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Situation Awareness and Interruption Handling During Medication Administration

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Abstract

Medication administration error remains a leading cause of preventable death. A gap exists in understanding attentional dynamics, such as nurse situation awareness (SA) while managing interruptions during medication administration. The aim was to describe SA during medication administration and interruption handling strategies. A cross-sectional, descriptive design was used. Cognitive task analysis (CTA) methods informed analysis of 230 interruptions. Themes were analyzed by SA level. The nature of the stimuli noticed emerged as a Level 1 theme, in contrast to themes of uncertainty, relevance, and expectations (Level 2 themes). Projected or anticipated interventions (Level 3 themes) reflected workload balance between team and patient foregrounds. The prevalence of cognitive time-sharing during the medication administration process was remarkable. Findings substantiated the importance of the concept of SA within nursing as well as the contribution of CTA in understanding the cognitive work of nursing during medication administration.

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Medication use process errors account for more than 1.5 million preventable errors and 7,000 deaths per year (Kohn, Corrigan, & Donaldson, 2000). Human error experts suggest the area of study least explored, regardless of industry, is attention—more specifically, situation awareness (SA). The impact of SA on attention in high-hazard, demanding environments is well documented (Cornell, Riordan, Townsend-Gervis, & Mobley, 2011; Weick & Sutcliffe, 2007; Wickens & McCarley, 2008; Woods, Johannesen, Cook, & Sarter, 1994). Research describing human error-related elements is necessary and fundamental to understand the cognitive work of nursing and the impact on patient care and medication administration safety. Interruptions during medication administration are frequent and costly (Westbrook et al., 2010). Less understood is the description of SA during medication administration and direct-care nurse selection of interruption handling strategies during the medication administration process. Such research is necessary to design interventions that might enhance SA among direct-care nurses during medication preparation and administration.

The urgency to understand and mitigate factors influencing interruptions in nursing and safe medication administration is well documented (McGillis, Pedersen, & Fairley, 2010; McGillis, Pedersen, Hubley, et al., 2010; Redding & Robinson, 2009). It is important to understand what factors influence the experience of SA in nursing that describe, explain, and/or predict why a nurse might select a particular interruption handling strategy and task-switch during the medication administration process. Answering these questions can inform the design of strategies to enhance SA and the facilitation of patient-centric, value-added interruptions during medication administration. The need to reduce preventable deaths as a result of human error during the medication administration process has been issued by policy makers, payors, and the public with marginal response from the discipline in terms of mitigation strategies (Classen et al., 2011).

The human and financial cost of medication administration error is significant and well documented (Barker, Flynn, Pepper, Bates, & Mikeal, 2002; Classen et al., 2011; Cohen, 2007; Institute of Medicine, 2000; Kopp, Erstad, Allen, Theodorou, & Priestley, 2006; Sharek & Classen, 2006). Nursing work interruptions during medication administration and the implications for patient harm as a result are well documented (Anthony, Wiencek, Bauer, Daly, & Anthony, 2010; Biron, Lavoie-Tremblay, & Loiselle, 2009; Grundgeiger & Sanderson, 2009; Pape, 2003; Relihan, O'Brien, O'Hara, & Silke, 2010; Rivera-Rodriguez & Karsch, 2009; Trbovich, Prakash, Steward, Trip, & Savage, 2010; Wakefield et al., 1999; Westbrook et al., 2010). Definition, categories, types, and a taxonomy for interruption handling strategies have been proposed (Brixey et al., 2007; Brixey et al., 2008; Colligan & Bass, 2012; Jett & George, 2003).

The most common method to measure interruptions has been through observational study (Biron, Lavoie-Tremblay, & Loiselle, 2009; Brixey et al., 2007; Cornell et al., 2011; Westbrook et al., 2010; Wolf et al., 2006). Self-reporting and focus groups have been utilized to explore and describe nursing work, perceived cognitive workload and interruptions (Biron, Loiselle, & Lavoie-Tremblay, 2009; Westbrook et al., 2010). Numerous scholarly contributions verify the need to understand the cognitive work of nursing and patient care delivery (Benner, Hooper-Kyriakidis, & Stannard, 2011; Benner, Tanner, & Chesla, 2009; Ebright, Patterson, Chalko, & Render, 2003; Ebright, Urden, Patterson, & Chalko, 2004; Patterson, Ebright, & Saleem, 2011; Potter et al., 2005; Sandelowski, 2000; Sitterding, Broome, Everett, & Ebright, 2012; Tanner, 2005). The impact of interruptions on the cognitive work of nursing includes SA, working memory, and clinical reasoning in transition is inferred but without evidence (Biron, Loiselle, & Lavoie-Tremblay, 2009; Brixey et al., 2007; Cornell et al., 2011; Wickens & McCarley, 2008). However, absent from the literature is a description of attentional dynamics such as nursing SA and interruption handling strategies during the primary task of medication administration.

Cognitive scientists commonly use cognitive task analysis (CTA) methods to elicit information about the manner in which a person perceives a situation, comprehends the situation's components, and makes decision or plans based on the aforementioned comprehension of cues. CTA is a "family of methods used for studying and describing reasoning and knowledge" (Crandall, Klein, & Hoffman, 2006, p. 3).

