While Erin Beneteau is an employee of Tobii ATI, this research was conducted outside of her work duties, as a speech-language pathology researcher and in no way is a product of or affiliated with Tobii ATI. The article represents solely the views or opinions of the authors.

Functional Performance Using Eye Control and Single Switch Scanning by People With ALS

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Abstract

Eye control and switch scanning are commonly considered as augmentative and alternative communication (AAC) access options by people with amyotrophic lateral sclerosis (ALS) at the same clinical intervention point. Choosing optimal access methods must be supported by performance and qualitative feedback, as well as considerations of cognitive changes sometimes associated with ALS. We present quantitative and qualitative data comparing access methods used by five people with ALS and five adults without ALS. Each participant accessed an on-screen keyboard during repeated exposure to two conditions: single switch scanning and eye control. Participants were required to copy sentences presented on a computer screen. Keyboard letter organization was held constant between conditions, and rate enhancement and word prediction techniques were not used. Measures of speed and accuracy revealed a significant speed advantage for eye control and a significant accuracy advantage for single switch scanning. Speed and accuracy for both access methods improved with practice. Predictably, people with ALS performed significantly slower than participants without ALS using both access methods. Participants rated eye control as the more efficient access method overall. Participants without ALS rated both access methods significantly more fatiguing than people with ALS. Post study interviews revealed that eye control was the preferred access option for people with ALS. Clinical implications and extensions of this study are discussed.

Amyotrophic lateral sclerosis (ALS), a neurodegenerative disease that affects both upper and lower motor neurons, results in weakness and eventual paralysis of voluntary muscles. The disease is variable in its presentation, with the majority of affected individuals initially exhibiting spinal symptoms related to limb weakness. A smaller number exhibit primarily bulbar symptoms, which can quickly affect speech and swallowing. An additional subgroup presents with mixed symptomatology (Traynor, Alexander, Corr, Frost, & Hardiman, 2003). The prevalence of ALS is estimated to be approximately 30,000 in the U.S. (ALS Association, 2010).

Currently, there is no known cure for ALS; however, people with ALS often benefit from assistive technology as the disease progresses. In particular, augmentative and alternative communication (AAC) is an integral part of intervention for people with ALS, because they often lose the ability to speak and/or write (Ball, Beukelman, & Pattee, 2004). Recently, there has also been increased acknowledgment, identification, and explanation of cognitive deficits and personality changes associated with ALS (Phukan, Pender, & Hardiman, 2007; Ringholz et al.,

2005; Strong, 2008). Recent reports suggest that up to half of all people with ALS experience cognitive change to some degree, often as a result of frontotemporal dementia, which will likely have dynamic effects on AAC use (Lomen-Heorth et al., 2003; Roman & Woolley Levine, 2006). The rapid progression of ALS itself presents challenges for clinicians attempting to prescribe appropriate access methods to AAC devices as physical symptoms evolve (Beukelman, Fager, Ball, & Dietz, 2007). This challenge is compounded by changes in cognition that may make learning or adapting new access methods difficult. Evidence-based AAC clinical pathways for people with ALS experiencing physical and cognitive decline have yet to be clearly delineated.

Direct selection techniques are certainly preferable as long as possible. At some point, transition to an alternative selection method is warranted for most people with ALS, due to reduced efficiency with direct selection related to motor impairment. A complete discussion of the vast array of potential alternative access strategies and equipment for people with ALS is beyond the scope of this article. Instead, we will focus on a common decision point that presents itself to clinicians and people with ALS who are transitioning from direct selection to alternative AAC access. They can either choose to employ a switch (or switches) to control a scanning system or use one of the eye control systems now available for most computer-based AAC systems.

Both solutions offer the user typing and cursor control via various onscreen keyboards and mouse control emulation software. We hypothesize that eye control is faster and more efficient than switch use for people with ALS, yet we do not have clear evidence-based guidance regarding the value of each solution based on performance. While research on a variety of access methods exists, conclusions often have been based on use by typically functioning participants (Horn & Jones, 1996; Majaranta, MacKenzie, Aula, & Raiha, 2006; Petersen, Reichle, & Johnston, 2000; Szeto, Allen, & Littrell, 1993; Venkatagiri, 1999). User perception of fatigue and efficiency, as well as the user's learning style and acceptance of a new access system, seems to be affected by personality and cognitive changes throughout disease progression. Additionally, the cost disparity between switch- and eye-controlled technology is an important variable in clinical decision making. The research reported here is a preliminary attempt to collect quantitative data on differences in functional performance between two access methods used by people with and without ALS, as well as qualitative data on how those access methods may affect users' perceptions of fatigue, efficiency, and preferences.

