Use of Scanning Wizard Can Enhance Text Entry Rate: Preliminary Results

Heidi Horstmann KOESTER, Ph.D.[a,1] and Richard C. SIMPSON, Ph.D.[b]
[a] *Koester Performance Research, Ann Arbor MI, USA*
[b] *Duquesne University, USA*

Abstract. Scanning Wizard software helps scanning users improve the setup of their switch and scanning system. This study is evaluating Scanning Wizard's effectiveness, with nine people who use single-switch scanning participating to date. Text entry rates have improved by an average of 71%, ranging from 29 to 172% improvement.

Keywords. Augmentative communication, computer access, physical impairment, switch scanning, switch access, text entry, user performance.

1. Introduction/Background

Switch scanning allows people with severe physical impairments, who may also be unable to speak, to independently use a computer or augmentative communication (AAC) device with only one or two controlled movements. However, it is a slow method of text entry [1-5]. Despite its limitations, scanning may be the only alternative for individuals who cannot use other interfaces.

A common type of scanning is *row-column scanning*, which can be used with as little as one switch for input. Typical use with one switch requires two switch hits to select an item from a matrix of letters, symbols, words, or phrases. Each row is highlighted in turn until the first switch hit is made to select a row. Each column of that row is then highlighted until the target is highlighted, when the second switch hit is made to select the target. Variations include *group-row-column scanning* (see Fig 1), which adds another level in which a group is first selected, as well as *manual initiation*, which requires another switch hit to resume scanning after a selection is made.

Given the challenges of efficient text entry with scanning, product developers have implemented numerous configuration settings to allow for customization (Table 1). Proper configuration of the features available within scanning systems can make a major difference in communication rate [3-6].

Our overall goal is to establish an effective and efficient process for tailoring a scanning interface to a particular user. Previous work detailed a manual method for enhancing performance and demonstrated its effectiveness, as the nine switch users in the study improved their text entry rate by an average of more than 120% [3]. The next step was to make this method readily and efficiently usable by practitioners and switch users, which led to the development of the Scanning Wizard software.

[1] Heidi Koester, Koester Performance Research, 2408 Antietam, Ann Arbor MI 48105, USA. Email: hhk@kpronline.com

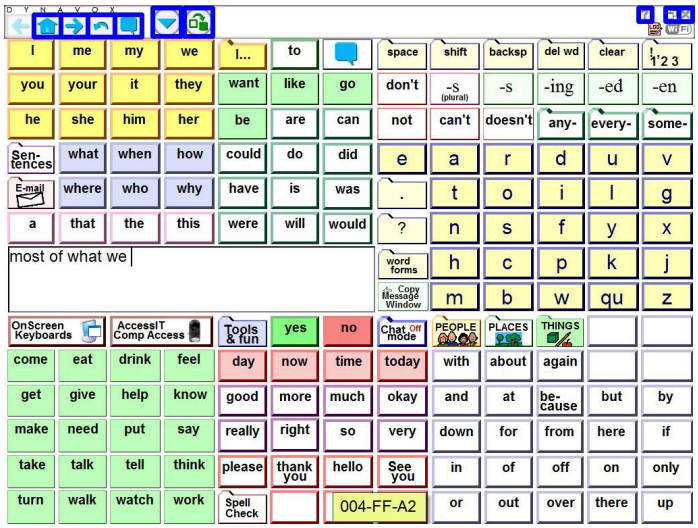

Figure 1. A group-row-column scanning display with 8 groups: titlebar, message window, pronouns, helping verbs, letters+prediction, verbs, chat, and prepositions.

Table 1. Some configuration options found in commercial scanning interfaces [4].

Category	Configuration Option	Definition
Language Features	Character Prediction	One or more items in the matrix are dynamically updated based on which letters are most likely to be selected next.
	Word Prediction	One or more items are dynamically updated based on what word the user is most likely entering. Additional settings control the number of words in the prediction list, etc.
	Fixed Words	One or more items contain fixed words or phrases.
Item Positions	Group Layout	Positions of groups of items relative to each other.
	Item Layout	Positions of letters or items relative to each other.
Scan Pattern	Number of Levels	Nesting of levels in the scan pattern (e.g., group-row-column or row-column).
	Manual/Auto Initiation	After a selection, Manual requires a switch hit to resume scanning, while Auto resumes automatically.
	Loop Count	Number of passes through the columns in a row before returning to the row scan.
Dead Time	Scan Message Window	Include the message window as an item in the scan pattern.
	Scan Titlebar	Include the title bar as an item in the scan pattern.
	Post-item Delay	Time delay after each selection before scanning resumes.
Timing	Scan Time	How long an item is highlighted for selection.
	1st-Item Delay	Delay added to the scan time for the first row or column.
	Acceptance Time	Length of time a switch must be activated before the activation is registered. Can reduce effect of bouncing.

