Evaluating the Efficiency of Two Different Search Strategies for Patient Identification in Computerized Provider Order Entry

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ABSTRACT

This experiment investigates two visual search strategies in order to determine if one strategy helps clinicians identify patients in medical computer systems. There are patient safety issues when trying to find patients in electronic health records such as a clinician unintentionally selecting the wrong patient and ordering a treatment for them. To examine how people may try to better identify patients, we investigated two different search strategies of finding a patient in patient information list. Participants were asked to search for a patient using one method, then the other. We measured accuracy and speed and utilized eye tracking to collect fixation metrics. This data was used to investigate if one of the methods was more efficient. The findings of the current study suggest that neither of methods used in this experiment were more beneficial compared to the other. However, the analysis of participants' fixation duration provides some insight into search strategies when searching in a simulated patient list that could be built on in future work to improve this process of making sure the right patient gets the right care.

Author Keywords

Medical error, eye tracking, visual search, computerized provider order entry, electronic medical records

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Human Factors.

INTRODUCTION

The Institute of Medicine's 1999 seminal report "To Err Is Human" approximated that each year 44,000 to 98,000 deaths are due to medical errors [5]. This has led to efforts focusing on reducing medical errors with the goal of improving patient safety in the healthcare field. In order to achieve this goal, new technologies and systems are being introduced and implemented in healthcare. One example is the implementation of patient care information systems (PCISs), which are technologies that support clinicians in providing care to patients by allowing direct access to patient information, order entry systems, etc., all from a central location [1]. Examples of such systems include electronic medical records (EMRs), which are an electronic version of a patient's health record [4]. Another example is a computerized provider order entry system (CPOE), where care providers can order medications and tests for patients. This is considered to be safer than providers relying on handwritten orders, which can be illegible [1, 3].

The challenge with implementing new technologies to reduce medical errors is that new technologies and systems create the potential for new types of errors [1]. In the case of computer order entry, one error that can occur is a patient identification error resulting from a provider failing to verify a patient's identification [3]. An example of a patient identification error is a provider entering an order for the wrong patient [1]. Ranger and Bothwell [9] emphasize the importance of matching patients with their right care. Furthermore, they point out that mismatching errors, i.e. when a patient is given the wrong treatment, can sometimes occur due to the failure to verify a patient's identity [9]. These types of errors of mismatching patients with their care can lead to unintended outcomes ranging from minor effects to serious consequences such as chronic pain or even death [9].

Ash et al. [1] conducted qualitative studies at hospital sites in three different countries, all of which had implemented patient care information systems. They conducted several hours of observations and several interviews to collect qualitative data on PCIS-related errors. They found that their data contained many instances of patient identification type errors, where an order was entered for the incorrect patient [1]. However, due to these studies being qualitative, they did not attempt to estimate how often the types of errors identified occurred, but rather just noted that they did occur [1].

To further complicate the potential for errors within a CPOE system, there are reports of duplicate patient records, where one or more patients on record at a hospital have the same last name [3, 7]. There are also reports of one or more patients on record at a hospital with the same first and last name and date of birth (DOB) [7]. Occurrences such as these contribute to the potential for error resulting from the misidentification of a patient, which can lead to the types of errors described above (e.g., unintentionally entering an order for the wrong patient) [7].

There are also other contextual factors which complicate health care professionals' interactions with health information technologies, such as how clinicians are rarely working in an isolated environment on a computer [1]. Due to the nature of clinical work, they are often carrying out multiple tasks simultaneously or constantly being interrupted by colleagues, patients, pagers, etc. [1]. Therefore, the very nature of health care professionals' work increases the likelihood of errors.

The introduction of technologies, such as CPOE systems, which are more often than not designed for workers who are able to concentrate on their task, does not necessarily help providers deliver safer care. These technologies need to be designed with the clinician's work environment in mind so as to support the clinician in providing safe care to patients by reducing the potential for PCIS-related medical errors. This requires employing tools and techniques to investigate how these systems can be improved to support health care providers. In studies which investigate the use of systems such as CPOE systems, the use of eye tracking can help support this goal by providing insights into the visual search patterns of users of these systems. While this study does not aim to redesign the system, there may be fundamental changes that can be made to the search strategy and/or visual scanning patterns, to improve the accuracy or efficiency of visual search [6].

BACKGROUND

With the introduction of EMRs and CPOE systems creating the potential for new types of medical errors, such as computer order entry errors, there is a need to investigate what aspects of these systems are problematic. Furthermore, investigation of the use of these systems needs to occur so that the design of EMR systems can be improved to support the delivery of safe care to patients. To our knowledge, limited studies have been conducted using eye tracking to evaluate tasks requiring clinicians to interact with an EMR or CPOE system. However, a study by Moacdieh and Sarter [8] used eye tracking to investigate which aspects of attention underlie the performance costs of searching for a target (i.e. piece of information about a patient) within a cluttered EMR page. They also investigated how stress and clutter in an EMR page affected search for a target by varying stress levels and the amount of clutter on the EMR page.

The purpose of our study is to investigate patient ID errors during a CPOE system task; however, there are other processes in health care where similar types of patient ID errors occur. Henneman et al. [2] conducted a study on the medication administration process of nurses, and found that some nurses misidentified patients and gave medication to the wrong patient. A study by Marquard et al. [6] used eye tracking to investigate similar patient ID errors made by nurses during the medication administration process. They found that nurses who correctly identified an embedded patient ID error observed nonrandom visual scanning patterns as well as more consistent fixation patterns when moving from looking at a patient's chart to ID band or vice versa [6]. Furthermore, they suggested that evidence such as theirs could be used to revise and design training programs for nursing students to better prepare them for real clinical work, for instance by teaching them recommended visual scanning strategies [6].

