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Examining the patterns of uncertainty across clinical reasoning tasks: effects of contextual factors on the clinical reasoning process

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Abstract

Objectives: Uncertainty is common in clinical reasoning given the dynamic processes required to come to a diagnosis. Though some uncertainty is expected during clinical encounters, it can have detrimental effects on clinical reasoning. Likewise, evidence has established the potentially detrimental effects of the presence of distracting contextual factors (i.e., factors other than case content needed to establish a diagnosis) in a clinical encounter on clinical reasoning. The purpose of this study was to examine how linguistic markers of uncertainty overlap with different clinical reasoning tasks and how distracting contextual factors might affect physicians' clinical reasoning process.

Methods: In this descriptive exploratory study, physicians participated in a live or video recorded simulated clinical encounter depicting a patient with unstable angina with and without contextual factors. Transcribed think-aloud reflections were coded using Goldszmidt's clinical reasoning task typology (26 tasks encompassing the domains of framing, diagnosis, management, and reflection) and then those coded categories were examined using linguistic markers of uncertainty (e.g., probably, possibly, etc.).

Results: Thirty physicians with varying levels of experience participated. Consistent with expectations, descriptive analysis revealed that physicians expressed more uncertainty in cases with distracting contextual factors compared to those without. Across the four domains of reasoning tasks, physicians expressed the most uncertainty in diagnosis and least in reflection.

Conclusions: These results highlight how linguistic markers of uncertainty can shed light on the role contextual factors might play in uncertainty which can lead to error and why it is essential to find ways of managing it.

Keywords: clinical reasoning; clinical reasoning tasks; context specificity; contextual factors; linguistics; uncertainty.

Introduction

Clinical reasoning is best conceptualized as the steps up to and including arriving at a diagnosis and devising a treatment plan based on the integration of information derived from the clinical encounter (e.g., patient interview, physical exam findings, etc.) [1, 2]. Clinical reasoning is an emergent process that is jointly constructed by the patient, physician and other participants in the encounter, and thus is influenced by *contextual factors* (factors arising from patient, physician, and environment like language barriers or misleading diagnostic suggestion) [3, 4]. When contextual factors are present, physicians may arrive at two different diagnoses for two patients with identical symptoms and findings who have the same diagnosis, a phenomenon called *context specificity* [4–6]. In this way, the presence of contextual factors can lead to diagnostic error (see Figure 1).

Situated cognition theory argues that learning and performance are shaped by and inseparable from the contexts of human behavior, cultural and social practices (e.g., clinical practices), and language [7]. Situated cognition can help illuminate the phenomenon of context specificity by emphasizing how participants (e.g., physician and patient), environment (e.g., availability or

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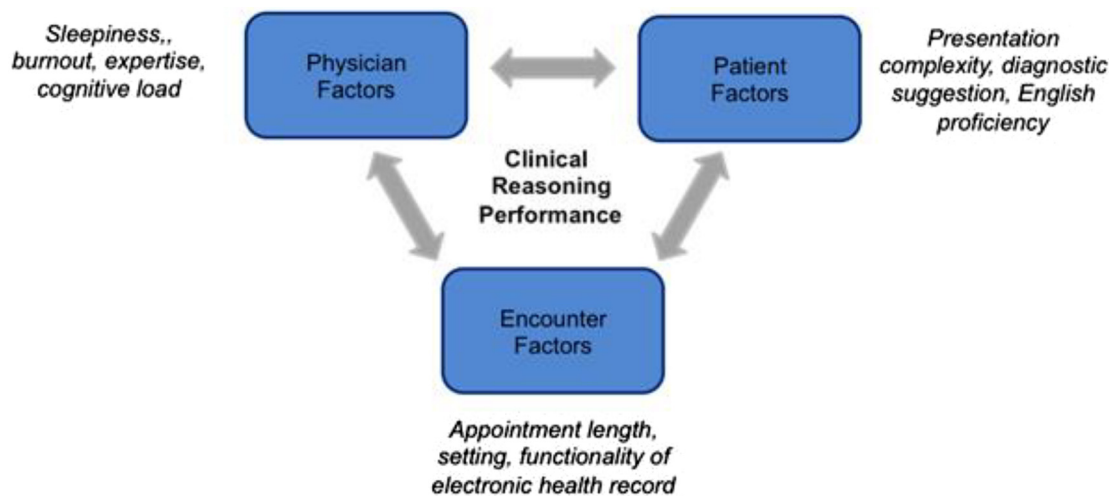


