Journal of the Association for Information Systems

JAIS

Research Article

From Prediction to Explanation: Reconceptualizing and Extending the Perceived Characteristics of Innovating *

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Abstract:

Individual adoption and use of technology remains a critical concern for both managers and professionals. Despite the widespread integration of technology into work and organizations, there remain many opportunities for individuals to either extend or limit their use of IT at work. This paper extends work on the Perceived Characteristics of Innovating (PCI), as defined by Moore and Benbasat in 1991. Building on studies over the past ten years as well as on additional empirical research, we provide two contributions – a reconceptualization and refinement of the PCI constructs, and an extended theoretical model of their influence on users' behavior. The construct refinements aim to provide greater theoretical clarity and to address challenges in the measurement of the constructs. The extended theoretical model provides a more complete picture of the influence of the PCIs, by considering the complex web of relationships among them in addition to their potential direct effects on usage.

* *Detmar Straub was the accepting Senior Editor. Patrick Chau was one of the reviewers and the other reviewer wanted to remain anonymous. This paper was submitted on March 12, 2004 and went through 3 revisions.*

Volume 8, Issue 8, Article 1, pp. 409-439, August 2007

1. Introduction

The processes by which individuals adopt technologies in the workplace and the factors that influence their usage remain a central focus of information systems research (see Venkatesh *et al.* 2003) and an important managerial problem. Information technology-based innovations are being introduced into the workplace at a rapid rate. Facilitating the introduction of IT innovations requires an understanding of the factors that influence users' adoption and continuing use decisions. Such factors are important for both voluntary use systems and those that are mandatory, as specific feature use and extended use may fall into the realm of voluntary use behavior, even for systems that are mandated for adoption (Jasperson *et al.* 2005).

IS research has focused on this problem for many years. Initially, the focus was largely on developing parsimonious models, such as Davis *et al.*'s (1989) Technology Acceptance Model (TAM), to predict users' choices. While excellent for the purposes of prediction, parsimonious models do not provide the same level of understanding about how choices might be influenced. For example, TAM would tell us that the way to improve user adoption and use is to make systems useful and easy to use. This is, without doubt, an important component of the solution, but it is not the whole solution. It does not address the political and social factors (e.g., Klein and Sorra 1996; Markus 1983) that also influence the user's behavior, even if they do so indirectly through Usefulness and Ease of Use.

Later studies have developed richer models of technology acceptance. IS researchers (Mathieson 1991; Taylor and Todd 1995) have used Ajzen's (1991) Theory of Planned Behavior which incorporates normative and control influences as well as perceptions of the technology. Moore and Benbasat (1991) expanded the technology characteristics that could be considered as antecedents to adoption based on the work of Everett Rogers (2003). Venkatesh *et al.*(2003) developed the Unified Theory of the Acceptance and Use of Technology, which includes a broad range of antecedents to intention, as well as moderators. Plouffe *et al.* (2001a) argued strongly for the need to pursue richer models to aid in developing understanding, as well as parsimonious models to aid in prediction.

Work pursuing richer models, however, has been more focused on construct richness than on model richness. That is, while the models noted above include many more influences on technology adoption, they are dominated by direct effects. Such models assume that each independent construct exerts an effect on adoption directly. Following the principles of regression analysis (Pedhazur 1997), they also assume that the independent constructs are not highly correlated. But this assumption is not entirely satisfactory, either theoretically or empirically. Klein and Sorra (1996) theorize, for example, that social influences can operate both directly through a process of compliance and indirectly through a process of internalization. This implies that social factors influence perceptions of the technology in addition to influencing adoption directly. Empirical evidence also shows the inter-relatedness of the antecedents to technology acceptance. Davis *et al.* (1989) posited Ease of Use as influencing adoption indirectly, through its influence on Perceived Usefulness. Compeau and Higgins (1995) demonstrated that the encouragement of others in an individual's reference group influenced the user's perceptions of the outcomes of using computers at work.

If one's goal is to predict acceptance or use, then focusing on direct effects is acceptable. But if, as is increasingly the case, one is looking to use the results to influence behavior, then it is more important to understand the ways in which antecedents might operate. Thus, more work remains to unravel the complex linkages between antecedents to technology adoption and use.

A second challenge in deepening our understanding of technology acceptance stems from problems in the measurement of constructs. Measure development and validation is a challenging and time-consuming task that must be part of our ongoing efforts in research (Boudreau *et al.* 2001). Since theory and measurement are closely intertwined (Bagozzi 1984), our progress in developing theory can move only as fast as our progress in developing measures.

The purpose of this paper, then, is twofold. First it seeks to extend our understanding of the adoption and use of information technology-based innovations, by developing a more complex model of the factors that influence behavior, including both direct and indirect effects. Second, it seeks to pursue further development and validation of the measures for one important set of independent influences, specifically the Perceived Characteristics of Innovating (Moore and Benbasat 1991). We focus on the Perceived Characteristics of Innovating (PCIs), since these represent a rich set of influences (Plouffe *et al.* 2001a) that have been shown to affect adoption in numerous settings (e.g., Agarwal and Prasad 1997; Cooke *et al.* 1999; Karahanna *et al.* 1999; Moore and Benbasat 1991; Plouffe *et al.* 2001a; Plouffe *et al.* 2001b). Yet, little attention has focused on the inter-relationships between these characteristics, and thus the theoretical potential of the influences has not been fully investigated.