One of the goals set forth by the Joint Commission to reduce patient identification errors is having providers verify patient identification using at least two patient identifiers: the patient's full name, date of birth (DOB), and medical record number. Although the Joint Commission recommends using two patient identifiers to verify patient identity in computer order entry, there is evidence to suggest that some providers do not verify patient identity [2, 3].

Henneman et al. [3] conducted a study, which used eye tracking to determine how often a patient's identification is verified during computer order entry. For this study, participants were given triage charts of patients and told to select the patient from an alphabetized list in the CPOE system and order tests based on the triage note [3]. This study included two patients with embedded ID errors, where the patient on the triage chart could not be matched exactly to a patient in the list in the CPOE system [3]. One patient had a slightly different spelling of their last name and another had a different DOB [3]. Since the purpose of this study was to investigate whether providers use the Joint Commission's recommendations for verifying patient ID, the experimenters recorded whether each participant verified patient ID before ordering tests on these embedded error patients [3]. They found that some of the providers participating in the experiment did not verify patient ID and therefore did not notice the embedded error, resulting in the provider ordering a test for the wrong patient in the experiment [3]. The experimenters utilized eye-tracking data to determine if providers looked at patient ID information on the screen for the two patients with errors and found that some participants who looked at the identification information did not notice the errors and still ordered tests on the incorrect patient [3]. These findings are important as they emphasize the issue that providers may not always verify patient identification, and even when they do, they may not correctly identify that they have selected the wrong patient.

Correctly verifying patient ID during CPOE is essential to ensuring a patient's safety, i.e. that they receive the correct treatment, as misidentification errors can cause adverse and possibly fatal outcomes for patients. However, Henneman et al. [3] provided evidence that relying on providers to verify patient ID is not sufficient to ensure patient safety as providers sometimes incorrectly ID a patient or do not verify their identity at all. Furthermore, clinicians often work in chaotic, fast-paced, interruption prone environments and the burden of making sure the right patient gets the right care should not solely rest with them. Instead, the process of CPOE should be reexamined to determine the ways in which the design of these types of systems can be improved in order to reduce or prevent the potential for patient errors during CPOE. Furthermore, methods such as the ones used by Marquard et al. [6] should be used to investigate visual scanning patterns to determine if they differ between clinicians who make patient ID errors compared to those who make fewer patient ID errors.

In this study, we asked participants to find patients in a simulated CPOE system list using two different search strategies each utilizing a different visual scanning pattern. The goal of this study was to investigate whether there is a difference in the efficiency and/or accuracy of identifying similarly named patients using two different search strategies. We hypothesize that one of the search strategies may be more beneficial in terms of speed and/or accuracy of searching for a patient and that this may depend on where the patient is located in the list (e.g., top, middle or bottom).

EXPERIMENT

In order to investigate differences in efficiency and accuracy of two different visual search strategies when finding a patient in a simulated computerized provider order entry system, we simulated a list of patients that a clinician might see after searching for a patient's last name in a CPOE system, prior to selecting a specific patient to order treatment or tests for them. We also had participants use two different search strategies to find a patient:

- *Search Strategy 1* - Find the patient by first looking for their name and then looking for their date of birth.
- *Search Strategy 2* - Find the patient by first looking for their date of birth and then looking for their name.

Stimulus

The simulated list of patients was populated with fabricated but realistic data belonging to 36 fictional patients. The information was then put through a random generator six different times, creating six uniquely ordered lists for the same 36 patients. Each row represented a unique patient, with each row containing the following information for each patient: full name, medical record number (MRN), primary care physician (PCP), date of birth (DOB), and sex (see Figure 1).

As demonstrated in Figure 1, all of the patients had the last name "Johnson" and every patient had a first name starting with the letter "J". The reason for this is because a realistic situation that a provider could experience is searching for a patient by typing their last name in the search box. If multiple patients have the same last name, an alphabetized list would show up with all patients with that last name. Although our lists are randomized and not alphabetized, in order to allow multiple trials of searching for a patient, having patients with similar length first names all starting with the same letter may still cause the search for the patient to be difficult as compared to patients with very unique first names.