Figure 1: Situated cognition model for clinical reasoning.

absence of medical resources), and linguistic production (e.g., conversation) are part of the larger processes that shape clinical reasoning during a patient encounter [4, 7]. Rather than viewing clinical reasoning solely as a linear series of internal decisions, situated cognition conceptualizes reasoning as emerging dynamically from the specifics of the situation. Thus, situated cognition is an imperative lens for understanding *how* contextual factors such as diagnostic suggestion, patient language barriers, physician burnout, limited encounter time, and lack of medical resources, among others, may affect diagnostic reliability and hamper patient safety (see Figure 1) [4, 6, 8].

According to Goldszmidt and colleagues, physicians engage in distinct clinical reasoning *tasks* as they work towards a diagnosis and treatment [9–11]. Based on interviews with experts, Goldszmidt and colleagues developed a unified list of 24 clinical reasoning tasks—expanded in later applied work to 26—which physicians engage in during a clinical encounter [9–11]. These tasks are divided into four domains: a) framing (e.g., identifying active issues), b) diagnosis (e.g.,

identifying risk factors), c) management (e.g., establishing goals of care), and d) reflection (e.g., identifying knowledge gaps) [9, 11]. While recent work has begun to describe patterns in the use of these tasks, no study has yet used the framework of these tasks to examine physician uncertainty and how that may shift depending upon the unique context.

Reasoning through and having to make decisions based on numerous interwoven factors can lead physicians to feelings of uncertainty [12, 13]. Uncertainty, “an awareness of incomplete understanding of a situation or event” (p. 866), manifests sometimes in clinical reasoning as difficulty determining diagnosis and treatment plans [14]. Thus, it has become a topic of increasing interest in medicine where efforts are focused on understanding uncertainty’s role in clinical encounters as well as addressing ways of overcoming it [15]. Among other sources, uncertainty in clinical reasoning arises from case complexity or ambiguity, a lack of information or experience with a specific case, and the complex and emergent relationship between patient and physician [13–15]

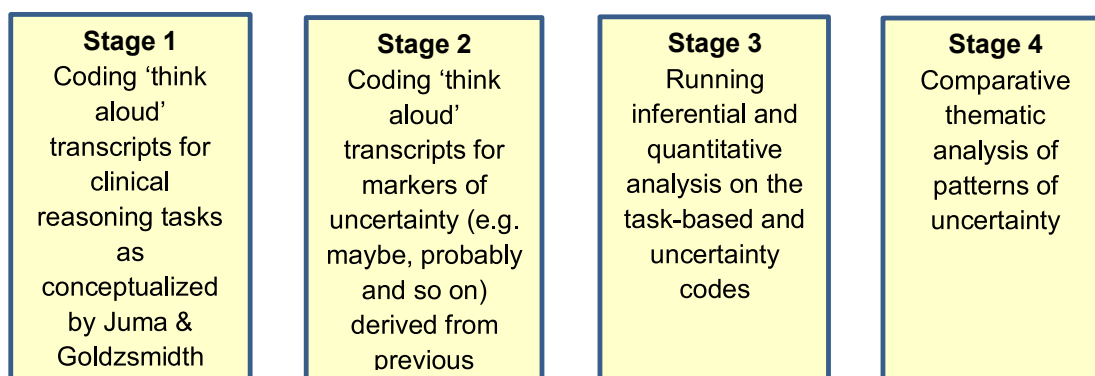


Figure 2: Stages of analysis.

