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Effective use of patient-centric health information systems: The influence

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ARTICLE DE RECHERCHE

Effective use of patient-centric health information systems: The influence of patient emotions

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ABSTRACT

The present study examined how patients' emotional responses to a Portal (i.e., a patient-centric health IT designed to help patients self-manage their chronic condition) influenced their effective use of the Portal. Based on interview data collected from 34 asthma patients, we identified six categories of emotions that the Portal's usage evoked in patients who participated in the study. While patients who had negative emotions about the Portal tended to always use it ineffectively, the effectiveness with which patients who had positive emotions used the Portal varied according to their differing perceptions of the Portal. In addition, while all positive emotions were associated with high frequencies of Portal use, this usage was not always effective as it was sometimes not aligned with the Portal's goal of asthma self-management. These findings suggest that designers and implementers need to pay greater attention to the emotional responses that patient-users can have, and to try to minimize the emergence of negative emotions by designing systems that induce in patients a positive experience and self-image, as well as joy while promoting their effective usage of these systems.

Keywords: *Emotions, Asthma self-management, Effective use, Health information technologies, Qualitative research.*

RÉSUMÉ

La présente étude a examiné comment les réponses émotionnelles des patients face à un Portail (c.-à-d. un système de gestion des maladies chroniques centrée sur l'utilisateur et conçu pour aider les patients à autogérer leur maladie) ont influencé l'efficacité avec laquelle ils ont utilisé le Portail. Grâce à l'analyse des entretiens avec 34 patients asthmatiques qui ont utilisé un Portail d'autogestion de l'asthme, la présente étude a identifié six catégories d'émotion que le Portail a suscitées chez les patients ayant participé à l'étude. Bien que les patients qui avaient des émotions négatives envers le Portail l'ont utilisé de façon inefficace, les émotions positives, quant à elles, étaient liées aux utilisations efficaces autant qu'inefficaces, selon la perception que les patients avaient du Portail. Par ailleurs, malgré le fait que les émotions positives étaient toujours associées à une fréquence d'utilisation élevée du Portail, cette utilisation n'était pas toujours efficace car elle n'était pas toujours alignée avec l'objectif d'autogestion de l'asthme. Ces résultats indiquent que les concepteurs et les analystes des systèmes ont besoin de porter plus d'attention aux réponses émotionnelles des patients-utilisateurs, tout en essayant de minimiser l'émergence des émotions négatives en concevant des systèmes qui génèrent chez des patients une expérience et une image de soi positives ainsi qu'une certaine joie, et d'encourager une utilisation efficace de ces systèmes.

Mots-clés : *Emotions, Système de gestion d'asthme, Utilisation efficace, Technologies de l'information de la santé, Recherche qualitative.*

1. INTRODUCTION

IT can evoke in users different positive and negative emotions which can influence their usage behaviors (Cenfetelli, 2004; Desmet, 2012; Gregor *et al.*, 2014). For example, while an easy to use interface of high quality can evoke joy and liking, the intrusiveness and poor usability of an IT can create stress and frustration (Ayyagari *et al.*, 2011; Ethier *et al.*, 2006). Also, while positive emotions can lead to the acceptance and continued use of an IT, negative emotions can result in resistance and abandonment (Djamasbi *et al.*, 2010, Maier *et al.*, 2015). As many patients need to cope with the emotional effects of their disease, the role played by emotions is likely to be more important for patient-centric health IT, i.e., health record systems that are initiated and maintained by a patient and are designed to empower patients by helping them transition from a passive role in which the patient is the recipient of care services, to an active role in which they are involved in the decision-making process (Demiris *et al.*, 2008). Today, many patient-centric health IT help patients manage chronic diseases, such as asthma and diabetes

(Demiris *et al.*, 2008), as they enable them to communicate with their health care providers or other patient communities, while also helping them engage in self-care activities and solve problems that arise in their everyday life (Solomon, 2008).

It is important to note that patients who suffer from chronic diseases often need to adjust their lifestyle and employment conditions, which in turn can lead to stress, anxiety, and depression, and a need to cope with the emotional aspects of their situation (Turner & Kelly, 2000). As such, examining the emotional consequences of using patient-centric health IT could help researchers identify useful approaches for improving patient health by helping patients to use such IT more effectively. While a few IS studies have explored the effect of emotions on IT usage behaviors (e.g., Beaudry & Pinsonneault, 2010; Cenfetelli, 2004; Tractinsky *et al.*, 2000), the impact of emotions on IT usage effectiveness, particularly in health care contexts, remains largely unexplored. As such, the present study's objective is to begin answering the question: *how do patients' emotional responses to a patient-centric health IT, designed to help them self-manage their chronic condition, influence their effective use of the IT?*

In health care contexts, self-management (SM) refers to the medical management of one's illness and the maintenance of important life roles (Lorig *et al.*, 2006), in order to promote a patient's ability to manage the symptoms, treatments, and physical, as well as the psychosocial consequences and lifestyle changes of living with a chronic condition (Coleman & Newton, 2005). IT can provide SM support for chronic illnesses, especially when it is integrated with ongoing medical care. Patient-centric health IT can encourage patient participation in disease prevention and management (Polomano *et al.*, 2007) and can help improve SM by being available at home or at work, at the convenience of the patient, and by providing information when needed. Such IT are often designed to help increase patient participation in disease prevention and management, as well as to help them manage the intense anxiety that often accompanies the need to live with a chronic disease such as asthma, by allowing them to communicate with a care provider and by reassuring them that they will receive support when they need it. It is important to note that past research has also found that such IT do not always help patients reach their health objectives (Garcia-Lizana & Sarria-Santamera, 2007).

While past research in IS and HCI has examined the influence of emotions on IT use and the emotional consequences of IT use (e.g., Beaudry & Pinsonneault, 2010; Cenfetelli, 2004; Norman, 2004; Tractinsky *et al.*, 2000), current knowledge regarding the emotions that patient-centric health IT can evoke and how such emotions can influence their behaviors, their effective usage of the IT, and ultimately their health is quite limited. Hence, we investigated patient emotions in the context of a patient-centric IT via an inductive qualitative study of patients who used an asthma SM system for three to six months. In addition, drawing from Burton-Jones & Grange's (2012) theoretical framework of effective IT use, we also examined how patients' emotional responses influenced their effective use of the system.

The present study contributes to the IS literature by identifying the strong influence of emotions in health IT contexts and how the different emotions that health IT tend to evoke in patients can influence their effective usage, acceptance and routinized use, as well as the

quality of the health care that is provided. The present study's findings can also be useful for designers and implementers, as it can help them better manage the potential emotional consequences of patient-centric health IT by designs that can help patients have more positive experiences and self-images, while limiting their feeling of negative emotions.

2. LITERATURE REVIEW

According to Yin *et al.* (2014), different disciplines have focused on different conceptual paradigms in studying emotions. While some of these paradigms assume that emotions essentially vary along a limited number of dimensions (Mano, 1991; Watson & Tellegen, 1985), such as valence, arousal, and power, the present study is aligned with the more dominant paradigm which is aligned with cognitive appraisal theories (e.g., Lazarus, 1991; Scherer *et al.*, 2001; Smith & Ellsworth, 1985) and assumes that emotions are consequences of individuals' personal interpretations of events and their situational environment, such as pleasantness, certainty, and control (Yin *et al.*, 2014).