Substantial scholarly contributions have described medication administration error, interruptions science, and cognitive work of nursing implications on patient care error; however there has been limited study examining the cognitive work or SA and the selection of interruption handling strategies during medication administration. Especially noteworthy is the limited number of medication administration error studies using cognitive science procedures such as CTA.

Purpose

The purpose of the study was to describe SA during the medication administration process, including the selection of interruption handling strategies. The specific aims of the study were to describe SA during the medication administration process among direct-care registered nurses (RNs) serving acute critical care and medical-surgical environments, and to describe SA and the selection of interruption handling strategies during the medication administration process among direct-care RNs serving acute critical care and medical-surgical environments.

Definitions of terms used in this study are summarized in Table 1.

Method

Using a cross-sectional, qualitative descriptive design, direct-care nurses were recruited and consented for participation following Institutional Review Board approval. Potential participants were recruited via the hospital and nursing unit newsletters, and during regularly scheduled nursing practice forums. Observational and video data were collected during the medication administration process on randomly selected days. Audiotape data were collected within 1 week of observations.

Data about interruptions, selection of interruption handling strategies, and nurse workload tasks were collected and analyzed from 13 nurses until saturation was achieved during the medication administration process on randomly selected days and shifts (Monday, Wednesday, Thursday, and Saturday). Purposive sampling resulted in two discrete groups. Group A included 7 RNs with 3 to 24 months of practice experience. Group B included 6 RNs evaluated by peers and staged as expert and/or proficient nursing practice. Inclusion criteria were as follows: (a) RNs who were employed within large hospital systems located in the Midwest and designated Magnet, (b) with 3 to 24 months of experience and consistent practice in the nursing unit of observation and with medication administration. Exclusion criteria were the following: (a) RNs in management, supervisory, or nurse education roles with <50% of job responsibilities in direct-care; (b) identified as agency, traveler, or contract RNs or as new hires or internal transfers employed in the nursing unit of observation <3 months; and (c) those within 3 months of recent leave of absence.

Inclusion criteria for nurse participants were based on stages of development and skill acquisition (Benner, 1999) and consisted of the following: advanced beginners, competent and expert practice nurses. All nurse participants had experience with medication administration.

Table 1. Definitions.

Term	Meaning
Attentional dynamics	Work complexity patterns and cognitive factors driving nursing performance and decision-making strategies.
Cognitive stacking	A decision-making strategy for dealing with multiple care delivery requirements, including a mental list of to-be-done tasks and a strategy for preventing error and/or minimizing bad outcomes.
Cognitive task analysis	A family of methods used for studying and describing reasoning and knowledge.
Critical decision method	One of the two (with goal-directed task analysis) preferred interview methods that enables an investigator to probe an actual situation, the discovery of details, challenges, subtle cues, background influences, and strategies that would not otherwise have been discovered in an open-ended interview following controlled simulation.
Directed content analysis	A method that reveals theme phrases describing situation awareness and the selection of interruption handling strategies during the medication administration process.
Foreground/ background	Alternating cognitive prioritization described as used in conjunction with medication administration, cognitive anticipation of interventions alternating patient-centric activities between foreground versus all other stimuli background.
Goal-directed task analysis	One of the two (with critical decision method) preferred interview methods that reveals what information nurses need to perform safe medication administration.
Interruption	A break in the performance of a human activity initiated by a source internal or external to the recipient, with occurrence situated within the context of a setting or location.
Patient-centric	Of or with respect to the patient (used primarily in the context of situational awareness).
Pulling medications	Acquiring medications from a secure area prior to administering them to the patient.
SA1	Situational Awareness Phase 1, or the nature of the stimuli noticed, a dynamic process where the nurse perceives visual, auditory, or interrupting thought stimuli relevant to the patient or environment.
SA2	Situational Awareness Phase 2, or the meaning assigned to the stimuli noticed, the comprehension and assigned relevance, uncertainty, or expectations to the nature of stimuli noticed influencing nurse interpretation of stimuli salience.

(continued)

Table 1. (continued)

Term	Meaning
SA3	Situational Awareness Phase 3 or the projected or anticipated workflow priorities as a result of assigned meaning to the nature of stimuli noticed.
Situational awareness	A dynamic process in which a nurse perceives each clinical cue relevant to the patient and his or her environment; comprehends and assigns meaning to those cues resulting in a patient-centric sense of salience; and projects or anticipates required interventions based on those cues.
Six sigma	A disciplined, data-driven approach and methodology for eliminating defects (driving toward six standard deviations between the mean and the nearest specification limit) in any process.
Task-centric	Of or with respect to the task (used primarily in the context of situational awareness).

A second aim was to describe SA and the selection of the interruption handling strategies during the medication administration process among direct-care nurses serving adult acute medical-surgical and critical care environments. Thirty-six hours of videography, observation, and interviews were conducted informing an analysis of 230 interruptions and interruption handling strategies during the medication administration process. Twenty hours of videography and observation were completed with an average of 92 min of observation and videography of direct-care RNs experiencing a range of 8 to 34 interruptions over the course of those 92 min. Nurse participants represented medical-surgical, critical care, and emergency departments. Interviews were scheduled and conducted within 7 days of the videography and observation sessions.