Another source that could lead to uncertainty is presence of contextual factors in a clinical encounter (i.e., factors other than case content associated with the physician, patient, and environment; see Figure 1) [5]. These contextual factors (e.g., misleading diagnostic suggestion, language barrier, burnout, etc.) can impede physicians' ability to collect appropriate evidence (e.g., not asking about certain symptoms due to challenges with processing information provided) or with the use of that evidence to make an appropriate diagnosis (e.g., ignoring certain symptoms due to uncertainty contextual factors create about patient reliability) [16, 17].

Therefore examining uncertainty markers within the Goldszmidt framework [11]. of clinical reasoning tasks may help us to better understand where in the clinical reasoning process uncertainty emerges and how, if at all, the presence of contextual factors changes this pattern.

Even though in this exploratory study we do not examine physicians' uncertainty in relation to diagnostic accuracy, it is an important step towards that end as it will enable us to garner a better understanding of the prevalence of uncertainty in clinical reasoning so that we can appropriately support physicians in their uncertainty across a variety of contexts. Thus, this study examines patterns of uncertainty within clinical reasoning tasks in cases with and without potentially distracting contextual factors. We asked the following research questions:

- (1) Does the frequency of uncertainty markers differ in clinical reasoning tasks in cases with and without contextual factors?
- (2) Do patterns of uncertainty markers across framing, diagnosis, management, and reflection differ in cases with and without contextual factors? If so how?
- (3) How, if at all, does the use of uncertainty in diagnostic tasks differ in cases with and without contextual factors?

Materials and methods

This mixed methods study is a part of a larger body of research using situated cognition (among other theoretical constructs) to examine effects of contextual factors on physicians' clinical reasoning process [27, 28].

Sample selection

Study participants were practicing physicians (*intermediate*, with 10 years' or less experience, and *experienced*, with over 10 years' experience) in internal medicine, family medicine, and surgery. Since findings from the larger study revealed that participants experienced more difficulty with one of the clinical encounters (i.e., the unstable angina case) [26], we purposefully sampled every participant's unstable angina case for this study, comparing those participants who

had an unstable angina case with distracting contextual factors to those without the distracting contextual factor [16].

Procedure

Participants were randomly assigned to either a video or live simulation condition, depending upon their schedule availability (this scheduling aspect makes it not completely random, but we do not believe this influenced study results). Participants in both conditions were asked to either view a pre-recorded video depicting a clinical encounter or engage in a live scenario-based simulation with a standardized patient and then provide a diagnosis and treatment plan. The case content along with the distracting contextual factors was controlled for both conditions, but due to resource constraints, all live simulation participants experienced an angina case with contextual factors and a diabetes case without (resulting in an unequal sample size for this study). The chosen contextual factors were based on common occurrences in clinical practice (the patient offering a misleading diagnostic suggestion and reporting history in circuitous manner). Immediately following participation in the live or video encounter, participants were asked to "think aloud" about how they arrived at the diagnosis and treatment while they either rewatched the video or watched their own video performance [18, 19]. This think-aloud method has been a valuable tool in prior studies to explore clinical reasoning [19, 20]. The study protocol was approved by the Institutional Review Board at the Uniformed Services University in Bethesda, Maryland.

Data analysis

Analysis of transcribed think-aloud for this study was conducted in four stages. The clinical reasoning tasks and uncertainty markers were coded by two separate teams (EM & TR) and (DR, MS, & JM) based on their expertise and fields of knowledge (see Figure 2: stages of analysis).

Stage I: Task-based coding. To support our goal of examining uncertainty within clinical reasoning tasks, two clinicians (EM & TR) first coded each transcript for 26 possible tasks drawing on prior work [11]. using Goldszmidt and colleagues' four domains: a) framing (made up of three tasks, including: identifying active issues), b) diagnosis (made up of eight tasks, including: prioritizing differential diagnosis and selecting diagnostic investigations), c) management (made up of 13 tasks, including: establishing goals of care and assessing illness severity), and d) reflection (made up of two tasks: considering cognitive bias and identifying knowledge gaps) [11]. The think aloud were coded separately and later reviewed together. EM and TR, following procedures in prior work [11], discussed codes they either did not agree on or were unsure about, incorporating insights into a growing code book, to arrive at complete consensus.