Cognitive appraisal theories (e.g., Lazarus, 1991), define emotions as "*mental states of readiness that arise from the appraisal of events and one's own thoughts*" (Bagozzi *et al.* 1999, p. 184), and according to Bagozzi *et al.* (1999), emotions are often accompanied by physiological processes that are expressed in gestures, facial features, and postures. An emotion can also result in specific actions that are undertaken in order to cope with it (Lazarus, 1991). Note that, emotions are not produced solely by an event since different individuals can have different emotional reactions to the same event, and their reactions can also be deliberate and conscious, or automatic and unconscious (Bagozzi *et al.*, 1999). Zhang (2013) examined affective concepts in an IS context, investigating their similarities and differences, and how they relate to each other, categorizing them as core affect, stimulus, perceived affective quality, affective quality, affective cue, mood, temperament, emotions, and attitude. Further, and in line with Bagozzi (1999), she suggested that emotions reside between a person and a stimulus, that they typically arise as reactions to situational events in the individual's environment, and that when activated, they can generate feelings and action tendencies.

The HCI and IS literatures have studied the relationship between emotions and IT use from different perspectives. For example, some researchers studied the influence of emotions on IT use, such as Todman & Monaghan (1995) who found in an experimental study that IT usage was influenced by the pressure users felt when interacting with a computer and the extent to which they thought they were in control, and Maier *et al.* (2015) who found that emotions like technostress could lead to intentions to discontinue usage. As noted by Cenfetelli (2004) and Zhang (2013), affect and emotions are significant predictors of IT use and, according to Zhang (2013), one's affective state and an IT's affective cues and quality can influence one's affective reactions, as well as their affective evaluations during interaction with a particular IT. It is important to note that Beaudry & Pinsonneault (2010) classified emotions into four groups: challenge, achievement, loss, and deterrence. They argued that while the perception of achievement can result in positive emotions like happiness, satisfaction, joy, and pleasure, perceiving an IT event as a loss or lack of control can

lead to emotions such as anger, dissatisfaction, frustration, and disgust. On the other hand, when one perceives an IT event as a threat (deterrence), one tends to experience emotions such as anxiety, worry, fear, and distress, and perceptions of a challenge can lead to excitement, eagerness, playfulness, and arousal. Other studies have suggested that, when using complex IT, positive emotions can reduce usage anxiety and improve the usability experience (Tractinsky *et al.*, 2000), and positive mood and emotions can lead to IT acceptance (Djamasbi *et al.*, 2010).

Adopting a different perspective, some researchers have examined how IT can evoke different emotions. For example, Ethier *et al.* (2006) studied the impact of website quality on the cognitive processes that lead to consumer emotions and found that it can influence emotions such as joy, liking, pride, dislike, and frustration. Ayyagari *et al.* (2011) investigated the influence of IT use on stress and found that IT characteristics such as usability, intrusiveness, and dynamism affected users' stress levels, while Thuring & Mahlke (2007) found that poor mobile phone usability increased the negative emotions felt by users.

2.1. Health IT and user emotions

The main objectives of health IT are to improve access to health care and the quality of care. Examples include Electronic Health Record systems (EHR) or Electronic Medical Record systems (EMR) which are designed to improve communication among different providers in a health care organization and also to facilitate integration of patient health history for planning accurate treatment (Kohli & Tan, 2016; McCullough *et al.*, 2010), as well as patient-centric systems, i.e., health record systems that are initiated and maintained by individual patients.

Interestingly, health IT have been observed to arouse different emotions. For example, Gustafson *et al.* (1999) studied an IT that provided HIV-positive patients with information, decision support, as well as with connections to experts and other patients, and found that the IT significantly decreased patients' negative emotions by helping them seek support for dealing with their emotional responses to their health problems. Moreover, health information seeking behavior is also argued to have emotion-focused coping functions by reducing negative reactions (e.g., anxiety) and by providing reassurance. Overall, information seeking efforts are thought to help manage the relationship between patients and stress sources, contributing to positive health outcomes (Lambert & Loiselle, 2007; Fourie, 2009). In addition, a study of online EMR found that such tools evoked positive emotions in patients who suffered from chronic diseases by creating a perception of support, which in turn eventually improved patients' adjustment to their chronic illness (Winkelman *et al.*, 2005).

While the extant literature provides examples of the arousal of positive emotions as a consequence of using health IT, some studies have observed that health IT can also evoke negative emotions. For example, Sittig *et al.* (2005) examined emotional responses to a Computer-based Provider Order Entry (CPOE) system which enabled a patient's care provider to enter orders for medications, radiology or clinical laboratory tests. Having observed both positive and negative emotions as a consequence of using CPOE systems, the authors provided design guidelines for evoking positive emotions via positive feedback.

Patients' appraisal of an IT and its emotional consequences can also influence how they interact with them, which in turn can influence their health outcomes. For example, Anderson & Agarwal (2011) found that patients' health-related emotions influenced their willingness to disclose personal health information and to allow its digitization. It is also important to note that, while positive emotions are likely to help the adoption of health IT, it does not necessarily mean that people who adopt an IT and use it routinely will also be using it effectively.

2.2. Effective use of information technologies

The use of IT is generally thought to provide a key indicator of their adoption and implementation success, as well as to be a prerequisite for deriving their benefits (DeLone & McLean, 1992; Petter *et al.*, 2008). However, while IT use can be an appropriate measure of IT adoption success in some contexts, it may not necessarily yield the benefits that system designers or managers expect or consider to be desirable. As such, researchers argue that IT use needs to be effective if it is to produce desired benefits (e.g., Burton-Jones & Grange, 2012; Seddon & Kiew, 1996), defining effective use as "*using a system in a way that helps attain the goals for using the system*" (Burton-Jones & Grange, 2012, p. 633). According to this view, systems are used in order to perform a task, and tasks are goal-oriented activities. For example, using Excel in an accounting firm can be considered effective if it is used to perform accounting-related tasks, but it will not necessarily help achieve its desired benefits when used for other purposes. Further, as stakeholders can have different goals, effective use can also be defined according to their differing perspectives.

A concept similar to effective use is proficient use, defined as "*the extent to which individuals fully utilize a system as 'designed and intended by the designers' to perform an array of relevant job-related tasks*" (Viega *et al.* 2014, p. 694), and operationalized as the extent to which individuals fully utilize the core applications within a specific software that are designed and intended to enhance their performance on essential tasks. Other related concepts include enhanced use (Bagayogo *et al.* 2014), which reflects novel ways of employing IT features, and expectable use (Walsh *et al.*, 2016), defined as a *"user's disposition, or inclination, to use any IT pro-actively and in a self-determined fashion"* (p. 178). Expectable use includes affective, cognitive and behavioral components, and it is thought that, depending on context, the dispositional aspect of IT usage may evolve over time, and that some components of expectable use can have a significant impact on effective use.

