ABSTRACT:

User frustration research has been one way of looking into clinicians’ experience with health information technology use and interaction. In order to understand how clinician frustration with Health Information Technology (HIT) use occurs, there is the need to explore Human-Computer Interaction (HCI) literature that addresses both frustration and HIT use. In the past three decades, HCI frustration research has increased and expanded. Researchers have done a lot of work to understand emotions, end-user frustration and affect. This paper uses a historical literature review approach to review the origins of emotion and frustration research and explore the research question; Does HCI research on frustration provide insights on clinicians’ frustration with HIT interfaces? From the literature review HCI research on emotion and frustration provides additional insights that can indeed help explain user frustration in HIT. Different approaches and HCI perspectives also help frame HIT user frustration research as well as inform HIT system design. The paper concludes with a suggested directions on how future design and research may take.

Author Keywords:
Frustration, Emotional design, Affective Computing, Health Information Technology (HIT), Human-Computer Interaction (HCI), Interface design, Clinicians, User Experience (UX).

ACM Classification Keywords:
H5.2. Information interfaces and presentation: User Interfaces.

INTRODUCTION:

One of the overarching goals of Human-Computer Interaction (HCI) research has been to increase the good experiences and possibly reduce or mitigate horrible first experiences with technology. Licklider, in his “Man-Computer Symbiosis” [14] article decades ago, envisioned how a perfect, and relatively mutual relationship between humans and computer systems should be. When we think of times or experiences when we had to use technology for the first time or switch to a different technology, the thought may not always be pleasant. In fact, mostly unpleasant. Generally speaking, depending on one’s generation and “mental model”
of the new technology, the thought of this experience will generate either a happy or not so happy feeling. When technology is used, regardless of the type of technology used and reason for use, there is a formation of an initial relationship with the technology. Should the initial relationship last, a long-term relationship is sustained as well. Frustration which has long been defined by Lawson [25] as an “emotional state resulting from the occurrence of an obstacle that prevents the satisfaction of a need”, summarizes what the lasting relationship may entail.

**RESEARCH PROBLEM:**

As the American healthcare system slowly moves through technology adoption, implementation and meaningful use of Health Information Technology (HIT), one of the main areas of concern is the Human-Computer Interaction (HCI) and user experience of clinicians as they adopt, implement and use HIT. The problem here is that there has been research showing that frustration is one of the top unintended consequences that occur during Electronic Health Records (EHR) implementation and also through the first few months of post-implementation usage [5, 21, 22, and 25]. With literature repeatedly confirming the incidence of frustration in HIT system usage, there should be work done to finding successful approaches to solving frustration in HIT interfaces. This paper attempts to use such HCI research to explain and possibly inform design that could reduce frustration in HIT use.

**ORIGINS AND EARLY RESEARCH ON END-USER FRUSTRATION:**

With this concept of human-technology relationships, HCI research has re-defined itself to explore first experience interactions to find interdependencies, shared workload and address different emotional states such as frustration in technology use. HCI research has gone into issues such as why humans develop emotions towards technology and how to mitigate negative emotions towards technology. Domains like emotional design, affective computing and frustration research are born out of researching into these kinds of problems.

One of the main HCI research disciplines for some time now has been exploring ways in which human feelings towards technology can defined, quantified and monitored. The basic goal of this field is to know more about HCI and how to sustain and maintain this ‘relationship’ as ethically as possible [1]. The beginning of a shift in focus of emotion design and end-user frustration research started with cognitive and social research. Before the 2000s, research was already being done on frustration, affective computing as well as studying emotional states. Researchers such as Rosalind Picard and the likes, have spent years in Massachusetts Institute of technology (MIT) Media Lab studying the recognition, measurement and description of affect [9, 11, and 12]. Her work over time, especially on affective computing explores how computing relates to emotion.

**RESEARCH IN THE 2000s:**
The early 2000s saw research on emotional design such as works by Don Norman [17, 18, and 19]. Don Norman’s article “Emotional design: Why we love (or hate) everyday things” and his book on “Emotional Design” started a way of thinking that suggested that good design was imperative and that bad design not only generates a negative feeling like frustration but is also was not cost effective. Norman also collaborated with Ortony in “Designers and users: Two perspectives on emotion and design”. The goal of this article was to find out and share perspectives of emotion and design by both designers of technology and users of technology [19]. This research explains how a shared needs analysis between designers and users is essential to understanding what emotions are and how emotion is experienced with technology.