1.1. Scanning Wizard

Scanning Wizard software guides switch users and practitioners through a series of tasks and generates individually-tailored recommendations based on the data collected and principles of scanning optimization. It includes three main parts:

1. Switch Test: checks basic switch use by measuring response time to an onscreen prompt.
2. Scan Test: checks basic scanning skill by selecting items using a simplified scanning layout (with either letters or symbols).
3. Final Recommendations: presents a set of recommendations for configuring the user's scanning system to best meet their needs.

Generally, a practitioner and a switch user run through the wizard together. At the conclusion of the session, the team decides which recommendations to implement and then makes those adjustments to the user's scanning system. Scanning Wizard runs as a web application within any browser, and is freely available at scanningwizard.com.

1.2. Research Objectives

The purpose of this study is to evaluate the effectiveness of Scanning Wizard at enhancing text entry rate and to gather user feedback about its usability and utility.

2. Methods

2.1. Study Design

This study used a longitudinal ABA design to compare the performance of switch users with the scanning settings that they use every day (Condition A, baseline settings) to their performance after 4 weeks using the settings recommended by Scanning Wizard (Condition B, revised settings). The protocol was also designed to provide meaningful data from the initial session alone.

2.2. Subjects

The protocol was approved for human subjects, and all participants provided informed consent. Subjects included users who either already use switch scanning or were being evaluated for the use of switch scanning, as well as assistive technology practitioners with experience working with switch users. Practitioners were recruited primarily from disability-related organizations in the New York City and Detroit metropolitan areas. Interested practitioners then assisted with recruiting switch users from their client base. To date, 9 practitioners and 9 switch users have participated. Practitioners include 3 men and 6 women, working in a variety of practice settings.

As shown in Table 2, eight of the switch users regularly use single-switch scanning to access their AAC system, while one was being evaluated for provision of his first switch scanning system. Four subjects activated their switch with head motion; four used hand activation, and one used a cheek twitch. Self-reported satisfaction with their AAC systems averaged 4.2 on a scale of 1 (very dissatisfied) to 5 (very satisfied). All subjects had had the help of a practitioner to establish their scanning setup.

Table 2. Key characteristics of switch user participants and their baseline systems.

ID	Sex	Age	Dx	Scanning System	Letter Layout	Prediction	Scan Time (s)
001	M	14	CP	Dynavox Series 5	Alphabetic	None	2.35
002	M	38	CP	Tobii I15 Communicator 5	QWERTY	11-word	1.00
003	M	45	DMD	Dynavox Vmax+	QWERTY	5-word	0.83
004	M	50	SMA	EZKeys	Freq-based	6-word	0.12
005	F	32	CP	EZKeys	Freq-based	6-word	0.75
006	F	56	CP	iPad, TouchChat	QWERTY	5-word	1.90
007	F	6	CP	Dynavox Compass	Symbols (12)	None	2.00
008	M	53	CP	None	.	.	.
009	F	30	Enc	Tobii I15 WordPower	Freq-based	3-word	1.50

Diagnoses: CP=cerebral palsy, DMD=Duchenne's muscular dystrophy, SMA=spinal muscular atrophy, Enc=encephalopathy

2.3. Baseline Measurement (Condition A1)

In the first session, each subject's baseline performance was measured on the subject's original (pre-intervention) scanning system and configuration. They completed a two-sentence transcription task.

2.4. Scanning Wizard Run-through

Also in the first session, the practitioner and the switch user ran through the Scanning Wizard software together. They then completed a short survey. The questions for switch users asked whether they understood the tasks, and whether using Scanning Wizard took a reasonable amount of time and effort. Practitioners had questions on whether Scanning Wizard was pleasant, understandable, worth the effort, took an acceptable amount of time, and whether they were likely to use it in the future. All questions were 5-point Likert-type, from 1 = strongly disagree to 5 = strongly agree.

2.5. Defining and Implementing Revised Settings

Based on the recommendations provided by Scanning Wizard, the practitioner and switch user decided what changes to make to the switch user's scanning system. Then the practitioner or a researcher actually made the changes prior to the next session.

