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LOW-TECH, EYE-MOVEMENT-ACCESSIBLE AAC AND TYPICAL ADULTS

A Thesis

Presented to

The Faculty of the Department of Communicative Disorders and Sciences

San José State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Sarah M. Swift

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The Designated Thesis Committee Approves the Thesis Titled

LOW-TECH, EYE-MOVEMENT-ACCESSIBLE AAC AND TYPICAL ADULTS

by

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APPROVED FOR THE DEPARTMENT OF

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May 2012

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ABSTRACT

LOW-TECH, EYE-MOVEMENT-ACCESSIBLE AAC AND TYPICAL ADULTS

by Sarah M. Swift

Low-tech, eye-gaze-accessible augmentative and alternative communication

(AAC) options are important for individuals with motor impairments which result in

limited voluntary movement, including many diagnosed with amyotrophic lateral

sclerosis (ALS). Available devices include EyeLink, partner-assisted scanning (PAS),

and E-tran. The purpose of this study was to examine the rates of use for these devices,

the user preferences related to them, and changes in rates and preferences over time. In

another ongoing study component, Roman, Quach, Coggiola, and Moore (2010)

investigated these devices with pairs of participants that included persons with ALS

(PALS) and their communication partners. In this component, seven pairs of typical

adults aged 45 or older participated. Over the course of five sessions with each pair,

participants were taught to use and practiced use of these three devices. The quickest

communication was accomplished through the use of EyeLink, but its rate of use did not

differ significantly from that of E-tran. Use of PAS resulted in the slowest

communication throughout the sessions. E-tran was the device most preferred by

participants overall, and PAS was the least preferred. Through comparison of these

results to those of the other study component, which included PALS as participants, the

researchers hope to increase the generalizability of the study results and to better

understand the ways a diagnosis of ALS may influence results.

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Introduction

Many of us take for granted the fundamental ability for natural, oral speech as an essential part of our daily lives. Oral speech is one method of communication that most of us rely on routinely along with writing and nonverbal modes, such as gestures and facial expressions. For those with complex communication needs though, the modes by which communication is accomplished are not so straightforward; for many children and adults with such needs, the ability to use natural speech is not guaranteed. The causes by which one's verbal ability may be limited are varied; congenital impairments including cerebral palsy, autism, and intellectual disability as well as acquired conditions such as amyotrophic lateral sclerosis, multiple sclerosis, and stroke all have the potential to compromise effective communication via oral speech (Beukelman & Mirenda, 2005b). However, as Michael Williams (2000), an individual with complex communication needs secondary to cerebral palsy, explained:

> The silence of speechlessness is never golden. We all need to communicate and connect with each other—not just in one way, but also in as many ways as possible. It is a basic human need, a basic human right. And much more than this, it is a basic human power. (p. 248)

For those with verbal communicative deficits then, it may be necessary to address communication needs in a manner other than through natural speech.

One approach may be provided through the use of augmentative and alternative communication (AAC), a type of assistive technology with applications for communication (Beukelman & Mirenda, 2005b). According to the American Speech-Language-Hearing Association ([ASHA], 2005), AAC systems may "compensate for

temporary or permanent impairments . . . of individuals with severe disorders of speech-language production and/or comprehension, including spoken and written modes of communication" (p. 1). As suggested, a multitude of disorders can give rise to communicative deficits; similarly, the individuals with those deficits are themselves a diverse group, and the AAC systems used to address those deficits comprise a widely varied set of aids and devices, from to icons printed on paper to computerized eye-tracking devices (Beukelman & Mirenda, 2005b). It is the job of speech-language pathologists (SLPs) to assess the appropriateness of various AAC options for individuals with complex communication needs and to implement and assist those clients in the use of AAC systems.

One acquired disease that commonly results in communicative deficits is amyotrophic lateral sclerosis (ALS) (Ball et al., 2010; Beukelman, Fager, & Nordness, 2011; Beukelman & Mirenda, 2005b; Beukelman, Mirenda, & Ball, 2005). A progressive, neurodegenerative disorder, ALS generally leads to severe loss of motor ability, including for most of those affected the loss of natural speech and limb mobility (Beukelman et al., 2005). Individuals with ALS may benefit from a variety of AAC systems, but devices that are commonly recommended are those through which eye movements are transformed into meaningful communication through eye pointing (i.e., communicating messages by directing one's gaze at letters and symbols displayed on an device) or identification of eye movements that signify "yes" and "no" (Adams, Kazandjian, & Cheng, 2009; Beukelman et al., 2005). Despite the motor deterioration

that is the hallmark of ALS, the capacity for voluntary eye movements generally remains intact (Mitsumoto, 2009). As a result, eye movement provides a means for communicative interactions for many people with ALS (PALS—and this term may also refer singularly to a person with ALS) whose voluntary movements have been otherwise limited. Various AAC devices are available that can be operated through eye gaze alone and allow for the formulation of novel messages; EyeLink, partner-assisted scanning (PAS), and E-tran—the devices used in this study—are three such options. In general, there have been few comparisons of the effectiveness of these devices or preferences for them.

The purpose of this study was to examine the rates of use (i.e., how quickly communication is accomplished through their use) for these three devices, the user preferences concerning them, and the effects of learning in the form of changing rates of use and preferences over time. This study is part of a larger study; another ongoing component by Roman, Quach, Coggiola, & Moore (2010) includes PALS and their communication partners as participants. In this study component, seven pairs of typical, literate adults aged 45 or older participated, and the same materials and methods as those of Roman et al. (2010) were utilized. Five sessions were completed with each pair during which they were instructed in methods of use for each of the three devices and practiced those methods by using the devices to communicate. Results from this study can be compared to those of Roman et al. (2010), following conclusion of that study component, with potential clinical implications for recommendation and training of these methods.

Literature Review

What Is AAC?

Augmentative and alternative communication is technically something that we are all familiar with, whether one is aware of it or not. According to ASHA, AAC includes any type of communication other than oral speech, and many communication modes that most of us use every day including writing, gestures, and facial expressions fall into this category (ASHA, n.d.). However, for some individuals with speech or language problems, AAC can be used to supplement or replace oral speech or writing abilities that are not adequately functional; this type of use is generally referred to when discussing AAC and in AAC research (ASHA 2004; ASHA, 2005). Nonetheless, even when the term *AAC* is narrowed in such a way, the resultant field remains large and varied. An individual who communicates through American Sign Language, for example, uses a form of AAC. Some users of AAC operate speech-generating devices that offer synthesized speech output as they type letters and messages. Tools used for AAC run the gamut from icons or letters written on a piece of paper to iPad applications. In short, any means through which a person can supplement or replace oral speech falls into the realm of AAC.

According to ASHA (2004), AAC is used by between two and 2.5 million Americans to supplement or replace spoken communication. According to a survey conducted by ASHA in 2008, 45% of SLPs who work in schools reported serving individuals who use AAC as a regular part of their caseloads (Janota, 2008). Those

benefitted by AAC encompass a heterogeneous array of individuals with varying

etiologies, ages, and abilities, and the nature of a person's AAC use may be temporary or

permanent (ASHA, 2004; Hurtig & Downey, 2009). Communicative difficulties

resulting from congenital impairments—cerebral palsy, autism, and intellectual disability,

to name a few—or acquired disorders such as stroke, traumatic brain injury, or ALS may

be ameliorated through AAC use (ASHA, 2004; Lasker & Bedrosian, 2001; Murphy,

2004b).

   According to ASHA (2005), it is within the scope of practice of an SLP to

recognize an individual's need for AAC, to implement and provide ongoing assessment

of individualized AAC systems, and to advocate for individuals who benefit from AAC

use. In addition, the SLP must integrate information from various sources to design an

individualized AAC program. The SLP must combine his or her own expertise in the

field with input from other members of their clients' intervention teams (e.g., physicians,

physical and occupational therapists, teachers, psychologists, social workers), individuals

close to the clients (e.g., parents, significant others, employers, family members), and of

course, the clients themselves (ASHA, 2004). Furthermore, according to Beukelman and

Mirenda (2005c), the SLP must consider not only the current but also the future

communication needs of the individual and assist clients in making informed decisions in

both areas.

   Understanding of AAC use and the field of AAC in general involves the

consideration of multiple components. As a whole, AAC can best be described as a

system with four primary elements: aids, symbols, techniques, and strategies (ASHA, 2004; Beukelman & Mirenda, 2005b; Hurtig & Downey, 2009). First, an aid is defined as a "device, either electronic or non-electronic that is used to transmit messages" (ASHA, 2004, p. 6). Devices are extremely varied and range from low-tech (i.e., nonelectronic devices) to high-tech (i.e., electronic devices) (Beukelman & Mirenda, 2005b). Moreover, they differ greatly in degree of complexity, manner of access, and type of output: Some involve sophisticated eye-tracking software and computer displays and others are composed of icons on a piece of paper (ASHA, 2004). Furthermore, some types of AAC such as sign language do not require devices at all.