Data Collection

Observation alone has been insufficient to understand the experience of SA and interruption handling during the medication administration process. Quantitative surveys and open-ended unstructured interviews have been absent a CTA technique that allowed for describing the knowledge, reasoning, and decision making during the MA process. CTA is a family of methods used for studying and describing reasoning and knowledge (Crandall et al., 2006). Examples of CTA methods include the critical decision method (CDM) and goal-directed task analysis (GDTA). CDM is an interview technique that enables the investigator to probe cognitive function including, but not limited to SA. Use of the CDM enables the capture of the nature of the decision maker's understanding prior to and during the interruption (Klein, 2000). Examples of semi-structured interview questions, including a rationale for the inclusion of each question are illustrated in Table 2. These questions served as the initial means of generating data during interviews coupled with participant review of videography data. Interviews using the CDM technique were also informed by observation and videography.

Observation and videography enabled us to capture authentic behavior on the part of the nurse during medication administration. Observation and videography informed interruption case selection. Videography was integrated as a data collection method given the concern that there would be limited or variation in recall of a non-critical incident (medication administration) among RNs on a usual day on an acute care unit. Observation coupled with videography was intended to supplement completeness and accuracy of recall (Colligan & Bass, 2012). The risk of the intrusive nature of observation and videography were balanced with the benefit of completeness and accuracy of recall.

The objective of observations and in situ interviews for CTA was to capture the authentic behavior of the worker—in this case, the nurse. Decision making and selection of interruption handling strategies was documented through the aforementioned CTA in combination with observation.

Analysis

The theory of SA (Endsley, Bolte, & Jones, 2003) and levels of SA in nursing had previously been defined (Sitterding et al., 2012); therefore, directional content analysis (Hsieh & Shannon, 2005) was conducted. This approach determined the initial coding scheme. A beginning list of codes consistent with the CDM techniques was used including the following: (a) cues (what did the participant notice), (b) information (what information did you use to make that decision—where did you get the information), (c) standard operating procedure (was this case or example typical), (d) goals and priorities (what was most important to accomplish at this particular time), (e) mental models (did you imagine the consequences of what was happening), and (f) decision making (what told you this was the right decision—how long did it take you to make the decision). Final consensus about themes/code assignments was achieved. Descriptive statistics were conducted to understand study sample characteristics. Data analysis was conducted by the investigators that included the principal investigator (PI), one doctoral student, and two researchers familiar with this particular design and CTA methods. All team members were trained in interview and analysis methods consistent with qualitative descriptive design and CTA.

Table 2. Semi-Structured Interview Examples of Questions.

Situation Awareness in Nursing Probe Topics	Examples of Probing Questions: Guided Interview	Rationale and Listening for
Cues/knowledge	What were you hearing, seeing, and noticing? What was it about the interruption that let you know what was going to happen? What did you decide to do with that information? Did your previous experience seem relevant in this case?	Situation Awareness Level 1 (stimuli): Perception of interruption specific to clinical cues relevant to the patient and his or her environment; perception of the situation and the severity or complexity of the interruption; cues and their implications.
Expectations	What were your expectations at this time?	Situation Awareness Level 2 (meaning): Comprehension and assignment of meaning to those cues specific to the interruption resulting in a patient-centric sense of salience.
Goals	What were your specific goals and objectives at this time? What was most important to accomplish at this point in the process?	Situation Awareness Level 3 (action): Projection and/or anticipation of required interventions based on those meaning assigned from interruption cues.
Decision point	What interruption handling decision did you make in this situation? How was this particular decision chosen or others rejected? How much pressure was involved in making this decision? What training or experience was helpful in making this decision?	Situation Awareness Level 3 (Action): Projection and/or anticipation of required interventions based on those meanings assigned from interruption cues.

Table 3. Description of Situation Awareness in Medication Administration.

Aim 1	Stimuli	Meaning	Action
Describe SA during MA	A dynamic process where the nurse *perceives cues* relevant to the patient or environment	*Comprehension and assigned meaning to cues* influencing sense of cue salience	*Projects or anticipates required interventions* informing cognitive stacking and nursing actions
Themes	Nature of stimuli noticed: Visual (patients, family, team, equip) Auditory (people, phones, alarm, intercom) Interrupting thought	Uncertainty Relevance Expectations	Projected workflow: Patient-centric foreground Projected workload: Team-centric foreground

Results

One aim of this study was to describe SA during the medication administration process. The major theme regarding the description of SA perception (SA1) was the nature of the stimuli noticed. Three sub-themes emerged regarding the description of SA perception (SA1), an additional three major themes triggering comprehension (SA2), and two major themes emerged regarding the description of SA projection (SA3) during medication administration. Themes reflecting SA1 include the nature of stimuli noticed (visual, auditory, and interrupting thought); themes demonstrated in SA2 include uncertainty, relevance, and expectations; and SA3 themes include patient- and team-centric workload (see Table 3).