2.6. Intervention Phase (Condition B)

In four weekly sessions, the switch user completed a two-sentence transcription task. The text used in each test was unique, but all sentences were equivalent in terms of letter frequency and reading level. All subjects used the new setup during daily life for the duration of the Intervention Phase.

2.7. Reversal Phase (Condition A2)

After four weeks of using the revised settings, the baseline settings were restored to each subject's system. They then completed a two-sentence transcription task.

2.8. Post-study Survey Questions

At the end of the study, switch users were asked to complete the following questionnaire, using the same 1-5 Likert scale:

1. Overall, I now prefer the new settings to my original ones.
2. I did not like the new settings at first.
3. I think I typed faster with the new settings.
4. I would like to keep some of the new settings to use permanently.

2.9. Dependent Variables

Text entry rate (TER) was measured for each transcription test as the number of correct characters present at the end of the test, divided by the total time for the test. The total time included any time for fixing incorrect selections. This character/seconds measure was converted to words/minute (wpm) by assuming 5 characters/word. The responses to the survey questions also served as dependent variables.

2.10. Data Analysis

To analyze the text entry rate data on a group basis, paired t-tests (with an alpha of .05) were conducted to examine the main effect of baseline vs. revised settings. The *baseline* (Condition A) was calculated from the average of session A1 and A2 results for each subject, and *revised* (Condition B) was the results from each subject's fourth session with the revised settings (B4).

Text entry rate was also analyzed on a single-subject basis. Data from each individual subject was examined for a clear increase in TER (at least 20%) with revised settings relative to baseline, and a full reversal back to baseline performance when settings were reverted to their original values.

Responses to the questionnaire were analyzed using Nielsen's guidelines [7], to accommodate for subjects' tendency to be polite. Responses to positive questions were considered significant if the mean response was greater than 3.6 (or lower than 2.4 for a negative question), based on a one-sample t-test at a p=0.05 level.

3. Results

3.1. Trajectory of Subjects through the Protocol

Five of nine subjects have completed the full protocol. Four completed only the initial session (baseline measurement and Scanning Wizard run-through): two because Scanning Wizard didn't recommend any changes (004, 005), one who didn't have his own scanning system yet (008), and one who couldn't attend additional sessions (007).

3.2. Baseline Text Entry Rate

Figure 2 shows the baseline text entry rates from the initial session. TER averaged 2.94 wpm with a standard deviation of 4.19, a maximum of 12.94, and minimum of 0.15. 6 of 8 subjects had TER below 3 wpm.

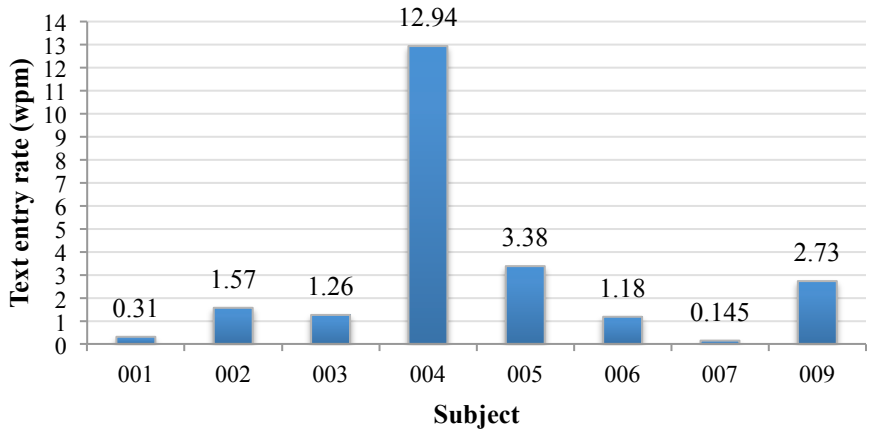

Figure 2. Baseline text entry rates for participants, using their original scanning setup.

3.3. Characteristics of Modified Configurations

Table 3 summarizes the types of changes made to the scanning setups for the five subjects who continued through the full protocol. Letter layouts were modified for all 5 subjects; 3 were originally using a QWERTY layout, 1 an alphabetic layout, and 1 a quasi-frequency layout that was not optimally efficient. The other change made for all 5 subjects was to reduce dead time; typically this involved moving the message window or other infrequently-used item from the top of the scan pattern to a location further down, thus allowing the scan to reach the letters and words sooner.