Patient Name: Johnson, Jamie **DOB: 10/27/1967**

Number	PATIENT NAME	MRN	PCP	DOB	SEX
1.	Johnson, Jason	001541681	Smith, Elizabeth	12/21/1987	M
2.	Johnson, Jason	001387181	Smith, Elizabeth	10/27/1967	M
3.	Johnson, Jason	001563381	Smith, Elizabeth	11/21/1967	M
4.	Johnson, Jeffery	001940281	Smith, Elizabeth	12/21/1987	M
5.	Johnson, Jeremy	001915781	Smith, Elizabeth	12/21/1987	M
6.	Johnson, Justin	001373381	Smith, Elizabeth	10/27/1967	M
7.	Johnson, Jamie	001586781	Smith, Elizabeth	10/21/1987	M
8.	Johnson, Jeffery	001881581	Smith, Elizabeth	12/21/1997	M
9.	Johnson, Justin	001906481	Smith, Elizabeth	10/21/1987	M
10.	Johnson, Jeffery	001062281	Smith, Elizabeth	10/21/1987	M
11.	Johnson, Jamie	001715581	Smith, Elizabeth	12/21/1997	M
12.	Johnson, Jamie	001567581	Smith, Elizabeth	11/21/1967	M
13.	Johnson, Jason	001555081	Smith, Elizabeth	11/27/1987	M
14.	Johnson, Jeremy	001314581	Smith, Elizabeth	11/21/1967	M
15.	Johnson, Johnny	001816381	Smith, Elizabeth	10/21/1967	M
16.	Johnson, Justin	001181881	Smith, Elizabeth	11/27/1987	M
17.	Johnson, Jeffery	001381981	Smith, Elizabeth	10/27/1967	M
18.	Johnson, Jeffery	001129181	Smith, Elizabeth	11/21/1967	M
19.	Johnson, Jason	001393281	Smith, Elizabeth	12/21/1997	M
20.	Johnson, Jeremy	001506481	Smith, Elizabeth	12/21/1997	M
21.	Johnson, Jamie	001745881	Smith, Elizabeth	10/21/1987	M
22.	Johnson, Jamie	001717381	Smith, Elizabeth	12/21/1987	M
23.	Johnson, Jeremy	002530381	Smith, Elizabeth	11/27/1987	M
24.	Johnson, Johnny	002539081	Smith, Elizabeth	10/27/1967	M
25.	Johnson, Johnny	001866681	Smith, Elizabeth	12/21/1987	M
26.	Johnson, Johnny	001932581	Smith, Elizabeth	11/27/1987	M
27.	Johnson, Justin	002630481	Smith, Elizabeth	12/21/1987	M
28.	Johnson, Justin	001970681	Smith, Elizabeth	11/21/1967	M
29.	Johnson, Jeremy	001514381	Smith, Elizabeth	10/27/1967	M
30.	Johnson, Jeremy	001728581	Smith, Elizabeth	12/21/1997	M
31.	Johnson, Jeffery	001728581	Smith, Elizabeth	11/27/1987	M
32.	Johnson, Johnny	001047681	Smith, Elizabeth	11/21/1967	M
33.	Johnson, Jason	002543481	Smith, Elizabeth	10/21/1987	M
34.	Johnson, Justin	001046581	Smith, Elizabeth	12/21/1997	M
35.	Johnson, Johnny	002538281	Smith, Elizabeth	12/21/1997	M
36.	Johnson, Jamie	001705281	Smith, Elizabeth	10/27/1967	M

Figure 1. Example of one of the randomized patient lists.

In order to balance the number of similarities for each search strategy, exactly six sets of six patients had the same first and last name. Also, six sets of six different patients had the exact same date of birth. Similar to the names of patients, the dates of births were created to be similar, always having the same number of digits. Furthermore each date had at least one factor (i.e., month, day or year) in common with the date of birth of the target patient.

The name and date of birth of the target patient that participants were required to find was displayed in the top right hand corner of the stimulus image. This information was displayed to the participants for their reference throughout the entirety of each trial.

Apparatus

The participants' eye movements were tracked using the Gazepoint GP3 eye tracker with a visual angle accuracy of 0.5-1 degree (as reported by the manufacturer). The eye tracker sampled the position of participant's eyes at a rate of 60 Hz. All stimuli were presented on a 22" Dell Professional LED monitor with a screen resolution of 1680 x 1050.

Participants

Twelve participants were recruited for this study (7 male, aged 18 to 31, M = 21.58, SD = 3.68). All participants were Clemson University undergraduate or graduate students. All had normal or corrected to normal vision. One participant's data was excluded from our analysis because they did not follow the instructions for the different search strategies. Therefore, the sample size was $N = 11$.

Experimental Design and Procedure

The experiment was a single factor within-subjects design. The independent variable was varied on two levels and it was the search strategy used by the participants to find the patient in the list. Each participant experienced both search strategies and the order of presentation of the search strategy used was counterbalanced. There were two sessions consisting of six trials each, where within each trial the patient list was randomized to present the patients in a different order. However, the same six randomized lists were used in session one and again in session two of the experiment. But the order of presentation of each uniquely ordered patient list was randomized for each participant and each session, so the participant would not see the lists in the exact same order in session two as they saw in session one.

For each trial of the experiment, participants were required to find a specific patient in the list displayed to them using the specific search strategy described to them prior to beginning the session. Participants were required to find the same patient in every trial; however, the patient was in a different location in the list for each trial to ensure that they would need to search for the patient each time. When the participant felt they had found the correct patient in the list, they were told to look at that patient's name for a couple of seconds and then press the space bar on the keyboard to move to the next trial.

Prior to the experiment, participants were provided an informational letter, after reading this they were required to provide verbal consent to be able to participate. They were then asked to fill out a demographic survey asking for their gender, age, year in school (if applicable), and their area of study. Next, the participants were explained the instructions to complete the task required of them in the experiment, including explaining the appropriate search strategy prior to beginning each session. Additionally, to ensure participants understood the search strategy required of them, prior to the start of each session, participants completed a practice run using the specific search strategy consisting of one trial. Prior to the start of each session, the eye tracker was calibrated to the participant's eyes using Gazepoint's software. Upon the conclusion of the experiment, participants were asked to fill out a debrief survey asking whether they followed the search strategy described in each session and if not, to explain why.

Measures and Dependent Variables

The dependent variable is whether the participant correctly identified the patient in each trial. The measures collected were the speed of the participant finding the patient, the accuracy or number of errors made in selecting the patient and whether the participant looked at the areas of interest in the order corresponding to their search strategy when identifying patients. Furthermore, the eye tracking metrics collected were fixation duration and total number of fixations in areas of interest (AOIs).

