Design of a Role-Playing Game to Study the Trajectories of Health Care Workers in an Operating Room

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Abstract
Drawing on an ethnographic study of hospital work in an operating room, we present the design and implementation of a web-based role-playing application of a master schedule. We show how we simulate the coordination mechanisms and trajectories of hospital personnel as they move patients in and out of OR. Experiments are proposed to show how active and passive notification systems (interruptions) are expected to affect trajectory management and performance over time.

Keywords
Trajectories, interruptions, coordination, health care, operating room, role-playing game

ACM Classification Keywords
H.5.3 Information interfaces and presentation (e.g. HCI): Group and Organization Interfaces; J.4 Social and Behavioral Sciences

Introduction
Vital organizations (e.g. hospitals, airlines, security agencies, and others) operate in high-stakes, critical environments, and are often characterized by the interdependence of different professionals working on multiple tasks. For example, in an operating room

(OR), physicians, nurses, and anesthesiologists are brought together as a team when a surgery is performed. In critical environments like this, unpredicted events and emergencies can upset plans at any moment, affecting the individual schedule of professionals and their interaction. Such a dynamic context calls for the careful coordination of expertise and resources to ensure operational efficiency and high performance levels.

We adopt the concept of trajectory to refer to the sequence of activities and paths through which people and resources move in organizations [9]. In distributed and dynamic environments, the orchestration of trajectories is needed to ensure that people and resources intersect at the right time to achieve an objective [9].

Because of the interwoven nature of trajectories, interruptions are expected as people move from one activity to another [5]. Interruptions can actively alert people of a problem (e.g., when a surgeon tells a charge nurse that a surgery will take longer). Interruptions can also be passive (e.g., when a nurse walks by the OR master schedule and notices a surgery will be late) [1]. Interruptions can also have both positive and negative consequences. They can constitute valuable cues for the proper execution of work, as well as negatively affect performance and emotional well-being [2].

Managing trajectories in hospital work

As an example of critical environments, hospital operating rooms require intensive coordination among the trajectories of professionals. Although scheduling algorithms can be used as a starting point for coordination, the dynamic nature of medical work makes preset schedules untenable in many situations [6]. At the same time as any one trajectory is experiencing change, others are changing too, necessitating adjustments in still other, related trajectories.

Though there has been a growing body of field and ethnographic research investigating the dynamics of an operating room [e.g., 3, 4, 9], there has been a lack of empirical studies to understand how people actually perform when faced with multiple tasks and interruptions. To our knowledge, no study has ever developed an experimental simulation to understand how different types of interruptions affect coordination of trajectories and performance over time. We designed and developed a web-based role-playing game to simulate a master schedule in an OR unit. In this game, we ask three players to take on the role of charge nurse, anesthesiologist in charge, and surgeon coordinator, with the goal of attending to OR scheduling dynamics as they manage their individual trajectories and objectives in the face of interruptions. Our goal is to answer the following research questions:

- How do interruptions to the master schedule affect the players' trajectories over time?
- Are active or passive interruptions more or less disruptive for the successful accomplishment of the scheduling task?

The qualitative study

To inform the design of the OR role-playing game, we performed an ethnographic study of an OR unit at Southwest Medical Center (SMC). We conducted semi-structured interviews with OR professionals, observed

OR activities, and consulted internal documents. We coded the qualitative material by identifying recurrent themes associated with OR scheduling [9]: trajectory coordination, interruptions, conflict, and patient safety.

Trajectory coordination. The members of different professional teams have multiple tasks to accomplish (an anesthesiologist divides his day schedule between visiting patients, reading cases, performing surgeries…), requiring them to manage their own trajectories. The trajectory of every professional also intersects with the trajectories of others (e.g., during surgery, the trajectory of an anesthesiologist intersects with the trajectory of a surgeon) or fails to do so (e.g., the anesthesiologist needs to postpone a surgery because the surgeon is late). The effective coordination of these activities is performed by the charge nurse through face-to-face interactions, phone calls and the use of visual artifacts. The main visual artifact is the master schedule, a whiteboard that represents all the surgeries that are scheduled for that day.

Interruptions. When a patient arrives at the OR unit, the charge nurse notifies the anesthesiologist in charge so the patient can be moved to the pre-operating room. The charge nurse also informs the surgeon that the patient is in the unit. In doing so, the charge nurse can interrupt the current trajectories of the anesthesiologist and surgeon. Interruptions may arise from other professionals or from unpredictable events (e.g. a piece of equipment breaking down). If an interruption concerns a conflict or problem with a surgery, OR professionals need to agree on how to update the master schedule. Such updates, however, may affect other professionals in the unit who are scheduled for that day.

Conflict. We observed some conflict between all members of the OR unit. Different professional groups have varying priorities, experience, and backgrounds. Their different work schedules, attitudes, and incentives can engender an atmosphere of misunderstanding, and can thus add to the cost of coordination.

Patient safety. In spite of their differences, health care workers agreed that the ultimate objective was to ensure patient safety, i.e., ensuring that all surgeries are performed without harm to the patients. This objective superseded adherence to the master schedule.

Design of the role-playing game

The observations and interviews we conducted in the OR, as well as the field studies and observations from the literature [e.g., 3, 4, 6, 9] informed the design of an OR scheduling game. The purpose of the game is to provide a semi-controlled environment in which the dynamic and highly collaborative environment of an OR unit is imitated. Game players manage resources under their supervision and are responsible for allocating these resources to surgeries. Each player has the common objective of ensuring that surgeries are adequately staffed and run smoothly. In addition, each player has individual tasks and objectives that may conflict with (or distract from) the common objective (objectives are discussed in further detail later).