Lazar et al[13], also did some work that explored frustration focusing on what influenced a frustration experience. They wanted to find out more about causes and effects of frustration and so they looked at a bunch of users’ frustration events and reported on incidental (happening at one time) events versus session (over a period) events. These frustration events were the generic HCI frustrations or annoyances experienced when using a computer anywhere and were measured in levels. In the research, the authors found out that although a lot of user factors accounted for frustration, more people are angry at the computer than they were angry at themselves or even determined to fix the problem. Whether or not a frustration event was incidental or session was really critical in terms of the rating of frustration severity. Findings also included the fact that the user’s mood before and after a frustration event played a huge role in frustration severity.

In terms of emotional design research, round about the same time as Lazar and team were working on frustration experience research, Boehner et al [4] put out a paper that was unlike the then current approaches which defined emotion as just a cognitive experience. They argued that emotion was not just a state of being but interactional as well. Emotion information could be captured processed and output just like Card et al’s Human Processor Model. This argument and their research as a whole not only made it easier to break down emotion information and measure emotion in the 3 phases of the IPO model( i.e. during input, processing and output) but their explanation of how emotion can be treated as both information and interaction helps define, understand and explain emotion as well as measure it. Emotion can be socially and culturally understood and interpreted and this means that we should be able to understand and define emotion as both internal and also expressed differently in different contexts by different people.

Two years before this research, Boehner et al [3] did some research on affect. In their paper “Affect: From Information to Interaction”. Similar to their work on emotion as information, they explained how affect in affective computing approached as merely processed and expressed as information leaves no room for the feeling part of affect. Their approach (interactional) was rather from a perspective where the emotion or human users in affective computing is not lost but understood and supported as well. They came up with reasons to support why and how the interactional approach will work better. In essence when you approach affective computing and define affect as interaction as well, then one is able to see affect from both a social and cultural
product which relies on and supports flexibility and is not confined or formalized. Their work also acknowledged some challenges in this kind of approach however, the understanding that emotion is one way of looking into interactions helps think about ways to design for a more broader population and use. Bickmore and Picard’s research article “Establishing and maintaining long-term Human-Computer Relationships” in 2005 expanded on what human–computer relationships were in the first place.

Their goal was to find out how personal and interpersonal social relationship constructs can be applied to human-computer relationships. It is interesting to note that they were able to identify that the same reasons for relationships in human-human interaction could be applied to human-computer interaction. So for example, people could form relationships with ATM machines for economic gains just as people form relationships with other people for economic gains. Human relationship communication and management also applied to human-computer relationships. The authors also introduced relational agents to help with long term human-computer relationships that focused on and sustained despite multiple interactions. In research like this, there is a new window opened for HCI designers and researchers to look into. It is easier to understand human-computer relationships if we can compare it with human relationships. User frustration research was still being done.

Research on general computer usage and frustrating experiences like those by Ceaparu et al[7,8] measured how often frustration occurred, what caused frustration and how bad the experience was. These research looking at user experiences on common applications on web platforms and how users handled it. They recorded that some common experiences were during mailing and word processes. The perceived causes of end–user frustration ranged from error messages to dropped network connections to hard-to-find features on interface. These research showed that frustration is a huge problem that needed to be addressed. Based on the data they received, it was evident that self-reported high levels of frustration and wasted time was among the top list of concerns in a frustration occurrence. These data also could be expanded into both financial and usage ramifications in the future. Knowing these causes, and frequencies of user frustration, research is a critical first step in exploring more about what could be done to reduce user frustration. Other researchers also studied how computer systems and interfaces could automatically detect frustration in users [11] and also how to design computers to respond to user frustration [12].

RECENT RESEARCH ON HCI FRUstration:

More recently, research on frustration has focused on more dynamic aspects on end-user frustration like how we can harness frustration for the good. In fact, Frustration, sometimes referred to as confusion or anxiety or anger, is a special type of negative feeling or emotional state experienced not only in life but also in HCI. This is described as “A strong, negative emotional state” that users feel when they interact with technology or computer system interfaces [7, 9]. Frustration in HCI has been considered to hinder system
usability. For example, the research by Lazar et al [13] showed that there is a difference in frustration experience in student users versus worker users of a computer system. Which means a more tailored approach can be researched into so that narrowly focused research and design suggestions can be made for EHR design so as to mitigate frustration.