Next, communication via an AAC device relies on the use of symbols. Sign language represents a series of symbols in the form of hand and arm movements, but many AAC devices incorporate a display of icons as symbols representing words or phrases. Many others simply use letters as symbols, including the three devices used in this study. In other words, symbols can be graphic (including orthographic), gestural, auditory, or tactile in nature (ASHA, 2004). Additionally, these symbols can be unaided or aided. In the case of unaided symbols, no outside device is required as is the case with signing or facial expressions (ASHA, 2004). Conversely, aided symbols "rely on supports beyond those which are available naturally," such as physical objects, pictures, or written orthographic symbols (ASHA, 2004, p.6).

Techniques refer to the manner in which messages are transmitted. Devices can be accessed in multiple ways from eye gaze to finger pointing to voice. The two main

methods of symbol selection for users of AAC devices are direct and indirect (Beukelman & Mirenda, 2005a). In the former, the individual, through varying methods of access, independently selects the desired symbol (e.g., he or she gazes at, points to, or presses a button corresponding to a symbol) (ASHA, 2004; Beukelman & Mirenda, 2005a). The latter type of technique is known as indirect selection or scanning and requires a communication partner or the device itself (through visual, tactile, or auditory output) to present choices until the desired symbol is offered and chosen by the individual who uses AAC (ASHA, 2004; Beukelman & Mirenda, 2005a).

Lastly, methods by which messages can be relayed more efficiently and effectively are referred to as strategies (ASHA, 2004; Beukelman & Mirenda, 2005b). Understandably, the use of most AAC systems requires a longer amount of time to generate a message compared to natural speech (Beukelman & Mirenda, 2005d). Generally, strategies are implemented to increase the rate at which messages are transmitted or retrieved by making more efficient use of an AAC system (ASHA, 2004). Many types of rate enhancement techniques exist depending on the nature of the specific AAC symbols and/or device used. For example, with a technique known as contraction, words are distilled to their most salient letters for transmission through a device (e.g., "hamburger" becomes "HMBGR") (Beukelman & Mirenda, 2005d). Strategies along with the other three aforementioned components interact to provide a system of communication and must be tailored to the needs and abilities of each individual.

Amyotrophic Lateral Sclerosis

One disorder that often results in utilization of AAC technologies is amyotrophic lateral sclerosis (ALS), a progressive, fatal, neurodegenerative disease, the cause of which is largely unknown and for which there currently exists no cure (Beukelman et al., 2005). It attacks the motor neurons of the brain and spinal cord, which control movement of voluntary muscles throughout the body resulting in muscle weakness, atrophy, and eventual paralysis while leaving sensation intact. Though the order of progression of the disease is variable, atrophy and paralysis tend to spread throughout the body affecting limbs, muscles of the trunk, and the muscles of speech, swallowing, and breathing (Darley, Aronson, & Brown, 1975; Mitsumoto, 2009).

First described in 1869 by a French physician, Jean Martin Charcot, ALS is also known as Lou Gehrig's disease; the famed athlete retired as a result of his diagnosis in 1939, bringing international attention to the disease (Cwik, 2009). Roughly 5,000 new cases of ALS are diagnosed annually in the United States with 20,000 to 30,000 people living with ALS in this country at any given time, and it is one of the most prevalent neuromuscular diseases in the world (U.S. Department of Health and Human Services [HHS], 2010). This disease affects 1-2 in 100,000 adults annually worldwide, and the distribution of cases internationally has remained roughly stable for the past 50 to 60 years (Cwik, 2009). The average age of onset is 55 with most of those diagnosed falling between the ages of 40 and 70; however, although uncommon, onset is possible even in

individuals in their twenties and thirties and, extremely rarely, in childhood (Cwik, 2009; HHS, 2010).

Forms of ALS can be differentiated by mode of acquisition or type of onset. For the former, sporadic ALS is contrasted with familial ALS. The sporadic manifestation accounts for an overwhelming majority of cases—in the U.S., between 90% and 95% (HHS, 2010). The familial mode, in which a genetic mutation can be implicated, accounts for the remaining minority of cases. In patients with this form the likelihood of each of their children acquiring the genetic mutation responsible and likely developing the disease is 50% (Cwik, 2009).

When considering type of onset, three major distinctions emerge: bulbar, spinal, or mixed, referring to the neurological region of the first symptoms. *Bulbar* references nerves associated with the brainstem, and initial symptoms tend to involve muscles of speech and swallowing with eventual progression to the limbs. *Spinal* involves initial symptom presentation in muscles innervated by spinal nerves; it begins in the limbs and progresses to affect swallowing, speech, and breathing. *Mixed* presentation is also possible, though even in this form symptoms of one neuronal region (bulbar or spinal) tend to dominate (Mitsumoto, 2009). Though these classifications characterize symptom onset in individuals with ALS, symptoms generally progress to include both spinal and bulbar areas regardless of onset type.

The prognosis of ALS is highly variable among individuals. Average life expectancy is from three to five years, though approximately 10% of individuals survive

a decade or more (HHS, 2010). Prognosis is influenced by multiple factors such as age, psychological state and attitude of the patient, area of onset (bulbar onset generally has stronger adverse implications for survival), and length of time between onset of symptoms and diagnosis. Generally, a shorter interval between onset and diagnosis leads to a poorer prognosis; however, this aspect is being affected by improved awareness of the disease and increased reliability of diagnoses (Mitsumoto, 2009). Death is most often a result of the weakening of the diaphragm and chest wall muscles to the point of respiratory failure (HHS, 2010; Mitsumoto, 2009).

Symptoms of ALS are related to the areas of motor neuron involvement. Roughly 60% of PALS report muscle weakness as their first symptom with one third of those patients experiencing weakness in an arm, one third in a leg, and one quarter in the muscles of speech or swallowing; the remaining patients first experienced generalized muscle weakness. Spinal symptoms include those that affect muscle quality and function in the limbs and trunk: weakness, atrophy, cramping, and fasciculations (twitching). Also, spasticity and/or flaccidity are commonly present as are deficits in reflexes in the form of hyperreflexia (exaggerated reflexes) or hyporeflexia (lack of reflexes) (Mitchell & Borasio, 2007; Mitsumoto, 2009). Bulbar symptoms are manifested in the musculature of speech and swallowing and include dysarthria (weakness in the muscles of speech), and dysphagia (difficulty swallowing). Aforementioned muscle symptoms affecting the limbs and torso can also occur in muscles of the head and neck with bulbar involvement, and often even muscles of respiration are ultimately affected. Other generalized

symptoms commonly associated with ALS are fatigue, weight loss, and psychological stress (Mistumoto, 2009).

Additionally, it is important to note that many ALS symptoms carry negative ramifications for the patient's ability to communicate verbally. As Murphy (2004a) explained, "one of the most distressing aspects of ALS is the loss of speech" (p. 1). Research has shown that from 75% (Saunders, Walsh, & Smith, 1981) to 94% (Beukelman, Ball, & Pattee, 2004) of PALS become unable to speak at some point in disease progression. Though dysphagia, sialorrhea, and emotional lability are likely to negatively impact communication abilities, dysarthria generally provides the largest barrier to natural speech (Murphy, 2004a).

According to Darley et al. (1975), the term *dysarthria* comprises "a group of related speech disorders that are due to disturbances in muscular control of the speech mechanism resulting from impairment of any of the basic motor processes involved in the execution of speech" (p. 2). With ALS, dysarthria occurs when the weakness and spasticity inherent in the disease affect the musculature of speech and respiration. As a result, it is generally of a mixed spastic–flaccid type and manifests eventually in almost all PALS (Beukelman et al., 2005; Darley et al., 1975; Duffy, 2005). The verbal abilities of PALS with dysarthria are thusly impacted in multiple ways. Involvement of respiratory musculature can result in a weak or soft voice and weakness of laryngeal muscles may impact vocal quality leading to hoarseness, harshness, breathiness, as well as irregularities in vocal pitch (Darley et al., 1975; Duffy, 2005). Inadequacy in function

of the soft palate is common with ALS and results in a highly nasal voice (Darley et al.,

1975; Duffy, 2005). Additionally, deficiencies in tongue and lip movement often give

rise to slowed rate of speech, slurred or imprecise articulation of speech sounds, and

overall reduction in intelligibility (Adams, et al., 2009; Duffy, 2005; Murphy, 2004b).

Overall, the majority of PALS eventually experience a severe communication disorder

(Beukelman et al., 2005).

The Nature of AAC Need Among PALS

As the ability for natural speech declines, the need for AAC often becomes an

imperative (Adams et al., 2009; Beukelman et al., 2004; Saunders et al., 1981).

Interventions to regain the use of oral speech or slow its decline tend to be ineffective

(Ball, Beukelman, & Pattee, 2004). The reality of ALS as a progressive, currently

incurable disease means that the decrease in oral speech abilities although not necessarily

steady is nonetheless unavoidable (Duffy, 2005). Various forms of AAC can be used to

ameliorate communicative difficulties and improve an individual's quality of life.