The paper is organized as follows. We begin with a review of the PCIs as articulated by Rogers (2003), and their development within the IS context as exampled by Moore and Benbasat and others. We identify challenges that we have encountered with the instrument's reliability across different research settings and make the case that additional development of the constructs and measures is needed. Our process for redeveloping the instrument is laid out in the next section and in an appendix to the paper. Our final section describes the extended theoretical model we have developed and tests the model (including both the measurement and structural model) using a sample of 380 hospital employees.

2. Refining The PCI Constructs

2.1. Analysis of Moore and Benbasat's PCI instrument

Rogers (2003) identified five salient characteristics of an innovation, which influence the formation of an individual's intention to adopt it:

> ***Relative Advantage:*** *the degree to which an innovation is perceived as being better than its precursor;*
>
> ***Compatibility:*** *the degree to which an innovation is perceived as being consistent with the existing values, needs and past experiences of potential adopters;*
>
> ***Complexity:*** *the degree to which an innovation is perceived as being difficult to use;*
>
> ***Observability:*** *the degree to which the results of an innovation are observable to others; and,*
>
> ***Trialability:*** *the degree to which an innovation may be experimented with before adoption.*

In their efforts to operationalize Rogers' innovation characteristics, and based on their review of existing diffusion literature, Moore and Benbasat (1991) isolated two additional characteristics: Image, which Rogers included as a component of Relative Advantage, and Voluntariness of Use. Image was defined as the extent to which using the innovation was perceived to enhance one's Image or status in the organization. Voluntariness of Use was defined as "the degree to which use of the innovation is perceived as being voluntary, or of free will" (Moore and Benbasat 1991).

Moore and Benbasat developed scales for each of the seven characteristics, and followed a comprehensive process for assessing their construct validity, including card sorts in multiple rounds and instrument testing with 3 groups of potential adopters of personal workstations. Based on their analyses, Moore and Benbasat concluded the following regarding the dimensionality of PCIs:

1. Relative Advantage and Compatibility, while conceptually distinct (as determined by card sorting) were empirically indistinguishable. In factor analysis, these two dimensions loaded together.
2. The Observability construct included two distinctly different dimensions: Result Demonstrability and Visibility. Visibility refers to the observability of the innovation itself, while Result Demonstrability focuses on the observability of the outcomes of using the innovation.
3. Trialability items were confused in some of the sorting rounds with Voluntariness, suggesting lack of conceptual clarity. However, factor analysis revealed no high cross-loadings.
4. The reliabilities (Cronbach's Alpha) of all scales in the final field tests exceeded 0.70.
   In addition, Moore and Benbasat concluded that:

> *"while the various items were developed to be as general as possible, they were worded and tested with respect to a particular innovation, the Personal Work Station, in a particular context … [and while] it is believed that they could easily be reworded by substituting the names of different IT innovations … additional checks for validity and reliability would be prudent after rewording" (p. 211)*

A search of the Social Sciences Citation Index (SSCI) in February 2003 found 178 citations to this article. Of these references, 31 have used the scales developed by Moore and Benbasat. Four studies (Agarwal and Prasad 1997; Cooke *et al.* 1999; Karahanna *et al.* 1999; Plouffe *et al.* 2001a; Plouffe *et al.* 2001b) have used the entire set of constructs from the model, though in all four cases with fewer items than proposed by Moore and Benbasat. Other studies have used subsets of the model, as follows:

- Relative Advantage – 26 studies
- Ease of Use – 30 studies
- Compatibility – 23 studies
- Result Demonstrability – 16 studies
- Voluntariness – 15 studies
- Visibility – 14 studies
- Image – 13 studies
- Trialability – 8 studies

In all cases, the researchers reported shorter versions of the instrument, often with only two items per construct. They noted problems with reliability for the constructs of Result Demonstrability, Visibility and Trialability. This mirrors our own experience with the instrument, and suggests that in spite of the careful approach to instrument development used by Moore and Benbasat, problems in the measures may exist.

Between 1994 and 1997, we participated in three studies using various versions of the Moore and Benbasat PCIs. The first study involved 155 government employees in an agency that was contemplating a move toward smart cards for identification purposes (Gagliardi and Compeau 1995). The second involved samples of bank managers in Canada and Taiwan, and focused on their use of email (Wang 1997). The third study was a pilot test of an instrument for assessing perceptions of using the Internet for business information gathering.

Our experiences with the measures echoed those we saw in the literature. For example, our analysis of the reliabilities of the scales across these three studies showed that while Relative Advantage, Compatibility, Image and Ease of Use had stable reliabilities across the studies, the remaining scales were sensitive to changes in context. Result Demonstrability evidenced acceptable reliability for the smart card study (Study 1), and for the Canadian sample in Study 2. For the Taiwan sample in Study 2 and for Study 3 (using the Internet for business information gathering), however, Cronbach's αs were 0.57 and 0.59 respectively (after dropping items that would improve Alpha). Trialability was reliable in Study 2 for the Canadian sample and in Study 3, but not for the Taiwan sample in Study 2 or for Study 1. Visibility and Voluntariness were only reliable in the Canadian data for Study 2.