Areas of Interest (AOIs)

A total of eight AOIs were created for each list, with the exception of list 1 due to the target patient being on the bottom row of the list. Figure 2 shows there were two AOIs in the top right hand corner for the information provided to participants about the patient they needed to find. AOI 1 designated the patient's name and AOI 2 designated the patient's date of birth.

Three AOIs were created for the column where patient names were presented. AOI 3 designated all the names above the target patient's name. AOI 5 designated all the names below the target patient's name. AOI 4 designated the target patient's name.

Similar to the AOIs for the patients' names, there were three AOIs for the column where patient dates of birth (DOBs) were presented. AOI 6 designated the DOBs above the target patient's DOB. AOI 8 designated the DOBs below the target patient's DOB. AOI 7 designated the target patient's DOB. AOIs for the target name and target DOB (AOI 4 and 7) were expanded to include approximately one line above and below the target line in order to account for errors in accuracy of the eye tracker.

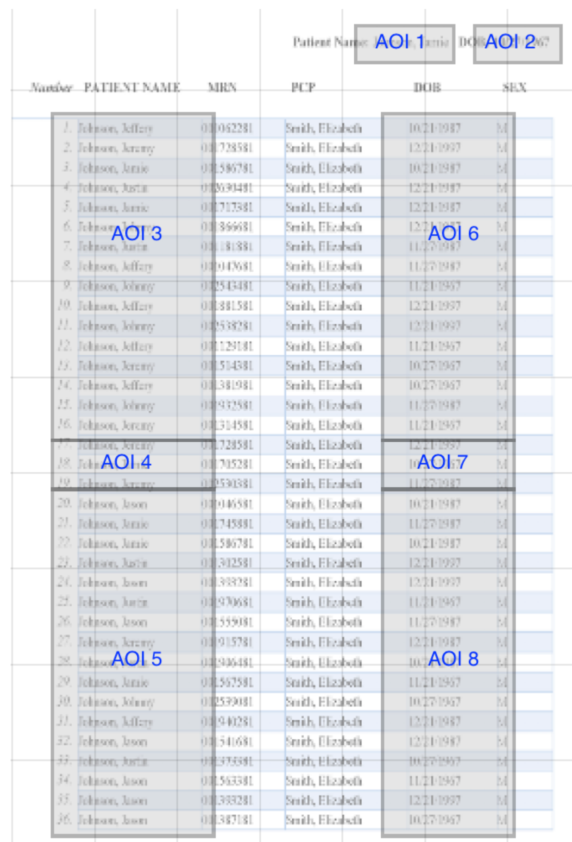

Figure 2. Example of how AOIs were designated for each list.

Data Collection

The accuracy of participants finding the target patient was determined for each trial by looking at data showing all fixations within any of the AOIs defined for a given trial of a participant. Whether or not the participant found the correct patient within a trial was determined by whether or not they had a fixation in either the target name AOI or target DOB AOI as one of their last fixations and this fixation duration needed to be at least 500 ms. Also, in order for it to be considered correct, they could not have any fixations in other non-target name or DOB AOIs after this target AOI fixation. The number of trials where a participant correctly found the patient was recorded separately for each search strategy.

The speed or time to find the target was determined for correct trials by the time stamp at the beginning of the fixation that determined the participant had found the correct patient. For incorrect trials, the time to find the target was determined by the total time the participant took until they moved to the next trial. This data was collected from the output files provided by Gazepoint.

Two fixation duration metrics were calculated for each trial/list for each search strategy. The first metric was the average fixation duration for all fixations within patient name AOIs in the list (i.e., AOI 3, 4, and 5 in Figure 2). The second was the average fixation duration for all fixations within patient DOB AOIs in the list (i.e., AOI 6, 7, and 8 in Figure 2). The duration of fixations within target patient AOIs was included due to the fact that participants may have had fixations within the target before successfully finding the target patient.

Two metrics for the number of fixations in AOIs were calculated for each list for each search strategy. Similar to the fixation duration metrics, the number of fixations within patient name AOIs (i.e. AOI 3, 4, and 5 in Figure 2) and the number of fixations within patient DOB AOIs (i.e., AOI 6, 7, and 8 in Figure 2) were calculated as separate metrics.

RESULTS

Various statistical tests and analyses were performed using SPSS version 23.0. Multiple statistical tests were conducted to determine whether search strategy influenced any of the following measures: accuracy, speed, fixation duration, and number of fixations.

Accuracy

In order to determine whether there was a difference in the accuracy of finding the correct patient for each search strategy, a paired samples t-test was conducted on the number of trials where a participant found the patient for each search strategy. It was found that there was no difference in accuracy between the two search strategies (t_{10} = 1.15, p = .28, n.s., Figure 3). Figure 3 displays the mean accuracy for each search strategy.

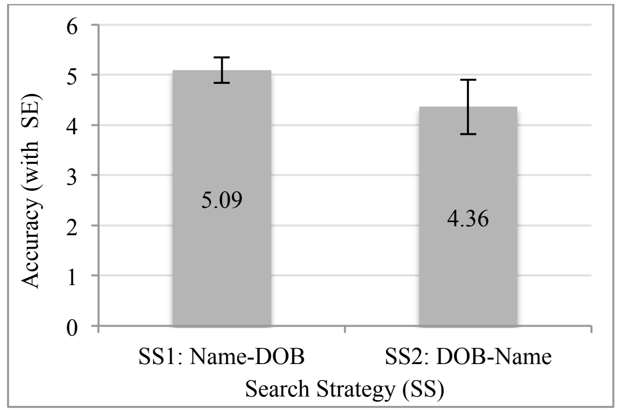

Figure 3. Accuracy of finding the correct patient for each search strategy. Accuracy is the mean number of trials where participants found the correct patient.