Greater levels of independence and psychological well-being, improved opportunities to

maintain and develop relationships, and even a higher degree of involvement in medical

decisions are all potential benefits of AAC interventions (Brownlee & Palovcak, 2007;

Murphy, 2004a).

Although the decline in speaking abilities for PALS is largely inevitable, the speed

of decline and severity of symptoms are variable and not necessarily steady (Duffy,

2005). The timing of AAC use in terms of duration and point of implementation are

dependent on a variety of factors, but ultimately the introduction of AAC technologies

depends on how functional and intelligible the individual is in his or her activities of

daily living (Doyle & Phillips, 2001). Beukelman et al. (2005) explained how monitoring

speaking rate can lead to reliable predictions concerning intelligibility. The average

person speaks at a rate of about 200 to 250 words per minute with roughly 100%

intelligibility. When the speaking rate of someone with ALS decreases to between 100

and 120 words per minute, due either to direct effects of dysarthria symptoms or to the

individual's deliberate physical compensation for them, intelligibility tends to fall to

levels below 90%. At this point, individuals benefit from implementation of an AAC

program, which can potentially be utilized until the end of one's life. In a study by Ball

et al. (2007), all participants with ALS used AAC devices until within one month of their

deaths (of those deceased when the study was published) with 46% of those individuals

using AAC during their last week of life.

   Once the decision is made to implement AAC use, a variety of considerations

guide the selection of specific systems in a treatment plan individualized to the PALS.

Multiple AAC options exist with varying levels of appropriateness based on a client's

cognitive and motor abilities, availability of funding, personal preferences, and specific

communication needs (Beukelman & Mirenda, 2005c). Doyle and Phillips (2001)

explained a few elements of such clinical decisions as follows:

> For example, individuals with bulbar ALS who are ambulatory and have poor
> speech but adequate hand function may use low-technology AAC approaches
> such as writing or an alphabet board to either augment speech or act as an
> alternative to it. These individuals may also use small, dedicated voice output

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communication aids (VOCAs) for specific communication situations or needs. Individuals with spinal ALS who are confined to bed and who have poor speech and hand function may use a range of low-technology AAC approaches as well as a switch to access high-technology options such as dedicated or integrated (i.e., computer-based or multipurpose) communication devices. All individuals with ALS may use unaided AAC approaches such as gestures, facial expressions, and yes/no responses to meet specific needs. (p. 168)

Overall, SLPs have a wide variety of devices at their disposal and make recommendations to clients based on an individualized set of medical, personal, and functional factors. Furthermore, as suggested in the aforementioned quote from Doyle and Phillips (2001), AAC treatment programs very often incorporate a variety of devices as some are more suitable to certain communicative interactions than others.

With regard to PALS specifically, device access is an important consideration in AAC system selection and recommendation due to the nature of disease progression (Beukelman et al., 2005). In other words, PALS must be able to select items on an AAC device despite significant motor impairment, and as the disease progresses, devices that necessitate hand or head movements in their use will likely become inappropriate and nonfunctional. However, even as ALS affects an individual's motor abilities to increasing degrees, functions controlled by cranial nerves including hearing, vision, and eye movement generally remain intact (Mitsumoto, 2009). Therefore, selection of items on AAC devices through the use of eye movements can be especially useful for PALS who are unable to engage limb or other movements to make selections, for example, finger pointing (Adams et al., 2009). The knowledge that a PALS' ability to move his or her eyes will likely be retained is an important consideration in system selection, and devices

that rely on item selection via eye movements are often selected in these cases (Yorkston, Miller, & Strand, 2004).

Low-tech, Eye-Movement-Accessible AAC systems

This study examined three eye-gaze-accessible devices (i.e., those that require only eye movement to use). Each of the three is classified as a low-tech device; that is, they require no electrical power source. High-tech, eye-movement-accessible devices (that do require a power source) exist and can potentially offer greater speed than low-tech, the possibility of electronic speech output, and the capacity for computer use (Ball et al., 2010; Beukelman et al., 2011; Higginbotham, Shane, Russell, & Caves, 2007). Though such computer-based, eye-tracking technologies are available, understanding of low-tech options among PALS is important: An AAC program for a PALS should encompass an assortment of devices including both low- and high-tech options, and moreover, situations exist in which low-tech devices are preferred by PALS and other users of AAC over high-tech counterparts for various reasons.

First, as suggested in the aforementioned quote from Doyle & Phillips (2001), those who rely on AAC, including PALS, often employ more than one device to meet their communication needs in different contexts. Similarly, Mathy, Yorkston, and Gutmann (2000) found that among PALS low-tech devices were generally used in transmitting brief messages or communicating with familiar partners, and high-tech options were chosen when relaying more complicated messages. Moreover, Williams, Krezman, and McNaughton (2008) explained the concept that "one is never enough" (p.

3) as one of the five principles that should guide AAC assessment and intervention over the next 25 years. They discussed the importance of making available multiple devices as well as strategies, communication partners, and communicative environments. They asserted that having access to a variety of devices allows for the use of an applicable tool for the desired communication goal and ensures backup possibilities in the event of failure of one device. In general, access to an array of AAC devices ensures that PALS can make choices about the best approach to the specific communicative context based on situational variables (Blackstone, Williams, & Wilkins, 2007; Mathy et al., 2000; Williams et al., 2008).

Secondly, PALS and other users of AAC may prefer low-tech choices for a variety of reasons, some of which may stem from the very sophistication of high-tech devices. The increased cost of high-tech versus low-tech devices, the possibility of breakdown of electronic components, and the complicated support and setup that computer-based systems can entail may prohibit an AAC program composed solely of high-tech devices (Higginbotham et al., 2007; McNaughton, Light, & Gulla, 2003; Murphy, 2004b). In terms of eye-tracking devices specifically, calibration can be difficult, fluorescent lights and bright sunlight often interfere with device performance, and use of such devices limits social eye contact (Beukelman, Fager, Ball, & Dietz, 2007; Higginbotham et al., 2007). Furthermore, high-tech devices are sometimes less accessible given the physical and motor activities of some situations. For example, Beukelman, Ball, & Fager (2008)

identified communicative contexts in which nonelectronic devices may be preferable including when eating, dressing, resting, or in the bathroom.

Additionally, more personal, social motivations exist for low-tech preferences. Light (1988) originally explained that the maintenance of social closeness is an important motivation for communication among those who use AAC. Murphy (2004a, 2004b) found this social inducement to be significant specifically among individuals with motor neuron disease (in the United Kingdom, this term is used for a class of disorders that includes ALS). Furthermore, participants found low-tech AAC options to interfere less with social aspects of communication and be more personal while high-tech devices limited social closeness (Murphy, 2004b).

The Three AAC Devices Used in This Study

Given the applicability of eye-gaze-accessible AAC systems for use among PALS and the importance of low-tech device use in conjunction with high-tech options, this study examined three low-tech devices and the methods of use for each: EyeLink, E-tran, and partner-assisted scanning (PAS). Each entails the selection of individual letters through the eye movements of the AAC device user (the *sender* of the message) and interpretation and verification of those movements and the intended targets by his or her communication partner (the *receiver* of the message). The first two devices utilize a direct selection method of eye pointing; senders essentially direct their gaze at an item to indicate their choice (Beukelman & Mirenda, 2005a). The third—as the name suggests—involves scanning by the receiver. In other words, items are verbally called out

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sequentially by the receiver until the sender indicates through eye movements that the

desired item has been reached (Beukelman & Mirenda, 2005a).

EyeLink. The first device, EyeLink, is a transparent board on which letters,

numbers, and other important items (e.g., "space") are displayed (see Figure 1) (Adams et

al., 2009; Beukelman et al., 2005; Goossens & Crain, 1987).
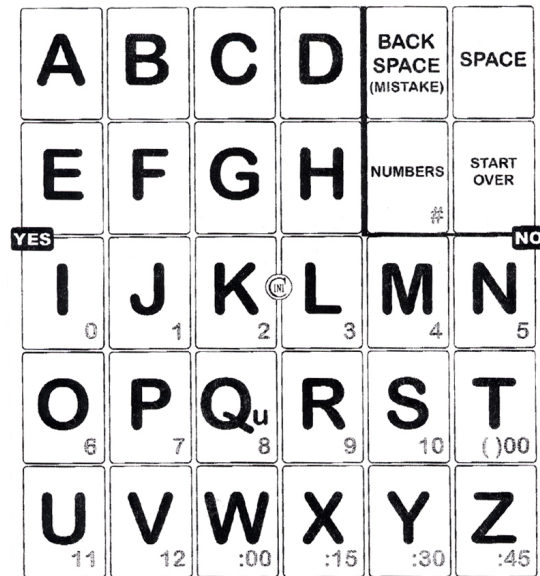
Figure 1. EyeLink board. The EyeLink board above represents the one used for this study. The actual board used measured approximately 16 by 17.5 in. (40.6 by 44.5 cm).