We identified four primary reasons for the reliability problems.[1] First, there were problems in wording. A number of the poorly correlated items were negatively worded. When items in a scale are negated by adding the word "not", as is often the case, the possibility of respondent error through misreading the question is increased. We discovered another wording problem for one of the Image items. The original item read "People in my organization who use Personal Workstations have more prestige than those who do not." In an organization where different groups of people have differential access to technology, this item might reflect the status of the group in general, rather than the status conferred by the innovation.

Second, the conceptualizations of Result Demonstrability and Visibility are potentially problematic. Result Demonstrability and Visibility were derived by Moore and Benbasat from Rogers' Observability construct. Observability is the degree to which the results of an innovation are visible to others (Rogers 2003). The combination of Result Demonstrability (ability to explain the results of an innovation to others) and Visibility (ability to see an innovation in use) does not capture all of Observability. The ability to comprehend the results of other's use of an innovation (either having the results explained or see the results) has not been captured. One item does address this concept, but it is only a single item included in the Result Demonstrability construct.

A third reason for the weak reliabilities of constructs in some of our research contexts may be that time in the adoption cycle influences the meaning of different PCIs. Our studies were generally conducted earlier in the adoption cycle than Moore and Benbasat's study. Karahanna *et al.* (1999) found that while Perceived Usefulness, Ease of Use, Trialability, Result Demonstrability and Visibility influenced potential adopters' intentions to use email, only Perceived Usefulness and Image influenced the intentions of current users for continued use. The arguments made by the authors for why these differences might exist allude to the notion that the constructs might take on different meanings. For example, they argue that potential adopters might spend more time weighing the pros and cons of the innovation, and thus might perceive higher Result Demonstrability. This difference in the cognitive processing of potential adopters vs. users suggests that the constructs may evidence subtle changes as the innovation cycle unfolds. Moreover, examination of the principal components analysis for potential adopters and users shows differences in the loadings of items on their respective constructs, which further support the idea that the construct meaning (as derived from the relative weights of the items) changes over time.

Finally, differences in the innovations themselves may produce differences in the construct measurement. Moore and Benbasat studied personal computer workstations, a hardware innovation that may serve multiple purposes for its users. Our studies, by contrast, dealt with innovations that were less physically observable and less radical. While they were not strictly software innovations, they bore the same lack of observability that has been attributed to software innovations (Karahanna *et al.* 1999; Rogers 2003). A smart card can be carried in a pocket and thus remain unseen, while the use of email and the Internet might be unseen by others, depending on when and where it is carried out (e.g., in an office where the computer monitor faces away from the door, the existence of email and the Internet might be unnoticed). Study 3 (the Internet) focused specifically on the use of the Internet *for business information gathering*. This specification of a business process for which the innovation is used is consistent with arguments that beliefs and attitudes must be measured with respect to an appropriate attitude object (e.g., Bandura 1986; e.g., Fishbein and Ajzen 1975), and with the arguments of Fichman and Kemmerer (1997) that innovation research should adopt a more precise focus on specific innovations in order to generate strong and stable results. So, while Moore and Benbasat focused on the *use of a technology*, Study 3 adopted an even more restrictive definition (*use of a technology for a specific purpose*), to allow for the fact that different uses of an innovation may activate different beliefs and attitudes on the part of adopters.

This paper addresses three of the reasons we identified. The issue of timing is not addressed, since our data, like that of Moore and Benbasat, were collected after implementation. This remains an area for future research. We have undertaken a reconceptualization of the PCI that includes reassessment of the constructs and their definitions, as well as rewording items, and generation of new items. The aim of this activity is to present a revised set of scales that will be more robust to changes in context. It is followed by a theoretical reconsideration that examines a more complete model of how the PCI influences technology acceptance by individuals.

2.2. Refinement of Categories

Our first revision to the instrument was to further refine the categories of the PCI construct. Figure 1 shows the genesis of the categories, from Rogers' initial formulation, through Moore and Benbasat's revision, to our own revisions.

[1] A fifth reason, relating to cultural and language differences in Study 2 was also identified, but is beyond this paper's scope. Cross-cultural research (Karahanna *et al.* 2002) suggests that scales do not translate equally well across cultural settings due to language and culture differences. While we do not address the issue of cross-cultural development in this paper, we believe it is an important issue for future study.