SA1: The Nature of the Stimuli Noticed Visual

A direct-care nurse's perception of clinical cues, relevant to the patient and his or her environment and illustrated in visual processing, was evident in all observations and verified during the interview process. People and equipment were the obvious stimuli apparent to the observer, illustrated on the video, and verified by the participant. Sub-categories of visual processing—as a result of the people stimulus—included the types of people, such as the patient, patient's families, and the care delivery team. Subtle differences were noted between the direct-care nurses with less than 24 months experience and the expert nurses. While the less experienced nurses responded to visual cues presented to them, the expert nurses responded both to the cues presented. In addition, visual cues were observed as a result of the nurse's constant scanning areas around themselves, including all patient rooms regardless of whether those particular rooms were assigned to the nurse.

SA1: The Nature of the Stimuli Noticed Auditory

The direct-care nurse's perception of clinical cues, relevant to the patient and his or her environment and illustrated in auditory processing, was evident in all observations and verified during the interview process. Auditory cues stimulated not only auditory attention but also visual attention. People, phones, the intercom, and alarms were the obvious stimuli apparent to the observer, illustrated on the video, and verified by the participants. When nurses heard people talking while they were administering medications, their reactions varied depending on whether the person was the patient, the patient's family, or someone from the patient care and medical team.

Consistent with the visual theme, the majority of auditory cues and auditory processing observed and verified during the interview processes reflected cognitive processing and decision making about patients other than those for whom current medication administration was occurring. Although there was very consistent recognition in the differentiation of sounds and definition of alarms, there seemed to be variation in the less experienced nurses' response to alarms compared with the more experienced nurses.

SA1: The Nature of the Stimuli Noticed Interrupting Thought Cue

The direct-care nurse's perception, and assigned meaning of clinical cues relevant to the patient and his or her environment, was also illustrated in what is described as interrupting thought cues. SA depends on one's capacity to constantly manage competing sources of information and differentiating between unnecessary information and only information that is relevant to the particular task at hand (Endsley et al., 2003). The notion of interrupting thought cues (SA1) verifies the direct-care nurse's systematic visual and auditory scans to ensure she or he is up-to-date with knowledge of what's happening around them, their patient, and within their environment. Illustrated in the video, and then verified during the interview, was the development of an interrupting thought influenced by a particular knowing or relevance of knowledge the nurse brought to that particular situation. The thought influenced how the nurse assigned meaning (SA2) to the interrupting thought. Interestingly, interrupting thought cues were illustrated in the videos of all participants; however, the direct-care nurses with less than

24 months experienced far fewer interrupting thought cues. In addition, the less experienced nurses were unable to explain the origin or rationale for the interrupting thought, even though they acted upon it. It is worth mentioning that each of the interrupting thought cues were closely aligned with some sense of threat or concern for either the patient and/or team members.

SA2: Uncertainty, Relevance, and Expectations

Themes representing the comprehension or assigned meaning (SA2) by the nurse to visual (Table 4), auditory (Table 5), and interrupting thought cues (Table 6) included (a) uncertainty (most often related to patient condition), (b) relevance, and (c) expectations. Performance expectations and relative consequences are illustrated in terms of the direct-care nurse response to the phone. Of note, most auditory and visual cues and processing observed and verified during the interview processes reflected cognitive processing and decision making about patients other than those for whom current medication administration was occurring.

SA3

Two major themes that emerged regarding the projection or anticipated required interventions based on cues from SA1 and SA2 and influencing how the direct-care nurse made decisions in terms of stacking and nursing care actions included team-centered workflow foreground and patient-centered workflow foreground (Table 7). Among all direct-care nurse participants was the prioritizing of their attention to workflow. Although all direct-care nurses demonstrated a patient-centric sense of salience, there were moments (observed and verified on video and interviews) when the team and team tasks were of greatest priority, in contrast to observations where the patient's condition informed the priority foreground. As previously reported, the data reflected nursing SA and projected or anticipated required interventions (SA3) for one patient, while in the midst of the medication administration process for another patient.

Both groups of nurses (expert and less experienced) responded to two key visual stimuli—people and equipment. However, in addition to responding to visual cues presented to them, expert nurses also constantly scanned areas and looked in patient rooms, even if they were not responsible for those patients. This is in contrast to less experienced nurses, who seemed to take a more focused approach. All study participants displayed reflected cognitive processing and decision making about patients other than those for whom current medication administration was occurring. The factors that influenced

Table 4. Situation Awareness During Medication Administration: Visual Cues and Assigned Meaning.

Theme: Stimuli	A Dynamic Process Where the Nurse Perceives Visual Cues Relevant to the Patient or Environment (Experience of Nurse in Months)	Theme: Meaning	Quotes Reflecting Comprehension and Assigned Meaning to Visual Cues Influencing the Nurse's Sense of Cue Salience
Patients	The olive scrubs was the respiratory therapist (<24 months)	Relevance	My (other) patient in 15 was on venti mask. She had gotten up to use the restroom and when she got up she had de-satted, she had bumped her up to 100% which was overkill
	I think that was 46 (other patient), she was walking with her husband (30 months)		It's important to know how far they're able to walk
Family	I saw the husband (other patient; <24 months)	Expectations	Pretty simple—was it okay if he walked her in the hallway. We get a lot of that . . . if the patient or family member sees us in the hallway, I guess they believe it's fair game for them to stop us, even if they see our hands are full
Team	I recognized that was the ENT team . . . I saw them walking down the hall, we don't have a whole lot of ENT patients . . . I happened to see one of them was holding a trach box in their hand (staged expert)	Uncertainty: Patient condition	. . . I was like, you know, hey are you changing out his (other patient) trach, are you downsizing him, like what's going on? Downsizing his trach could be very uncomfortable for the patient . . . painful . . . when they downsize a trach . . . best described as you breathe through a bigger straw and then all of a sudden they give you a little straw and try and breathe through it!
Equipment	So when in his room, I noticed there were no supplies (<24 months)	Expectations	I knew I would need throughout the day . . .