The board is held vertically by the receiver between him or herself and the sender with

the letters facing the sender (hence, they are oriented correctly for the user of the device

and backward from the point of view of the partner) (Adams et al., 2009; Goossens &

Crain, 1987). The sender then points his or her eye gaze at the desired item while the

receiver looks through the board at the sender's eyes (Beukelman et al., 2005). The gaze

of the sender remains fixed on the item while the receiver moves the board in an attempt

to "link" eyes with the sender, at which point they will both be looking at the desired

letter or the word *space* (Beukelman et al., 2005; Goossens & Crain, 1987).

      E-tran. Short for "eye transfer," E-tran also makes use of a transparent board

displaying similar symbols to those found on an EyeLink board, and again the sender

selects desired items by pointing with his or her eyes. However, this method relies on a

system of color encoding, and the colors and visual grouping of items are critical in

message transmission (see Figure 2) (Beukelman & Mirenda, 2005d).
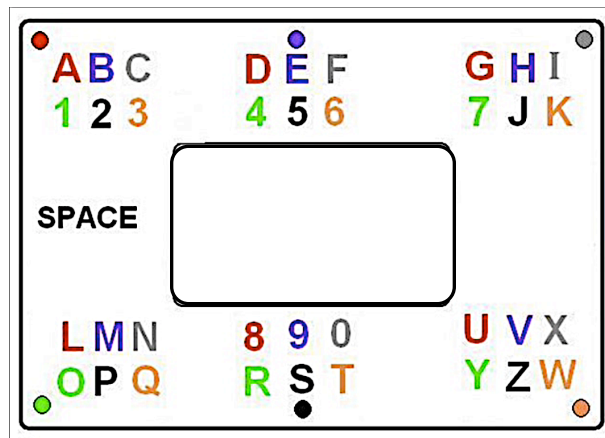
Figure 2. E-tran board. Above is a representation of the E-tran board used in this study.
The actual board measured approximately 11.5 by 17 in. (29.2 by 43.2 cm) and was color
coded as described with each item in a group being a different color corresponding to the
dots along the board's edge.

      To begin, the board is positioned between the sender and receiver with the letters

facing the sender and with the two able to see one another through the opening in the

board's center (Roman et al., 2010). Items are arranged in groups of six. Within each

group, each item is a different color, and each group as a whole is identified by the color

of the dot closest to it (Roman et al., 2010). The sender selects individual items through a

process of two eye movements for each; the first indicates the group containing the desired item, while the second communicates the color of the individual item itself via selection of the group corresponding to that color (Beukelman & Mirenda, 2005d). For example, to select the letter *d*, the user first points with his or her eyes to the purple group, and then he or she points to the red group, indicating that the selected letter is the red letter within the purple group (Roman et al., 2010).

Partner-Assisted Scanning (PAS). Unlike E-tran and EyeLink, PAS is not a method of direct selection. Instead, it incorporates a group–item scanning technique (specifically, row–column scanning) in which the communication partner (the receiver) verbally presents items, and the user of the device (the sender) responds through eye movements that signify "yes" and "no" (Beukelman & Mirenda, 2005a). For instance, the eye movements used by multiple pairs in this study were a wink to express "yes" and a blink to signify "no." A nontransparent PAS board displaying the same items on each side is positioned between the sender and receiver. Letters are arranged alphabetically into columns and rows with vowels occupying the leftmost column and a varying number of consonants in each row (see Figure 3) (Roman et al., 2010).

A	B	C	D				Yes
E	F	G	H				No
I	J	K	L	M	N		Don't Care/Know
O	P	Q	R	S	T		Thank You
U	V	W	X	Y	Z		Turn Over
space	New Word	Start Over	Please Guess				Don't Guess

Figure 3. PAS board. This figure depicts the PAS board used in this study. The actual board was 8.5 by 11 in. (21.6 by 27.9 cm).

The receiver calls out items first by moving downward through the leftmost column. The sender gives no eye signal until the row containing the desired item or letter is reached, at which point the sender indicates the row by giving the *yes signal*. Then the receiver calls out items in that row, moving left to right, and the sender gives the yes signal again when the target item is spoken by the partner. For example, to select the letter *b*, the receiver calls out the letter *a*, following which the sender gives the yes signal. The receiver then reads that row. Immediately after the receiver says "b," the user gives the yes signal again.

Importance of this Research and its Inclusion in a Larger Study

In general, very little evidence exists regarding the effectiveness of low-tech devices in comparison to one another or the preferences of those who use them (Murphy, 2004b). As discussed, such AAC devices can provide important options for individuals who require eye-movement-accessible AAC devices and a means for communicative

interactions for those whose voluntary movements have been otherwise limited. Fried-Oken et al. (2006) pointed to the especial paucity of research examining preferences of caregivers as AAC communication partners, and Blackstone et al. (2007) noted the lack of research undertaken with the perspective of those who rely on AAC in mind.

Furthermore, despite availability of eye-gaze-accessible devices, many medical practitioners and SLPs may not be aware of them, and those who are may not know how to best use or teach them: Currently, no standardized, successful protocols outlining these methods exist in the literature. In a study by O'Keefe, Kozak, and Schuller (2007), individuals who used AAC and their facilitators suggested that "improving AAC communications training for all healthcare professionals" should be a priority in the field of AAC research (p. 89). Beukelman et al. (2008) highlighted the particular importance of preparing and educating AAC finders (those who identify individuals with complex communication needs and play a role in developing AAC treatment plans) in interventions for those with particular medical conditions that influence AAC decisions—such a category would include ALS. In addition, other authors have underscored the influence of informing SLPs of functional outcomes and user preferences related to specific AAC systems in order that they may make better recommendations and provide better support (Blackstone et al., 2007; Johnson, Inglebret, Jones, and Ray, 2006; Murphy, 2004b).

This study is one component of a larger study and has the following aims: to determine the rate of use and preferences in typical adults concerning three eye-

movement-accessible, low-tech AAC devices, and to examine changes in rates and

preferences over time. In another study component, Roman et al. (2010) examined these

low-tech methods with pairs that included PALS and their communication partners. This

portion of the study researched rate of use of these devices and user preferences among

seven pairs of typical adults (those without a diagnosis of ALS or any other medical

condition that could potentially affect cognition or communicative abilities) and utilized

the same methodology and materials as those of Roman et al. (2010). Following

completion of the ongoing component by Roman et al. (2010), the next step in the larger

study will be to compare results of this component (with typical adult participants) to

those of the PALS participants and their partners.

Higginbotham has elaborated on the value of using nondisabled participants in

AAC research with regard to generalizability of research findings and understanding the

effects, if any, of the presence of a communicative disorder on research results

(Higginbotham, 1990; Higginbotham, 1995; Higginbotham & Bedrosian, 1995). As

explained previously, the devices included in this study are often appropriate for use by

PALS. However, ALS is certainly not the only disorder with which those who may

benefit from these devices are diagnosed. Use of eye-gaze-accessible devices may be

appropriate for individuals with a variety of conditions limiting motor movement

including locked-in syndrome, Guillain-Barré syndrome, and brain stem stroke

(Beukelman et al., 2005). Because PALS are included as participants in the study

component by Roman et al. (2010), this portion of the study with typical adults is

important in providing information about the potential for generalization of study results to individuals who are not PALS. Comparison of results from typical adults to those of the PALS participants and their partners will aid in determining what if any effect the presence of ALS may have on results. In other words, in examining low-tech, eye-movement-accessible AAC devices, the results of this study component together with that of Roman et al. (2010) may have clinical implications for literate individuals with only eye movement; information from the pairs of normal adults will determine whether trends seen in the study component with PALS are similar or deviant when the two sets of results are compared.

Moreover, results may provide a better understanding of learning and preferences with regard to low-tech, eye-gaze-accessible AAC devices, which may have clinical implications for recommendation and training of these methods. By comparing results of the typical adult pairs to those of the pairs with PALS participants following completion of the component by Roman et al. (2010), we will be able to ascertain the extent to which PALS data agrees or deviates from that of the typical adults. Hopefully, this comparison will either increase the generalizability of the results of Roman et al. (2010)—to adults with communicative disorders (ALS or otherwise) who may benefit from use of these low-tech, eye-gaze-accessible AAC devices—or help us better understand in what ways a diagnosis of ALS may influence rate of use, learning effects, and preferences concerning these three devices.

Research Questions

Specifically, the research questions that guided this study along with hypothesized results are as follows:

• What is the average rate of use for each device? It is hypothesized that the average rate of use of EyeLink will be the quickest followed by E-tran, and participants' use of PAS will be the slowest. Both E-tran and EyeLink involve methods of direct selection, but EyeLink requires only one selection whereas E-tran requires two to choose a symbol. Of the three devices, PAS is the only one that requires scanning. Research has shown that scanning methods tend to be slower to use than direct selection methods (Goossens & Crain, 1987).

• Do average rates of use change over the course of study participation, lasting approximately two to three weeks? The lack of available research comparing low-tech, eye-gaze-accessible methods led to the null hypothesis that rates of use from session to session would not differ significantly for any of the three devices. However, as with the first research question, it is predicted that the rate of use for PAS will be the slowest throughout participation due to the requirements of scanning and that EyeLink will be the quickest due to the reduced number of required selections compared to E-tran.

