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## ASSESSING PATIENT AND DOCTOR EYE GAZE PATTERNS BETWEEN TWO STYLES OF DOCTOR EHR USE IN PRIMARY CARE ENCOUNTERS

Onur Asan, Enid N. H. Montague and Jie Xu

The purpose of this study is to understand the potential relationship between the ways primary care doctors interact with electronic health records (EHRs) and the eye gaze patterns of doctors and patients during primary care visits. Forty primary care encounters where doctors used two different EHR interaction styles were analyzed. This study used a lag analysis method to analyze the eye-gaze patterns between doctor and patient for each style. Differences and similarities in eye gaze behavior patterns were found between the two styles. The results of this study may inform guidelines for EHR design and implementation and inform EHR interaction training.

### INTRODUCTION

Doctor-patient communication is a fundamental aspect of the health care system. Doctor-patient communication in primary care settings influences patient outcomes of medical visits, such as satisfaction and health status (Ong et al., 1995). Understanding the dynamics of this communication is a necessary part of redesigning the work system of health providers (Montague et al., 2011). Doctor-patient communication includes both nonverbal and verbal components. The verbal component refers primarily to communicating information using sound, words, speech, and language (Silverman & Kinnersley, 2010). On the other hand, nonverbal communication (including gaze, eye contact, etc.) helps to establish the doctor-patient relationship, provides cues to underlying concerns and emotions, and helps verbal comments to be well understood (Hall et al., 1996). In nonverbal communication, gaze is an important aspect of establishing common ground, which is a mutual belief that both sides understand each other (Clark & Brennan, 1991). Gaze and other nonverbal cues also help exchange emotional content (Bensing, 1991). In addition, when the messages from nonverbal and verbal communication are contradictory, the nonverbal message tends to outweigh the verbal message (Silverman & Kinnersley, 2010). Eye gaze patterns are an essential part of doctor-patient nonverbal interaction. Doctors might use gazing to show

affiliation towards the patient, but they also might show control of the communication encounter through nonreciprocal gazing (Kiesler & Auerbach, 2003). Studies have analyzed the duration of doctor gaze at patient, patient gaze at doctor, and mutual gaze to understand the effect of each on patient outcomes (Beck et al., 2002). Gaze has also been used as a variable to analyze clinician-computer interaction in previous studies (Makoul et al., 2001). Gaze at computer is an indicator of data gathering when it is done solely by the doctor or of data sharing when it is done collaboratively with patients (Margalit et al., 2006).

Technologies or other characteristics of work system designs may affect the communication process. Multiple studies have explored the effect of health information technology on interpersonal communication in health care (Shachak & Reis, 2009). For instance, one study analyzed the effect of an EHR system on clinician-patient interaction and found computer use had hindered communication (Margalit et al., 2006). EHRs are often described as influencing information exchange between doctor and patient in a positive way; however, they might also have negative impacts on patient-centered care (Shachak & Reis, 2009). Furthermore, computer use also changes the way doctors communicate with patients by encouraging reduced eye contact and closed communication body postures (Noordman et al., 2010). Previous studies have used holistic or qualitative measures to evaluate the effects of technologies on interpersonal communication in

primary care, which may not account for the complexity of communication patterns. As discussed above, many studies used duration of gaze in their analysis (Mast, 2007), however it might be more effective to explore patterns and optimal sequences of gaze behaviors. Lag sequential analysis methods might be used to show the influence of technology on interpersonal interactions and important communication outcomes, such as eye contact (Montague et al., 2011). This study used two clinician groups that have two distinct interactive styles: computer-oriented and patient-oriented. The purpose of this study is to describe patient and clinician interactions with EHRs in primary care environments using eye gaze patterns.

## METHODS

### Participants

Four doctors and forty patients participated in the study. The age of patients ranged from 18 to 65. The clinicians were classified into one of two EHR interactive styles for the analysis: computer-oriented or patient-oriented. These interactive styles were classified based on percentage of typing and gazing at the computer in the visits and qualitative assessment of behavior: doctors who used a computer-oriented style spent more time typing (mean > 15% of visit length) and gazing at the computer (mean = 45% of visit length) during the visit. The patient-oriented group spent minimal typing time (mean = < 3% of visit length) and focused almost exclusively on the patient.