Burton-Jones & Grange (2012) examined the nature of effective use by drawing from Representation Theory (RT) and argued that an IT needs to provide a faithful representation of its real world domain that meets the needs of its stakeholders' (i.e., designers, users, managers). Based on RT, while IT may be used for task-specific purposes, the main purpose of all IT is to help people understand the state of some real-world phenomena. For example, a word processing IT can represent the state of a user's mind when he or she is writing a text, and an accounting system can represent the state of a company's business. It is important to note that users generally desire to see in a system a faithful representation of their domain of interest, e.g.,

a faithful representation of the status of employees in a human resource management system. Hence, an important condition that needs to be taken into account when assessing whether or not the use of a system is effective is the extent to which a user is able to access representations of his/her state of interest through the IT's interface and physical structure. This characteristic of the user-IT interaction has been labeled *transparent interaction* and is defined as "*the extent to which a user is accessing the system's representations unimpeded by its surface and physical structures*" (p. 642). For example, if users are able to easily find and use the features they need to perform their work, their interaction can be viewed as transparent. A second characteristic of effective IT usage is the extent to which a system faithfully represents the real domain, i.e., *representational fidelity***,** defined as "*the extent to which a user is obtaining representations from the system that faithfully reflect the domain being represented*" (p. 642). For example, if a user has a contact list database that is up to date with the most recent email addresses of her contacts, then she can be sure that the email list faithfully represents her contacts, and that her contacts will receive her emails. A third dimension, labeled *informed action*, focuses on how users interact with a system when they have access to a faithful representation, and is defined as "*the extent to which a user acts upon the faithful representations he or she obtains from the system to improve his or her state*." (p. 642). An example would be an accountant who acts based on correct data to produce the required reports. Thus, according to Burton-Jones & Grange (2012), effective use involves transparent interaction, representational fidelity, and informed action.

It is important to note that the above dimensions are hierarchically related (Burton-Jones & Grange, 2012): informed action cannot be performed without representations that are faithful to the real domain, and representational fidelity cannot exist if users are unable to access representations. Moreover, the three dimensions refer to user-system interactions, and not independently to only the system or the user. Thus, the objective of the present study is to first inductively identify the emotional responses of the users (i.e., patients) of a user-centric asthma SM system and then to explain the relationship between their emotions and effective use of the system according to the Burton-Jones & Grange (2012) framework.

3. RESEARCH DESIGN

3.1. Study context

Self-management (SM) of asthma is mainly concerned with the systematic education of asthma patients in order to engage their active participation in controlling their asthma by avoiding its triggers and reducing its symptoms (Kotses & Creer, 2010). As such, asthma SM promotes patient ability to manage the symptoms, treatments, and the physical, as well as psychosocial consequences and lifestyle changes inherent in living with an asthmatic condition. Integrating SM into their daily life requires patients to master skills related to medical SM, and to develop problem solving and coping skills to deal with emotions that arise from living with asthma and its exacerbations (Holman & Lorig, 2004). IT can provide opportunities to improve SM support for chronic illnesses such as asthma by integrating it with ongoing medical care.

As well, such systems allow patients to modify the way information is presented to them and to receive information that is specifically relevant to their personal condition.

The IT examined in the present study is a web-based asthma SM Portal developed by the Clinical and Health Informatics research group of a North American university. In a trial study, 52 patients used the Portal for a period of three to six months. The Portal's patient interface required each patient to answer, approximately twice a week, pre-determined questions about his/her health status and medication-adherence. Based on the data they entered, the Portal provided feedback about the patients' health status. The pre-determined questions and the feedback mechanism were designed so as to enable patients to self-monitor their symptoms, medication adherence and physical activity. The Portal also advised them about what to do if their asthma was not under control. Further, a nurse case manager used the Portal's nurse interface to monitor each patient's asthma status. When the nurse noticed any problems, such as ambiguous data or an out-of-control asthma status, she e-mailed the patient and provided feedback. The patient could also e-mail the nurse to ask questions or share information.

3.2. Data collection

The University research group recruited individuals who had asthma from two North American hospitals and asked them to use the Portal for three to six months. The patients had been in poor control of their asthma despite having been prescribed appropriate therapy and a written action plan. Patients who had serious medical diagnoses such as lung cancer or with severely limited mobility that prevented them from leaving home were excluded from the study.

To examine their use of the Portal and emotions, semi-structured interviews were conducted with patients in locals provided by the university research group. The choice of a qualitative research approach was mainly due to the exploratory and inductive nature of the study and its objective was to help identify patients' emotional responses to the Portal and provide a better understanding of the relationship between their emotions and Portal usage. Hence, we developed an interview protocol to capture patients' general experience with the Portal, their perceptions of its functionalities and their usage. The interviews were conducted at one point in time (cross sectional) and shortly after their usage period which lasted from October 2011 to May 2012, with each interview lasting around one hour. Interview data was collected from 34 patients (Table 1) and the interviews were transcribed for analysis.

3.3. Inductive identification of emotions

In the first phase of the analysis, we identified patients' emotional responses to the Portal according to emotion-related codes that were based on a taxonomy of emotions proposed by Storm & Storm (1987), considered to be one of the seminal studies in psychology regarding emotions (Laros & Steenkamp, 2005). Storm & Storm (1987) identified 525 everyday English words related to emotions and suggested that these could be grouped into clusters, yielding a hierarchical structure where specific emotions represent particular instances of more general underlying basic emotions. They then grouped semantically homogenous terms associated with specific emotions,

Age	Number of patients	Gender Female (n=21) Male (n=13)
18-24	1	Average usage of
25-29	3	computers per week 31.70 hours
30-34	3	Average age
35-39	3	diagnosed with asthma 27.18
40-44	5	
45-49	1	
50-54	10	
55-60	3	
over 60	5	

Table 1. Participant demographics.

associated each group with a basic emotion, and grouped positive emotions into five and negative emotions into eight categories (Table 2).

In Storm & Storm's (1987) taxonomy, each category has certain common characteristics. For example, "sadness" refers to a class of negative emotions, including melancholy, disappointment, wistful, guilt, hurt, sorrow, and grief. These negative emotions are considered to result in sadness because of the absence of something desired (e.g., wistful), or someone's own behavior as the cause (e.g., guilt) or someone else's behavior as the cause (e.g., hurt), or implying a deep distress (e.g., sorrow). "Pride" is another general category which refers to a class of positive emotions, and according to Storm and Storm (1987), emotions in this group share a feature of superiority or ascendance. "Contentment" is another example that refers to a group of positive emotions that are all passive and low in arousal and which do not imply a specific external event. It is interesting to note that the next group, i.e., "happiness", also reflects a positive emotion, but it represents a different group than "contentment" since the latter does not imply a reaction to an external event but "happiness" and other similar terms do.

Positive terms	**Negative terms**
Love: desire, attraction, adoration	**Shame:** humiliated, shy
Liking: admiration, friendly, affection, empathy	**Sadness:** melancholy, wistful, guilt, hurt, sorrow, grief
Contentment: relaxed	**Pain:** agony - misery
Happiness: glad, amusement, hope, fun, thrill, joy	**Anxiety:** worried, nervous, tension, upset
Pride	**Fear:** dread, terror, shock
	Anger: frustration, indignant, dissatisfaction
	Hatred: revenge, defiant, spite, envy, dislike, distrust, bitterness
	Disgust: contempt, distaste

Table 2. Positive and negative emotional terms (adapted from Storm & Storm, 1987).