• Which device do participants prefer overall? It is hypothesized that participants will exhibit similar preferences for E-tran and EyeLink, and PAS will be the least

preferred device. As previously noted, E-tran and EyeLink are expected to yield

faster rates of use, and therefore, participants will likely prefer using them over PAS.

- Do participant preferences change over the course of study participation, lasting

  approximately two to three weeks? The lack of research concerning preferences of

  users of these devices and their partners led to the null hypothesis that participant

  preferences will not change over the course of the sessions.

Methods

Participants

Participants in this study included seven pairs of adults. Subject selection criteria were as follows: age of 45 or over, English literacy, and identification of English as the individual's native language. Exclusion criteria included a previous or concurrent diagnosis of a communication disorder and prior knowledge of the AAC devices used in the study. Additional demographic data and characteristics collected for each pair consisted of gender, the nature of the relationship of pair members to one another, the length of the pair's relationship in years, the level of education completed by each participant, and whether each wore glasses/contact lenses either during or outside of the study. With the exception of one pair, each consisted of one male and one female spouse. Two females comprised the remaining pair; their relationship was identified as "friends/ neighbors" by the participants themselves. Participants in each pair had known one another for at least 10 years, and each had completed at least college-level education. All of the participants wore glasses for at least some activities (either during or outside of participation) with the exception of one pair in which both participants reported not wearing glasses at any time. Prior to timed trials, each participant was administered and passed a visual screener that included identification of 10 letters in 20-point font at a distance of approximately 36 in. (91.4 cm). Participant demographic data and characteristics are reflected in Table 1.

Table 1

Demographic Data and Participant Characteristics

Pair	Age	Gender	Relationship	Length	Education	Glasses
1	59	Female	Spouses	40	College	Yes
	61	Male			College	Yes
2	60	Male	Spouses	41	Graduate school	Yes
	58	Female			College	Yes
3	56	Male	Spouses	32	College	Yes*
	54	Female			College	Yes
4	60	Male	Spouses	27	College	No
	59	Female			Graduate school	No
5	53	Female	Friends	22	College	Yes
	53	Female			College	Yes*
6	57	Female	Spouses	10	Graduate school	Yes*
	64	Male			College	Yes
7	59	Male	Spouses	13	Graduate school	Yes
	57	Female			College	Yes

Note. Length refers to the length of the relationship in years. Use of glasses included contact lenses, and * indicates that the participant reported wearing glasses or contacts but did not do so during study trials.

During the first meeting with each pair, one participant was designated as the *user* of the devices (i.e., the sender of the messages) and one as the communication *partner* (i.e., the receiver of the messages). These roles were chosen by the participants themselves and were kept consistent throughout the five research sessions conducted with each pair. Users were asked not to speak during timed trials, using only the study's AAC devices to communicate whereas partners were allowed to speak freely throughout the sessions.

Materials and Technology

Technology. Three low-tech, eye-gaze-accessible AAC devices were used in this study: EyeLink, E-tran, and PAS. Each device was used with each of the seven pairs during each of the research sessions, and devices were counterbalanced in presentation for each pair. Instructional videos, one for each device, were created by the research team prior to the onset of the study and used to teach methods of use to each pair of participants. These videos may be found on the website YouTube (see Appendix A for specific addresses).

Trials were timed using a stopwatch application on a cell phone. Instructional videos were shown to each pair on a MacBook laptop, and USB-connected speakers were used to ensure adequate volume. In addition, sessions were recorded using a Sony Handycam HD camera and a tripod. Information from the recordings was used in reliability testing of recorded times for each pair's trials.

Word lists. During each session, those participants identified as users were given word lists that they communicated via each method to the participant acting as the partner. These word lists were compiled by study researchers and consisted of two lists per method per session: one list of two practice words for each device (see Appendix B) and one list of eight time-trial words for each device (see Appendix C). Identical lists were used for each pair. Lists were printed on 8.5 by 11 in. paper (21.6 by 27.9 cm), one word per line in 60-point font.

Each word included in the lists was three or four letters in length. Feasibility testing prior to the onset of the study led to the conclusion that this word length yielded an appropriate duration for timed trials with each device; it was sufficient for appropriate analysis of results but resulted in a manageable session length and level of fatigue and frustration for participants. Aside from length, words were chosen with regard to their component letters rather than any properties of the word as a whole. Specifically, the letters included in the words were balanced in terms of their frequency of occurrence in the English language. The construction of lists based on letter properties rather word properties, such as semantic context or frequency of occurrence (of the word as a whole) in English, reduced predictability. The lack of predictability in turn promoted participants' communication of all letters and limited guesses.

Method ranking and Likert scales. At the conclusion of each session, participants completed method ranking forms (see Appendix D). Each of the three devices was ranked from most to least preferred by assigning each device a 1st (*most*

preferred), 2nd, or 3rd (*least preferred*) ranking. The same form was used for each

session with each pair. After each trial, surveys using 6-point Likert scales were

administered to each participant to gauge perceptions of usefulness, mental and physical

effort, and frustration with regard to each device.

Procedure

Over the course of participation, pairs were taught to use and practiced use of the

three devices: EyeLink, E-tran, and PAS. Five sessions, lasting approximately one hour

each, took place over the course of roughly three weeks with each pair; sessions occurred

between two and five days apart from one another. Each pair used each method during

every session, and sessions with all seven pairs took place in the participants' homes.

Order of presentation of the devices to each pair during each session was

randomized and determined prior to study initiation; the order varied from pair to pair

and from session to session. Instruction in the form of aforementioned videos was

provided during the first two sessions. Specifically, for the first session with each pair,

the instructional video corresponding to the first device to be used was shown at the start

of the session. Users were then given the practice word list (containing two words)

corresponding to that AAC device, and he or she spelled the list nonverbally to the

partner using the method instructed and demonstrated in the video. Communication of

the practice list was not timed, and the list was placed in view of the user but not the

partner. The practice list was followed by a timed trial using the same device during

which the user communicated the appropriate eight-word, time-trial list to the partner.

Again, the list was placed in view of the user but not the partner. Communication of the entire list (i.e., all eight words) was timed in seconds from the researcher's instruction to begin to acknowledgement by the partner of successful communication of the final word. Next, the video for the second device was presented to the pair, followed by a practice word list, then a timed trial—the same procedure as was used for the first device. The same was done for the third AAC device. At the conclusion of the session, participants were administered the method ranking form (see Appendix D) to gauge overall device preference from most to least preferred. The procedure for the second session with each pair was identical. For Sessions 3, 4, and 5, instructional videos were available on request but were not necessarily presented; otherwise, the procedure was the same.

Reliability

An additional observer was recruited for reliability testing of the duration of timed trials in seconds and provided observations for approximately 10% of the videos recorded of participants' use of each method during each session (11 of 105 videos). Because the dependent variable, time in seconds, is a ratio variable, inter-rater reliability was calculated using Krippendorff's alpha. A high correlation between the judges was demonstrated, $\alpha = .9994$, 95% CI [.9988, .9999]. Thus, the durations originally determined during timed trials by the primary researcher were used in calculations of rate to determine results.

Results

The purpose of this study was to examine the learning and subsequent use of three low-tech, eye-gaze-accessible AAC devices: EyeLink, PAS, and E-tran. Seven pairs of participants completed five sessions each using each of the three devices during every session. Results pertaining to the average rates of use, changes in rates of use across sessions, overall user preferences, and changes in those preferences over time are explained in this section.

Rate of Use

Average rate of use for each method. Rate of use was determined by measuring average seconds per selection of each letter included in an eight-word list during a timed trial. Indication of a space at the end of each word was considered a letter for purposes of rate calculation. The average rate of use for each method was calculated across all timed trials pertaining to the given device across sessions and participants; thus, 35 trials were considered for each of the three. These averages were used to answer the first research question. The device with the quickest average rate was EyeLink ($M = 7.99$ s per selection, $SD = 1.80$) followed by E-tran ($M = 8.56$ s per selection, $SD = 1.59$) and PAS ($M = 11.97$ s per selection, $SD = 1.53$).

A 3×5 repeated measures ANOVA was completed using a between-subjects factor of method (EyeLink, PAS, and E-tran) and a within-subjects factor of session (with five levels, one for each session) to determine the effect of method on rate of use over time. The assumption of sphericity for repeated measures was addressed with Mauchly's

test of sphericity. Mauchly's test revealed violation of the assumption with significance

at the .05 level (Mauchly's $W = .29$, $\chi^2 = 20.55$, $p = .015$), so a Greenhouse–Geisser

correction ($\varepsilon = 0.65$) was applied. In addition, Levene's test was used to assess the

assumption of homogeneity of variance among sessions. Results for each of the sessions

were nonsignificant, indicating that the assumption was not violated, and were as follows:

Session 1, $F(2,18) = 0.91$, $p = .422$; Session 2, $F(2,18) = 0.84$, $p = .448$; Session 3,

$F(2,18) = 0.48$, $p = .624$; Session 4, $F(2,18) = 2.70$, $p = .094$; and Session 5, $F(2,18) =$

1.15, $p = .340$.