Speed

We conducted a 2 (search strategy) x 6 (list) repeated measures analysis of variance (ANOVA) to examine whether there was a difference in the speed (i.e., time to find target patient) between the two search strategies or any of the different lists. Bonferroni corrections were performed to account for multiple paired comparisons. We included list as a factor because the speed of finding a patient may be influenced by where the patient is located in the list. Table 1 shows the line number of the target patient in each list.

List number	Line number of target patient
1	Line 36
2	Line 29
3	Line 32
4	Line 3
5	Line 25
6	Line 18

Table 1. Location of the target patient in each list. Line number corresponds to the line where the target patient was located. There were 36 lines of patients.

One attribute of the data that was taken into consideration for this analysis was that search times for trials where the participant did not find the correct patient were included with those where the participant did find the correct patient. Due to the small sample size, the experimenters felt there was no way to exclude the search times of incorrect trials.

We conducted two tests to assess whether including search times of incorrect trials would significantly affect the data analysis. First we conducted a paired samples t-test to determine if there was a difference between the mean search time of accurate trials only (i.e., participant found the correct patient) and the mean search time of all search times (i.e., including accurate and inaccurate trials). There was no significant difference between the mean search time of accurate trials and the mean search time of accurate and inaccurate trials (t_{10} = 0.776, p = .46, n.s.).

We also took the mean and standard deviation of the search times for every search strategy and list number combination (e.g., SS1_list1, SS2_list1, etc.). We then looked at each search time for inaccurate trials and determined if it fell within three standard deviations of the mean for the respective search strategy and list number. We found that all search times for inaccurate trials fell within three standard deviations of the respective mean. Therefore, we decided to proceed with the analysis.

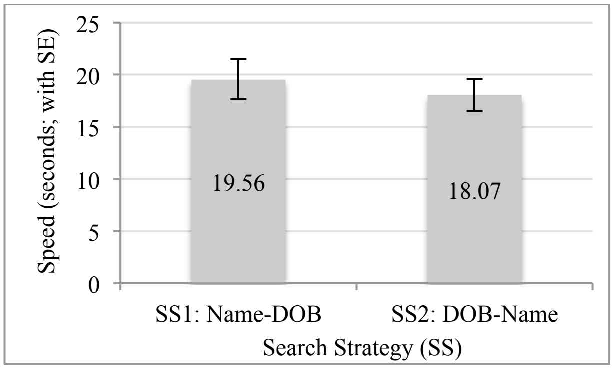

Figure 4. Mean time to find the patient for each search strategy.

The analysis showed that there was no significant effect of list on search time ($F_{5,50} = 2.77$, $p = .07$, n.s.). There was no significant effect of search strategy on search time ($F_{1,10} = 0.302$, $p = .6$, n.s.). Finally, there was no interaction effect of list and search strategy ($F_{5,50} = 1.49$, $p = .21$, n.s.). Figure 4 shows a bar graph of the mean time to find the patient in each search strategy.

Fixation Duration

We conducted a 2 (search strategy) x 6 (list) x 2 (AOI type: Name, DOB) to determine whether the search strategy used, location of the patient in the list or the type of AOI had an effect on fixation duration (i.e. length of fixations). Bonferroni corrections were performed to account for multiple paired comparisons.

There was a significant effect of list on fixation duration ($F_{5,50} = 6.49$, $p < .001$). Post-hoc tests showed fixation duration for list 1, 3, and 6 (M = 1.01, 1.07, and 1.12; SD = .09, .13, and .13, respectively) were significantly longer than for list 4 ($M = .65$, $SD = .11$). There was no effect of search strategy on fixation duration ($F_{1,10} = 3.65$, $p = .09$).

There was also a significant interaction of search strategy and AOI type ($F_{1,10} = 29.7$, $p < .001$). Post-hoc tests showed fixation durations in name AOIs were significantly longer than DOB AOIs ($p < .001$) using search strategy 1 (SS1 – searching by name then DOB). Conversely, fixation durations in DOB AOIs were significantly longer than name AOIs ($p < .001$) using search strategy 2 (SS2 – searching by DOB then name). Figure 5 shows the mean fixation duration for each AOI type and search strategy.

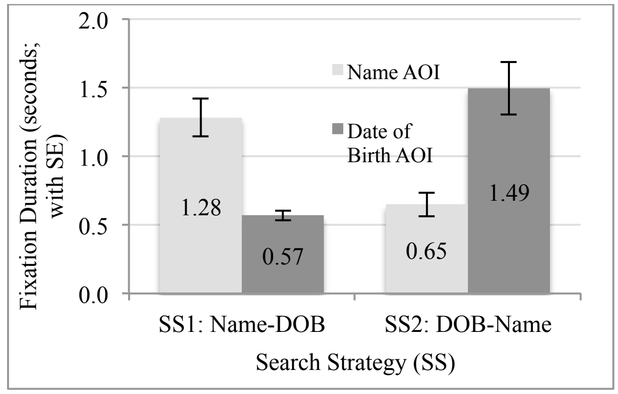

Figure 5. Comparison of the mean fixation duration in patient name AOIs (light gray) and patient DOB AOIs (dark gray) for each search strategy. The numbers in each show the mean fixation duration of the respective AOI and search strategy.