In order to identify patients' emotional responses to the Portal, one author coded the interview data via N'vivo (ver. 10), based on Storm & Storm's (1987) positive and negative emotional terms (Table 2). For example, when a patient stated: "*I feel like they [the Portal's feedbacks] don't give a proper sense of what it's like really… I'm a freak like that…I like things to be right*" (PA22), he indicated that he was "dissatisfied" with the Portal's functionality, and hence the sentence was coded as "dissatisfaction" which belongs to the "anger" category. As another example, Patient PA8 stated "*I like the idea of the Portal and the way it works. I think it's a very good idea. Just the idea that everything could be online somewhere where a doctor or a nurse or anyone could get a hold of it and see how you're doing seems very intelligent to me and it makes you take care of yourself better".* This statement was coded as "admiration", which belongs to the "liking" category.

3.4. Identifying instances of effective and ineffective usage

After extracting patients' emotional responses to the Portal, we searched for instances of effective or ineffective use based on what they had reported, and linked them to their emotions. To do so, we relied on Burton-Jones & Grange's (2012) three-dimensional framework of effective use and coded the interview data in terms of "transparent interaction" between the patient and the Portal, "representational fidelity" of use, and "informed actions" of the patients. As noted earlier, "transparent interaction" refers to whether users have access to system representations. In the Portal context, this included "accessing the Portal and being able to login to the Portal", "accessing a care-provider through the Portal" or "accessing the feedback mechanism". Further, "representational fidelity" was present when the content accessed by the patient was clear and correct. For example, when patients correctly and regularly entered their medication and symptoms history and hence the system provided them with feedback that accurately reflected their health status, their use of the Portal was considered to have representational fidelity. Finally, patient actions were classified as being informed if they helped achieve system goals. In the Portal context, this mainly consisted of actions that enabled patients' asthma SM. For example, when patients checked the feedback mechanism of the Portal (i.e., Asthma Diagram) and acted based on its advice, when they contacted the nurse for medical advice, or when they analyzed their health conditions based on historical graphs, we classified their interaction with the Portal as being informed and aligned with system goals. It is important to note that our assessments were based on patients' perspectives regarding the three dimensions, i.e., we relied on their perceptions of the Portal's "transparent interaction", "representational fidelity", and their "informed actions".

3.5. Analysis of the relationship between emotions and effective usage

In order to study the relationship between users' emotions and their Portal usage, we searched the interview data for instances of self-reported usage that were accompanied by patients' emotional expressions related to the Portal. For example, PA33 stated: *"My Action Plan I knew by heart so and I never really communicated with the nurse either so I didn't use any of those things. It was*

really just to update My Target and check the weather… but I'm a nurse so I know about asthma, I know what I need to do, I know what triggers it, I know what helps it…I just didn't feel that I need it". As PA33's comments indicated that she did not use the Portal regularly, and felt that the system did not provide her with feedback that accurately reflected her health status, her Portal use can be considered to *lack representational fidelity*. PA33's usage behavior was accompanied by feelings of being annoyed by the Portal.

In another example, PA24 described the Portal as *"It kind of pushed me to walk. Usually, I'm sitting all day long. I don't go out so often. So with the Portal, actually, I was moving much more, and then I noticed like OK, oh, if I walk from here to here, it makes a certain number of steps, I'd been counting steps. That was fun. I like this part."* In this case, the Portal appeared to encourage PA24 to exercise more, which also represents a way to SM her asthma, and can be viewed as *presence of informed action* since the patient used a tool to count steps and enter the data into the Portal. This self-reported behavior was accompanied by a feeling of joy.

3.6. Identifying emotion-usage patterns

In the last step of our analysis, we examined how patients' emotional responses to each of the three dimensions of effective usage influenced their consequent usage behavior, and depicted these relationships in terms of patterns. According to Burton-Jones & Grange (2012), the three dimensions of effective usage are hierarchically related: the first condition that needs to be satisfied for the usage of a system to be effective is the extent to which a user can access system representations, i.e., the presence of transparent interaction. If this condition is met, then the second needed condition is the system's faithful representation of the real domain, i.e., the presence of representational fidelity. Finally, when faithful representation is present, usage can be considered effective if a user's interaction with the system reaches its goals, i.e., the presence of informed action. In other words, informed action cannot be accomplished if the system's representations are not faithful to the real domain, and representational fidelity cannot exist if system representations are not accessible to the user.

It is important to note that, the hierarchical relations between the three dimensions yield only four possible patterns. If system usage is considered to be transparent, then it is possible for the user to have access to a faithful or unfaithful representation of it. On the other hand, if usage is not transparent, then the user will not be able to access a faithful representation of the system (Burton-Jones & Grange, 2012). The same condition applies to the relationship between a system's representational fidelity and users' informed actions. If the system does not represent the real domain, then it is not possible for the user to perform any informed action (Figure 1).

As noted above, we first coded interview data based on effective use dimensions and emotion categories, and then linked emotional responses to each of the three usage dimensions according to whether the respondent had expressed any emotions and feelings related to that usage behavior or not. Finally, by examining the interview data, we tried to identify if the presence or absence of an effective usage dimension was influenced by the emotional responses associated with that dimension.

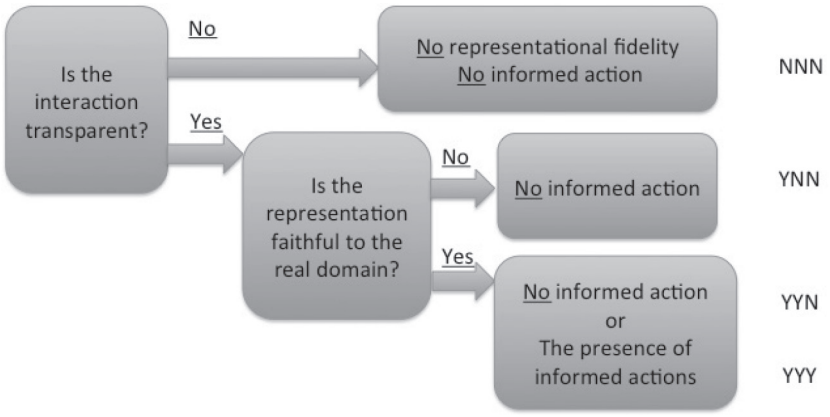

Figure 1. Possible usage patterns.

4. RESULTS

As described below, while using the Portal evoked in some patients positive emotions, such as love, liking, and joy, in other patients it generated negative emotions, such as anger, guilt, disappointment, frustration, and sadness (Table 3).