### Video coding

Coding is the process of converting complex data into measurable units (Miles & Huberman, 1994). A coding scheme was created for the variables of interest, which measure eye gaze behavior: doctor gaze patient (DGP), doctor gaze EHR (DGE), doctor gaze chart (DGC), doctor gaze other artifacts (DGO), doctor gaze unknown (DGU), patient gaze doctor (PGD), patient gaze EHR (PGE), patient gaze chart (PGC), patient gaze other artifacts (PGO), and patient gaze unknown (PGU). The behaviors by the same subject (doctor or patient) are mutually exclusive. In the coding

scheme, "chart" referred to documents with information about the patient or notes written by the clinician during the encounter. "Other artifacts" are the objects in the room, including chairs, exam table, sink, medical tools, magazines, etc. "Unknown" included two situations: (a) coder can see subject's eyes but is not able to specify object (this also includes the situation when the subject is moving and looking somewhere while thinking), and (b) subject is gazing at part of the patient's body, such as foot, back, etc.

Each video was coded temporally for the entire visit length. The doctor's and patient's behaviors were coded separately. Start and stop times for each code were annotated using software (Noldus Observer XT) designed for video coding, evaluation, and analysis. The software calculated the start and stop times, duration, and simultaneous occurrence of codes (i.e. codes that occurred at the same time).

### Data analysis

To identify the gaze behavior patterns in the encounters, a systematic approach was used (Montague et al., 2011; Xu, Asan, & Montague, 2011). This approach takes both static and dynamic aspects of interaction into consideration. In the static behavior analysis, the gaze behaviors were treated as a state and the duration of each behavior was calculated. In addition to the behaviors in the coding scheme, mutual gazing (the co-occurrence of DGP and PGD) is also addressed.

Lag sequential analysis (Bakeman & Gottman, 1997) was used to identify dynamic behavior patterns of the doctor and the patient. In this phase of analysis, the coded behaviors were considered as discrete events that happened at their start time with durations ignored. After transforming the coded data in this way, contingency tables were generated by counting the frequency of behavior pairs. For example, if DGP (doctor gaze at patient) is considered an initial behavior, then the frequency of PGD (patient gaze at doctor) as a response behavior (which happened right after DGP) could be counted. Then the association of the two behaviors was examined by fitting a general log-linear model to the contingency tables. For instance, one could test if the patient

tends to gaze back at the doctor once gazed at by the doctor by examining the strength of the association of the behavior pair DGP – PGD. Yule’s Q (Bakeman et al., 1996) was used to compare the associations of behavior pairs between the patient-oriented and computer-oriented groups. Yule’s Q value ranged from -1 to 1, with negative values indicating negative association of the two behaviors (i.e. the response behavior is not likely to happen given the initial behavior), zero indicating weak association (i.e. the occurrence of the two behaviors is at random), and positive values indicating positive association (i.e. the response behavior is likely to happen given the initial behavior).

## RESULTS

### Static behavior analysis

The computer-oriented group had significantly longer encounters than the patient-oriented group on average ( $t=2.15^*$ ,  $p<0.05$ ). Since the visit length varied between two groups, the rest of the comparisons for behaviors were measured based on % of visit instead of raw durations. The computer-oriented group spent more time gazing at the EHR ( $t=6.29^*$ ,  $p<0.01$ ) and less time gazing at the patient ( $t=2.62^*$ ,  $p<0.05$ ) and chart ( $t=2.94^*$ ,  $p<0.05$ ) than the patient-oriented group. Although the patients spent similar percentage of time in gazing at the EHR in both groups ( $t=0.073$ ), the patients in patient-oriented visits gazed at the doctor more ( $t=2.26^*$ ,  $p<0.05$ ). Longer duration of mutual gazing is observed in the patient-oriented visits than the computer-oriented visits ( $t=4.12^*$ ,  $p<0.01$ ).

### Dynamic behavior analysis

Four contingency tables were generated from the data. Two of them were generated using doctors’ behaviors as the initial behavior and patients’ behaviors as the response behavior (see table 2 for patient-oriented group and table 4 for computer-oriented group); the other two were generated using patients’ behaviors as the initial behavior and doctors’ behaviors as the response behavior (see table 3 for patient-oriented group and table 5 for computer-oriented group).

