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A MULTILEVEL PERSPECTIVE ON IT AFFORDANCES

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Research paper

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Abstract

The concept of affordance views IT as socio-technical artefacts and affordances as bridges between artefacts and their users, and has been defined as what an individual, group or organization with a particular purpose can do with a technology. The present research examines IT affordances via a multi-level perspective, with a focus on the relationship between feature-level and system-level affordances. More specifically, the present study examines how macro (system) level IT affordances emerge from micro (feature) level affordances via an exploratory case study approach in an e-health context to analyse data from 16 asthma patients who used a web-based, user-centric portal to self-manage their asthma. The results of our analysis suggest that system-level and feature-level affordances of the portal were not necessarily the same for each patient, and the system-level affordances played an essential role in determining their attitudes and behaviors toward the portal.

Keywords: Affordances, multi-level, health IT.

1 Introduction

Technology affordances have been defined as "…the possibilities for goal-oriented action afforded to specified user groups by technical objects" (Markus and Silver 2008, p. 622). The concept of affordance views IT as socio-technical artefacts and perceives affordances as bridges between the artefacts and the people who use them. The relational nature of affordances helps address many of the concerns raised in extant research regarding IT usage and its effects (Markus and Silver 2008, Leonardi 2011). For example, as it favours a non-deterministic view of IT impacts, IT properties become unlikely to be viewed as the only cause of change (Markus and Silver 2008). As such, both IT capabilities and the choices people make when using those capabilities can help better explain the ultimate effects of IT on social structures (Leonardi 2013). This view is also consistent with the non-deterministic view of IT advocated in past research (e.g., DeSanctis and Poole 1994).

In the IS literature, affordances have been conceptualized at the individual, group, or organizational levels (Majchrzak and Markus 2012, Leonardi 2013, Strong et al. 2014). As such, they have been defined as what an individual, group or organization with a particular purpose can do with a technology. Further, according to the IS literature, higher level affordances can be collectively created by lower level affordances (Leonardi 2013). For example, Leonardi (2013) introduced the concept of shared and collective affordances as action possibilities that are created by group members which in turn allow a group to accomplish something that it could not otherwise achieve.

Following a similar line of thinking, the present research also examines IT affordances via a multilevel perspective, but with a focus on feature-system structure of affordances. More specifically, the objective of the present study is to examine how macro (system) level IT affordances emerge from micro (feature) level affordances. We define feature-level affordances as "a given IT feature's afforded possibilities for action", and system-level affordances as "a given IT artefact's afforded possibilities for action", both of them as perceived by individual users. A central premise of the present study is that, because affordances at these two levels may not be the same for a given IT, researchers interested in the effects of IT affordances need to clearly distinguish them. To examine our research question, we followed an exploratory case study approach in an e-health context to analyse data from 16 asthma patients who used a web-based, user-centric portal to self-manage their asthma. Self-management (SM) support is the education and skills training provided to help individuals with asthma understand the central role they play in managing their illness, make informed decisions about healthcare, and engage in healthy behaviors, which includes controlling their illness (Kotses and Creer 2010).

The results of our analysis showed that system-level and feature-level affordances of the SM portal were not necessarily the same for each patient. In addition, system-level affordances emerged through a compilation process (Klein and Kozlowski, 2000) from feature-level affordances and played an essential role in determining their attitudes and behaviors toward the portal.

2 Theory

2.1 Affordances

The notion of affordance can be traced to ecological psychology where it has been used to describe the relationship of animals or human beings with objects (Gibson 1966). In the Gibsonian view, affordances primarily refer to action possibilities provided by the environment. Further, the "…affordance of an object refers to both the attributes of the object and the actor" (Gaver 1991, p.79), and as such cannot be the same for all actors. For example, in an IT context, a social networking tool can provide "information sharing and collaboration" opportunities for co-workers, but recruiters are more likely to perceive it as a way to "collect information about their candidates".