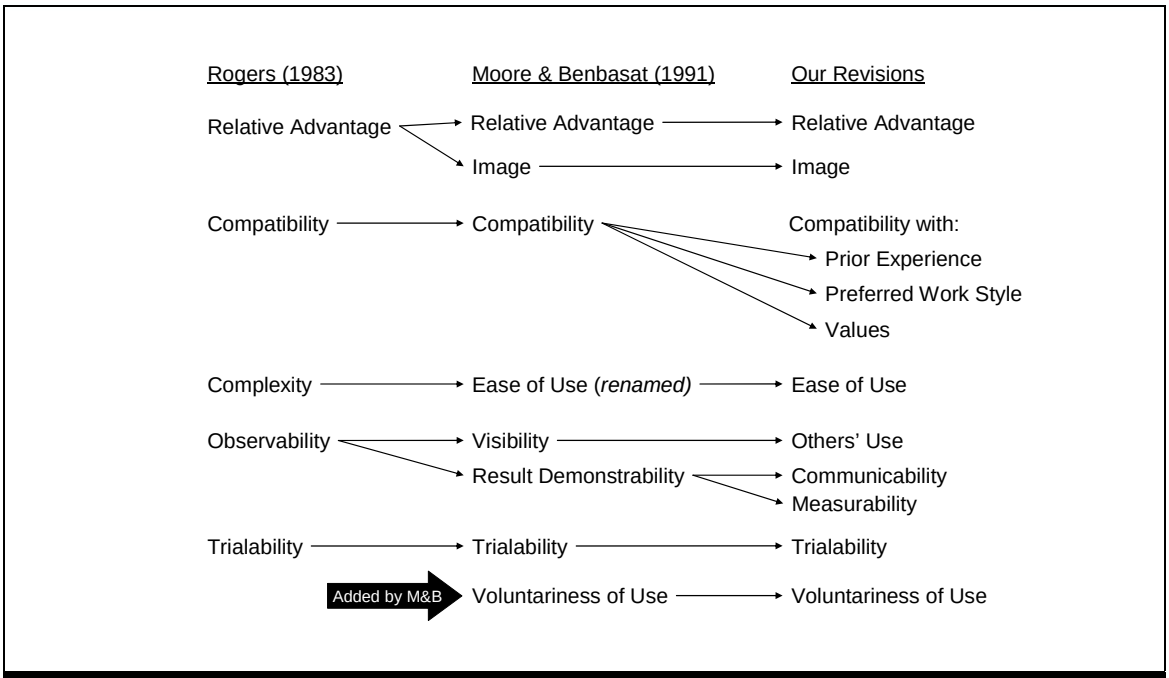

Figure 1. Evolution of the PCI Categories

Compatibility was separated into three constructs proposed by Karahanna *et al.* (2006). These three constructs reflect Compatibility with Preferred Work Style, Values and Previous Experience. Each of these elements appears in Rogers' discussions of Compatibility, but had not been fully operationalized. Karahanna *et al.* (2006) found the dimensions to be unique, and examined them in a model where Perceived Usefulness, Perceived Ease of Use, and the four [2] types of Compatibility, predict Use Intensity and Scope. They found that Compatibility with Preferred Work Style suffered discriminant validity problems with Perceived Usefulness, so they removed it from their analysis. Each of the remaining dimensions was found to exert strong direct and/or indirect effects on usage. Despite the problems Karahanna *et al.* experiences with the Compatibility with Preferred Work Style construct, we felt it important to retain this dimension to see if measurement refinements could improve discriminant validity.

Observability was also separated into three constructs. Rogers argued that Observability of an innovation – *the degree to which the results of using the innovation are visible to others* – fosters faster innovation. He explains, for example, that the visual and auditory observability of cellular telephones (reflecting the way they are used in public spaces) was a significant factor influencing their quick diffusion. But like most of Rogers' five characteristics, Observability is a complex construct. Various subdimensions of Observability have been proposed in the literature. Moore and Benbasat (1991) found evidence of two underlying dimensions in their measures of Observability. The first related to the visibility of the innovation, while the second related very specifically to the ability to concretely demonstrate the results of the innovation. Visibility reflected Rogers' assertions that innovations that can be readily seen would diffuse more quickly. The second element reflected the fact that the impact of some innovations might be more easily demonstrated than that of others, regardless of their visibility. Tornatzky and Klein (1982) considered Communicability, part of Rogers original definition of Observability, as a separate construct, as have scholars in the product innovation and marketing literatures (Holak and Lehmann 1990).

Based on our review of the literature and our experience with Moore and Benbasat's measures over several studies, we propose three distinct categories of measures in this area: Communicability, Measurability, and Others' Use. **Communicability** reflects the ease with which the results of using the innovation can be easily described to others. Communicability is much closer to the operationalization of Result Demonstrability in Moore and Benbasat's work. **Measurability**, on the other hand, reflects the degree to which the impact of the innovation can be assessed, in particular the ability to clearly attribute the effects to the innovation. An innovation whose outcomes can be measured concretely (e.g., using this innovation will save you 50percent of the time you spend on doing a task) has more demonstrable results than one whose outcomes can only be generally defined (e.g., using this innovation will help you make better decisions). The former would be expected to diffuse more quickly, because of the ease of making a business case for adoption. Items closer to the notion of Measurability were present in the longer lists that were generated by Moore (1989), but they were dropped in the early stages of instrument development.

For the third element of Observability, we replaced Moore and Benbasat's Visibility construct with Use by Others within the individual's reference group. The notion of Visibility emphasized by Moore and Benbasat was very much tied to the physical presence of the

[2] Karahanna *et al*'s fourth dimension of Compatibility, Compatibility with Current Work Practices, was not included in our model, primarily for pragmatic reasons. Our main study data were collected post-implementation, and thus we did not feel it was appropriate to try to retrospectively measure Compatibility with Current Work Practices. Doing so would have required respondents to assess how much change in their previous work practices was required in order to adopt the innovation which they now use. This is a very complex and difficult task and we were not confident of the validity and reliability of the construct.