Roles and tasks

The players in the game represent three roles responsible for coordinating the master schedule of an OR: the Charge Nurse (CN), the Anesthesiologist in Charge (AIC), and the Surgeon Coordinator (SC). Each

player is assigned certain tasks, which can be classified into four types:
1. Facilitating patient flow through the OR. These tasks involve admitting patients (CN) or moving patients to the OR (AIC).
2. Coordinating the master schedule. At the beginning of the game, the players are given an initial master schedule containing information about the surgeries that will be performed during the game shift (see figure 1). The initial master schedule is modified during the game as unexpected events (depicted by the warning icons) necessitate a change (e.g., the charge nurse is unable to move the patients to the pre-operating room on time). The initial master schedule was constructed based on the document data we obtained from the actual SMC OR unit.

Each surgery includes a surgeon, two nurses, an anaesthesiologist, and equipment. Yellow warning icons indicate a scheduling problem with one of these resources.

figure 1. The master schedule

3. Managing resources. In the game, medical professionals such as surgeons, nurses, and anaesthesiologists are represented as simulated entities. They can be viewed as resources that need to be managed by the game players to ensure successful operation of the OR unit. Each player is responsible for a subset of resources and must manage the availability of the resources under his supervision. Because information is distributed between the players, interaction among the players is required.
4. Completing tasks that are not associated with the activities of the OR unit. In addition to coordinating the master schedule, all players must also work individually to on a medical case exercise. The idea is that medical workers typically do not only work on the master schedule, so to simulate other activities, players will also read a medical case and answer a set of questions.

Notification of interruptions
During the game, players will receive notifications of events or problems both related and unrelated to the master schedule. In order to test our hypotheses about the effects of interruptions on trajectories and performance, we designed two the kinds of notifications the players will receive. In the active notification design, players are interrupted by pop-up messages that notify them of problems or events. In the passive notification design, interruptions are posted on an electronic whiteboard, which the player must remember to check periodically.

Individual and shared objectives
The overall objective of the scheduling game is to complete all scheduled surgeries safely and on time. In addition, each player should accomplish all of his/her individual tasks successfully. The presence of these competing objectives mimics the conflicting goals we and others observed in the OR [e.g., 10]. A global score is computed for the game (reflecting how well the

overall objective was met), and an individual score is computed for each of the players (reflecting each player's performance on individual objectives).

The game is designed so that the players can reach some optimal final state (depending on how interruptions are managed and when they are noticed), which is the execution of all the surgeries in the initial schedule and their other individual tasks. In the game, we assume that the execution of all surgeries guarantees patient safety. Performance is measured by the deviation from the optimal state.

Hypotheses and experimental design

We hypothesize that the way notifications are received (active vs. passive) will have an impact on work trajectories and, therefore, on performance. Specifically, we plan to test the following hypotheses in our experiment:

H1: Active notification (interruptions) will lead to jagged trajectories (players switch activities often)
H2: Passive notification will lead to smooth trajectories (players switch activities less often)
H3: Jagged trajectories will lead to improved group performance in scheduling surgeries
H4: Smooth trajectories will lead to improved individual performance in reading cases

The experimental design includes two treatment conditions: active notification (notifications delivered via pop-up messages) and passive notification (notifications delivered to an electronic whiteboard). Participants will include nursing students with clinical experience and OR medical workers from the local community. They will be randomly assigned to conditions and to a specific role in the game (charge nurse, anesthesiologist in charge, surgeon coordinator). Each condition will receive an equal number of notifications that relate to similar problems in the master schedule (e.g. a surgeon being late or a piece of equipment being unavailable).

At the end of the game, we reconstruct a trajectory for each player. The trajectory represents the temporal order and duration of the activities that the player was involved in (see figure 2). Moreover, we define a trajectory for each of the resources (surgeons, nurses, and anaesthesiologists) that are present in the master schedule. The shape of the trajectories over time is expected to be influenced by the type of notifications (active vs. passive) received during the game. Trajectories will be reconstructed through videotape and through activity tracking data collected automatically by the game.

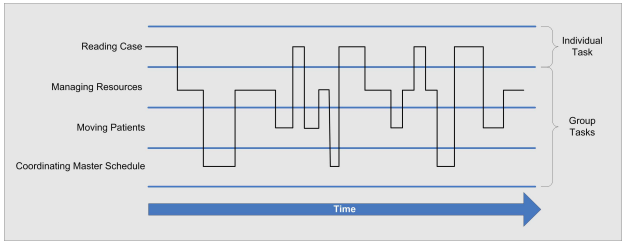

figure 2. A sample trajectory

We expect that trajectories will be influenced by the type and frequency of notifications encountered by the players. By superimposing notifications on the reconstructed trajectories, we will be able to discern how different types of notifications affect trajectories and performance. Future manipulations may include manipulating the perceived importance of competing

objectives to observe how these perceptions moderate the effect of notifications on trajectories.

Conclusion and Implications

Current studies of trajectory management in hospital work have emphasized the need for flexible coordination [3], awareness of events [2], and dealing with interruptions [4, 5]. We contribute to field research in this area by designing a role-playing game that simulates coordination of medical personnel in an operating room. We are in the process of conducting experiments and collecting empirical data on how interruptions will affect trajectory management and performance. Our findings will be relevant to the HCI community by showing how the design of our role-playing game can be used for measuring trajectories and interruptions to coordinate work. This novel design for studying trajectories and active and passive notifications will yield new insights into the processes that underlie collaborative work in critical environments.

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