Researchers have tried to more clearly define affordances to exploit their full potential (Kaptelinin and Nardi 2012; Pozzi et al. 2014). For example, Norman (1988) defined affordances as perceived or actu-

al properties of objects that determine how they can be used. Moreover, Gaver (1991) defined them as perceived possibilities for the actions that objects provide, and which depend on people's needs. In the IS literature, Markus and Silver (2008) defined functional affordance (FA) as "…the possibilities for goal oriented action afforded to specified user groups by technical objects" (p. 622), and suggested that the FA construct could be useful for studying IT effects as it encouraged a non-deterministic view of IT impacts, making IT properties unlikely to be viewed as the only cause of change.

Affordances have also been distinguished from actualization, with the former being viewed as action potentials, and the latter seen as individual actions undertaken in order to realize those potentials, while emphasizing that affordances not only enable actions, but that they can also constrain them (Pozzi et al. 2014; Strong et al. 2014). Accordingly, affordances represent "the potential for behaviors associated with achieving an immediate concrete outcome and arising from the relation between an object (e.g., an IT artefact) and a goal-oriented actor or actors" (Volkoff and Strong 2013, p.823). Some also view individuals to "actively construct perceptual affordances and constraints" (Leonardi, 2011, p.154) while attempting "to reconcile their own goals with the materiality of a technology".

2.2 Multilevel nature of affordances in the IS literature

The IS literature has conceptualized affordances at the individual and organizational levels in terms of action potentials, i.e., "what an individual or organization with a particular purpose can do with a technology or information system" (Majchrzak and Markus 2013). Further, Leonardi (2013) proposed the concepts of "individualized affordance", "collective affordance", and "shared affordance" to examine how people use IT in a group. Accordingly, "An individualized affordance is an affordance that someone enacts when using a technology's features, but that affordance is not common to his or her workgroup or department." (p. 752). Thus, an individual in a group can use an IT to do something that other group members cannot. A "collective affordance" results from "pooled individualized affordances", i.e., "individuals work on their own tasks and those tasks are aggregated to produce a final output" (Leonardi 2013, p. 752). Finally, a "shared affordance" represents all group members using an IT's features in similar ways, which in turn can facilitate coordinating their work for achieving individual and group goals. Following a similar line of multi-level reasoning, we suggest that, in addition to defining it at the individual and group/organizational levels, it can also be useful to conceptualize affordances at the IT feature and IT system levels.

2.3 Multilevel theory

According to multilevel theory (Klein and Kozlowski, 2000), a concept is considered to be collective when it represents the aggregate influence of its elements, i.e., a collective concept has its theoretical foundations in the characteristics of its elements, and has emergent properties that are manifested at higher levels. According to Klein and Kozlowski (2000), the emergence of a higher level can be based on composition and/or compilation. The composition process describes phenomena that are essentially the same as they emerge upward across levels (Klein and Kozlowski, 2000). That is, similar lower-level characteristics converge to yield a higher-level element that is essentially the same as its constituent elements. On the other hand, compilation "describes phenomena that comprise a common domain but are distinctively different as they emerge across levels", and "compilation processes describe the combination of related but different lower-level properties-that is, the configuration of different lower-level characteristics to yield a higher-level property that is functionally equivalent to its constituent elements." (p. 59). For example, individual and team performance can be seen through both composition and compilation perspectives. Individual performance requires specific skills, and abilities. If we assume that all individual performances equally contribute to performance at the team level, then we would be following a composition perspective. However, in many contexts, team performance can be a complex function of specific individual contributions, in which case a compilation model may provide a better representation.

In this research we argue that IT affordances need to be treated as a collective concept and studied via a multilevel perspective. To do so, we define a macro level affordance as "a given IT artefact's afforded possibilities for action", and a micro level affordance as "a given IT feature's afforded possibilities for action", both of them as perceived by individual users. As such, low-level elements are the affordances of each IT feature, and high-level elements are the affordances of an IT as a whole, representing the aggregate influence of its features.