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innovation. Consider, for example, a sample Visibility item from Moore and Benbasat's final items: "In my organization, one sees personal work stations on many desks." This item could invoke two sets of reactions. First of all, we must consider whether the innovation actually "sits on a desk." In the case of personal workstations, this would not be problematic. But now consider a software innovation such as email. Even in an organization where email is on every computer and used by every person, one might not see it "on the desk" or in some other easily analogous manner. For a process innovation, the situation is even worse, since there may be no physical manifestation of the new process at work. Even for another hardware innovation, such as smart cards, because they are very small or hidden within other hardware, one might not ever see another individual using them. Thus, the wording of this item (and others in Moore and Benbasat's scale) is problematic because it is difficult to apply to more software- oriented innovations. This item also invokes another set of judgments, which we believe are equally important. These are judgments about the number of people an individual knows who are already using the target innovation. This aspect of the response is likely to differ by respondent (since it reflects both the actual degree of diffusion and our awareness of it, independent of the actual stage), and thus can be assessed perceptually. It does not, however, depend on having actually seen someone using it. Thus, it adopts a broader posture toward Observability by allowing for something other than what is visible to the eyes (I may hear about it, or read about it being used – these are also observable, as Rogers described it). For example, if I tell colleagues about having used the web to search for some important information, then they are aware of me having done so, and may form an opinion about this behavior without ever seeing it. It is this element that we focus on. This notion is also consistent with theories regarding the importance of critical mass in the adoption of communications technology (Ilie *et al.* 2005; Li *et al.* 2005; Lou *et al.* 2000).[3] For purposes of clarity, we call this **Others' Use**.

In adopting these two dimensions of Result Demonstrability, we acknowledge that we have not fully covered the domain – the ability to see the results of the innovation is not fully captured by the three elements. In particular, by defining Measurability in a relatively narrow (quantitative) sense, we may have missed an important element. We will return to this notion in our discussion of results.

In summary, our approach to modification has been about increasing the specificity with which the constructs are defined. Rogers' original definitions for the PCI were quite broad, encompassing many ideas within each category. Moore and Benbasat (1991) and Karahanna *et al.* (2006) pushed for increasing specificity in order to turn these broad ideas into unidimensional constructs that can be reliably and validly measured across different contexts, and to allow managers a more focused opportunity to alter the perceptions of the target adoption group. On the basis of our reconceptualization of constructs, we have taken the eight categories from Moore and Benbasat, and expanded them to include a total of ten categories, as shown in Figure 1. Appendix 1 gives the definitions for the revised constructs.

2.3. Instrument development

Following our refinement of the categories of the perceived characteristics of innovating, we undertook a series of studies to develop measures for these new categories. We drew extensively on the measures developed by Moore and Benbasat, as well as the more detailed measure lists in Moore (1989), the extension of the Compatibility items by Karahanna *et al.* (2006) as well as our own experience with the constructs. In total we generated 21 new items.

An initial pool of 76 items was developed in two rounds of confirmatory card sorts (Moore and Benbasat 1991) and an initial field test to assess reliability. In our card sorting studies, we conducted separate sorts each of three different innovations: hardware (ergonomic keyboard), software (a spreadsheet), and process (online submission of expense claims). Testing the robustness of the items across different sorts of innovations was important to ensure that the revised scale would translate more easily across innovation contexts.

Based on our card sorts in round 1, we made numerous changes to the items, as well as clarifications to the definitions of the constructs. In round 2 our results were substantially improved and indicated a reasonable fit of the items to the categories.

Our preliminary field test, with 56 full-time MBA students using personal digital assistants provided to them by the program, also produced satisfactory results. All but one construct demonstrated adequate reliability (Compatibility with Prior Experience was the exception). Examination of correlations between these items and Use Intensity (the frequency and duration of use of the innovation by the individual) also supported the need for refinement of the categories. The different Compatibility constructs, for example, related differently to Use Intensity, as did Measurability and Communicability. Combining these into a single construct would mask such differences. Appendix 2 provides more detail on these activities.

3. Extended Theoretical Model

We propose an extended theoretical model of the influence of the PCI as a way of extending our understanding of the influences on users as they confront information technology innovations. Rogers model, and then Moore and Benbasat's, essentially hypothesizes that each characteristic of the PCI influences use directly. [4] Yet, as noted earlier, there is evidence to suggest that these are not the only influences. If our aim is to improve prediction, the other influences are not particularly important, since specifying the antecedents to Image, for example, will not improve the prediction of use. Yet, if our aim is to improve understanding and influence use, then it is important to know what things influence Image, and how that translates into ultimate user behavior.

[3] Conceptually, the notion of critical mass is different from Others' Use, in that critical mass reflects a threshold at which enough people are using the technology to make it worthwhile to adopt while Others' Use reflects more on the social context in which the results of using the innovation are observable. In Lou *et al*'s operationalization, they asked respondents about the extent to which *most of their peers* were using the innovation. Practically, these items are quite similar to our items representing Others' Use.

[4] The IS literature (e.g., TAM, TAM2) would suggest that the influence of the PCIs is mediated by Perceived Usefulness and perceived Ease of Use. While this is theoretically richer, it still reflects a narrow view of the web of influences that may promote or hinder innovation adoption and use.

Based on our review of the literature, and building on the perspectives of Rogers (2003), Klein and Sorra (1996), and Bandura (1986), we have formulated a research model that recognizes the web of influences between the PCI in addition to their influence on use. The PCI influences Intensity of Use either directly or indirectly. Relative Advantage plays a strong mediating role in the influence of the other dimensions on intensity of use, as does Ease of Use. This is consistent with TAM2 (Venkatesh and Davis 2000), where Perceived Usefulness (similar to Relative Advantage) mediates the influence of other constructs on Behavioral Intention. Our goal with this analysis is not to create the one right model of the PCI influences. Thus, we propose a subset of the possible paths, focusing on those with the strongest theoretical and empirical support. We also acknowledge that there are likely to be reciprocal relationships between the characteristics of the PCI over time. Such influences are difficult to sort out using cross-sectional survey data, as is typical in IS research and the method used in our field study. Thus, while we propose directional influences based on theory and prior research, others may consider the reverse relationships. Figure 2 shows our research model graphically.