**A little bit of frustration is good!**

Baker et al [1] in their article on frustration compare the “cognitive-affective” states of students in different computer-based learning environments. Amongst other things, they found out that frustration was better than boredom in the different kinds of “cognitive-affective” states they evaluated. It can be inferred from the article that in any learning environment like what clinicians experience during the implementation of EHRs, confusion and a little bit of frustration may be better for the learning experience that boredom. This meant that it will be prudent to invest in system designs that randomly interrupted with routine boring processes but also monitor the amount of interference so as not to create a terrible experience for clinicians.

Riseberg et al [24] had long before researched on using frustration for the good. In their article “Frustrating the User on Purpose: Using Bio-signals in a Pilot Study to Detect the User's Emotional State”, they show how frustration could be induced in computer game interfaces in order to be able to detect and group frustration events that create similar emotional states making it a great approach to explore users’ states during human computer interaction. Current research [9, 10] refine what Riseberg et al did. Mentis [16] also did some work on interruptions in cognitive workflow that elicits the experience of frustration. She found out that in instances where people remember their frustration moments in interface interactions, those moments were times where the system had to respond to user needs/actions and not times when users were figuring out how to translate their thoughts to actions on the interface. This means that remembered frustration experienced occurred in the second half of an interaction mostly because there was a break in what interfaces were supposed to be displaying or executing to users.

**WHY HCI LITERATURE REVIEW IS NEEDED:**
The HCI literature reviewed provides an understanding of some basic parts to frustration as well as emotional design research. The literature review explores origins of end-user frustration, what has been done quite recently and future directions that researchers could take. From the literature, we know that man and computers can form a symbiotic relationship in which each contributes to the relationship [14]. This means that it is essential to know which parts of an HCI that humans take responsibility versus which parts a computer should be left to complete. Not only do we know that such human-computer relationships can exist we also know that we can apply human-human concepts, definitions and constructs to human-computer relationships as well [2, 6]. The same way human relationships involve emotions and sometimes frustrations, we are able to understand that there is the need to design for emotions and cater to frustration events should they arise [2]. User-frustration research which can also be found in affective computing research championed by people like Picard, Norman, Dourish, Bohner, Schneiderman etc. have been able to narrow down research to reflect specific
interface use, human factors, system factors, and perspectives. This is very helpful because then in thinking about using HCI use-frustration to explain and possibly influence future research and design in HIT, I will consider such finding and use their results as baselines to further research in HIT user frustration.

From the literature, we know what the right questions should be. For example, we know that the question in user frustration is not whether frustration is a good emotional feeling or not. We even know that in certain contexts, a little bit of frustration is good [1] and frustration has been used to find out more about emotional states [9, 24]. However, in thinking about what contributes to frustration and what HCI concepts helps better understand frustrations in HIT interfaces, a lot of factors come to play; long-term HCI relationship[2], definition of the affective state called frustration (information or interaction)[3,4], severity of frustration(self-reported or actual)[7,8], implications of severity of frustration in a system(economic, social, usage, perceived)[8,12], perspectives(system, user or designer) [11, 12, 13, 19], ways to measure user frustration with systems[9,11,16,22] come into the picture.

The solution to HIT clinician frustration is to first identify what makes clinician frustration different from the frustration events described in the literature. Specifically, what is causing frustration at that moment? From Bickmore and Picard’s work [2], it is safe to assume that overarching goal of any HIT implemented is to maintain a long-term relationship between clinicians and the systems after implementation. With the HITECH act and meaningful use, there is even a higher incentive to mitigate frustration which hinders such long-term relationships. This a broader picture of why frustration hampers the goal of IT adoption in healthcare.

There is also the issue of context and expectations from the clinician. In trying to address frustration, it will be better to consider what role the HIT is playing and the consequences of interruptions such as frustration. This means that technology which most ideally satisfies its reason for being, is subtle. Just like breathing, we wouldn’t know we are using it. He further explains that this evolution of technology adoption and implementation is only natural “a fundamental consequence not of technology but of human psychology....Whenever people learn something sufficiently well, they cease to be aware of it.” There is therefore a presumption that the initial phases of computer or technology interactions are not as unconscious or spontaneous as later phases where the technology is pervasive. Our experiences with technology, especially for the first times are memorable; either in a good way or a horrible one.