4.1. Emotions

4.1.1. Love, adoration, attraction

One category of positive emotional response that we observed related to attraction to and adoration of the Portal. Patients who expressed such emotions noted that the Portal had saved their lives or had the potential to do so, and felt that they depended on it. For example, one patient viewed it as a mother who took care of her sick child: *"… it's like somebody is looking in on you. It's like when you're sick and you're a kid and your mother comes to look in on you. She's not going to make you any better, but if she looks in on you at night before you go to sleep you feel better. So someone's looking in. That's what I feel." (PA25)*

Thus, PA25 viewed the Portal as an extension of health care providers, felt emotionally dependent on it, and sought attention from it. Another patient noted that the Portal saved her from going to emergency rooms: *"I don't remember if there was some sort of accident or if there were fires, but there was smoke everywhere. Everywhere, everywhere, everywhere and there were advisories on the Portal, you know, if you have asthma or you're elderly, don't go outside and so I didn't and I saved myself probably two or three trips to the emergency room." (PA21)*

Similarly, another patient also thought that, in case of an emergency, the Portal could save his life by connecting him to healthcare providers: *"Well, I find, like I said, it's advantageous because if ever, God forbid, I need to contact a nurse, I can log into the Portal and there is a number that I can be in touch with somebody and get taken care of instantaneously or almost instantaneously… Many thanks for linking me up to this program! I love it!" (PA26)*

Emotions	Examples
Love, Adoration, Attraction	"… it's like somebody is looking in on you. It's like when you're sick and you're a kid and your mother comes to look in on you. She's not going to make you any better, but if she looks in on you at night before you go to sleep you feel better. So someone's looking in. That's what I feel." (PA25)
Liking, admiration	"Well that was probably the best thing. It was the contact, but I mean, it relieved the frustration that I was able to contact the asthma nurses and get some feedback and get an appointment with an asthma doctor, so that was good." (PA18)
Happiness, joy	"I found it to be very amusing. I succeeded in doing what I had to do." (PA29)
Anger, frustration	"I'm a nurse so I know about asthma, I know what I need to do, I know what triggers it, I know what helps it. So I didn't feel like I was very helpful to the study but I just didn't feel that I needed it, I guess." (PA33)
Disappointment	"I feel like they [the feedbacks] don't give a proper sense of what it's like really… I'm a freak like that…I like things to be right." (PA22)
Guilt, Sorrow	"I feel guilty. I know that's my own self, it's my own thing, you know, my own personal thing, I feel guilty for smoking. I don't smoke very much and I know that I should quit, but I just don't. I have maybe 3 or 5 cigarettes a day so, even at that, people say why do you smoke then? I don't know, it's a habit. So yeah, sure it would trigger something in me, guilt for being a nurse, being a smoker." (PA33)

Table 3. Examples of Patient Emotions.

4.1.2. Liking, admiration

A second category of positive emotions we observed included liking and admiration, and patients having these emotions also found the Portal useful. For example one of them stated: *"It was a nice way to keep track of the things that were necessary. I liked it because I found it useful" (PA21).* Similarly, another patient liked the fact that he could receive feedback from healthcare providers through the Portal: *"Well that was probably the best thing. It was the contact, but I mean, it relieved the frustration that I was able to contact the asthma nurses and get some feedback and get an appointment with an asthma doctor, so that was good." (PA18)*

4.1.3. Happiness, joy

A third category of positive emotions included joy and happiness. For example, one patient stated: *"I really enjoyed the program, and I was kind of disappointed*

when I found out it was terminated." (PA26) Another patient felt that using the Portal was fun because he viewed it as providing him with the challenge of reaching an objective. As such, he viewed the Portal's usage as a game and he was happy each time he overcame a new challenge: *"I found it to be very amusing. I succeeded in doing what I had to do." (PA29)*

4.1.4. Anger, frustration

One category of negative emotions we observed pertained to anger and frustration. Some patients felt that the Portal treated them as little kids who could not take care of themselves, and they thought that they were knowledgeable about asthma and that they did not need the Portal's help to manage their disease: *"I'm a nurse so I know about asthma, I know what I need to do, I know what triggers it, I know what helps it. So I didn't feel like I was very helpful to the study but I just didn't feel that I need it, I guess."(PA33)*

Another patient who was a nurse like PA33, also felt that she knew about asthma and that the Portal was imposing: *"I know this, you don't need to tell me this, but you know what I mean? This is not something I need to be told every day. It's not like I'm a little child, even a little child wouldn't need to be told that every day." (PA18)*

Another patient also felt anger and frustration when using the Portal as she felt knowledgeable about asthma and did not need a tool to help her manage it: "*If you get sick, blah, blah, blah. Yeah but even my action plan on paper I don't check it, I know what to do. So that's why I don't check it… for managing my asthma this wouldn't be the right tool because I know pretty much how to deal with it." (PA22)* She also felt angry with the Portal because it reinforced the self-image of a sick person: *"I didn't like it [the Portal], I was like, yeah it shows that I'm very sick… I don't consider myself sick, like if I have asthma I'm not a sick person per se." (PA22)*

4.1.5. Disappointment

Another category of negative emotions pertained to disappointment and stemmed mostly from the Portal's perceived lack of functionality to answer patients' needs. For example, a patient who preferred to use more natural remedies felt that the Portal encouraged the use of prescription medications too much: *"I think I would have liked to have seen a little bit more of other things you can do other than just drugs. You know, there are things I used to control my asthma that when the drugs don't work and they work, you know, so even just things like I find nettle and peppermint tea will help or Shiatsu pressure points things." (PA18)*

Another patient felt disappointed with the Portal because she found it to be inaccurate and of poor quality: *"I feel like they [the feedbacks] don't give a proper sense of what it's like really… I'm a freak like that…I like things to be right." (PA22*) Along the same vein, and contrary to PA22's expectations, the nurse did not regularly provide her with feedback on her health status: *"I thought this was going to be a little bit more present in a way but it turned out it's just like if you need her [the nurse] you go, but I had kind of the feeling that the nurse would give you feedback on what you would put in every week and there wasn't really that feature.*» (PA22)

4.1.6. Guilt, sorrow

A third group of negative emotions we observed related to guilt and sorrow. These feelings that usually lead to sadness imply that one's own behavior (e.g., guilt) creates

sadness or one feels distressed (e.g., sorrow). One patient who was a nurse felt that she knew about asthma, but because she smoked and did not manage her asthma well, she perceived the Portal as an imposer that made her feel guilty: "*Yeah, it does. I feel guilty. I know that's my own self, it's my own thing, you know, my own personal thing, I feel guilty for smoking. I don't smoke very much and I know that I should quit but I just don't. I have maybe 3 or 5 cigarettes a day so, even at that, people say why do you smoke then? I don't know, it's a habit. So yeah, sure it would trigger something in me, guilt for being a nurse, being a smoker." (PA33)*

4.2. Effective use

In order to investigate the emotions that were associated with effective use of the Portal, we searched the interview data for instances of self-reported usage that were accompanied by patients' emotional expressions related to the Portal. The dimensions of effective use, i.e., "transparent interaction", "representational fidelity" and "informed actions", differed across patients and time, with some patients using the Portal effectively in some instances of their usage period of several months, and ineffectively in other instances.

Transparent interaction: some patients noted the presence of transparent interaction when they indicated that the Portal provided them with the content they needed, such as getting connected to a health care provider, accessing a history of their medication usage, symptoms, and their action plans. On the other hand, some patients expressed a lack of transparent interaction during their usage period. For example, some had problems accessing the Portal due to a lack of browser compatibility, or reported that there was a system bug which prevented the "Asthma Diagram" to function properly.

Representational fidelity: while some patients found the Portal's content to be correct and complete, others thought that it differed from reality. For example, they thought that the Portal provided them with wrong feedback about their health status, that the nurse was not always available to answer their questions, or that their medication list was not complete, i.e., not all of their medications were present in the Portal's medication list. In such cases, the usage instance was coded as lacking "representational fidelity".

