Demonstrating Nomon: A Flexible Interface for Noisy Single-Switch Users

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ABSTRACT

Some individuals with motor impairments communicate using a single switch — such as a button click, air puff, or blink. Our software, Nomon, provides a method for single-switch users to select between items on a screen. Nomon's flexibility stems from its probabilistic selection method, which allows potential options to be arranged arbitrarily rather than requiring they be arranged in a grid. As a result, Nomon can be used for a host of applications — including gaming, drawing, and web browsing. Focusing on accessibility, we updated the Nomon interface in collaboration with a switch user and with experts in Augmentative and Alternative Communication (AAC). We present our updated Nomon interface as an open-source web application.

CCS CONCEPTS

• **Human-centered computing → Accessibility technologies**; **Accessibility systems and tools**; **Keyboards**.

KEYWORDS

Augmentative and alternative communication; accessibility; single-switch scanning systems; text entry;

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1 INTRODUCTION

For people living with severe motor impairments, Augmentative and Alternative Communication (AAC) devices with a single-switch input can provide a means of computer interaction. Users control the activation time of their single switch by, e.g., pressing a button, releasing a puff of air, or blinking. We henceforth call a switch activation a "click." Click times are commonly sent into an AAC interface that facilitates computer navigation or text composition. For instance, in a scanning system, individual interface options or sets of options are highlighted in a fixed sequence. To select an option, the user clicks when their target is highlighted. Row-column scanning (RCS) is a common scanning approach; rows of options are iteratively highlighted until the user clicks. Then columns within the selected row are highlighted until the user clicks again. RCS systems are typically limited to displaying options in a fixed grid and, when used for text composition by motor-impaired users, exhibit slow text entry rates; Koester and Simpson [4] report 0.3–2.9 words per minute (wpm), and Roark et al. [10] report 1.9 wpm.

1.1 Nomon

Our interface, Nomon, addresses the limitations of traditional single-switch input methods through its flexible selection scheme. Nomon was proposed in [2, 3]; for a more detailed description of our latest updates and user studies, see [1]. Nomon has many potential uses such as drawing [2], general operating system control [2], and even gaming [5–9]. The interface places a visual indicator next to each option and uses a probabilistic selection mechanism. This selection mechanism incorporates prior information on options and a model of user-input noise to perform Bayesian updates that adapt its selection criteria to a user's ability. This adaptation helps the user type quickly while avoiding errors. Further, Nomon is not limited to a strict grid layout as Nomon's visual indicators can be placed at arbitrary locations on the screen.

See Figure 1 for an example text-entry interface with Nomon. Each option has a clock indicator to its left. Each clock has a unique phase, and the minute hands of all clocks rotate at a constant, shared speed. A user is instructed to select an option by clicking when the clock adjacent to their target passes noon. The user needs to look only at the adjacent clock to select its corresponding target. After a click, all the clock hands change phase. The new phases are chosen to maximally separate the hour hands on the most likely clocks. The user then repeatedly clicks when the minute hand passes noon until their target is selected. The number of clicks required to select a target can vary; the number depends on the precision of the user and on how probable the target is. In a writing application that makes use of a language model, an experienced user can select a

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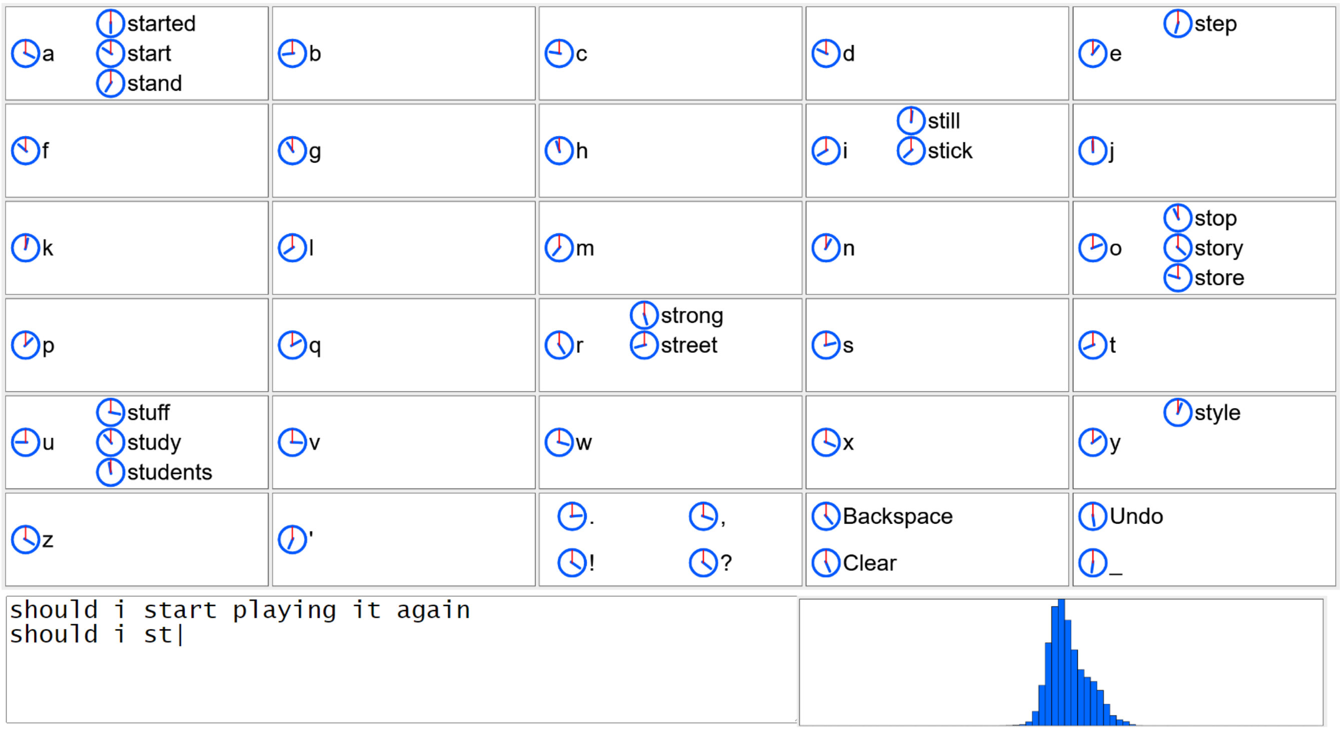