A significant main effect of method at the .05 level was shown, $F(2,18) = 11.97$,

$p < .001$, partial $\eta^2 = .57$. Pairwise comparisons revealed significant differences between

average rate of use of PAS compared with EyeLink, $p = .001$, and PAS compared with

E-tran, $p = .003$. In other words, average rates of use for the EyeLink and E-tran were

relatively similar, and PAS differed significantly from both. Complete ANOVA results

are provided in Table 2.

Table 2

Repeated Measures ANOVA Results Across Devices

Source	SS	df	MS	F	p	Partial η^2
Within subjects						
Session	115.90	2.59	44.76	11.36	<.001	.39
Session × Method	29.93	5.18	5.78	1.47	.217	.14
Error	183.58	46.59	3.94			
Between subjects						
Method	323.92	2	161.96	11.97	<.001	.57
Error	243.22	18	13.51			

Note. Due to violation of the sphericity assumption, within-subjects values reflect application of a Greenhouse–Geisser correction.

Changes in rate over the course of five sessions. To address the second research question, data concerning rate of use was also analyzed session by session to assess learning or changes in rate of use over time with practice. Figure 4 depicts the average rate of use for each method for each of the five sessions across participants.
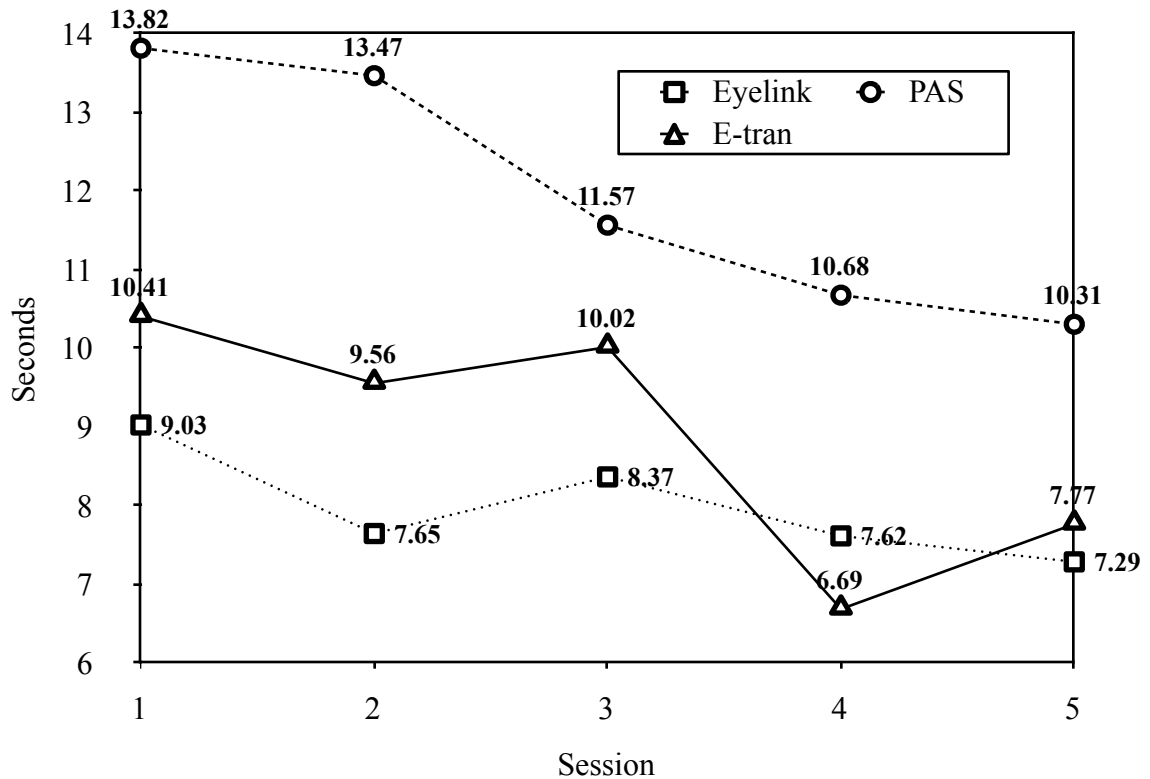
Figure 4. Average seconds per selection for each device across participants by session.

As illustrated, EyeLink was the quickest method on average for Sessions 1, 2, and 3. At

Session 4, it was overtaken by E-tran; however, results from session 5 yielded a lower

rate of use once again for EyeLink. PAS was not only the slowest method on average

overall, but, as shown in Figure 4, it also carried the highest average rate of use during all

five sessions.

For each of the methods, an overall decrease in rate of use can be seen in Figure 4

from the first to the fifth sessions. Additionally, in session-to-session pairwise

comparisons across devices, the repeated measures ANOVA explained previously (and

reflected in Table 2) showed that average rates of use differed significantly between

certain sessions. As discussed above, Mauchly's test of sphericity was violated

(Mauchly's $W = .29$, $\chi^2 = 20.55$, $p = .015$). Resultantly, the Greenhouse–Geisser

correction was applied ($\varepsilon = 0.65$), which yielded a significant effect of session at the .05

level, $F(2.59, 46.59) = 11.36$, $p < .001$, partial $\eta^2 = .39$. Specifically, pairwise

comparisons indicated that Session 1 rates differed significantly from those of Sessions 3,

4, and 5 ($p = .002$, $p = .005$, and $p = .001$, respectively) when considering all devices

together, indicating a significant decrease in average rate of use in later sessions.

Furthermore, Session 2 rates were shown to differ significantly from the rates of Sessions

4 and 5 ($p = .009$ and $p = .002$, in order).

To determine if changes in rate of use were significant for each device across

sessions, the data set was split by method, and the ANOVA was repeated yielding

session-to-session pairwise comparisons by device. Results are displayed in Table 3.

Table 3

Repeated Measures ANOVA Results by Device

Source	SS	df	MS	F	p	Partial η^2
EyeLink						
Session	13.79	4	3.45	1.29	.303	.18
Error	64.24	24	2.68			
E-tran						
Session	60.10	4	15.02	7.17	.001	.54
Error	50.33	24	2.10			
PAS						
Session	71.91	4	17.98	6.25	.001	.51
Error	69.02	24	2.88			

Mauchly's test indicated that the assumption of sphericity was not violated for EyeLink (Mauchly's $W = .15$, $\chi^2 = 8.39$, $p = .526$), E-tran (Mauchly's $W = .08$, $\chi^2 = 11.03$, $p = .305$), or PAS (Mauchly's $W = .60$, $\chi^2 = 12.40$, $p = .221$). As shown in Table 3, the effect of session was nonsignificant for EyeLink, $F(4,24) = 1.29$, $p = .303$. A significant

main effect of session was shown for E-tran, $F(4,24) = 7.17$, $p = .001$; however, pairwise comparisons revealed no significant results. The effect of session was also significant for PAS, $F(4,24) = 6.25$, $p = .001$, partial $\eta^2 = .51$. Furthermore, pairwise comparisons showed significant differences between Sessions 2 and 4, $p = .007$, as well as 2 and 5, $p = .045$, indicating a significant decrease in rate of PAS use over time.

User Preferences

Overall preferences. User preferences concerning each of the three devices were determined using the method ranking forms administered at the end of each session. *Cumulative composite preference scores* for each device reflect combined preferences across participants and sessions and were calculated by assigning a constant multiplier to each ranking. They were used to answer the third research question. Specifically, a multiplier of 3 was applied to a ranking of 1st, 2 to 2nd, and 1 to 3rd; thus, higher composite scores indicate higher overall preference. Then the number of instances of each ranking for each device was multiplied accordingly to arrive at a cumulative composite preference score. Results were as follows: EyeLink scored 138, PAS received a score of 111, and E-tran scored 171. Therefore, E-tran was the most preferred method overall followed by EyeLink and, lastly, PAS. Table 4 outlines the number of times each ranking was given to each device across participants during each session as well as cumulatively.

Table 4

Number of Occurrences of Rankings by Device Across Participants by Session and Cumulatively

Device	Rank	Session					Cumulative
		1	2	3	4	5	
EyeLink	1st	6	4	4	3	2	19
	2nd	6	6	5	7	6	30
	3rd	2	4	5	4	6	21
PAS	1st	2	1	2	1	2	8
	2nd	3	8	7	3	4	25
	3rd	9	5	5	10	8	37
E-tran	1st	6	9	8	10	10	43
	2nd	5	0	2	4	4	15
	3rd	3	5	4	0	0	12

As shown, E-tran received the most 1st rankings, a total of 43. EyeLink was ranked 1st by participants 19 times and PAS only eight. Fittingly, PAS also was deemed 3rd the most times with 37 instances of the ranking. EyeLink followed with 21 occurrences of being least preferred, and E-tran had only 12.