The likelihood-ratio chi-square tests indicate that the cell counts in all four tables were not distributed by chance (see table 1), that the initial behaviors and response behaviors were dependent. The analysis then proceeded to examine the significant tests for specific cells in the tables. If the adjusted residual in a cell is higher than 2.58, then the association of the initial behavior and response behavior in that cell is significant; in other words, these two behaviors are dependent (Montague et al., 2011).

**TABLE 1:** Likelihood-ratio chi-square result of the contingency tables

	Patient-Oriented		Computer-oriented	
	Doctor-Patient	Patient-Doctor	Doctor-Patient	Patient-Doctor
G <sup>2</sup>	332.43	76.36	633.65	146.75

Note. Highlighted cells showed statistical significance,  $\alpha<0.01$ .

In the visits of the patient-oriented group, the patients responded to the doctors by gazing back at the doctors when the doctors gazed at them, and they also gazed where the doctors gazed when the doctors looked at something other than the patient. As shown in table 2, the associations of four behavior pairs are significant: DGP-PGD, DGE-PGE, DGC-PGC, and DGO-PGO. However, the doctors did not engage in reciprocal gazing as the patients did, and the doctors did not follow the patients’ gaze orientation towards the EHR (see table 3). The significant associated pairs of doctors’ behaviors in response to patients’ behaviors are PGC-DGC, PGO-DGO, and PGU-DGU.

**TABLE 2:** Observed frequencies and conditional probabilities of patients’ behaviors in response to doctors’ behaviors in patient-oriented group

Initial behavior	Response behavior				
	PGD	PGE	PGC	PGO	PGU
DGP	252 (50%)	6 (1%)	36 (7%)	16 (3%)	196 (39%)
DGE	73 (31%)	65 (27%)	13 (6%)	7 (3%)	78 (33%)
DGC	62 (27%)	10 (4%)	77 (34%)	8 (4%)	71 (31%)
DGO	26 (34%)	2 (3%)	6 (8%)	20 (26%)	22 (29%)
DGU	62 (50%)	0 (0%)	0 (0%)	6 (5%)	55 (45%)

Note. Highlighted cells showed statistical significance,  $\alpha<0.01$ .

**TABLE 3:** Observed frequencies and conditional probabilities of doctors' behaviors in response to patients' behaviors in patient-oriented group

Initial behavior	Response behavior				
	DGP	DGE	DGC	DGO	DGU
PGD	269 (46%)	103 (18%)	109 (19%)	26 (4%)	79 (13%)
PGE	38 (59%)	12 (19%)	11 (17%)	2 (3%)	1 (16%)
PGC	53 (43%)	19 (15%)	<b>38</b> <b>(31%)</b>	10 (8%)	3 (2%)
PGO	17 (36%)	6 (13%)	5 (11%)	<b>9</b> <b>(19%)</b>	10 (21%)
PGU	132 (39%)	53 (16%)	55 (16%)	20 (6%)	<b>75</b> <b>(22%)</b>

Note. Highlighted cells showed statistical significance,  $\alpha < 0.01$ .

Similar to the patient-oriented group, the patients in the computer-oriented group did reciprocal gazing and followed the doctors' gaze orientation (see table 4). However, the doctors responded to the patients with a different pattern. In the patient-oriented group, the doctors did not respond to PGD and PGE with any significant pattern. In the computer-oriented group, however, when the patients gazed at the doctors, the doctors tended to gaze at the EHR; when the patients gazed at the EHR, the doctors tended to gaze at the patients (see table 5).

**TABLE 4:** Observed frequencies and conditional probabilities of patients' behaviors in response to doctors' behaviors in computer-oriented group

Initial behavior	Response behavior				
	PGD	PGE	PGC	PGO	PGU
DGP	<b>426</b> <b>(66%)</b>	20 (3%)	10 (2%)	12 (2%)	152 (27%)
DGE	231 (26%)	<b>257</b> <b>(30%)</b>	24 (3%)	23 (3%)	<b>312</b> <b>(36%)</b>
DGC	28 (24%)	2 (2%)	<b>61</b> <b>(52%)</b>	1 (1%)	25 (21%)
DGO	14 (20%)	1 (1%)	7 (10%)	<b>28</b> <b>(39%)</b>	21 (30%)
DGU	54 (47%)	2 (2%)	10 (9%)	4 (4%)	44 (39%)

Note. Highlighted cells showed statistical significance,  $\alpha < 0.01$ .

