stimuli is more reinforcing than natural speech, making VOCA a desirable addition to the AAC intervention process in order to make it more efficient and effective.

Brady (2000) also studied the effects of VOCA on the AAC intervention process. This researcher noted that added auditory stimuli benefits persons by facilitating the comprehension of object names and the development of speech and language. VOCA users are also more apt to respond to graphic selection when it is added than when it is not.

In the Brady (2000) study, two children – Amy and Peter - were taught to communicate using the Picture Exchange Communication System (PECS) during a joint activity routine. Symbols were introduced to the children using the VOCA. The results showed that the children learned the three symbols associated with each routine. Amy had 100% comprehension of the spoken names of the symbols for both activities, however Peter had 100% comprehension for one activity and only 60% for the other. The children in this study appeared to learn and comprehend the symbols they were taught. The improved speech comprehension of the two children was an added bonus that came with the use of the VOCA, however the researcher cautioned about the concreteness of this relationship.

More research must be done before a definite link can be made between symbol learning and retention and the use of a voice output communication aid. The debate over the use of VOCA in AAC intervention warrants further investigation, however many persons who are nonspeaking already utilize this in everyday interactions. For these persons, the question is not
the use of this auditory output, but which output method helps them to communicate most effectively. Higginbotham, D., Scally, C., Lundy, D., & Kowarsky, K. (1995) investigated this factor associated with the use of auditory stimuli. These researchers noted that many problems exist with the synthetic speech of the VOCA systems. The quality of the synthetic speech signal is low, consisting of low acoustic redundancy and suprasegmental information. These problems lead to low comprehension by listeners in the interaction process because of the increased processing demands.

In the Higgenbotham, et al. (1995) study, three output methods were studied to discover which led to the best discourse comprehension – the word, sentence, or mixed output method. The word method consists of spoken word sequences and the sentence method consists of spoken sentences. The mixed method is where a combination of spoken and spelled out words is given. Problems existed in the comprehension of all three methods. The researchers concluded that the type of output method influences the comprehension performance of listeners.

Current research appears to be inconclusive as to the effectiveness of VOCA on symbol learning and retention. This factor may be addressed in future research to determine if it would reduce the cognitive demands some AAC Users face. Another factor that is known to affect symbol learning and retention is the age of the AAC User. This factor will be discussed in the following section.

The age of the AAC User is one factor that may be overlooked during AAC assessment and intervention. In the discussion of information processing, this thesis reviewed the theory that younger children have increased processing demands. This is due to their inability to effectively utilize memory strategies when processing auditory stimuli. AAC interventionists
must keep this in mind when working with younger AAC Users. Teaching these children the strategies they do not yet use would facilitate an effective symbol learning process.

AAC interventionists must realize that the younger the child is, the less experience they have had with the environment. Persons who are nonspeaking tend to have more limited environmental exposure compared to typical communicators. This insufficient exposure means that their communication needs and wants will vary greatly from typically developing persons. The communication needs of younger AAC Users will be much different than those of the older AAC User. For instance, the younger AAC User may have the need to communicate only basic needs to parents or teachers. In contrast, the older AAC User may need a more complex communication board that allows them to communicate messages that are more social and varied in nature.

The age of the AAC User also affects cognitive processing. Researchers (Best & Ornstein, 1986) have noted that younger children fail to use mnemonic strategies effectively. This must be taken into account during assessment and intervention of persons who are nonspeaking. If these children do not utilize strategies effectively, symbol learning and retention may also be ineffective. In combination with limited environmental experience, young AAC Users appear to need a more intensive intervention process. Part of this process could be to teach them mnemonic strategies and expose them to different environments and situations through the intervention program.

**Summary**

Iconicity, naturalistic intervention, voice output systems, and age are all factors that contribute to symbol learning and retention. However, this list is not exhaustive. Each person who is nonspeaking is unique and will have unique cognitive processing demands that must be
addressed. AAC assessment and intervention must address these matters in order to be successful.
Chapter II

Conclusions

This thesis has discussed a broad hypothesis dealing with the relationship between information processing theory and augmentative and alternative communication. The review of literature produced a connection between these two areas of study. The relationship revealed that persons who are nonspeaking face unique cognitive demands during the symbol learning and retention process. Persons who are nonspeaking must hold onto stimuli for a longer period of time than the typical communicator must. This processing occurs while they are formulating a response to the stimuli and searching for the correct symbol to communicate their response. This thesis discussed the hypothesis that some AAC Users may have difficulty formulating a response to auditory stimuli due to an inability to form a mental model. This hypothesis should be tested in future research efforts. In the discussion of symbol learning and retention, several factors were addressed including degree of iconicity, naturalistic intervention techniques, voice output systems, and the age of the AAC User. It is apparent that these factors can further contribute to cognitive processing demands by utilizing limited cognitive resources. Future research efforts should explore these factors and their effects on the cognitive processing of persons who are nonspeaking. The various environments that the AAC User may encounter in daily life should also be addressed. Including these in the intervention process may be another key to reducing cognitive demands for the AAC User. Future research should also address any other factors associated with the learning and retention of symbols. Most importantly, the discussion of AAC intervention techniques showed that little is currently done to address the information processing needs of AAC Users. Future research should address the need for a theoretical intervention that encompasses the unique cognitive processing of persons who are nonspeaking.
Appendix A

Figure 1. The Atkinson and Shiffrin model of the flow of information through the memory system (as cited by Baddeley, 1999, p. 10).
References