Changes in preferences over the course of five sessions. Composite preference scores were also calculated for each session to determine trends over time as a means of addressing the final research question. The method of calculation was similar to that of cumulative composite preference scores (the same multipliers were applied to results in

Table 4) with the exception that *session composite preference scores* were calculated

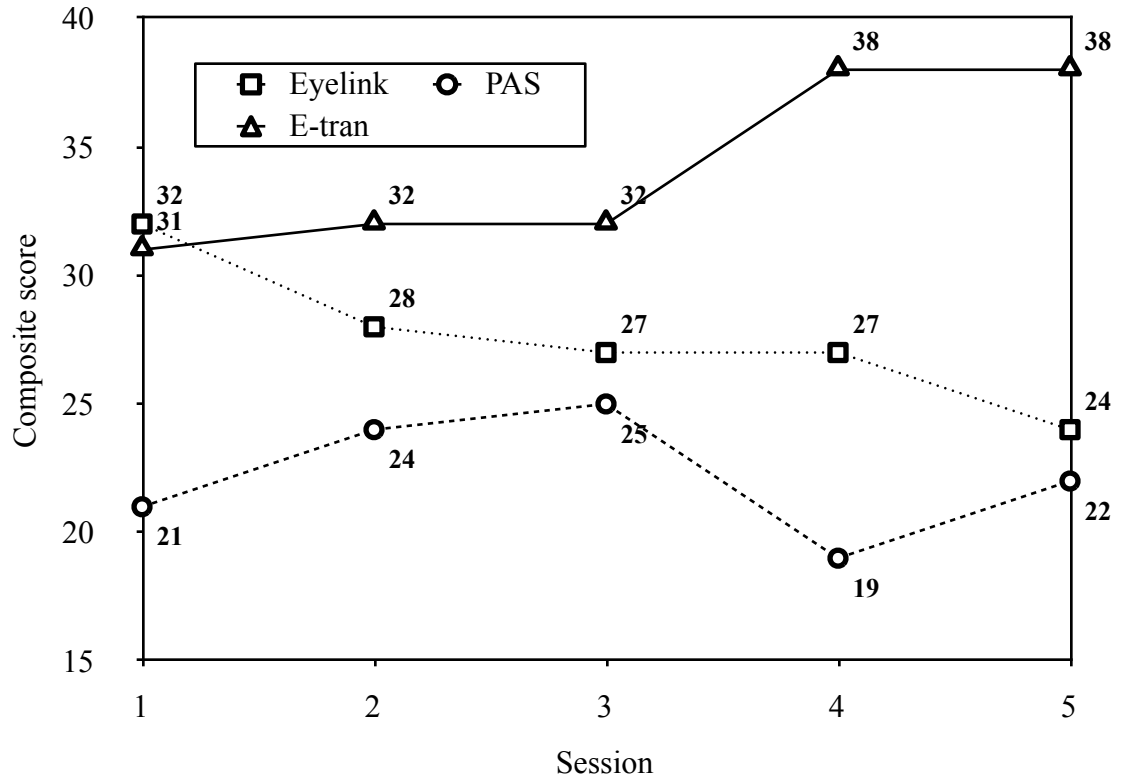across participants but not sessions. The results are depicted in Figure 5.

Figure 5. Session composite preference scores for each device.

The information shown in Table 4 corresponds with the trends seen in Figure 5.

As illustrated, EyeLink was very slightly more preferred at Session 1 with a session

composite preference score of 32 compared to the 31 associated with E-tran; similarly,

both EyeLink and E-tran were ranked 1st six times across participants at Session 1, but

EyeLink received six 2nd rankings and two 3rd whereas E-tran garnered five 2nd

rankings and three for 3rd. However, E-tran was not only the device most preferred

overall (as explained previously) but also the most preferred during most of the

individual sessions; it was ranked highest by Session 2 (with a session composite preference score of 32 and nine instances of 1st) and continued to be so through Session 5 (at which point its score was 38, and 10 participants rated it as 1st). EyeLink was the only method with an overall decrease in preference over the course of all five sessions, with a session composite preference score of 32 at Session 1 and 24 at Session 5. This trend is supported by the information in Table 4, which shows that the device was ranked 1st at Session 1 by six participants, but only two issued it this ranking at Session 5.

Regarding PAS, an increase can be seen in Figure 5 in Sessions 1 through 3 and from Session 4 to 5 with a decline at Session 4. On the whole though, its session composite preference score at Session 1 was similar to that at Session 5 (21 and 22, respectively) indicating an overall lack of change in preference across the participants. Indeed, two participants rated the device 1st at both Sessions 1 and 5, and it was rated 3rd nine times for the first session and eight for the fifth.

Discussion

The purpose of this study was to examine the rates of use for three low-tech, eye-gaze-accessible AAC devices, the user preferences related to each of the methods, and the effects of learning over the course of study through changes in preferences and rate of use. Typical adults (without a diagnosis of ALS) participated for the purpose of providing a basis of comparison with results of another study component by Roman et al. (2010) in which PALS were selected for participation. Taken in conjunction, results may have implications for the recommendation and training of such AAC devices by SLPs.

The research questions answered by the data collected for this study along with original hypotheses are as follows:

- What is the average rate of use for each device? It is hypothesized that the average rate of use of EyeLink will be the quickest followed by E-tran, and participants' use of PAS will be the slowest. Both E-tran and EyeLink involve methods of direct selection, but EyeLink requires only one selection whereas E-tran requires two to choose a symbol. Of the three devices, PAS is the only one that requires scanning. Research has shown that scanning methods tend to be slower to use than direct selection methods (Goossens & Crain, 1987).

- Do average rates of use change over the course of study participation, lasting approximately two to three weeks? The lack of available research comparing low-tech, eye-gaze-accessible methods led to the null hypothesis that rates of use from session to session would not differ significantly for any of the three devices.

However, as with the first research question, it is predicted that the rate of use for PAS will be the slowest throughout participation due to the requirements of scanning and that EyeLink will be the quickest due to the reduced number of required selections compared to E-tran.

- Which device do participants prefer overall? It is hypothesized that participants will exhibit similar preferences for E-tran and EyeLink, and PAS will be the least preferred device. As previously noted, E-tran and EyeLink are expected to yield faster rates of use, and therefore, participants will likely prefer using them over PAS.

- Do participant preferences change over the course of study participation, lasting approximately two to three weeks? The lack of research concerning preferences of users of these devices and their partners led to the null hypothesis that participant preferences will not change over the course of the sessions.

Rate of Use

Average rate of use for each method. In terms of the first research question, EyeLink was in fact the quickest device to use on average followed by E-tran, thereby supporting the original hypothesis. Furthermore, PAS was the slowest device to use on average. As stated by Goossens & Crain (1987), scanning generally tends to be slower than direct selection by eye gaze. Given the basic nature of scanning, this is unsurprising. With scanning, communication partners must generally offer multiple items or letters before a selection is made. Direct selection of an item or letter, however, involves immediate eye pointing by the sender of the message to the desired item or group,

thereby reducing the amount of time needed to complete the communication. Taking the assumption of increased speed with direct selection a step further, as hypothesized one may reason that the single selection required for use of EyeLink would provide a quicker method than the two selections demanded for use of E-tran. The data revealed, however, that the average rate of use was in fact quicker for E-tran, but the difference in average rates between the two was not shown to be significant.

Changes in rate over the course of five sessions. The examination of rate of use on a session-by-session basis was used to answer the second research question and showed that, despite the lesser number of selections required for EyeLink use (as opposed to E-tran), EyeLink was not consistently the quickest method. At Session 4, the device was briefly overtaken in terms of rate by E-tran. However, at Session 5, EyeLink was once again the fastest. In addition, in support of the hypothesis, rates of use did not differ significantly from session to session for these two devices.

A higher potential for mistakes with EyeLink compared to E-tran may factor into the difference in rates of use for the two. Despite the fact that EyeLink required half the eye movements that E-tran did (one direct selection was necessary as opposed to two), differences in rate were not statistically significant, and E-tran was actually quicker to use at Session 4. However, with the E-tran board used in this study, only seven targets were possible for the user's gaze: each of the six groups, and "space." Additional specificity was accomplished through interpretation of combinations of selection of these targets. The EyeLink board, on the other hand, had 27 target areas: one for each letter, and one

45

for "space." Therefore, misinterpretation of the user's gaze may have occurred more easily with EyeLink versus E-tran.

As hypothesized, PAS was associated with the slowest rate of use for all five sessions. Moreover, PAS remained the slowest despite three of the seven pairs' independent development of shortcuts to selecting a space to signal the conclusion of a word. No use of shortcuts was shown in the instructional videos, and pairs were instructed to scan to "space" at the end of each word in a manner similar to the selection of letters. Nonetheless, one pair began to incorporate an additional eye movement (to a corner of the PAS board) to indicate "space." Another began to reject the use of "space" entirely and simply guessed the word after sufficient letters were communicated. A third pair initiated seemingly perfunctory scanning to "space"—the partner verbally listed options so quickly that it would not have been possible for the user to select an item other than "space." Additionally, in contrast to the hypothesis, differences in rate of use were significant in some session-to-session comparisons for PAS.