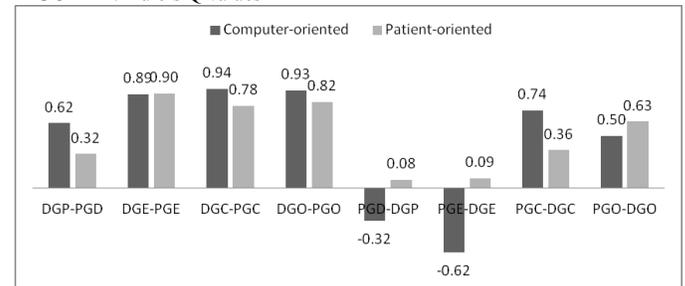
**TABLE 5:** Observed frequencies and conditional probabilities of doctors' behaviors in response to patients' behaviors in computer-oriented group

Initial behavior	Response behavior				
	DGP	DGE	DGC	DGO	DGU
PGD	364 (36%)	<b>417</b> <b>(45%)</b>	53 (6%)	46 (5%)	79 (8%)
PGE	<b>198</b> <b>(76%)</b>	35 (16%)	7 (3%)	10 (4%)	6 (2%)
PGC	40 (40%)	24 (24%)	<b>23</b> <b>(24%)</b>	4 (4%)	9 (9%)
PGO	31 (52%)	16 (27%)	1 (2%)	6 (1%)	6 (1%)
PGU	265 (46%)	225 (40%)	20 (3%)	12 (2%)	50 (9%)

Note. Highlighted cells showed statistical significance,  $\alpha < 0.01$ .

The results of Yule's Q values suggest some interesting patterns in terms of associations of behavior pairs in the two groups (see figure 1). The pairs with doctors' behavior as initial behavior and patients' behavior as response behavior did not show much differences between the two groups. However, the doctors responded differently to the patients' behavior in the two groups. In the patient-oriented group, the associations of PGD – DGP and PGE – DGE are weak; while in the computer-oriented group, these associations are negative.

**FIGURE 1:** Yule's Q values



## DISCUSSION

This study described the doctor-patient eye gaze patterns in computerized primary care settings and indicated differences in eye gaze patterns between the two doctor groups, which have two distinct interactive styles: a computer-oriented style and a patient-oriented style. In other words, this study provided insight into how doctors' interactive styles inform gaze patterns in the encounters. The results indicated considerable differences between the two styles. In general, the results supported

Montague's (2011) findings, which had analyzed doctor-patient eye gaze patterns in non-computerized settings. The patient followed where the doctor gazed and this occurred relatively soon after the doctor's gaze behavior. This implies that the doctor's gaze is related to the patient's gaze during the medical encounter and may influence the patient's gaze. However, various interactive styles of computer use have created differences in eye gaze patterns and also duration of eye gaze.

This study used a systematic approach to quantitatively explore doctor-patient eye gaze patterns in primary care encounters with EHRs. A lag sequential analysis method was used to compare two EHR interaction styles of doctors. Differences and similarities were found in the analysis, and their interpretations are discussed. Especially, doctor gaze at the EHR was followed with different significant patient eye gaze patterns sequences based on the doctor's interactive style.

This study has implications for new health information technology design and current HIT evaluation. Increased computer use might create different patient eye gaze patterns. A previous study found that increased computer use could decrease patient-directed gaze and mutual gazing, and lower ratings in patient-centered communication (Margalit et al., 2006). New EHR systems should be designed to improve patient-doctor mutual gaze as well as patient gaze at EHR (when this supports information sharing) while doctor using the computer. The lag analysis method can be used to develop and assess technological interventions for settings in which interpersonal communication is important (Montague et al., 2011). Future studies should examine the associations between the styles and any type of outcome in terms of satisfaction, reduced visits, and care metrics with a larger sample size.

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