There was also a significant three way interaction between list, search strategy, and AOI type ($F_{5,50} = 2.91$, $p < .05$). Post-hoc tests revealed that when searching lists 1, 2, 3, and 5, mean fixation durations in patient name AOIs were significantly longer than in DOB AOIs when using SS1 (all $p < .01$; see Figures 6, 7, 8, and 9, respectively). For these same lists, mean fixation durations in patient DOB AOIs were longer than in name AOIs when using SS2 (all $p < .05$; see Figures 6, 7, 8, and 9, respectively).

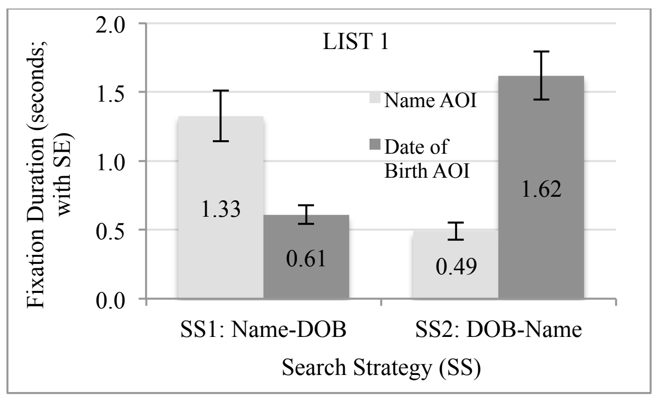

Figure 6. Mean fixation duration for each AOI type and search strategy in LIST 1.

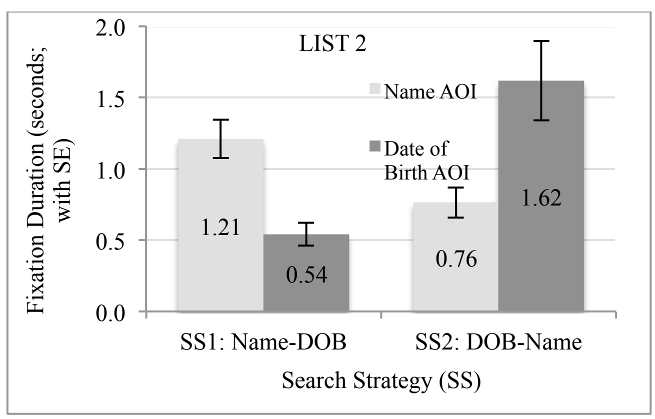

Figure 7. Mean fixation duration for each AOI type and search strategy in LIST 2.

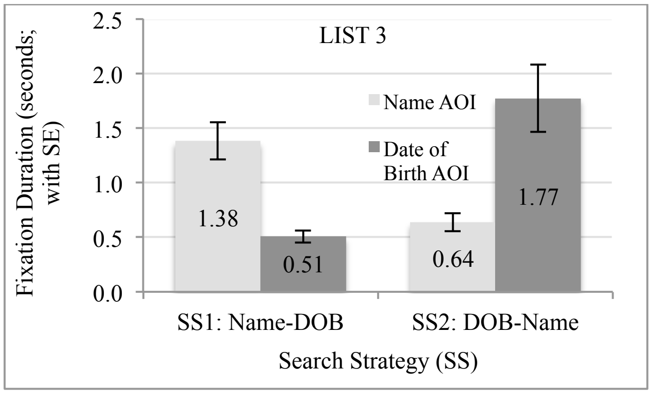

Figure 8. Mean fixation duration for each AOI type and search strategy in LIST 3.

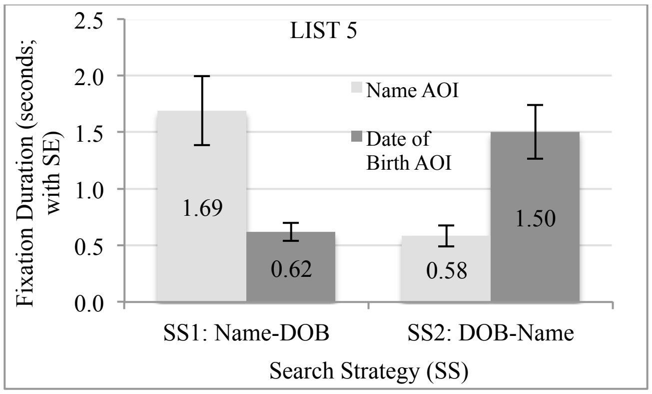

Figure 9. Mean fixation duration for each AOI type and search strategy in LIST 5.

For list 6, there was a significant difference in mean fixation duration only when using SS1 where mean fixation duration was longer in name AOIs compared to DOB AOIs ($p < .01$; see Figure 10). No significant differences in mean fixation duration were found for list 4. Figures 6–10 show the comparison of mean fixation duration in each AOI type for each search strategy for all lists except list 4.

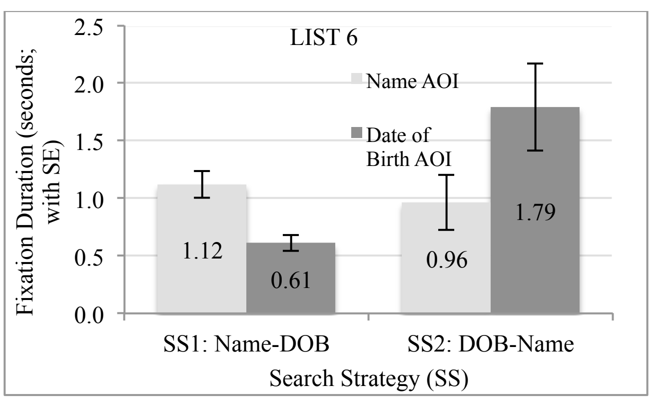

Figure 10. Mean fixation duration for each AOI type and search strategy in LIST 6.