Informed action: some patient actions were not well-aligned with the broader objective of asthma SM. For example, some patients only entered their health information to the Portal and never consulted its feedback, which meant that they did not use it to analyze their health status. Such usage instance cases were coded as ineffective in terms of lack of "informed action".

4.3. Emotions and effectiveness of portal use

As can be seen in the summarized results of Table 4, while negative emotions were invariably associated with ineffective use of the Portal, positive emotions were sometimes associated with effective use and sometimes with ineffective use.

4.4. Usage-emotion patterns

To further examine the relationship between patients' emotions and usage behaviors we searched for emotional responses that could be observed for each of the three effective usage dimensions. We also examined how patients' emotional responses to each dimension influenced

Emotion	Portal Use
Love, Adoration, Attraction	Effective use: The patients expressing these emotions frequently used the Portal to enter their medication usage and also to check its feedback. They could easily access the Portal and its features (most of the patients) *(Presence of transparent interaction).* Some patients who expressed love toward the Portal, regularly and correctly entered their medication usage and their symptoms and perceived the feedback mechanism as being correct (e.g., PA21, PA26, PA31) *(Presence of representational fidelity).* They analyzed their symptoms and self-managed their asthma accordingly. They were also interested in communicating with the nurse via the Portal in order to ask health-related questions (e.g., PA21, PA26, PA31) *(Presence of informed action).* Ineffective use: The patients who expressed these feelings also used the Portal frequently to enter information. However in some cases the information they provided was incomplete or incorrect which in turn influenced the accuracy of the feedback they got from the Portal (e.g., PA29) *(Lack of representational fidelity).* Some patients used the Portal mostly to send information to health care providers without checking its feedback. They also had frequent email exchanges with the nurse, but rarely asked for help to solve health-related problems. As such, they were not using the Portal to self-manage their asthma (e.g., PA25, PA29) *(Lack of informed action).*
Liking, admiration	Effective use: Some patients who expressed liking and admiration toward the portal frequently used it to enter their medication usage and also to check its feedback, analyze their symptoms and SM their asthma accordingly. They were also interested in communicating with the nurse via the Portal to ask health related questions (e.g., PA21), used the Portal as a personal assistant to help them manage their asthma (e.g., PA27), or as a reminder to take their medication on time *(Presence of transparent interaction and informed action).* As well, the Portal provided some of them with useful asthma information which they appreciated (e.g., PA24) as it reflected their health status correctly *(Presence of representational fidelity).* Ineffective use: Some patients expressed liking and admiration toward the Portal, but they were not willing to use it as they thought that it was not useful for their situation. For example, PA14 considered himself to have a very mild asthma condition and did not feel the need for a tool to manage it. But he thought that the Portal could be useful for more severe asthmatic patients *(Lack of informed action).*

Emotion	Portal Use
Happiness, joy	Effective use: These patients used the Portal frequently and perceived its features to be easily accessible. Some of them expressed joy toward the Portal and found its content to be accurate and a correct representation of their health status (Presence of *transparent interaction and representational fidelity).* Some of them monitored their health status by using the Portal's historical graphs (e.g., PA26). Its feedback encouraged some patients to exercise more and they followed its advice (e.g., PA24). Also, some found its Asthma Diagram feature to be like a game in which they had to get a higher score in terms of SM, which was an activity they enjoyed (e.g., PA4) (*Presence of informed action).* Ineffective use: Some patients who expressed feelings of joy toward the Portal used it frequently, but they did not correctly update their weekly symptoms and medications, which in turn made their feedbacks unreliable (e.g., PA5) *(Lack of representational fidelity)*. Some patients used it for other purposes than asthma self-management. For example, PA29 who liked the Portal and admired it, used it to contact the nurse and chat with her about issues unrelated to self-management *(Lack of informed action).*
Anger, frustration	Ineffective use: Some of these patients could not access the Portal at the beginning of their usage (*Lack of transparent interaction).* They did not use the Portal frequently, had very limited communications with the nurse, and did not properly update their data (e.g., PA33, PA18, PA22) *(Lack of representational fidelity).* Some refused to do what the Portal asked them to do because they did not think it was useful for their health (e.g., PA34) or they found it offensive (e.g., PA1) *(Lack of informed action).*
Disappointment	Ineffective use: Some of these patients did not properly update their data (e.g., PA18, PA22) *(Lack of representational fidelity).* They refused to use the Portal because some of them expected all feedback to come from real people and not from an automated software (e.g., PA34). Also, some believed that the Portal did not function as expected or found it to be irrelevant for them (e.g., PA22). For example, PA20 expected the Portal to be connected to her doctor in the hospital which was not the case. Hence, such patients refused to use the Portal to manage their asthma *(Lack of informed action).*
Guilt, Sorrow	Ineffective use: Some of the patients were not interested in using the Portal and communicating with the nurse via the Portal because they did not find the Portal useful. They also thought that if they were to receive negative feedback from the Portal about their asthma management status, it would remind them of their neglect in controlling their asthma, which would evoke feelings of guilt and sorrow. Hence, they essentially did not use it to self-manage their asthma (e.g., PA33) *(Lack of informed action)* and did not properly update their data (e.g., PA33) *(Lack of representational fidelity).*

Table 4. Emotions and Effectiveness of Portal use.

their consequent usage behaviors and overall emotional responses. This analysis helped identify four usage-emotion patterns that are described below.

4.4.1. Pattern 1: NNN

In the NNN pattern, the difficulties some patients experienced in accessing the Portal's content (*Lack of transparent interaction*) seemed to evoke negative feelings, which in turn led them to perceive the Portal as *lacking representational fidelity*, i.e., they saw the Portal as being unable to provide them with correct and trustworthy information, and as a result, they did not engage in any action that would represent SM of their asthma with the Portal. That is, they either reduced their usage or, because they did not trust the Portal's feedback, they ignored it, resulting in negative feelings toward the Portal. For example, one patient mentioned that there was a bug in the Portal's Asthma Diagram feature, which made it difficult for him to access his health feedback, which in turn made him feel dissatisfied. Difficulty in accessing the Portal's feedback mechanism discouraged him from entering his health data regularly (i.e., leading to the Portal's *Lack of representational fidelity*) and negatively influenced his trust in the system. He expressed feelings of dissatisfaction and anger toward the Portal, which consequently hindered him from performing informed actions to manage his health (he was infrequently logging into the Portal during this period) until the bug was fixed. He was disappointed throughout this period.

4.4.2. Pattern 2: YNN

A second pattern we observed was YNN, where the patients felt they could access the Portal and its features without any difficulty (*Presence of transparent interaction*), and hence they did not express any negative feelings. However, they viewed the Portal's content as being incorrect and unreliable (*Lack of representational fidelity*), which evoked negative feelings, and hence these patients did not undertake SM actions (*Lack of informed action*). For example, one patient stated that he could not find his medications in the Portal's medication list database, which evoked in him feelings of dissatisfaction. Thus, *Lack of representational fidelity* discouraged him to enter correct data into the Portal, which consequently rendered its feedback unreliable for him. Thus, he could not use the Portal effectively until his medications were added to the Portal's database. In another case, a patient entered incorrect information into the Portal because of her lack of interest in the Portal, which consequently made the Portal's feedback unreliable, and therefore no informed action could be performed. She expressed guilt and sorrow for not using the Portal correctly, while also expressing a lack of interest in, and disappointment toward the Portal.