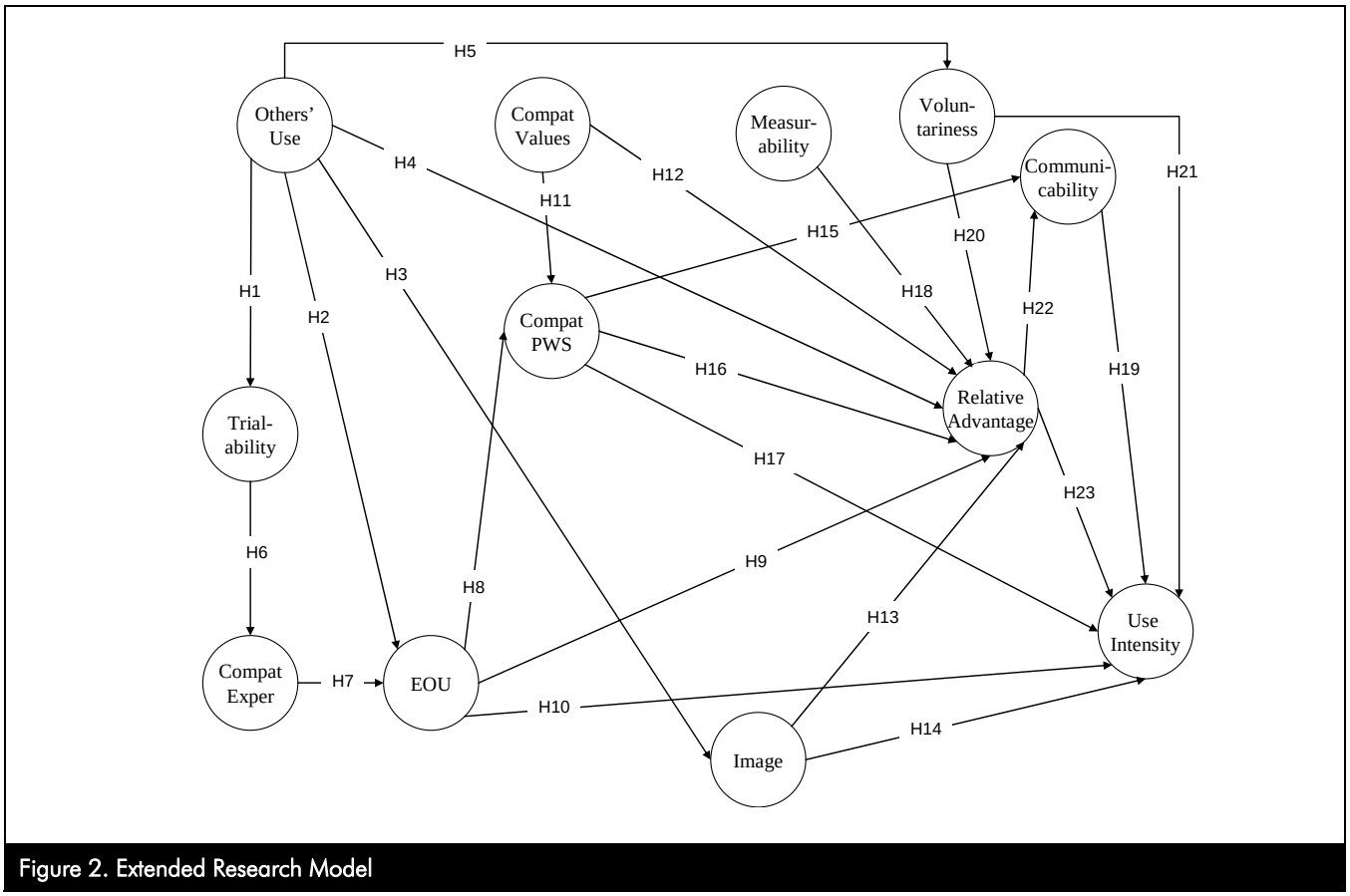

Figure 2. Extended Research Model

3.1. Others' Use

As noted earlier, a significant aspect of visibility, and the focus of this study, is the awareness of others using the technology. This awareness is important for several reasons, reflected in the various hypothesized influences of this construct. Others' Use exerts a direct influence on five characteristics of PCI.