Number of Fixations

We conducted a 2 (search strategy) x 6 (list) x 2 (AOI type: Name, DOB) to determine whether the search strategy used, location of the patient in the list or the type of AOI had an effect on the number of fixations in specific AOIs. Bonferroni corrections were performed to account for multiple paired comparisons.

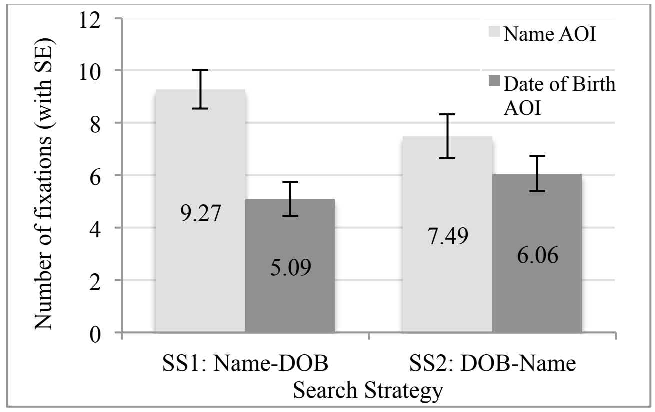

Figure 11. Comparison of the mean number of fixations in patient name AOIs (light gray) and patient DOB AOIs (dark gray) for each search strategy. The numbers in each show the means of the respective AOI and search strategy.

There was no significant effect of list on number of fixations ($F_{5,50} = 2.03$, $p = .15$, n.s). There was no effect of search strategy on number of fixations ($F_{1,10} = 0.163$, $p = .7$, n.s.). However, there was a significant interaction between search strategy and AOI type ($F_{1,10} = 7.88$, $p < .05$). Post-hoc tests showed a significant difference only for SS1 where there were significantly more fixations in name AOIs compared to DOB AOIs when using SS1 ($p < .001$, see Figure 11). There was no three way interaction between list, search strategy and AOI type on number of fixations ($F_{5,50} = 0.932$, $p = .47$, n.s.).

DISCUSSION

The current study investigated whether two different search strategies utilizing different visual search patterns had an effect on the accuracy or speed of finding a patient in a computerized provider order entry list with similarly named patients. The first search strategy, SS1, had participants look for a patient in a CPOE list by looking for their name first and then the patient's date of birth. The second strategy, SS2, had participants look for a patient in the list by looking for their date of birth first and then their name.

Accuracy

Our main hypothesis was that one search strategy would result in a more accurate search however the results of our analyses suggested that was not the case. Accuracy of finding the correct patient in a list is most important in medicine as this directly affects a patient's safety. If the incorrect patient is selected in a CPOE list and a treatment is ordered for them, this can potentially harm two patients; one patient would receive an unintended treatment while the other would experience a delay in their treatment.

Our findings provide evidence to suggest that neither search strategy, i.e. looking for the patient's name first then DOB or vice versa, improves accuracy. Therefore, if a clinician typically searches for a patient by looking for their name first and then verifying their DOB, changing the way they search by having them look for the DOB first and then the patient's name may not necessarily decrease the likelihood that they choose the incorrect patient and order a treatment for the wrong patient.

Although search strategy did not have an effect on the accuracy of finding a patient, there was an interesting finding from looking at the fixation maps showing scanpaths. Participants who found the correct patient in fewer lists (i.e. were more inaccurate in finding the patient) *seemed* to have more random scanpaths than participants who found the correct patient in more or all six lists. Figure 12 shows the scanpath of a participant who did not identify the correct patient for one of the lists when using SS2. This participant also did not find the correct patient in all six lists when using SS2, having an accuracy of 0 out of 6. Figure 13 shows the scanpath of a participant who did correctly identify the target patient for a list using SS2 and this participant found the correct patient in all six lists using SS2, having an accuracy of 6 out of 6.

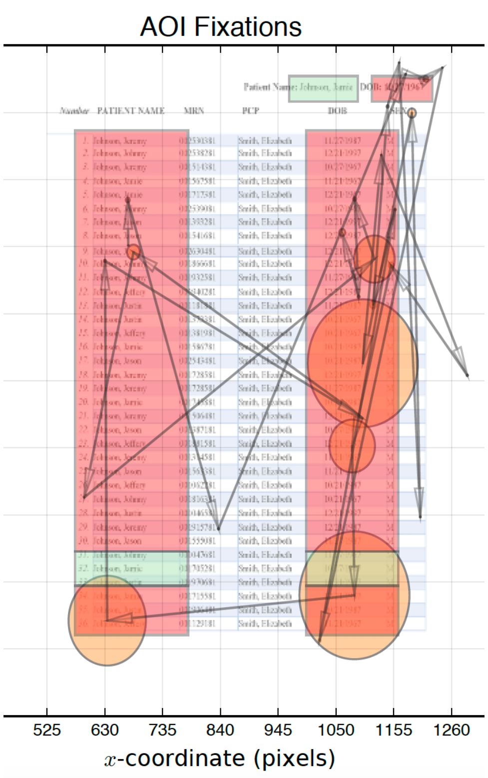

Figure 12. Scanpath with fixations of a participant who did not find the correct patient.