Figure 1: A screenshot of the Nomon Keyboard web application. Users can type by selecting between characters, word predictions, and corrective options. All options have a clock indicator to their left, which allows for selection. A user can select an option by clicking when the clock adjacent to their desired option passes noon. After a click, the clock hands change phase. The user then repeatedly clicks when the minute hand passes noon until their target is selected.

target in approximately two clicks [3]. A demonstration of typing with the Nomon interface can be found in our video submission.

Contributions. In this paper, we (1) detail how we updated the Nomon interface to increase its accessibility and (2) present an educational Nomon web application that provides insight into using single-switch communication methods.

2 UPDATING THE NOMON INTERFACE

2.1 End-User and AAC Consultant Involvement in Design Process

To redesign the Nomon interface, we collaborated with two charities specializing in individuals with severe motor impairments: The Ace Centre[1] and SpecialEffect.[2] Ten staff members from these charities provided us with feedback on the usability and accessibility of our proposed updates. Further, one of the charities arranged for a single-switch user to trial Nomon and provide recommendations. This switch user's feedback played a major role in our design choices, including: color options (e.g. to help prevent seizures or migraines), clock design, font choice, text contrast, the addition of a tutorial and calibration phase, and improved visual/audio selection feedback.

2.2 Accessibility Friendly Design

As suggested by our charity contacts, we considered alternative indicators beyond the original Nomon clocks. Our visualization choice should make it as easy as possible for users to observe when they should click. Figure 2 shows the various alternatives we considered: progress bars, clocks with radar trails, a "pac-man" filling clock, and filling circles. Based on the charities' feedback, we settled on a larger clock design with thicker borders and higher contrast, and a larger, bolder font. López et al. made similar adaptations to the clock indicators to increase usability in their gaming interface based on Nomon [6].

2.3 Tutorial and Calibration Phase

Our charity contacts noted that initializing the parameters governing any AAC interface can often be a cumbersome and error-prone process. Like other AAC interfaces, Nomon has parameters that require initialization. For instance, while Nomon is operating, it learns an error model for the user as they type; however, this model must be initialized prior to use. To provide an initialization that would allow users to quickly and painlessly start using the Nomon interface, we designed a calibration phase that initializes Nomon's error model of a user before they start using Nomon. This calibration phase doubles as an introductory tutorial on how to use the Nomon keyboard to type text.

[1] https://acecentre.org.uk/
[2] https://www.specialeffect.org.uk/

Figure 2: From left to right: (1) a clock used in the original Nomon interface [3], (2) *our final choice for the clock design,* (3) a filling ball clock, (4) a "pac-man" clock, (5) a radar clock, (6) a progress bar. Clock sizes are relative to the clock from the original interface.

3 NOMON WEB APPLICATION

3.1 Open Source and Browser Based

Originally, Nomon was designed as a standalone application to be installed on a user's computer. Due to technical constraints, this distribution method limited Nomon's use to people with Windows computers, or people with the experience needed to download and set up Nomon's Python code base. However, we would like for Nomon to be free and easily accessible to anyone who could benefit from using it. Therefore, we ported the Nomon code to a self-contained web application running in a user's browser via HTML and JavaScript. This web application allows instant use of the Nomon interface on any common browser without the need for software installation. Further, the Nomon interface is open source. We encourage the reader to try it out at https://nomon.app/demo and send us any feedback.

3.2 Better Simulating the Single-switch Experience for Non–switch Users

Motivation. In what follows, we refer to individuals who do not regularly use AAC switches as "non–switch users." Actual single switch users may exhibit slower reaction times, and less accurate click timing, than typical non–switch users. We designed a method of approximating this reduction in speed and accuracy with non–switch-using individuals. This method allows these individuals to experience a more representative simulation of using a single switch to communicate. Our "webcam switch" requires a wide motion of the user's torso to trigger a switch activation, thus lowering accuracy and decreasing reaction time relative to a simple button press.