Table 5. Situation Awareness During Medication Administration: Auditory Cues and Assigned Meaning.

Theme: Stimuli	A Dynamic Process Where the Nurse Perceives Auditory Cues Relevant to the Patient or Environment (Nature of Stimuli Noticed)	Theme: Meaning	The Comprehension and Assigned Meaning to Auditory Cues Influencing Sense of Cue Salience
People	I heard a voice. I noticed someone was in his room (staged expert)	Uncertainty: Patient condition	I heard a voice. I noticed someone was in his room
	I happened to hear some people walk down the hallway . . . I seen the two nurses . . . blue surgical scrubs (<24 months)	Relevance	IV team and I also knew that my patient in 21 needed an IV because he did not have any access
Phones	I heard the phone (<24 months)	Uncertainty: Patient condition and expectations	Well, we always answer the phone because it could be a physician looking for you. It could be the secretary . . . telling you that your patient's not breathing, your patient's in v-tach, your patient's de-satting 50%, there is a number of reasons
	Heard the phone. If I'm just, you know, administering medicine, I'll usually excuse myself to answer the phone (staged expert)	Expectations	If I'm just, you know, administering medicine, I'll usually excuse myself to answer the phone. Expected
	Phone rings (staged expert)	Expectations	We have to answer the phone. They expect it
Alarms	I heard and broke to silence that alarm and then resume (<24 months)	Uncertainty: Patient condition	Depending on the alarm, cause now I'm accustomed to the different types of noises and what that alarm might mean
	I heard an IV pump. (staged expert)	Uncertainty: Patient condition	I'm going to check it out, and if it's something I can handle quickly, I handle it
Intercom	Heard the intercom (<24 months)	Expectations	It was a transport call during med pass . . . if I'm with Patient 1 and administering meds transport calls (about another patient) and they say, "we're ready for him to go to CT," we take 'em down . . . everybody's STAT, everybody wants their CT now, today

Table 6. Situation Awareness During Medication Administration: Interrupting Thought Cues and Assigned Meaning.

Stimuli: A Dynamic Process Where the Nurse Perceives Interrupting Thought Cues Relevant to the Patient or Environment (Nature of Stimuli Noticed)	Meaning	The Comprehension and Assigned Meaning to Interrupting Thought Cues Influencing Sense of Cue Salience
I noticed they were all meds (staged expert) (response to noticing the meds were all oral and what that information meant for the future . . . for her patient that was near non-responsive)	Uncertainty/concern: Patient condition	(thought to self) I gotta get her ammonia level down. I can't give these, the lady's gonna aspirate. Those meds have to go on hold
I just remember hearing he put in an order for potassium (staged expert)	Uncertainty/concern: Patient condition	(thought to self) I thought I don't really remember this patient's potassium . . . pulled his labs back up . . . too much potassium in their system—heart could stop and that's huge. Saw that he actually hadn't had labs drawn in 3 days, so, and that's when I called the doctor and I said, "so what are you basing this 40 of K on?"
I honestly don't know. I just remember I think it's just one of those things in the morning . . . (<24 months) (her response to simply stopping herself in the middle of the hallway between the medication room and her other patient's room)	Uncertainty/concern: Patient condition	. . . probably the only patient who had an 8:00 med due because usually the med times are 9:00. How I remembered was just luck, 'cause there's been many times

their comprehension included the patient's condition, the relevance of the provider that was noticed, and obligations to the patient's family and the medical team. The findings of the auditory cues were similar to the findings of the visual cues for both groups of nurses. As with the results of the visual cues, people and equipment were the two main stimuli that interrupt nurses during the delivery of medications. While the hospital can be a noisy

Table 7. Situation Awareness in Medication Administration: Situation Awareness 3 Workflow Themes.

Action: Projects or anticipates required interventions informing cognitive stacking and nursing actions in a team-centric workflow foreground	Saw PT. PT needed to know that he doesn't speak English. PT needed to find out information—if I knew anything about an interpreter coming. I'm her first source of information. Plus, it's important for our surgery patients to work with PT, especially if they're going to go to a rehab because physical therapy helps write notes on their recommendations for level of care. I can't delay therapy. If therapy doesn't get their note in on time I can delay social work or case management recommending a placement (staged expert)
Action: Projects or anticipated required interventions informing cognitive stacking and nursing actions in a patient-centric workflow foreground	I just saw him (doctor) standing in there (another patient's room while she was on her way to pass meds for another patient). He was a GI. He was a doctor who was doing ERCP. So, he was in to get her consent. Well, I had to find out if she was for sure going to be going down for the ERCP so that I did not let her eat or drink anything before she went down . . . drinking would put her at risk for aspiration when they gave her the conscious sedation so, you know, we had to make sure that we didn't jeopardize anything because if they eat or drink they won't do the procedure, either (<24 months)

environment, nurses were very adept in differentiating noise, and possessed the cognitive reasoning to respond differently depending on the stimuli. The phone, both personal cell phones and phones ringing with earshot, was the only stimuli that caused almost immediate interruption of medicine delivery for all nurses. Nurses' actions in both groups were patient-centric, yet workflow was a major priority for direct-care nurses. During the administration of medication, they were also cognizant of the needs of the medical team and the needs of the patients. To that end, SA was also influenced by the need of the team or the need of the patient. Cognitive stacking (Ebright et al., 2004) followed accordingly.