4.4.3. Pattern 3: YYN

In the third observed pattern, and similar to Pattern 2, the Portal and its features could be accessed without any difficulty, indicating *Presence of transparent interaction*. Moreover, patients who exhibited Pattern 3 also entered correct information into the Portal and received feedback that corresponded to their health situation, indicating that the Portal *had representational fidelity* (for these patients). While the Portal's feedback was encouraging for some of them, i.e., it was viewed as an indication that they were doing a good job of managing their asthma, it was not perceived as such by others who felt that it reminded them that they were not

managing their asthma well. It is interesting to note that the Portal' advice could have helped this latter group identify problematic patterns and initiate a search for solutions and actions to minimize these effects, but did not do because of their reaction.

The YYN patients' reactions to the Portal's feedback differed: while some expressed negative feelings toward the Portal and therefore did not use it to perform SM activities, some accepted the Portal's feedback, regardless of whether it was encouraging or not, and expressed feelings of admiration or adoration for it. For example, in one episode, a patient who entered her asthma status, medication, and symptoms correctly, received feedback from the Asthma Diagram feature that she was not managing her asthma well, i.e., her health status was yellow. Although she was aware of her poor SM, she felt bothered by the fact that the Portal kept reminding her about it over and over again. As such, she had feelings of anger and frustration toward the Portal, and did not use it to manage her health; she used it only to enter her data (because the medical team needed it), but did not follow the Portal's advice to manage her asthma.

In another case, a patient entered his health data very frequently and accurately, and felt that the Portal's content could be trusted (*Presence of representational fidelity*), and he expressed feelings of satisfaction toward it. However, he did not engage in any informed actions, i.e., he did not check the Portal's feedback graphs or Asthma Diagram, and consequently did not follow the Portal's advice irrespective of its positive or negative nature. He essentially reacted passively, expecting that he would be taken care of either by the Portal or the health care team: "*… somebody is actually watching and taking care to monitor what I'm feeding in. So if I'm feeding in information that goes outside of my personal profile, someone's going to pick up on it."(PA25)* He expressed emotions such as love or adoration toward the Portal mostly because he thought that the Portal and the people behind it had the responsibility to take care of him. As such, he basically provided the data that the system needed and the feedback he received from the Portal did not make him engage in SM actions, despite his strong positive emotions toward the Portal.

4.4.4. Pattern 4: YYY

The fourth pattern we observed was exhibited by patients for whom all three dimensions of effective use existed and were perceived as such by them. That is, the Portal and its content could be accessed easily (*Presence of transparent interaction*), they entered their health status data correctly, and the feedback they received represented their health status regardless of being positive or negative (*Presence of representational fidelity*). They also used this feedback to better manage their disease (*Presence of informed action*). In general, patients who reported this usage pattern also expressed positive emotions toward the Portal, such as admiration and happiness. For example, a patient who entered her data frequently, noted that the Portal motivated her to walk and that it was fun for her to count her steps and enter that data on her next login into the Portal. Her wish was to be able to play with her kids (her condition did not allow her to do so at that moment) and she felt that the Portal could help her reach that goal. She expressed feelings of joy and admiration toward the Portal.

The four usage-emotion patterns described above are aligned with the Burton-Jones & Grange (2012) theoretical framework in which the three dimensions are hierarchically related to each other. That is, informed action cannot be performed if the representations are not faithful to the real domain, and representational fidelity cannot exist if system representations are not accessible to users. Moreover, it is important to note that, each patient could experience one or more usage-emotion patterns during the three to six month usage period. For example, some patients initially went through an ineffective Portal usage span due to a technical problem (*Lack of transparent interaction*) and expressed negative emotions, but when the problem was resolved, they could use the Portal effectively and expressed positive emotions toward it.

5. DISCUSSION

Self-management systems are designed to help patients manage their chronic condition by making them active participants in their treatment process. Moreover, these systems are designed to facilitate the care process and help patients deal with the physical and emotional consequences of their disease. The present study examined the emotional consequences of using such a system, i.e., an asthma SM Portal, as well as how different categories of positive and negative emotions influenced how effectively asthma patients used it. We found that, while the Portal evoked in some patients positive emotions, such as adoration, admiration, and joy, in others it led to negative emotions, such as feelings of anger, guilt, or disappointment.

The extant literature has often discussed anxiety, affect, anger, and playfulness as consequences of IT use (Beaudry & Pinsonnault, 2010; Ethier *et al.*, 2006; Ayyagari *et al.*, 2011; Thuring & Mahlke, 2007), with other emotions remaining largely uninvestigated. Perhaps partly due to the nature of e-health IT and the emotional aspects of the care delivery process, the present study observed emotions such as love, guilt and sorrow which have not been noted in past IS research. In addition, the present study also found that, in a health IT context, feelings of anger could be triggered by system-induced perceptions, such as making patients feel helpless and unqualified, which complement other causes that have been observed in past research, such as "loss" or "lack of control" (Beaudry & Pinsonnault, 2010).

We also found that, while patients who had positive emotions were interested in using the Portal and used it frequently, their usage was not always effective. For example, while adoration and liking seemed to encourage patients to use the Portal more frequently, their usage was not always effective. On the other hand, those with negative emotions were reluctant to use the Portal and used it ineffectively and very little. For example, patients who felt anger, disappointment, and guilt tended to make ineffective use of the Portal and did not engage in proper SM, which ultimately influenced their quality of care.

Although positive emotions seemed to encourage the Portal's usage and acceptance, they were not always associated with its effective usage. Some patients who expressed feelings of love toward the Portal used it for purposes other than asthma SM. For example, one of the Portal's main functions was to provide feedback to patients so that they could self-monitor their symptoms, medications

and physical activities. However, some patients only entered their health data and did not consult the Portal's feedback, and hence they were not managing their disease via the Portal. It appeared that they were basically hoping that a health care provider would receive their data and help them in case of an emergency. In other words, they undertook a passive role in the process, which ran counter to the goal of the system and the Portal, i.e., asthma SM. For these patients, their love of the Portal can be explained by their strong need to receive care and support in order to deal with their chronic disease. As such, they viewed the Portal as a tool which could take care of them, and had a positive emotional connection with it, but they did not use it effectively. Chronic disease patients are personally responsible for their own day-to-day care, and are often best placed to assess the severity of their symptoms and the efficacy of their treatment. As such, they need to be active participants in their treatment, i.e., patients are considered to be key to SM, and without their active participation, controlling their disease becomes very difficult (Lorig *et al.*, 2006).

We also observed other instances of positive emotions and ineffective Portal usage. For example, using the Portal was like playing a game for some patients, and some used it to chat and for social relationships, but without considering the Portal's feedback on their health status. Yet, although these patients had strong positive emotions about the Portal, they failed to achieve its intended purpose, i.e., SM. This finding further supports the view that more frequent usage is not necessarily a valid measurement of adoption or implementation success, as it may not always lead to improved performance or greater satisfaction (Burton-Jones & Straub, 2006; DeLone & McLean, 2003).