It is important to note that each IT typically has several sets of features. According to Griffith (1999), technology features are "the building blocks or components of a technology" (p. 473). Moreover, DeSanctis and Poole (1994) define features as specific types of system rules and resources. Core features are those that make a technology identifiable as a certain type of technology (DeSanctis and Poole, 1994). For example, a social networking website might have features such as, "search and filtering boxes", "commenting feature", and "share feature". While each feature can provide a set of affordances to its users, following a multilevel perspective, we argue that the IT as whole can be an entity that is more than a simple sum of its features. Hence, it would be helpful to distinguish between the micro and macro level affordances of IT. Next, we describe an exploratory study that examined how the two levels can be related and how they can help explain IT effects.

3 Method

To examine how IT affordances can be conceptualized via a multilevel perspective, we relied on an exploratory case research in a health care setting where each individual patient was treated as a case. To do so, we collected data from 16 asthma patients who used an asthma SM portal over a six-month trial period, and examined how they perceived the portal's affordances from feature and system-level perspectives, i.e. micro and macro levels, how the affordances of the two levels were interrelated, and how they influenced the patients' attitudes and behaviours.

3.1 Study context

Our contextual focus was a user-centric self-management (SM) system designed to promote asthma self-management for asthma patients. Asthma self-management is mainly concerned with the systematic education of asthma patients in order to promote their active participation in controlling their asthma by avoiding its triggers and reducing its symptoms (Kotses and Creer 2010). As such, it 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. The integration of self-management into daily life requires patients to master skills related to medical self-management, and to develop problem solving and coping skills that deal with emotions that arise from living with asthma and its exacerbations (Holman and Lorig 2004). Web-based and patient-focused tools provide one form of health IT that help increase patient participation in disease prevention and management (Polomano et al. 2007).

The system examined in the present study is a web-based portal that was developed in 2010 by a Clinical and Health Informatics research group in a North American university. Each patient weekly answered some questions about their health status and medications during the usage period. After they answered these questions, a graphical feedback mechanism and graphs provided them with information about their asthma control status, as well as a history of their medications, exercises and symptoms. The weekly questionnaire and the graphical feedback mechanism were devised to enable patients to self-monitor their symptoms, medication adherence and physical activity. The portal also advised patients about what to do (i.e. Action Plan) if their asthma was not under control. During the trial period, a nurse case manager also used the portal's nurse interface to monitor each patient's asthma status and to provide him or her with individual feedback via e-mail (a detailed description of the portal's features are provided in Appendix A).

3.2 Data collection

The North American University research group recruited 30 asthma patients in two hospitals and asked them to use the portal for six months. A research coordinator provided two hours of training to the patients on how to use the portal. Further, patients were encouraged to access it at least once a week for six months, a time period deemed necessary to reinforce SM. Patients were sent automated e-mail messages to encourage them to log on to the portal and to promote their continued participation. A nurse was also recruited from one of the hospitals as the case manager with access to the portal's nurse interface in order to monitor the patients' health status. She contacted the patients if their situation was deteriorating or if she felt that they required urgent care. At the end of the six-month usage period we interviewed the 16 patients who had agreed to participate in our study. The interview protocol contained open-ended questions that asked patients to describe how they used the portal, their perceptions of its capabilities and constraints, their attitudes toward it and their asthma SM behaviours. They were interviewed shortly after the end of the trial period.

3.3 Analysis

Each interview was transcribed and the transcripts were codified to distinguish between system-level and feature-level affordances by relying on how each patient referred to the possible functionalities of the portal's features or to the functionalities of the portal as whole. For example, if a patient referred to a specific feature of the portal, such as "Historical Graphs", or "Asthma Diagram", these comments were coded at the feature-level. On the other hand, when a patient referred to the action possibilities of the whole system without referring to specific features, then they were coded as system-level affordances. We used N'vivo (ver. 9) to facilitate the coding process. In examining the multilevel structure of affordances, the primary and secondary units of analysis were the patients' interaction with each function/feature and with the portal as a whole, respectively. Further, the interviews were coded in terms of patient attitudes toward the portal, how they used it, and their asthma SM behaviour.