The participant who was inaccurate seemed to have a more variable scanpath compared to that of the participant who was more accurate. The more accurate participant seemed to have a more orderly and consistent scanpath of looking back and forth at DOB and then name. While we did not conduct statistical analyses on this data, this could be a suggestion for future work to investigate whether users who are more accurate have different scanpaths than those who are less accurate as Marquard et al. [6] did.

Figure 13. Scanpath with fixations of a participant who found the correct patient.

Speed

Speed of finding the correct patient in a list can be essential for a clinician, as they have limited time due to the many activities required in caring for many patients. Therefore, another hypothesis of the current study was that one search strategy would result in a faster or more efficient search in finding a patient in a list of similarly named patients. Additionally we hypothesized that the effect of search strategy on speed of the search may be moderated by where the patient was located in the list. However, our findings provided evidence to suggest that speed or time it takes to find a patient does not depend on where a patient is located in a list or the search strategy used to find the patient.

Fixation Duration

One interesting finding of our analyses was that where the patient was located in a list affected average fixation duration. Fixation duration was shorter with list 4 compared to lists 1, 3, and 6 having longer fixation durations. This may possibly be attributed to where the target patient was located in the list. The patient was located close to the top of the list in list 4 and very close to the bottom of the list in lists 1 and 3, while the patient was in the middle of the list for list 6.

It may be the case that when a target patient is at the bottom of a list, fixation durations tend to be longer compared to when patients are located at the top of the list such as in list 4. However, more extensive investigation may be needed to provide sufficient evidence for this finding. The fact that list 6 had longer fixation durations and the patient was located in the middle of the list may be due to the fact that most lists had the patient located near the bottom (in 4 out of 6 lists the patient was located on line 25 or below). Participants may have expected to find the patient closer to the bottom of the list, possibly causing longer fixations.

The findings also suggest that search strategy had an effect on fixation duration when looking at names compared to dates of birth and this was influenced by where the patient was located in the list. The results showed that when using SS1, the fixation duration was longer when looking at patient names. The reverse of this was shown when using SS2, that fixation duration was longer when looking at patient DOBs. This effect might be expected as the item that a user is looking for first may naturally result in them fixating longer on this item (e.g., names having longer fixations when looking for the name first). However, this effect was significant for only lists 1, 2, 3, and 5. This may be due to the fact that all of these lists had the target located in the bottom part of the list, where as in lists 4 and 6, the target was located closer to the top.

Number of Fixations

Another finding we found surprising was where the patient was located in the list did not significantly affect the number of fixations until the patient was found. This was surprising as one might intuitively think that if a patient is further down in the list, it would take more fixations before finding the patient. However, this may be due to the lack of variation in where the patient fell in the list, as most of the lists had the patient located closer to the bottom.

Our findings did show that there was a significant difference in the number of fixations when looking at names compared to DOBs, but only for SS1. The results showed that when using SS1, participants had more fixations on the patient names compared to the DOBs. While this again might be expected as in SS1, the participants were first looking for the patient's name so there would likely be more fixations, the fact that there was no difference for SS2 was interesting. This might possibly be attributed to looking at names first being more intuitive as some participants commented during the experiment that looking at names first felt more natural and intuitive.

Limitations

The current study had many limitations that should be taken into consideration in future work on this topic. First, we did not have access or the resources to recruit clinical persons and therefore only university students took part in this research. This may decrease the external validity, as the findings may be different if we were to use clinical persons, such as doctors or nurses. Furthermore, this study was conducted with a small sample size, which may affect the validity and generalizability of the results.

Additionally, some of the data included in the analyses had the potential to skew the results. This was due to not being able to have participants click on the name of the patient they selected, they had to fixate on the name of the patient, which causes there to be longer and more variable fixation durations when participants selected the patient they thought was the target. It was difficult to exclude this data from the fixation duration metric as sometimes participants had multiple fixations on the target name and we were not sure which fixation was the participant's selection. Due to this difficulty of not being able to click on the patient's name, the search times may not be completely accurate as we sometimes had to guess which fixation was the participant selecting a patient. Future work should develop a simulation that allows participant's to click on their selection to maximize validity of the data used to conduct statistical analyses.

Another limitation of this work was due to the limited time we had to design and conduct an experiment, we were only able to look at changing one variable, which was search strategy. Contrary to our hypothesis, we found that search strategy did not affect search speed or accuracy. However, future work could investigate whether manipulating a different variable when searching for a patient would improve the efficiency of searching for a patient in CPOE lists. Alternatively, future work could conduct a qualitative study to investigate how clinicians currently search in these systems for a patient, and then suggest modifications to search strategies that could then be tested in future studies.

Other limitations included having the participant search for the same patient in every trial in both conditions as well as the lack of variability in where targets were located in the list. Future work should consider varying the patient that participants look for in different trials, as there may be a learning effect when looking for the same patient each time that could have affected metrics such as search time or fixation duration. Future work should also consider the location of the patient in multiple lists and ensure the patient is evenly dispersed between the top, middle and bottom across the numerous lists.

CONCLUSION

It is crucial for clinicians to be able to find the correct patient that they need to prescribe a treatment for when using electronic systems such as CPOEs because this directly affects patient safety. Therefore, the process of finding patients in a list of similarly named patients needs to be examined so that possible solutions can be investigated to improve the accuracy of this process and reduce the likelihood that the wrong patient gets prescribed the wrong treatment. While this study investigated whether one of two different search strategies could help improve the accuracy of finding a patient, we failed to provide evidence to suggest this. However, future work should be done on this topic and should consider some of the points mentioned above that may have been a limitation in the findings of our study. Some of these include considering external validity in using clinicians, better data collection methods, and more carefully designed stimuli.

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