Methods

Study participants included one woman and four men with ALS, with a mean age of 49.4 years (range=38 to 71), and an average of 2.1 years since diagnosis. Two people with ALS had used switch scanning as AAC input for more than 1 year, while another had used direct selection via index finger for 6 months. One of the people with ALS using switch scanning had previously attempted eye control during an AAC assessment. The two remaining people with ALS were unfamiliar with switch scanning access and eye control. Five participants without ALS, or any other neurodegenerative history, included three women and two men, with an average age of 38.4 years (range=33 to 64). Participants without ALS had no experience with switch scanning, and one had attempted eye control while a relative with an eye control system was visiting.

The study consisted of each participant copying short sentences using an onscreen keyboard in two conditions, row/column single-switch scanning, and eye control. Sentences were derived from the MacKenzie and Soukoreff (2003) corpus for evaluation of text entry. The MyTobii P10© was employed during both conditions and was configured with a page set specifically designed for the study using TobiiATI© Communicator 4 software (Tobii Assistive Technology, Inc., 2008). The page set consisted of 32 keys. Letter keys appeared in alphabetical order with a few function keys for spacing and deletion. Participants were instructed to add spaces between each word; no other capitalization or punctuation was required. In an attempt

to isolate speed and accuracy specifically related to access method, the typing page did not include letter or phrase acceleration techniques.

During the switch scanning condition, participants were first familiarized with the onscreen keyboard and trained to use a single switch during row/column scanning. The goal during this practice session was to increase each participant's scanning rate to the fastest, most comfortable rate possible without error. All participants accessed the MyTobii P10© using an AbleNet® Jelly Bean switch placed on a tabletop with their dominant hand except for two people with ALS who already used switch access. These participants used their most optimal switch and switch location; one relied on her chin switch, and the other accessed a Micro Light™ finger switch mounted to his wheelchair. All switches were routed through a Crick© USB switch box software (Crick Software, 2007). Scanning speed was adjusted to maximum proficiency and comfort before beginning test sentences. Participants were provided with the option to adjust scanning speed between trials to achieve optimal performance. Participants then completed two sets of four sentences. Each sentence was composed of three words and balanced for letter frequency and word length (i.e., 14 characters per sentence).

For the eye control portion of the experiment, participants were again familiarized with the keyboard layout. Participants were provided with instruction and a brief visual tutorial regarding eye control, after which each was positioned appropriately and the eye control software was calibrated. A practice session ensued to familiarize participants with eye control, dwell, and to ensure access to the entire screen. Dwell time was adjusted to the fastest, most comfortable time for each participant. The goal during the practice portion of the eye control trial was for each participant to access a 5x6 grid without error. To this end, a step-down approach was used from two large buttons to successively smaller, more populated grids. All participants completed this training successfully. Participants were provided with the option to adjust dwell time between trials to achieve optimal performance.

For both conditions, precise timing and accuracy was determined using the analysis software Compass (Koester Performance Research, 2010). Compass is designed to run in conjunction with any typing program (in our case, the Communicator 4 typing grid) and collect real-time data on a range of parameters including errors (e.g., total, net, corrected, etc.) and timing (e.g, seconds per trial, words per minute, etc.). Compass was configured to provide two sets of target sentences for each condition, with each set consisting of 4 sentences totaling eight sentences via switch scanning and eight sentences via eye control. Participants were required to reproduce each sentence using the on-screen keyboard. Thus, each participant copied a total of 16 sentences. Capitalization and punctuation were not included in the target sentences or factored into the results. Immediately following each trial, participants were asked to rate their physical and mental fatigue, using a 5-point Likert scale where 1=no physical or mental fatigue, and 5=maximal fatigue. Participants were asked to distinguish if their fatigue was mental, physical, or both mental and physical fatigue. A 3-point scale was used for rating perceived efficiency; 1=highly efficient and 3=highly inefficient. An informal interview after completing the study gave participants an opportunity to indicate which access method they preferred at that moment.

Results

As depicted in Tables 1 and 2 below, analysis of the number of seconds required to construct a sentence revealed significantly faster times using eye control compared to row/column scanning. Similarly, words per minute were generated significantly faster using eye control than row/column scanning. Predictably, sentences completed by people with ALS took more time regardless of access modality than those completed by people without ALS.

Total errors, as determined by all selections requiring correction, was not significantly higher in either condition. Net errors, as determined by uncorrected errors before moving on to

the next sentence in a trial, were higher in the eye control condition than row/column scanning condition. Sentences completed by people with ALS were more likely to have errors than those completed by people without ALS. Error rate totals decreased and speed increased for both access methods between trials one and two.