SA and Selection of Interruption Handling Strategies

Emergent themes regarding SA in the selection of interruption handling strategies during medication administration were consistent with emergent themes related to all three levels of SA in medication administration *prior* to the interruption (Table 3). Interestingly, the most frequently selected interruption handling strategy direct-care nurses selected was to engage. That is, the nurse assessed the interruption to be a high priority therefore suspending the primary task (medication administration), so that the higher priority secondary task (interruption) could be engaged immediately. The primary task of medication administration was later resumed. There were no observed differences in the selection of interruption handling strategies when comparing the staged expert nurses and the nurses with less than 24 months of experience. Among interruptions observed, videotaped, and analyzed, 60% (130/215) were handled immediately through engagement. However, 18% (40/215) of the interruptions were blocked, as administering medication took priority as the primary task, while the interruption was perceived as a secondary task. Nurses multi-tasked medication administration while also responding to the interruption 12% (26/215) of the time observed and verified during the interview. The least likely interruption handling strategy to be chosen was mediation. That is, the interruption was identified as a high-priority task, and the direct-care nurse deflected the secondary task to another team member. Data reflecting thematic analysis regarding the description of SA in the selection of interruption handling strategies during medication administration are illustrated in Tables 8 and 9.

To summarize, during the study period, 13 direct-care nurses were observed and videotaped before and during the administration of medication. CTA techniques such as CDM and GDTA enabled the discovery and description of SA before and in the selection of IHS during medication administration. The expert nurses responded not only to the auditory and visual stimulation, but they were also constantly scanning areas, whereas the less experienced nurses responded almost entirely to the visual cues presented in front of them. Despite the volume or type of interruption, nurses displayed SA at all levels and decision making informed by the nurse's interpretation of the patient's condition, relevance, or expectations associated with perceived triggers. Striking was the finding that 81% of interruptions were permitted during medication administration with mediation as the least likely interruption handling strategy selected. Workload prioritization was evident among all participants with workload foregrounds alternating between patient and team priorities.

Discussion

These research findings affirm previous research demonstrating that medication administration is inseparable from other nursing work and challenges current paradigms reinforcing the need for reduction of interruptions based

Table 8. Situation Awareness and the Selection of Interruption Handling Strategies During Medication Administration: Engaging and Blocking Strategies.

Interruption Handling Strategy	Experience Level	Stimuli: Perception of Interrupting Cue	Meaning: Comprehension and Assigned Meaning of Interrupting Cue	Action: Projection or Anticipation of Required Intervention Based on SA1 and SA2
Block	Staged expert	Saw the nurse, I glanced at it (blood sugar report) when he gave it to me. Theme: Visual (team)	It was fine. Fine meant . . . within the parameters that I knew. Theme: Relevance	I wasn't going to have to cover that patient at that moment Theme: Patient-centric workflow
Block	Staged expert	I heard the alarm and that means it's time to either give insulin, check a blood sugar, or you need to draw a lab. Theme: Auditory (alarm)	I think we were hearing another patient with alarming on the actual computer screen. It wasn't my patient. Theme: Relevance	There was nothing for me to do. You just know if your patient is on insulin or heparin. Theme: Patient-centric workflow
Engage	Staged expert	Resident came in during med pass and said he was just going to do staple removal. I had to see. Any time somebody comes into a patient room, you want to be there because you just never know. Theme: Visual (team)	I knew it might go more in depth than just an actual staple removal itself . . . knowing that it was a surgical intern, they are knowledgeable, but sometimes they only focus on the task at hand, kind of like a new nurse. Theme: Uncertainty/ patient condition	They don't necessarily think about the supplies they need, about the patient, you know the patient, the pain medication, whatever. Interns go in, open up wounds, and leave it open you really want to assess the wound. Theme: Patient-centric workflow
Engage	Staged expert	RT came in to do treatments interrupting my med pass. They are very busy, they see lots of patients gentlemen was a trach, he had lots of secretions. Theme: Visual (team)	He needed RT right then asking them to come back . . . if they go see a lot of other patients they may not come and see him until after they've seen four or five other people. Theme: Uncertainty/ patient condition	I could have backed him up . . . respiratory treatment was more important. And there were other things I could go do. I would be stuck with suctioning him more frequently, him becoming more agitated and restless about it . . . mean I would be pulled back in the room much more often. Theme: Patient-centric workflow

Table 9. Situation Awareness and the Selection of Interruption Handling Strategies During Medication Administration: Multi-Tasking and Mediation Strategies.