4 Results

4.1 Affordances were perceived differently by different patients

As discussed earlier, affordance is a relational concept that depends on both users and IT properties. That different individuals can perceive the capabilities and constraints of an IT artefact differently was clearly observed in the interview data: although all patients used the same IT artefact, i.e. the portal, they viewed its capabilities and constraints differently. For example, a key feature of the portal, "Asthma Diagram", tracks and monitors patient health, and depending on their answers to a series of questions about their symptoms, it provides them feedback on their health status. However, patients perceived the Asthma Diagram differently: some viewed it as something that "rewarded them if they took care of themselves", some saw it as something which "reassured them that they were healthy", and some viewed it as something which "criticized them for their lack of SM".

4.2 Feature and system-level affordances

As many patients viewed certain affordances at the feature level and saw other affordances at the system level, we coded and analysed them at these two levels. When asked about the portal's affordances, patients sometimes referred to its features (e.g., Asthma Diagram, Email), while at other times they referred to the system as a whole. For example, when asked about the portal's capabilities and constraints, P12 stated, "… *using that [the portal] reinforces medications and I don't want to do that*". Here P12 was referring to the portal as a whole. However, at other times he referred to its specific features: *"... graphs just bang me on the head that I'm not doing enough*". Further, each patient's feature and system-level affordances were not always similar, and system-level affordances were not neces-

sarily a sum of feature-level affordances. In fact, in most cases system-level affordances were influenced by a limited number of features. For example, P1 saw the "messaging feature (Email)" of the portal as a reminder: *"So once in a while the nurse would remind me, oh have you tried this? Oh yes, I forgot; thank you. ...."*. Moreover, he did not see any affordances in the portal's information page: "*I never went onto it [information page]… Basically I never knew how to get onto*". However, when describing the portal as a whole, he saw it differently:

> *"…it's a place [the portal] to keep track of all of them [medication usage], including the changes, so that I can see, oh I took this for three months and it didn't work, and I took this for two months and it did work."* (P1).

Thus, P1 perceived the portal as a tool that provided him with the opportunity to keep track of changes in his health status. Similarly, P37 viewed the Asthma Diagram as a feature that provided no affordances: *"So periodically I would look at it, but it never changed. It wasn't an issue for me to look at the Asthma Diagram"*. However, when describing the portal as a whole, he saw it differently:

> *"…it was in my face, it was there, it was very visible and it was my daily reminder that I have to watch these guidelines. I have to stick to them."*

Thus, representing a patient's overall view of the whole system's functionality, system-level affordances appeared to be influenced by some of the feature-level affordance(s). For example, P122 was frustrated with the portal and described it as:

> *"…it is like treating people who are not capable of feeling that they have problems… Look, you're not able to feel yourself. We'll show you".*

Thus, P122 viewed the portal as forcing a patient to follow its orders. However, from P122's perspective, the only feature that influenced this system-level affordance of the portal was "Asthma Diagram": *"The target tells me you have to do this…me, I know what to do"*. Other features did not influence his perceptions of the portal's functionality. For example, P122 described Feedback Graphs as "*It gives you a very good idea of the… evolution, of where you were standing a week ago and what… how it changed"*. Thus, Asthma Diagram's alerts and advice (a feature-level affordance) strongly affected how P122 saw the portal's affordances as a whole (a system-level affordance), while its other features appeared not to have influenced his global perception of the portal.