How does it work? Our webcam switch (Figure 3) uses facial recognition to detect the location of a user's face. It then displays this face location in the form of an orange box that moves with the user. The switch consists of two regions: (1) a blue reset region that activates when the user's face is in a neutral position, and (2) a green trigger region that activates when a user moves their head to the other side. To "click" (i.e., to activate the webcam switch) the user first moves their head so that the orange box intersects the blue reset region, and then moves their head into the green trigger region. The green trigger region triggers a switch activation only if the blue reset region has been activated first.

3.3 Text Entry Competition Demo

We have adapted the Nomon web application into a demo that provides non–switch users a chance to experience what it is like to communicate with Nomon. Especially when combined with our noisy webcam switch, users will get a window into the slower communication rate experienced by many AAC switch users

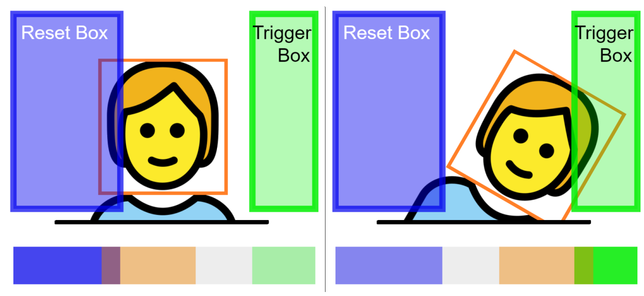

Figure 3: An illustration of our webcam switch, designed to slow down and remove precision from the input of its users. To activate the switch, the user must first move their head to intersect the blue reset box (adjusted to their resting position) and then move their head into the green trigger box (adjusted with an offset from their resting position). The emojis in this figure are adapted from [11].

In this demo, the user will start by going through a short tutorial on how to use Nomon that doubles as a calibration phase to learn the distribution of errors in the user's clicks. The tutorial explains how to select a clock and guides the user through selecting among increasingly large sets of possible clocks. The tutorial also explains the main features of the Nomon interface — including how to change the clock speed and how to correct errors.

Once the user finishes the tutorial, the Nomon keyboard presents the user with a series of phrases to copy as quickly and accurately as they can. After each phrase, the user is shown their entry and error rate on that phrase as well as their average performance thus far. After completing the set of phrases, the user is scored based on their typing speed and accuracy. Speed will be the primary performance metric, but users will be required to maintain an overall character error rate below 5%. This error constraint ensures that users make a reasonable effort to write the specified phrases. Participants' results are published to a live leaderboard on our website as in Figure 4. On this leaderboard, users can compete among each other and see statistics on their past performances.

4 CONCLUSION AND FUTURE WORK

Conclusion. We detailed our work modifying the Nomon interface to increase its accessibility in terms of layout and design, its availability as an open-source web application, and the ease with which users can learn to use Nomon through our new tutorial and calibration phase. We provided an educational demo of the

Search...

Rank	Name	Date | Time	Entry Rate (words/min)	Error Rate (%)	Click Load (clicks/char)
1 🎉	Keith V	Feb 21, 2022 | 01:35:27	2.51	0.00	1.71
2	Tamara B	Feb 21, 2022 | 01:25:54	2.48	2.03	1.63
3	Nick B	Feb 22, 2022 | 10:03:16	1.63	1.20	2.87
4	Emli-Mari N	Feb 22, 2022 | 10:15:36	1.62	0.00	1.94

Figure 4: A screenshot of the leader board that is available on our demo website. Participants are ranked primarily by their entry rate subject to having an error rate below 5%. Entry rate is calculated as the number of correct words typed per minute. Ties are broken by the participant who has the lowest click load (number of clicks per character). Participants can use the search function to find themselves on the leader board.

Nomon interface for the general public to experience typing with an AAC interface. Finally, we present our webcam switch method that allows non–switch users to better simulate the communication challenges of AAC switch users.

Future Work. Activating a single switch can be especially exhausting for motor-impaired individuals. Therefore any single-switch interface should aim to reduce the number of clicks required to make a selection. In Nomon, there is no set number of clicks required to make a selection; rather this number is determined by the precision of the user. While our recent studies [1] suggest that this number averages around 1.4 clicks per character in the keyboard version of Nomon, we are actively exploring ideas to further reduce the click load.

First, we posit that incorporating additional prior information, e.g. information from an eye-gaze tracker, could reduce the amount of information needed from the user's clicks to make a selection. For instance, we expect that a user will be looking at the clock they are trying to select, so we expect these clocks to be more likely a priori.

Concurrently, we are exploring alterations to the Nomon interface that we believe could allow for just one click per letter for predictable words. The current Nomon method requires each individual character to exceed a probability threshold before that character is selected. We believe it could be advantageous to postpone committing to any one character until the end of a word is typed (similar to how auto-correction works on a touchscreen keyboard). However, as users have only a noisy switch as input, it would be challenging to design how users will signal the end of a word, correct errors, and type less predictable words.

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