Interruption Handling Strategy	Experience Level	Stimuli: Perception of Interrupting Cue	Meaning: Comprehension and Assigned Meaning of Interrupting Cue	Action: Projection or Anticipation of Required Intervention Based on SA1 and SA2
Multi-task	<24 months	I was pulling meds and phone rang. I just did both at the same time Theme: Auditory (phone)	It's expected. You never know who it is or what they need Theme: Expectations	I've got three people behind me I'm going to try to hurry up for them Theme: Team-centric workflow
Multi-task	Staged expert	I answered the phone I can keep doing whatever I'm doing and I answer my phone Theme: Auditory (phone)	Expectations . . . you have to be able to multi-task and also think about multiple things at once Theme: Expectations	In the back of your head, while I'm doing this procedure (med pass. I am going to be in this room for a little bit, need to know what time it is. Do I need to check on my other patient . . . because have to think about your other patients, all at once Theme: Patient-centric workflow
Mediate	Staged expert	I heard the pump alarm. I knew it was his amniodarone drip. I could see he wasn't anxious, he was resting. He was calm. The only thing abnormal was the beeping Theme: Auditory (alarm)	I knew that nurse who had said something to me is extremely competent. The patient was fine. I'm looking at his heart rate and he's not in a fib currently. His heart rate is fine and his blood pressure is normal Theme: Relevance	I would need to put on an isolation gown and gloves . . . it's just extra steps that are unnecessary . . . so am I needed right this second? All those factors were enough for me to know the other nurse could handle Theme: Patient-centric workflow
Mediate	Staged expert	*I heard the alarm* Theme: Auditory (alarm)	*I knew it was my line* Theme: Relevance	I just asked "can you go in there real quickly and add some volume?" That way I would, you know, know the patient is still getting the medication that they need Theme: Patient-centric workflow

on limited evidence quantifying the relationship between interruptions, medication administration error, and patient harm (Hopkinson & Jennings, 2013; Jennings, Sandelowski, & Mark, 2011). Attention and specifically SA and cognitive time-sharing are facilitated by spatial abilities and visual scanning (Endsley et al., 2003; Wickens & McCarley, 2008). Cognitive time-sharing and task-switching in nursing may also be influenced by individual differences in verbal abilities as verbal abilities demonstrate a pattern of proficient executive cognitive control.

Skill automation may explain the natural tendency among some participants to choose multi-tasking or even engagement as the preferred interruption handling strategy. Engagement was the predominant interruption handling strategy among experts (IHS of choice: 62%-100% of interruptions), in contrast to nurses with less than 24 months experience (48%-75%). Skill automation may enable the expert nurse to more effortlessly engage and multi-task. Automaticity has been defined as "ability to perform a task while putting little thought into it" (Wright & Fallacaro, 2011, p. 485) and is a defining characteristic of an expert (Wickens & McCarley, 2008). Experts (Endsley et al., 2003; Wickens & McCarley, 2008) contend that experience contributes to SA enabling the development of mental models and goal-directed processes that can lead to automaticity in mental processing. That is, the pattern-recognition/action-selection sequence becomes routine to the point of becoming automatic for the expert nurse.

Wickens and McCarley (2008) asserts to the extent that two tasks are cognitively resource-demanding, allocating more cognitive resources to one task will improve performance on that particular task. However, but this reallocation will likely degrade performance on the secondary task as a result of withdrawal of cognitive resources from the secondary task. Furthermore, two people performing the same task can demonstrate identical performance, yet one may do so with spare attentional resources left to allocate to concurrent tasks (Wickens & McCarley, 2008). Automatic tasks can be time-shared (divided attention) efficiently with other resource-demanding tasks, that is, walking and decision making or for example in this study, pulling medications while answering the phone or administering medications while noticing and making a decision to engage with the other patient's physicians, or pulling medications while collaborating with colleagues in the medication room or answering the phone while completing intravenous medication tasks.

Automaticity or automatic processing is the result of consistent cognitive mapping and practice. For example, less familiar or practiced tasks—before consistently mapped or practiced requires cognitive resource loading. In contrast, tasks—after consistently mapped and practiced—become automatic and might explain the ease and prevalence of engagement as an interruption handling strategy. Engagement and multi-tasking in response to the nature of stimuli perceived may be the expected response, depending on the particular nursing work or practice environment.

Today's health care customers including payors, expect high performance in quality, the patient's experience or patient satisfaction, and at low costs. Financial consequences awarded to hospitals associated with performance in quality, satisfaction, and costs are remarkable and can influence the nursing work environment and expectations for nursing attention. Consider two examples of data demonstrating participant attention to the nature of auditory stimuli—the phone and assigned expectations:

> If I'm just, you know, administering medicine, I'll usually excuse myself to answer the phone. It's expected.

> It was a transport call during med pass. It's expected. If I'm with Patient 1 and administering meds, transport calls (about another patient) and they say, "We're ready for him to go to CT." We take them down. Everybody's STAT. Everybody wants their CT now, today.

High reliability within health care is expected within an environment—that for the most part—is absent high reliability design (Vogus, Sitterding, & Everett, 2014). In addition, the meaning assigned to the nature of stimuli perceived may be the result of the current nursing work environment and requirements for responsiveness, such as the prevalent response to auditory—phone interruptions among both groups of participants. Designing for SA in the midst of attentionally demanding nurse work environments is necessary.