First, it impacts Trialability. The ability to try out an innovation before deciding whether to adopt it can result from different things. It can result from an organizational action to make something available for trial, through the creation of an information or demonstration center. It can also result from being exposed to others around you who are users of the technology. So, for example, I may first try out the Treo personal digital assistant/cell phone by using one belonging to a colleague. Or I may try out a new website vicariously by watching a colleague. Thus, the presence of others who are using an innovation (either in the organization or in other parts of the individual's reference group) creates additional opportunities for experimentation and should result in higher Trialability. Rogers (2003) describes this in the context of cellular phones. Thus, we expect:

H1. **The more an individual is aware of Others' Use of the innovation, the more he or she will perceive it as having been available to try out before adoption (Others' Use → Trialability).**

Vicarious experience is an essential component of observational learning (Bandura 1986). By observing others and learning about the innovation, individuals can be expected to develop greater confidence in their ability to use the innovation and a greater sense of its usability. Compeau and Higgins (1995) found that Others' Use of computers influenced individuals' perceptions of their self-efficacy, an antecedent to Ease of Use (Venkatesh and Davis 1996). Lou *et al.* (2000) also found a relationship between Perceived Critical Mass, a similar construct to Others' Use, and Ease of Use. Thus:

H2. The more an individual is aware of Others' Use of the innovation, the more he or she will perceive it as easy to use (Others' Use → Ease of Use).

Others' Use also serves as a normative signal. This is an important aspect of the visibility of Others' Use. Rogers (2003) argues that individuals perceive that they will gain status by conforming to group desires. Conversely, not conforming to the norms of the group regarding use can decrease one's image within the group. Venkatesh and Davis (2000) found that Subjective Norm significantly influenced Image. Others' Use, while different from Subjective Norm, may provide the individual with signals regarding the group's desires. Thus we expect a similar relationship to hold, and we propose:

H3. The more an individual is aware of Others' Use of the innovation, the more he or she will perceive its image-enhancing potential (Others' Use → Image).

Next, individuals expect others to behave rationally; thus, if others are using it, there must be advantages. Venkatesh and Davis (2000) describe the link between Subjective Norm and use in terms of internalization of social influence. As noted for H3, we expect a similar logic to apply here. Empirically, Compeau and Higgins (1995) found a link between Others' Use and Outcome Expectations that is similar to Relative Advantage. Similarly, Lou *et al.* (2000) found a relationship between Perceived Critical Mass and Perceived Usefulness. Thus, we propose:

H4. The more an individual is aware of Others' Use of the innovation, the more he or she will perceive it as having Relative Advantage (Others' Use → RA).

The adoption of IT takes place within the context of social groups, with norms and work practices that strongly influence the individual (Venkatesh and Davis 2000). Perceived Voluntariness of Use reflects, at least in part, these norms. While some authors have focused on Voluntariness as a binary characteristic that indicates whether use of a system is mandatory or voluntary (Venkatesh *et al.* 2003), others suggest that perceptions of Voluntariness are less uniform and reflect more on norms of behavior than on pure constraints. Agarwal and Prasad (1997) and Karahanna *et al.* (1999) liken perceived Voluntariness to the construct of Subjective Norm in the Theory of Reasoned Action.

Use by others in the individual's reference group, especially by peers, reflects behaviorally on both the task requirements faced by the individual and the established norms regarding system use (Rice and Aydin 1991). Thus, if all of my peers and my manager use the technology, this is a reflection on (a) what is required to get the job done, and (b) what is expected in terms of conformity with group norms. Such pressures are expected to result in a lower perceived sense of Voluntariness about using the innovation. Thus:

H5. The more an individual is aware of Others' Use of the innovation, the less he or she will perceive its use as voluntary (Others' Use → Voluntariness).

3.2. Trialability

Trialability represents the perception that the individual had adequate opportunity to try out the innovation before adopting it. It reflects characteristics both of the technology itself (is it something that can be used on a trial basis) and of the implementation process by which it is introduced (did the organization choose to allow trial opportunities?).

While the act of trying out an innovation provides an opportunity to learn more about it, which could affect any PCI, most of the influences would be determined more by what was learned than by the trial itself. However, regardless of what is learned in trying out an innovation, the opportunity to try it out serves as a form of experience. Thus, we expect Trialability to be a positive influence on Compatibility with Prior Experience, in essence because through trials, using the innovation becomes part of one's prior experience. Thus, we propose:

H6. The more an individual perceives the innovation as having been available to try out before adoption, the more he or she will view the innovation as compatible with his or her prior experience (Trialability → Compatibility with Prior Experience).

3.3. Compatiblity with Prior Experience

Compatibility with Prior Experience reflects the degree to which the individual sees the innovation as being consistent with his or her past experiences, and is reflected by items such as "Using the innovation is different from everything I've done before" (reverse coded). Such prior experience shapes our mental models of an innovation; thus, to the extent that the new innovation is similar to those that have been used in the past by the individual, it will be perceived as easier to use. As a result, we hypothesize:

H7. The more an individual perceives the innovation as compatible with his or her prior experience, the more he or she will perceive it as easy to use (Compatibility with Prior Experience → Ease of Use).

3.4. Ease of Use

Perceived Ease of Use has been extensively studied in the IS literature. We have developed a good understanding of many of its consequences. Three are proposed in this model, consistent with prior theorizing and empirical evidence. First, all things being equal, we would expect people to prefer to work in ways that are easy for them. Few of us willingly and happily subject ourselves to difficult ways of accomplishing our work tasks. As a result, we expect that people will see innovations that are easy to use as being more compatible with their preferred way of working.