User Preferences

Overall preferences. The hypothesis associated with the third research question was upheld by the data for PAS but not for EyeLink or E-tran. Cumulative composite preference scores illustrated that E-tran was the most preferred device overall followed by in order by EyeLink and PAS. The unfavorable opinions toward PAS likely arose from the consistently slower rate of use; as discussed previously, rate of use of PAS differed significantly from the other two devices. The average rates of E-tran and

EyeLink though did not significantly differ from one another, and moreover, EyeLink actually provided the faster method for four of the five sessions. It is reasonable to suggest that participants likely factored their perceptions of rates of use into judgements of preference, and that as a result, PAS was the slowest and least preferred device.

Examination of participant comments about EyeLink provide an additional rationale for lower preference of EyeLink as opposed to E-tran. During at least one of the five sessions, participants from all seven pairs expressed complaints about the physical nature of the board itself, explaining that it would be easier to use if it were more rigid or had a frame. Although some participants became frustrated with use of E-tran and PAS and stated opinions about the methods, none made any mention of potentially useful changes to the boards physically. In the case of EyeLink, the physical aspects of the board including its size in relation to the thickness of the plastic used appeared to adversely impact the participant perceptions of preference.

Changes in preferences over the course of five sessions. The hypothesis associated with the fourth research question was supported by the data inasmuch as PAS was the least preferred throughout the sessions. With regard to the other two devices, EyeLink was preferred over E-tran at Session 1, though session composite preference scores for the two differed by only 1 point. Subsequently, the latter overtook the former (by Session 2) and remained the favored device throughout the remainder of the sessions. EyeLink was only briefly and very slightly the favored device. The degree and consistency of preference for E-tran over EyeLink was not anticipated.

Clinical Implications for Recommendation and Training of AAC Devices

Changes in both rates of use and user preferences across the five sessions of this study indicate the potential value of training participants in the use of these devices. Furthermore, results will contribute to the clinical implications drawn by the Roman et al. (2010) study component, currently in progress. Due to the use of typical adults as participants, no direct clinical implications concerning PALS or any other persons with communication disorders can be drawn from this investigation. Nonetheless, the changes in rates and preferences of these participants may reflect the overarching value of training in general. The typical adults were initially unfamiliar with these or any AAC devices as are many PALS and other potential users of AAC when first introduced.

Multiple authors highlight the importance of informing SLPs of functional outcomes and user preferences for specific AAC systems in order that they may make better recommendations regarding system selection and training (Blackstone et al., 2007; Johnson, Inglebret, Jones, and Ray, 2006; Murphy, 2004b). In conjunction with Roman et al. (2010), results of this study contribute to the literature comparing low-tech, eye-gaze-accessible AAC methods to one another, an area for which the literature is currently very limited. Furthermore, protocols outlining successful and efficient training of these devices do not currently exist; trends seen in this study and that of Roman et al. (2010) may contribute to development of such practice guidelines.

Although significant differences in rates were not found in session-to-session comparisons of all three individual devices (significance was found only with PAS), the

three taken together yielded significance. Specifically, significant differences were found

in rates when Session 1 was compared to Sessions 3, 4, and 5, and when Session 2 was

compared to Sessions 4 and 5. This suggests an overall decline in rate of use and may

support training of these devices on more than one occasion as opposed to introduction of

the devices followed by a decision of preference during the same first session.

The increasing preferences for E-tran across sessions coupled with the decreasing

preferences for EyeLink further suggest the value of training potential users of these

devices. That the rankings by participants for Session 1 were not the same as those for

Session 5 suggest changing opinions over time. Decisions made by users of AAC and

their partners following training in the devices may be different than those made

following only introduction to the devices. In addition, when examining preferences,

individual opinions should be considered in addition to overall trends. Though E-tran

was in general the most preferred device by participants in this study and PAS the least,

two individuals liked using PAS the most by Session 5. It may be appropriate for SLPs to

be educated on the use of multiple devices so that they may provide options to each

individual—as opposed to acquainting themselves only with the device that tends to be

the most preferred or familiar to them for use with clients with a certain type of

communication disorder; those who prefer PAS, though fewer than those who prefer

E-tran, would benefit from being offered the device they most prefer to use.

Limitations of This Research

Limitations of this study should be considered when evaluating and interpreting the results. First, the participants were typical adults, individuals without any communicative deficits. The intention of comparing results of this study to those of a study in which PALS are participants has been outlined; however, the degree to which findings of either study may be generalized is currently unclear. Furthermore, use of the low-tech, eye-gaze-accessible AAC devices included in this study may be appropriate for individuals with communication deficits resulting from a variety of disorders apart from ALS, including including locked-in syndrome, Guillain-Barré syndrome, and brain stem stroke (Beukelman et al., 2005); however, neither this study nor that of Roman et al. (2010) included participants with disorders other than ALS.

Also, the communication involved in study participation consisted of transmission of lists of predetermined experimental stimuli. Any differences in rates of use, preferences, or learning patterns that may come with more natural communication are unclear. Applicability of these results to naturalistic communicative contexts with varied content, intent, and communication partners is therefore limited.

Directions for Future Research

From the results of this study a number of directions for future research emerge. First, similar research is needed that includes adults with disorders aside from ALS as participants. Their inclusion would increase the applicability of conclusions concerning the training and recommendations of these AAC devices by SLPs to a broader client base.

In addition, research incorporating user preferences and functional outcomes related to both high-tech and low-tech AAC options could yield more functional recommendations for the individuals who rely on these devices. Williams et al. (2008) argued that "one is never enough" (p. 3) with regard to AAC systems. Research that takes into account the use of more than one device by an individual may more accurately replicate realistic communicative contexts. Similarly, this research concerned interactions between one user and one partner. In reality, a user of AAC may have multiple communication partners, and research that examines the use of these devices with different partners of the same user may be valuable in increasing the effectiveness of recommendations and training.

Summary and Conclusion

Results from this research expand the currently limited literature concerning three low-tech, eye-gaze-accessible AAC devices: EyeLink, PAS, and E-tran. At this time, very little evidence exists regarding learning and use of these devices or user preferences related to them. Continued research in this area can lead to evidence-based recommendation and training of these types of devices by SLPs and can thereby improve outcomes for the diverse group of those, PALs or otherwise, who rely on such devices for communication.

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Appendix A

Web Addresses for Instructional Videos

EyeLink: http://www.youtube.com/watch?v=zdTeVwTXjxI&feature=related

PAS: http://www.youtube.com/watch?v=nxw0oUb9ohw&feature=related

E-tran: http://www.youtube.com/watch?v=lfLuqGAxaz4&feature=related

Appendix B

Practice Word Lists

Practice List 1	Practice List 6	Practice List 11
FAN	BAT	ELM
MOM	LIE	ONE
Practice List 2	Practice List 7	Practice List 12
RUE	LAW	DOT
ADD	MAT	PAD
Practice List 3	Practice List 8	Practice List 13
BUT	HAD	NAP
KEN	SUP	WOE
Practice List 4	Practice List 9	Practice List 14
IMP	BAT	HOP
NOD	TOW	ANT
Practice List 5	Practice List 10	Practice List 15
NUB	TIN	LAP
CAD	DIM	SEA

Appendix C

Trial Word Lists

EyeLink List 1	EyeLink List 3	EyeLink List 5
BUST	SAY	PIES
ROSE	HUM	USE
DIME	RIFT	ART
CUR	NOSE	HARD
VAT	DOE	CANT
MAD	LILT	DOG
COIL	RUN	LIMN
GET	GIBE	KIT

EyeLink List 2	EyeLink List 4	
SOAP	FAME	
ERE	WED	
CUT	RIP	
LARD	SLOT	
SON	RICH	
DIG	PER	
ONLY	HENS	
DENT	BIT	

Trial Word Lists

PAS List 1	PAS List 3	PAS List 5
RAN	OAT	ICE
YELL	BENT	CALM
GRIP	LAN	SLAP
FEN	RAM	DON
HOT	BARS	SHIN
PAIR	CHIC	RAFT
END	SPED	VIE
SHOE	RON	LOB

PAS List 2	PAS List 4
MEW	RAIL
HOLE	OGLE
CENT	SHE
SOB	VOLE
RING	OAK
PAR	CURD
SUE	NOT
CURT	CUP

Trial Word Lists

E-tran List 1	E-tran List 3	E-tran List 5
MALT	VEST	YOU
CAN	LACK	TEAR
BOUT	HUT	PET
SEW	RAIN	HERE
SINE	GEM	SONG
LIP	POLE	NEW
HEN	DIP	CURL
RACK	OWE	MOB

E-tran List 2	E-tran List 4
TEA	BAG
VIM	MINT
ARCH	MAN
LEAP	NUT
HIM	CART
SAIL	SOY
KNOT	SIDE
FIB	LEAN

Method Ranking Form

Method Ranking

Pair # _____   PALS ☐

Session _____   Partner ☐ Relationship to PALS: _____

Researcher_____

Please rank your order of preference for the three methods you used today.

1 indicates the method you **like best**

3 indicates the method you **like least**

_____   E-tran

_____   EyeLink

_____   PAS