To illustrate the links between feature and system-level affordances, we summarized the perceived affordances of each patient in a table and highlighted the features that highly influenced their system level perceptions. For example, Table 1 shows how P14 perceived the portal's affordances at feature and system levels. He basically perceived no affordances for the portal's "Asthma Diagram", "Historical Graphs", and "Information Page" features, as he did not know much about their utility. Moreover, he perceived the Email feature as providing an opportunity to send messages to the nurse and to find answers to his questions. In addition, he described the "Asthma Questionnaire" as providing him a means to update his health status information which would be used by the health care team to monitor and protect him from potential unpredicted consequences of his disease. For P14, the Asthma Questionnaire can be viewed as an "instigating feature" that strongly influenced and shaped his overall view of the portal, which he perceived as providing him with monitoring and protection.

Feature-level	**Affordances**	**Quote**
Asthma Ques-	Monitoring the health status of	"[by updating the Questionnaire] I was giving the peo-

tionnaire	the patient	ple in the portal my data … so that they could see that I was doing what I was supposed to be doing."
Asthma Diagram	No affordances	"So periodically I would look at it, but it never changed. It wasn't an issue for me to look at the Asthma Diagram."
Historical Graphs	No Affordances	"I did not know how to use it"
Information Page	No Affordances	"I didn't know that that was going to be changing or updating as it went along."
Email	Asking questions to the nurse	"But if I had sort of questions about this or that, I'm not going to call her. But by emailing the nurse I would be able to do, because I knew that it wasn't an intrusion into her busy work time."
System-level	Monitoring the health status of the patient- Protecting the patient	"…like somebody is looking in on you. It's like taking too much alcohol. There's no one to tell you not to take too much alcohol but if you were part of a study and you were telling them how much alcohol you were taking every day and you're allowed a certain limit and you're taking more alcohol than you should there would be a warning come back and say uh, uh don't do that."

Table 1. Feature-level and system-level affordances as perceived by P14.

As illustrated in the above examples, the micro and macro level action possibilities of the portal were not necessarily the same. Some features were viewed as providing no affordances to the patient, or provided affordances that were different from the portal's overall affordances. This result further supports the idea that IT affordances can be viewed as being multilevel. Moreover, it is important to note that some of the portal's feature-level affordances helped form its system-level affordances. That is, some of its features played key roles in creating a system level image for the portal as a whole, which we labelled "instigating features". Table 2 summarizes each patient's perception of the portal's system- level affordances, its instigating features and their attitudes toward the portal.

Patient	**System-level affordances**	**Instigating features**	**Attitude**	**Portal usage**
P1	Keeping track of changes in patients' health status	Asthma Diagram, Historical Graphs	Positive	Frequent
P20	Monitoring patients' progress	Asthma Questionnaire, Asthma Diagram, Historical Graphs	Very positive	Frequent
P28	Assisting patients with asthma SM	Asthma Diagram, Email	Very positive	Frequent
P60	Assisting patients with asthma SM	Asthma Questionnaire, Asthma Diagram, Historical Graphs, Information Page	Positive	Frequent
P57	Inhibiting patients' SM	Asthma Questionnaire, Asthma Diagram	Negative	Not frequent
P7	Criticizing patients for their lack of SM	Asthma Diagram, Historical Graphs	Negative	Not frequent

P12	Forcing patients to act	Asthma Diagram, Historical Graphs	Negative	Not frequent
P71	Making patients feel shame and guilt for their lack of SM	Asthma Questionnaire	Negative	Not frequent
P101	Bothering patients	Email, Asthma Diagram	Negative	Not frequent
P122	Criticizing patients for their lack of SM	Asthma Diagram	Negative	Not frequent
P126	Making patients feel shame and guilt for their lack of SM	Asthma Diagram	Negative	Not frequent
P14	Protecting patients against their disease	Asthma Questionnaire	Very positive	Frequent
P13	Guiding patients during the process	Asthma Questionnaire, Asthma Diagram	Positive	Frequent
P66	Motivating patients to follow SM actions	Asthma Diagram	Positive	Frequent
P37	Reminding patients to take care of themselves	Asthma Questionnaire, Historical Graphs	Positive	Frequent
P40	Protecting patients against their disease	Asthma Diagram, Email	Very positive	Frequent