Stage II: Uncertainty coding. To examine patterns of uncertainty, three team members with experience in qualitative research (DR, MS, & JM) coded the think aloud that were coded for clinical reasoning tasks for linguistic markers of uncertainty (e.g., probably, possibly, etc.), that have been identified in prior work in medicine to be associated with uncertainty [16, 21]. The think aloud were coded separately and later reviewed together to arrive at consensus. The number of uncertainty markers for each case was then recorded. We checked for inter-rater reliability among three researchers and found an agreement of 90% for the uncertainty codes.

Stage III: Exploratory and inferential data analysis: Frequencies and percentages of uncertainty markers across all four clinical reasoning domains, with and without contextual factors, were calculated. Additionally, an independent samples *t*-test was conducted to compare the rate of uncertainty in the presence and absence of contextual factors.

Stage IV: Qualitative follow-on analysis: Next, to better understand differences between cases with and without contextual factors, we conducted a comparative thematic analysis of the pattern of uncertainty markers. We purposively selected all eight diagnostic tasks since the broader aim of our research is to understand clinical reasoning and diagnostic error. We compared instances of uncertainty markers in cases with and without contextual factors, seeking to categorize what aspect of the clinical situation (e.g., patient symptoms, participant clinical knowledge, etc.) participants were uncertain about and whether these patterns of uncertainty *differed* in cases with and without contextual factors.

Results

Participants were 30 physicians (11 women, 19 men) from internal medicine (n=22), family medicine (n=3), and surgery (n=5), with varying levels of experience (21 intermediate physicians, 10 years or less experience; 9 experienced physicians, over 10 years' experience). The unstable angina case of 20 participants had distracting contextual factors and the unstable angina case of 10 participants had no distracting contextual factors. Only one of the 30 transcripts did not have uncertainty markers and we excluded this outlier (which had no contextual factors) from further analysis. Overall, transcripts were coded for a total of 335 uncertainty markers (see Table 1 for examples) and 1117 clinical reasoning tasks (see Table 2 for examples). Intermediate physicians had more uncertainty markers (23% of clinical reasoning tasks had uncertainty markers) than experienced physicians (only 12% of tasks had uncertainty markers).

Quantitative results

Overall, physicians expressed a higher rate of uncertainty when in the presence of a contextual factor (31% of clinical reasoning tasks coded in a contextual factor case had uncertainty markers) than not (27% of clinical reasoning tasks in a non-contextual factor case had uncertainty markers). Independent sample *t*-test analysis revealed this difference to be non-significant ($t(457.65)=1.22$, $p=0.225$) with low practical significance ($d=0.09$). Subsequently, exploratory analysis of the four types of clinical reasoning tasks (framing, diagnosis, management, and reflection) revealed that physicians express uncertainty most during diagnosis (70% of uncertainty markers fall in diagnostic tasks), followed by framing (17% fall in framing tasks), then management (11% fall in management tasks) and least in reflection (2% fall in reflection tasks; see Table 3). As

Table 1: Examples from think alouds reflecting patterns of uncertainty.

Examples	
1	"You know, my leading diagnosis would be probably angina"
2	"He says maybe it is faster during these episodes of chest pain"
3	"so kind of leading to maybe a cardiac, um, cause of this pain"
4	"have to sort of exclude heart disease or ... until you think about anything else"
5	" perhaps if he was having panic attack"
6	"then I would be calling cardiology to find out when they could be getting him in for a stress test"

Table 2: Examples from "Think alouds" reflecting the four domains of task based clinical reasoning.