Table 1. Mean speed and error rates for eye control and switch scanning

Access Method	Time per Sent (s) (SD)	Words per Minute (SD)	Total Errors (SD)	Net Errors (SD)
Eye Control	**43.80**** (17.19)	**4.16**** (1.40)	0.10 (0.13)	**0.56*** (0.09)
Switch Scanning	**112.22**** (38.96)	**1.62**** (0.45)	0.05 (0.06)	**0.01*** (0.02)

T-Test significance: * = p < .05; ** = p < .001

Table 2. Mean speed and error rates for participants with ALS and participants without ALS

Participant Group	Time per Sent (s) (SD)	Words per Minute (SD)	Total Errors (SD)	Net Errors (SD)
with ALS	**92.56*** (55.36)	2.54 (1.72)	0.11 (0.13)	**0.60**** (0.10)
without ALS	**63.47*** (27.71)	3.25 (1.53)	0.04 (0.04)	**0.01**** (0.01)

T-Test significance: * = p < .05; ** = p < .01

As depicted in Table 3 below, participants without ALS rated eye control significantly more efficient than scanning. Participants with ALS also rated eye control as more efficient than scanning, but this difference was not significant. Participants without ALS rated sentence construction in both conditions as more fatiguing overall than people with ALS. Specifically, participants without ALS rated both conditions as more mentally fatiguing than participants with ALS. Ratings of physical fatigue were not significantly different between groups or conditions.

Table 3. Mean rating of perceived efficiency and fatigue

Participant Group	Efficiency (SD)		Overall Fatigue (SD)		Mental Fatigue (SD)		Physical Fatigue (SD)	
	Eye Cont	Switch Scan	Eye Cont	Switch Scan	Eye Cont	Switch Scan	Eye Cont	Switch Scan
with ALS	1.80 (0.79)	2.00 (0.94)	**1.10**** (0.32)	**1.40**** (0.69)	**0.20*** (0.42)	**0.30*** (0.48)	0.10 (0.31)	0.40 (0.52)
without ALS	**1.30**** (0.48)	**2.30**** (0.48)	**2.30**** (1.06)	**2.60**** (1.07)	**0.50*** (0.53)	**0.70*** (0.48)	0.30 (0.48)	0.20 (0.42)

T-Test significance: * = p < .05; ** = p < .001

Discussion and Clinical Implications

Results suggest that eye control is significantly faster than row/column scanning when the typing grid content and language efficiencies are held constant for people with and without ALS. This finding is relevant for communicators whose ability to access an alternative communication system is already compromised by reduced strength and mobility. Interestingly, error rates for both groups of participants were higher for eye control, yet every person with ALS reported a preference for eye control during a post-study interview. Given that all participants experienced an increase in speed with eye control access and that speed continued to increase with practice, it is possible that increased speed and perceived efficiency trumped errors (Hansen, Torning, Johansen, Itoh, & Aoki, 2004).

Whereas increased speed appears to be a natural bi-product of access method, accuracy may be more directly related to cognitive load. The cognitive demands of learning a new access method and using an unfamiliar keyboard layout combined with the pressure of a timed typing test may have negatively affected accuracy. It is also possible that a few ALS participants were beginning to exhibit subtle cognitive deficits that deleteriously affected performance (Lomen-Heorth et al., 2003). Additionally, people with ALS may have been less concerned with high rates of accuracy given that they have grown accustomed to less than optimal performance in other areas of everyday existence (Donegan et al., 2009).

In light of increasing verification of cognitive changes associated with this disease, clinicians must strive to determine what specific access attributes or fusion of access solutions best serves the communication technology needs of people with ALS (Beukelman, Fager, Ball, & Dietz, 2007). This is particularly important at a time when we have little evidence-based guidance for optimal AAC implementation with people with ALS experiencing cognitive decline. People with cognitive impairment may take longer to learn an access method and may make slower gains in accuracy and speed. Extended time for practice must be included when assessing any new access method (Roman, & Woolley Levine, 2006). It is likely that the practice of screening cognition at regular intervals throughout the ALS disease progression might help clinicians make appropriate decisions regarding access. Clinical sensitivity to user preferences and unique contextual constraints also should guide AAC access decision-making.

As noted above, the research reported here is preliminary and its limitations include a small sample size of people with ALS with a variety of AAC access experience. Access equipment was accurately calibrated for each participant, but extensive practice was not provided prior to participant testing and thus limits analysis of learning effects that may influence performance and satisfaction long term. Finally, the copying task used here is not fully representative of the daily communication tasks encountered by people with ALS.

Differences in performance and qualitative results between participant groups emphasize the importance of involving people with ALS in all aspects of AAC access decision-making and clinical research. In an attempt to measure functional performance in natural settings, future research should incorporate robust typing and language acceleration techniques, optimized grid layouts, analysis of novel utterance production, as well as hybrid access solutions (e.g., cursor eye control with button-press selection). Robust measures of participant cognition, especially frontal lobe function, should be part of clinical and research AAC evaluations to accurately describe effects of cognitive change on people with ALS alternative access performance and perception of AAC.

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