Table 2. Patients' system-level affordances, instigating features, attitudes, and usage

System-level affordances also appeared to more strongly influence patients' attitudes and behaviours, than feature-level affordances. For example, as shown in Table 2, P7 who viewed the portal as criticizing his actions, had a negative attitude towards it and used it minimally just for the purpose of satisfying the research team's requirements. However, as shown in Table 3, while describing the "Asthma Questionnaire" feature, P7 also noted that he found it to be a useful reminder. The "Asthma Diagram" and "Historical Graphs" seemed to reinforce the image he had of the portal as being "a criticizer". As such, these two features were clearly the dominant features that influenced his overall image of the IT.

Feature	Affordance	Quote
Asthma Questionnaire	Reminding patients to take care of themselves	"[The questionnaire] sort of reminded me that I just had to take care of myself"
Asthma Diagram (Instigating feature)	Criticizing patients for their lack of SM	"I didn't like it, I was like yeah it shows that I'm very sick when I just needed it...I like to be in the green. I had to be in the green. ... didn't like the fact that I got sick maybe once and then I was in the red and I was like, oh geez, this thing you know, you need to like focus and do your stuff so you're not sick anymore...it's like it's the sense of you're not doing it right"
Historical Graphs (Instigating feature)	Criticizing patients for their lack of SM	"I feel like they [Historical Graphs] don't give a proper sense of what it's like really... and I didn't like it, I was like yeah it shows that I'm very sick…And I always thought I wasn't sick. I don't consider myself sick, like if I have asthma I'm not a sick person per se.
Information Page	No affordances	"…I guess because I go on Google and stuff so I think what I did is probably that, instead of going to My Learning Centre. ... I

		didn't see the point in me learning about asthma"
Email	No affordances	"I don't remember asking anything about me being sick."
System-level affordance	Criticizing patients for their lack of SM	"I have a mild asthma, and I have a pretty good understanding of my symptoms…but it [the portal] just reminded me of, oh you have to do this"

Table 3. Feature-level and system-level affordances as perceived by P7.

As shown in Figure 1, patients perceived a set of feature-level affordances for the portal (e.g. A, B, C, D, E), some of which played an important role in defining their system-level affordances (e.g. A and C). As such, the instigating features created a higher image of the functionality and utility of the artefact, which in turn influenced their attitudes toward the portal and their behaviours.