Clinical reasoning task	Examples
Framing	"There's no swelling or pain in his legs"
Diagnosis	"I wanted to rule out, maybe, pulmonary embolism, anything like that, that could be contributing"
Management	"I just want to explain to him what's going on and what I'm thinking because he's clearly, probably already thinking about it. So, just acknowledging it and making sure that he gets a chance to answer any questions about the possibility".
Reflection	"I noticed that I asked a few leading questions, getting into it and I feel that I should have just asked 'pattern' first and then, if he needed prompting then go to, like, 'For example if ...'"

Table 3 indicates, this distribution of uncertainty markers across types of clinical reasoning tasks is relatively similar with and without distracting contextual factors (e.g., 16% of uncertainty markers occur in framing tasks in the presence of contextual factors and 21% occur in framing tasks in the absence of contextual factors).

Qualitative results

In order to better understand potential differences between the contexts, we qualitatively compared the use of uncertainty markers in clinical reasoning tasks between contexts, focusing on the diagnostic tasks (tasks 4 through 11, since most of the uncertainty markers fell in diagnosis domain of clinical reasoning tasks). First, for the critical task of determining the most likely diagnosis and underlying causes (task 7), only two participants denote uncertainty in the absence of contextual factors, versus five in their presence.

Of those five participants, two use uncertainty markers to pose what are incorrect diagnoses (“It’s **probably**, **likely**, pericarditis” and “reflux is probably the most likely thing”). Similarly, for the diagnostic task of considering and prioritizing differential diagnoses (task 4), participants in the contextual factor condition offer a wider range of possibilities of what the diagnosis “could” or “might” be (e.g., nicotine withdrawal, congestive heart failure, panic attack, etc.). Thus, the presence of contextual factors in this sample seemed to elicit a broader range of leading and differential diagnoses, which in some scenarios may be beneficial.

Second, for the tasks that involved generating underlying causes (identifying precipitants or triggers to the current problem [task 5] and identifying modifiable and non-modifiable risk factors [task 8]), participants express uncertainty around a wider variety of causes in the presence of contextual factors (e.g., caffeine or an energy supplement, a potential drinking problem). Meanwhile, in the non-contextual factor condition, participant uncertainty focuses on a narrower range of potentially relevant features like age, smoking history, and family history. Moreover, when generating reasoning processes like these when contextual factors are present, participants are more uncertain about their *own actions* versus the processes themselves (e.g., “I **should** have asked about, **like**, life stressors, work stressors”).

Third, regarding selection of diagnostic investigations (task 6), we found 15 uses of uncertainty markers in the contextual factors condition and only *one* in the non-contextual factors condition. In the presence of contextual factors, participants speculated uncertainty about a wide variety of potential diagnostic tests: “maybe” a TB workup; he “may” need an endoscopy; or “to kind of get a baseline.”

The other three diagnostic tasks—identifying complications associated with diagnosis or treatment (task 9), assessing rate of progression, response to treatment, and prognosis (task 10), and exploring physical and psychosocial consequences of treatment (task 11)—occurred sporadically in the data, but were *only* used with uncertainty markers in the presence of contextual factors. Of the 11 instances of these three tasks, four of them related to uncertainty about *patient* behavior or reporting, not the diagnosis, disease progression, or treatment consequences themselves (e.g., “if he does have uncontrolled blood pressure, **maybe** he isn’t taking his medications”).

Discussion

In this paper, we examined patterns in uncertainty markers while physicians engaged in framing, diagnostic, management, and reflection clinical reasoning tasks throughout a case of unstable angina with and without distracting contextual factors. The findings revealed that physician uncertainty trended higher, though not statistically significantly, in the presence of distracting contextual factors than in their absence, which is in line with our previous research [4, 16]. We also conducted a qualitative analysis to better understand the differences between expressions of uncertainty with and without contextual factors. On the other hand, we did not compare differences in uncertainty frequency between intermediate and experienced physicians. Given the scope of this exploratory study, we believe this additional comparison moves beyond our original RQs focused on the impact of contextual factors. However, we believe this is an interesting path to investigate as we dig deeper into the relationship between uncertainty, expertise, and the clinical reasoning process.