These findings support future research examining the effect of recommendations proposed by Li, Magrabi, and Coiera (2012) to minimize the disruptive effects of interruptions in clinical settings including (a) avoidance of interruptions at positions requiring high working memory demands; (b) utilization of practice on tasks to minimize disruption of interruption, that is, practicing a highly procedural task strengthening associated task memory; (c) interruption handling training; and (d) development and provision of environmental cues aiding recovery from interruptions.

Findings reported in this study also support previous research demonstrating the call for a framework to understand the complexity of interruptions and the effects of interruptions. Interruptions have been thought to have only negative effects on nursing practice and patient care. However, this assumption is unsubstantiated with evidence of only one source of empirical evidence demonstrating the statistically significant relationship between medication administration error and interruptions (Hopkinson & Jennings, 2013; Li et al., 2012; Westbrook et al., 2010). In a systematic review of the psychological literature on interruption and its patient safety implication, Li and colleagues (2012) reveal the effects of interruptions in health care predominantly to include working memory load, interruption similarity, interruption position, interruption modality, practice and experience, and interruption handling strategies. Decreased primary task performance (i.e., medication administration) may be negatively influenced if interruptions occur during particularly high working memory load. Li and colleagues (2012) propose the effect of the interruption and relationship to working memory load depending on whether the interruption is similar to the primary task (interruption similarity) and where in the primary task the interruption occurs (interruption position). Interruption modality is also proposed to influence the effect of interruptions, that is, the nature of an interruption presenting to a different modality from the primary task reduces disruption to performance. For example, a nurse may select to engage or multi-task taking a phone call while engaging in a visually oriented task of medications verification or electronic barcode scanning. In contrast, errors may be more likely when a nurse verifies medications for his or her patients and is interrupted by a nurse colleague to visually verify high-risk medications, as required in independent double check verification policies. Li and colleagues (2012) propose there will be less cognitive disruption with cross-modality interruptions because they utilize non-overlapping cognitive resources. Understanding nurse SA and the effects of interruption handling or task-switching was not the intent of this research study. However, future research in controlled environments exploring effects of task-switching and interruptions is necessary to expand our understanding of the association between SA, interruptions, task-switching, and patient safety.

Limitations of this study include the sample size and sample characteristics that may have influenced study findings and interpretation, so caution regarding generalization is warranted. Limitations of the directed content analysis approach include (a) researcher bias given research knowledge and experience with theory and pre-determined codes could influence interpretation, (b) probe questions that might give participants cues on how to answer the questions in a manner that would please the researcher, and (c) overemphasis on SA levels blinding the ability to see other aspects of the phenomenon (Hsieh & Shannon, 2005).

Interruption is identified as a break in nursing performance. What's unexplained is an understanding of what information was present—before the nurse—but not attended to by the nurse. Therefore, an evaluation of attention tunneling (Endsley et al., 2003) is not conducted in this research and may also limit the generalizability of the findings. In addition, it is possible that there are organizational variables that influence staff workflow, unit-design, nurse staffing on various days and shifts (fewer staff means more interruptions). There may even be organizational expectations of how interruptions are to be handled (e.g., an organization's focus on patient satisfaction may preclude patient safety such as stopping to answer a call light may be more important than passing a medication on time). Finally, there was up to 1 week's time between the video event and the interview. After that span of time, it is possible that participants could not recall the total event of each interruption. It is also possible that participants may have inflated the importance of stopping medication administration to support their decision after the fact.

Future research should identify and examine specific skills and perceptible patterns in the context of nursing work situation in which they have occurred, as well as the nurse expert's specific strategies for dealing with those particular cues within those particular situations. It will be important that we better understand the influence and/or impact of eliminating the RN cognitive work from the linear task of administering the oral medications, determining standard operating procedures and delegating a non-RN to medication administration. Future research should include study of individual differences not accounted for in this study that may have influenced study findings including differences between less experienced and expert nurses, differences in attention as an innate ability, and finally differences in attention control.

The results of this study contribute to the growing body of literature describing the impact of the cognitive work of nursing on patient care delivery and implications for patient care safety. This research may serve as a baseline for explanatory research—ultimately informing quantitative question, design, and interventions to influence SA, cognitive time-sharing, cognitive stacking, and decision making during the medication administration process. Primary research findings reveal the description of SA prior to and during medication administration and including the selection of interruption handling strategies during medication administration. Observations of SA associated with expertise were revealed and consistent with previous, limited research in nursing (Sitterding et al., 2012). Cognitive time-sharing was discovered and consistent among all participants. The concept of SA as significant and applicable to nursing was further substantiated through this research. The interaction between SA and stacking was reinforced as described in previous research (Sitterding et al., 2012) as was the concept of SA within the cognitive work of nursing model (Ebright & Sitterding, 2014).

Characteristics of the contribution of this research to the body of nursing science include the following: (a) recontextualization of an existing research technique (uniqueness of CTA methods); (b) demonstration of a concept within a model (the concept of SA in the cognitive work of nursing—working paper—model); (c) codification of the obvious, that is providing evidence (SA, IHS, and cognitive time-sharing in nursing) for the phenomena believed to be true, but absent substantial evidence; (d) demonstrated taxonomy proposed in previous research (Colligan & Bass, 2012); and (e) implications for practice, policy, education, and future research.

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