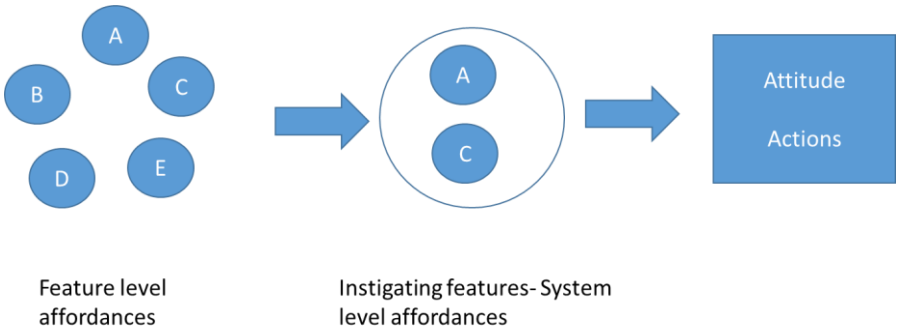

Figure 1. Multilevel structure of IT affordances

5 Discussion and Conclusion

In line with extant research (Kaptelinin and Nardi 2006, Leonardi 2013) we found that a health management IT, i.e., the portal, provided multiple affordances, and that while they used the same IT, its different users, i.e., asthma patients, enacted different affordances. This can be explained by the different and specific goals, desires or needs people have which influences how they interact with IT materiality. As such, the patients perceived the functionalities of the portal based on what they planned to do with it, or based on what they desired or needed to do (Hutchby, 2001). In essence, patients who had different desires, perceived and eventually used the portal's features in ways that were distinct from other patients. These observations are also consistent with Adaptive Structuration Theory (AST) (DeSanctis and Poole, 1994) according to which people within a social group can at times use identical technology in ways that are different from other group members. Such variations are largely due to examining IT at the level of the "feature set" (DeSanctis and Poole 1994, p. 126), instead of at the artefact (system) level.

It is important to note that, the present study only focused on perceived affordances, and did not examine affordances that might not have been perceived by the patients. However, in some cases, hidden affordances that are not perceived by a user might exist, and at times be actualized accidentally or unconsciously. While this may happen, we believe that it would occur fairly infrequently, as users are likely to eventually become aware of most hidden affordances that have been actualized accidentally. As such, they will become perceived after actualization, and can be captured during interviews, if these interviews are conducted after a reasonable time has elapsed since the start of usage. If an affordance becomes actualized without being eventually perceived, then it will not be captured through interviews, which would require direct observation of users during their usage period.

As the present study's results suggest, system-level affordances tend to emerge from individuals' perceptions of the affordances of an IT's features. However, system-level affordances do not simply reflect the sum of its feature-level affordances. Following the compilation perspective, our results indi-

cate that the portal as a whole could be seen by the patients as an entity that was a combination of related, but different lower-level affordances. That is, its system-level affordances were formed by the affordances of one or more of its instigating features, while the affordances of some of its features did not play any role in forming its system-level affordances. We also found that the instigating features were not perceived similarly by different patients. For example, while "Email" played a dominant role and influenced the system view of the portal for some patients, it did not influence how other patients perceived the portal's system (artefact) level affordances.

The above results suggest that a feature-level perspective may often be inadequate for understanding user attitudes and behaviours regarding an IT due to the fact that many users tend to react to system-level affordances, rather than feature-level ones. For example, a user might show some interest in one or more features of an IT, but from a macro level perspective, he/she might find the IT as a whole to be useless and without value. As such, when studying IT affordances, considering both the micro and macro perspectives can be highly useful. That is, researchers who are studying the influence of IT affordances on individual actions would have a more powerful lens by distinguishing between system-level and feature-level affordances. A macro perspective is likely to be useful for better understanding user attitudes and behaviours toward an IT as it accounts for contextual factors (Klein and Kozlowski, 2000). On the other hand, a micro level perspective can be useful for explaining what system characteristics form the macro perspective, which in turn can be used to improve an IT's design.

Although an IT's features remain the same in different contexts, they can be perceived very differently by different users, which in turn can render the usage of IT very dependent on its context of use (Burton-Jones and Straub 2006, Burton-Jones and Grange 2013). As such, depending on the social context's cultural characteristics, norms, values, and the individual characteristics of its users, some IT features can be perceived as valuable while others may be ignored. It would thus be interesting to examine in future research the reasons why some IT features are more influential in the creation or formation of an IT's system-level affordances in the views of its users. We hope that the present study's findings can provide an interesting avenue for further exploring how users perceive IT affordances and how they affect user behaviours.

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Appendix A

Feature	Description
Asthma Questionnaire	A series of questions that ask the patient to report on his/her health status since the last data entry.
Asthma Diagram	A feedback mechanism that assigns a colour (red, yellow, green) to mark the patient's health status.
Historical Graphs	Includes a symptoms graph, a medication graph, as well as a physical activity graph. They provide a history of the patient's symptoms, medication usage, and number of steps taken from the beginning of the study.
Information Page	Provides links to educational material about asthma.
Email (Messaging)	Provides the possibility to have ongoing email communication between a patient and the nurse case manager.

Table A1. The Portal's functions and features