While all clinical encounters inherently have a certain degree of uncertainty, these findings suggest that contextual factors can introduce an additional level of ambiguity or complexity that may impede the reasoning process, creating even more uncertainty [22]. Another possible reason for increased uncertainty is that, as argued in prior work, contextual factors may increase cognitive load, which constrains the use of working memory [4, 5, 8]. When the ability to make full use of working memory is hampered, it may further introduce uncertainty as the physician has less capacity to process the wealth of other information present in a clinical encounter. Furthermore, our findings indicated that intermediate physicians (with less than 10 years of work experience) exhibited more uncertainty than experienced physicians in the presence of distracting contextual factors. This further supports past research contending that physicians with less experience have lower tolerance towards uncertainty and, hence, are less able to manage it and warrants further research [22, 23]

Our examination of the distribution of these uncertainty markers across the four clinical reasoning task types did *not* reveal differences in cases with and without contextual factors. Looking more closely at each of the eight diagnostic tasks

Table 3: Overall emergence of uncertainty in task based reasoning (per think aloud).

	Framing	Diagnosis	Management	Reflection
Percent uncertainty with contextual factors	16%	68%	14%	3%
Percent uncertainty, no contextual factors	21%	77%	3%	0
Percent uncertainty across all transcripts	17%	70%	11%	2%

qualitatively, however, uncertainty emerged as a difference in the range of options that were observed. The presence of contextual factors was associated with uncertainty concerning a wider variety of potential diagnoses, underlying causes, and diagnostic tests. One effect of context specificity, then, appears to be the creation of conditions for positing a broader range of clinical *possibilities*, whether the possibility to be a diagnosis like costochondritis, a trigger like an energy supplement, or investigations like a TB workup. Physicians in the contextual factors condition were perhaps holding in their minds a wider variety of potential diagnostic and treatment paths, which could potentially contribute to increased cognitive load [5]. This increase in diagnostic and treatment paths may be beneficial for some patients, but not others [24]. As such, considering a wider range of possibilities could improve or hamper patient care and thus, requires context sensitivity.

Participants in contextual factors cases also appeared to exhibit more uncertainty around patient behavior and information derived from their reporting than participants in non-contextual factor cases. Thus, not only are they considering more diagnostic and treatment options, but they may also be debating whether the patient is a trustworthy reporter, yet another source of cognitive load that may prove counterproductive.

Our study has several limitations. First, our sample size is small and groups were unevenly distributed, owing to availability of schedule participants assignment was not fully randomized, however the results of the study was not affected. Second, this study did not examine the relationship between uncertainty and diagnostic accuracy with a performance measure. Future studies should examine this relationship and whether interventions may be needed to mitigate any effects of uncertainty on performance. Finally, participants were distributed across the video and live simulation conditions. Future studies might focus on a single simulation modality as this may have an effect on the way physician's reason clinically.

This work has several important implications. First, the available evidence suggests that uncertainty is influenced by context and task, which is consistent with situated cognition theory and the notion that clinical reasoning is an emergent phenomenon. Our work suggests that developing meta-cognitive awareness of patient, physician, and environmental factors in the presence of uncertainty could improve patient care as it seems uncertainty is related to high cognitive load and lack of metacognitive monitoring [25, 29]; that is to heighten awareness of these aforementioned factors Our work also suggests that there are myriad of reasons why uncertainty occurs and that a "one size fits all" approach is unlikely to be beneficial. Finally, there are times that uncertainty may improve clinical care by prompting the physician

to generate, for example, an expanded differential diagnoses. Whether this is a benefit or hindrance and how it unfolds in clinical reasoning should be explored in future studies.

Given the ubiquity of uncertainty in clinical reasoning and its potential influence on reasoning, an important research endeavor would be to expand upon the work of Goldszmidt and colleagues [9–11], exploring both the tolerance for and management of uncertainty as a clinical reasoning task. We hope this work initiates important research and practice discussions on how to better address uncertainty and its role in the clinical reasoning process.

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