**Combined-approach to frustration research in HIT:**

In any HCI, there is a human and a computer system involved. A combined approach to frustration research in HIT will be to combine the human-side research with the computer-side design approach to mitigate frustration. In this case, issues like shared interaction and designing for human users are discussed jointly with HCI themes and theories. Interaction theories may be in the form of visualization, peripheral vision, affordances, human cognition, user preferences, abilities, capabilities, limitations, mental models, etc.
DISCUSSIONS AND FUTURE RESEARCH:

Over the timeline of frustration in HCI research, there is much discovered. We know what frustration is, what causes it, how we can measure it, how we can attempt to mitigate it both from user side and system design side, we know what other human states (psycho-/physio-/socio-, cognitive, mental, effective, affective etc. etc.) are involved in HCI frustration. The next phase of research should probably focus also on prior experiences that feed onto frustration and how that better tells the story of how frustration is experienced.

There is also the need to critically research into what makes frustration in HIT hypothetically more severe or relatively unbearable that frustration in other interactions. We may (or may not) discover that the frustration experience is just what it is regardless of the kind of technology or interface interaction. Assuming HIT interaction frustration proves more annoying (due to many other factors like safety, lives at stake, timeline crunch etc.), then research much begin to address it in a more ‘wholistic’ way like the combined approach. Perhaps it will be best to approach it will be by framing a scenario (see fig 1).

Fig1: HIT frustration incidence model.

Framing a Scenario:

This scenario is just a way to approach an instance of frustration that can be comparable to a use case in system design. Assuming you have a nurse¹ experiencing frustration with a computer order entry (CPOE) interface, what could be a logical HCI research-based explanation to such experience? We know that frustration can happen in all stages of technology use especially the initial phases.

To frame this scenario and better explain the frustration; let’s break the experience into three (3) phases: Pre-experience, inter-experience, and Post-experiences;

- **Pre-experience Phase:** The pre-experience phase of any HCI is the collection of knowledge, experience, ideas, mental models and skills that a user already has before he or she experiences frustration. Most at times, stress which is a higher determinant of frustration may play a major role in inducing frustration.

¹ Note that this model may illustrate several frustration circumstances.
during interaction. In our scenario, the nurse’s background, prior experience (or not) with interface, values and beliefs, physical and intellectual capabilities and time constraints could factor into her pre-experience that leads to frustration.

- **Inter-experience Phase:** This phase will be the particular moment when the clinician is in front of the interface interacting with the computer. Here the clinician’s physical, social and cognitive abilities, capabilities and limitations influence the severity, instance and overall frustration experience at the moment. The interface’s design, visualization features, affordances, display and feedback also contribute to the experience.

- **Post-experience:** After the frustration experience, a clinician acts upon one of three feelings (see fig 1) that they are left with. 1. A self-motivating feeling that makes them want to try again and not give up. 2. An indifferent feeling that makes him/her only use the technology or interface when necessary but avoid the interaction most of the time. A perfect instance is when clinicians are required to use hospital technology. 3. A worst-case scenario when a clinician gives up and decides not to use the interface any more.

  These 3 post-frustration decisions are critical in that whichever one a clinician decides on: a) Determines the frustration threshold they have reached. b) Determines what mitigation steps to use. c) Could lead to insights on where the link broke.

**CONCLUSIONS:**

When user frustration is explained using HCI principles and themes, there will be a better way to address the issue. The US healthcare system still faces some push-back in adoption and use of HIT. Clinicians are frustrated by EHR systems; either by interface design or how these systems interrupt workflow. The goal is to move past current research into what frustration is, to applied research on how the knowledge of frustration can be applied to HIT. Unlike frustration in other interfaces like web navigation, HIT interfaces has the component of frustration by limited interface view.

There are other distinct differences that can be explored. Frustration in EHR interfaces occurs at all stages especially the initial implementation phase. When a clinician experiences frustration; there are three (3) phases involved: pre-experience, inter-experience and post-experience. All these three (3) phases have factors (especially HCI theories) that come to play. Health care interfaces may have certain distinct features or functions that makes frustration experiences in such HCI’s different.

Our interactions with the technology should be able to amount to a relationship that can be sustained rather that a relationship that makes it difficult to maintain due to experiences such as frustration.
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