Moreover, the four usage-emotion patterns we identified strongly suggest that patients' emotions can change during their usage period depending on changes that can occur in the interaction process. For example, patients who initially had negative emotions toward the Portal experienced positive emotions when their interactions with the Portal improved. For some patients, this seemed to be the result of a change in their access to the content of the Portal, e.g., a technical problem was resolved, or in the way they used the system, e.g., they learned how to make use of the Portal's different features. This observation is consistent with the findings of past research on emotions which views them as consequences of one's personal interpretation of events and the situational environment (Yin *et al.*, 2014). That is, when the situational environment changes, emotions toward it can change as well.

In addition, the four usage-emotion patterns we observed also suggest that during a given usage episode, negative emotional reactions that can stem from a lack of transparent interaction and representational fidelity can lead patients into not performing informed action, i.e., not using the system to achieve its goals. That is, a user who perceives that a system is not accurately representing its real domain will tend to express negative feelings toward it, and since he/she will view the system as unreliable, he/she will tend to *not* use it effectively. Thus, in order to encourage effective usage of SM systems, it would be important to design them in ways to increase the users' trust in the system's content and its feedback. In addition, we also found that all negative emotions were associated with ineffective Portal usage: patients who felt anger, disappointment, and guilt, used it either rarely or stopped using it after

a short while. Some of them even entered erroneous or incomplete information to the Portal, i.e., low representational fidelity, which suggests that it would be important to prevent or minimize negative emotions that can be generated by SM technologies.

As the results of our analysis suggest, emotions toward a user-centric system and its effective usage are closely linked. Our findings suggest that negative emotions toward a system tends to lead to its ineffective usage, hindering informed actions. As such, it would be preferable to design systems that are reliable and also loveable. Moreover, it is important to note that designing a high quality system is not enough to ensure that users will like it or use it because other factors also play important roles in evoking positive emotions toward a system.

According to Lazarus (1991), emotions are responses to stimuli that are relevant to the individual and which can be assessed in an appraisal to see if a stimulus has affected the individual. For example, Beaudry & Pinsonneault (2010) noted that the perception of achievement regarding an IT event can result in joy and pleasure, and the perception of lack of control can lead to frustration and dissatisfaction. According to Desmet (2012), there are six main sources of emotions in human computer interactions: 1- Object (emotions in response to the material qualities of a product), 2- Meaning (emotions in response to the meanings or beliefs associated with a product), 3- Interaction (emotions in response to the interactive qualities of using a product), 4- Activity (emotions in response to the activities enabled or facilitated by a product), 5- Self (emotions in response to oneself as a user), 6- Other (emotions evoked by other people's activities, in which the product plays an important role).

Our data suggests that the quality of the interaction the patients experienced when using the Portal, the activities that the Portal enabled or facilitated, and most importantly, its influence on patients' self-perception were the key sources of their emotions. When the functional capabilities of the Portal helped them fulfill their needs or achieve their goals, patients expressed positive emotions of liking and admiration. On the other hand, when they perceived the lack of a functionality they desired, it evoked disappointment, which is similar to the "achievement" emotions noted by Beaudry & Pinsonneault (2010). It is interesting to note that strong emotions such as adoration, anger, and guilt were evoked because of how the Portal affected patients' self-perception. Some of them experienced adoration because they felt they were valuable individuals who were being looked after by the Portal and the health care providers who ran it. Others felt guilt and sorrow because they felt disapproved by the Portal, which they viewed as an extension of health care providers. Still others experienced anger as a response to a self-perception of being a helpless, powerless, or sick person. As such, it would be important for the design process of an SM system to take into account the possibility that an IT can evoke such negative emotions, and to try to minimize them, e.g., by designing system feedbacks that are communicated via less authoritarian or harsh language in an effort to reduce feelings of guilt and anger in patients.

In order to improve the quality of care, and also to increase the chances of acceptance and routinized use of health IT, it would be helpful to identify ways of encouraging positive emotions, while alleviating negative emotions and their undesirable effects. However, it is also important to keep in mind that not all

positive emotions will necessarily lead to effective system use, and a high level or high frequency of use is unlikely to provide a valid measure of IT success in health care contexts, as very positive emotions can also lead to ineffective usage. It is important to note that, because a chronic illness can benefit from support that nurtures, such as self-esteem and emotional support (Winkelman *et al.*, 2005), it can be argued that the Portal was helpful for patients who experienced positive emotions. Nonetheless, active participation of patients in the process of their care still needs to be encouraged for better SM outcomes.

While emotions and use-emotion patterns identified in the present study were in an Asthma SM context, our results can be useful for studying emotional responses to other health SM systems, e.g., systems that support patients with diabetes. As discussed above, chronic diseases require the development of a collaborative daily SM plan which can be facilitated by IT usage. For example, for chronic diseases like diabetes, IT can be used to supplement healthcare providers by providing both educational and motivational support (Hunt, 2015). Systems that support chronic diseases often have certain key features in common, such as setting patients' personal goals, receiving feedback, problem solving and coping skills (Glasgow & Eakin, 2000). Moreover, patients suffering from chronic diseases, such as diabetes, also need to be active partners in their own care (Funnel & Anderson, 2004) and need emotional support in the care process (Turner & Kelly, 2000). As such, it is plausible that patients suffering from chronic diseases other than asthma are also likely to exhibit strong positive or negative emotions, including love, adoration, anger, or guilt toward such IT and use-emotion patterns similar to the four patterns observed in the present study.

However, while the emotions and use-emotion patterns identified here are likely to apply to other contexts, their importance and effects may be different. For example, diabetes patients usually carry feelings of shame and blame because some of them may feel that their disease might have been caused by their own failure of personal responsibility (Wolf & Liu, 2014). Such negative emotions can also influence the way these patients might react to SM systems, such as feeling more intense emotions which may influence how they view their disease and approach its management, providing interesting avenues for future research.

6. CONCLUSIONS

Based on an inductive analysis of interview data obtained from 34 asthma patients who used an asthma SM Portal, the present study identified six categories of patient emotional responses: "Love, adoration, attraction"; "Liking, Admiration"; "Happiness, Joy"; "Anger, Frustration"; "Disappointment"; "Guilt, Sorrow". We also analyzed the relationships between these emotions and the patients' use of the Portal and, based on a framework of effective usage (Burton-Jones & Grange, 2012), we identified instances of asthma patients' effective and ineffective usage of the Portal. A key finding of the present study is that, while all positive emotions were associated with high frequencies of Portal use, this usage was not always effective. That is, while positive emotions led to high levels of Portal use, this usage was not always aligned with the Portal's goal of asthma SM. It is also important to note that, negative emotions were always associated with ineffective usage of the Portal.

Moreover, we also found that emotions were evoked mostly in response to system content, its representational fidelity and the activities enabled by the system, and eventually the Portal's influence on how the patients perceived themselves. Given the importance of emotions in providing high quality health care, and also the important role played by emotions in the acceptance and routinized use of e-health IT, there is a need for designers and implementers to pay more attention to the potential emotional responses that their system can evoke in users and patients, and to especially try to minimize the emergence of negative emotions. The present study's findings suggest that creating loveable medical products – products that can create a positive experience and self-image in patients, and give them joy – is a design challenge that needs to be addressed in future research, while simultaneously trying to engage patients in behaviors that promote their effective usage of these systems.

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