Table 3. Types of changes made for subjects who received adjustments.

Settings Category	001	002	003	006	009
Language Features			✓		
Letter Layout	✓	✓	✓	✓	✓
Scan Pattern		✓		✓	✓
Less Dead Time	✓	✓	✓	✓	✓
Faster Timing				✓	✓

3.4. Effect of Revised Settings for Text Entry

All five subjects who completed the full protocol had higher TER with the new settings as compared to original. The average improvement was 70.9% and ranged from 28.6%

(002) to 171.8% (003). The 95% confidence interval was [-.36, 142.2], so the group TER improvement is not quite significant at the .05 level (p=.051). Figure 3 shows the individual ABA results. All subjects except 002 met the criterion for at least a 20% change in TER for each change in scanning setup.

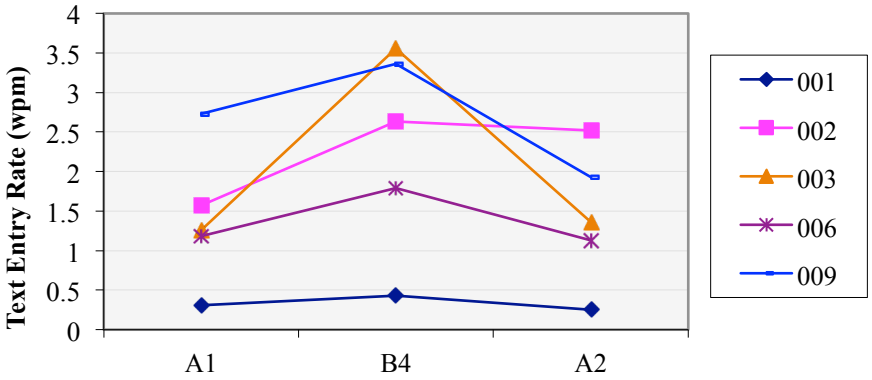

Figure 3. Baseline (A1), intervention (B4), and reversal (A2) TER for each subject.

3.5. Survey Question Responses

For the initial session questionnaire, answered by 9 switch users and 9 practitioners, responses to all 8 questions were significantly greater than the target of 3.6. For the post-study questionnaire, all 3 positive questions had responses significantly above 3.6. Notably, all 5 subjects gave the highest rating of 5 to the question on preferring new settings to old ones, and all subjects kept the new settings to use at the end of the study.

4. Discussion

4.1. Effectiveness of Scanning Wizard

These preliminary results suggest that use of Scanning Wizard can enhance a user's text entry rate, because it helps determine appropriate adjustments to the scanning setup. The suggestions made by Scanning Wizard are fairly straightforward, such as suggesting the use of a frequency-based letter layout, but none of the five subjects were using an appropriate letter layout at baseline. Scanning Wizard's recommendations also address areas that may not be as familiar, so they act as a checklist for making sure that all settings are considered and adjusted appropriately.

For the other four subjects who did not complete the full study and did not change their scanning settings, the use of Scanning Wizard in the initial session still provided some value. For 004 and 005, Scanning Wizard confirmed that their setups were already providing solid performance that was unlikely to improve with settings adjustments. For 008, the Scanning Wizard session allowed a comparison of two different switches as part of his initial exploration of single-switch scanning. The team learned that one of the switches gave much faster and more accurate performance, providing a good foundation for moving forward with that switch. And for 007, the

Scanning Wizard session demonstrated her ability to understand and use row-column scanning, whereas her prior experience had only been with linear scanning.

4.2. Text Entry Rates

It is worth noting that the baseline text entry rates for this group had a very large range from 0.15 to 12.94 wpm. The 12.94 wpm for 004 may well be a world record, and is twice as fast as the maximum we have seen in the literature [8]. This individual has been working to share his techniques with other switch users; many of these follow the same principles as Scanning Wizard's recommendations, but 004 somehow can use an incredibly fast scan time that may not be possible for the vast majority of people.

4.3. Limitations

While the 70% average TER improvement is encouraging, a primary limitation is the need for a larger sample of switch users.

5. Conclusions

These preliminary results suggest that Scanning Wizard can be a useful tool for improving the configuration of scanning systems for people who use switch scanning to communicate. These results are consistent with our previous work demonstrating that the performance of many scanning users can be improved substantially by systematic adjustments to the scanning system itself [3].

Acknowledgements

Thank you to the switch users and practitioners who have participated in this study. This work is supported by the National Institutes of Health.

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