H8. **The more the individual perceives the innovation as easy to use, the more he or she will feel that using it is compatible with his or her preferred work style (Ease of Use → Compatibility with Preferred Work Style).**

The link between perceived Ease of Use and Perceived Usefulness (essentially the same as Relative Advantage) has been established in countless studies based on TAM and TPB (Venkatesh *et al.* 2003). For the same reasons described for Compatibility with Preferred Work Style, it is logical to think that people will see greater advantage in those innovations that are seen as easy to use. Empirical support for this relationship is provided by Chen *et al.* (2002); Igbaria *et al.* (1997); Plouffe *et al.* (2001a); and Venkatesh (2000), among others. Thus, we propose:

H9. **The more the individual perceives the innovation as easy to use, the more it will be seen as having Relative Advantage (Ease of Use → Relative Advantage).**

TAM proposes that perceived Ease of Use influences behavior directly under some circumstances. There is substantial empirical support for this view (Agarwal and Karahanna 2000; Bhattacherjee 2001; Chen *et al.* 2002; Davis *et al.* 1989; Igbaria *et al.* 1997; Plouffe *et al.* 2001a; Venkatesh 2000; Venkatesh and Davis 2000; Venkatesh *et al.* 2003). Several authors have found the influence of EOU on use to be moderated by prior experience. While we acknowledge this, the complexity of our model does not permit the examination of moderators. Thus, we propose:

H10. **The more the individual perceives the innovation as easy to use, the more intensively it will be used (Ease of Use → Use Intensity).**

3.5. Compatiblity with Values

An individual's preferred work style is likely to be consistent with his or her values. People tend to want to behave in ways that are consistent with their deeply held views. Thus, we would expect that an innovation that is compatible with one's values is likely to be perceived as more compatible with one's preferred work style than is an innovation that runs counter to one's values. Formally stated:

H11. **The more the individual perceives that using the innovation is compatible with his or her values, the more he or she will feel that using it is compatible with his or her preferred work style (Compatibility with Values → Compatibility with Preferred Work Style).**

Similarly, Relative Advantage is expected to be partly determined by consistency with an individual's values. Because Relative Advantage refers to the personal benefits derived from using the innovation, it is difficult to imagine a rational decision maker finding advantage in an innovation that conflicts with deeply held values. Karahanna *et al.* (2006) provide some support for this notion – Compatibility with Values is an essential component of the overall Compatibility construct, which is shown to influence Perceived Usefulness. Thus, we propose:

H12. **The more the individual perceives that using the innovation is compatible with his or her values, the more he or she will see it as having Relative Advantage (Compatibility with Values → Relative Advantage).**

3.6. Image

Image represents the degree to which the individual believes that using the innovation will enhance his or her status or image. Rogers (2003) argues that individuals are more likely to adopt innovations that are seen as image enhancing, since the development and maintenance of a positive image is an important human motivation.

But the influence of Image may be both direct and indirect. Based on prior literature, we expect the influence of Image on Use Intensity to be partially mediated by Relative Advantage. Venkatesh and Davis (2000) argued that Perceived Image would influence Relative Advantage. Increased Image results in additional power, which is a source of advantage/benefits to the individual. This hypothesis is also supported by Webster and Hackley (1997) and Aubert and Hamel (2001):

H13. **The more the individual perceives that using the innovation will enhance his or her status or image, the more he or she will perceive its Relative Advantage (Image → Relative Advantage).**

Finally, and as noted earlier, we expect Image to influence Use Intensity directly. People's behavior in organizations does not exclusively focus on the rational elements of what is good for their job. Social and political motivations are also important in explaining our work behaviors. Empirical support for this hypothesis is provided by Plouffe *et al.* (2001a). Thus, we propose:

H14. **The more the individual perceives that using the innovation will enhance his or her status or image, the more intensively he or she will use it (Image → Use Intensity).**

3.7. Compatiblity with Preferred work style

We expect Compatibility with Preferred Work Style to have several effects. First, we expect that innovations that fit more naturally with an individual's preferred way of working will be easier for him or her to explain to others. Holak and Lehmann (1990) argue that the familiarity that comes from an innovation that is compatible with one's preferred way of working makes it easier for an individual to recognize and communicate its benefits to others. They found a significant relationship between these constructs for a collection of nineteen consumer durable products. This relationship is formalized as:

H15. **The more the individual perceives that using the innovation is compatible with his or her preferred work style, the higher the perceived Communicability of the results of using the innovation (Compatibility with Preferred Work Style → Communicability).**

Compatibility with Preferred Work Style has been shown to be strongly related to perceived Relative Advantage in previous research (Agarwal and Prasad 2000; Karahanna *et al.* 2006; Karahanna *et al.* 1999; Moore and Benbasat 1991; Plouffe *et al.* 2001a) In fact, the strength of the relationship is such that discriminant validity is sometimes called into question. Holak and Lehmann (1990) suggest that the link between these two constructs is causal. Part of the reason that individuals would believe an innovation to be useful (have Relative Advantage) is that they believe it will be compatible with how they would prefer to work, given the choice. Venkatesh and Davis (Venkatesh and Davis 2000) hypothesize an influence of job relevance that they liken to Compatibility. This relationship is also supported by Aubert and Hamel (2001), Chau and Hu (2001), and Chen *et al.* (2002). Thus we propose:

H16. **The more the individual perceives that using the innovation is compatible with his or her preferred work style, the more he or she will see it as having Relative Advantage (Compatibility with Preferred Work Style → Relative Advantage).**

Moreover, we expect Compatibility with Preferred Work Style to exert a direct influence on Use Intensity. Regardless of an individual's perception that an innovation would be better than available options in terms of effectiveness and efficiency, if the innovation is consistent with how that individual would prefer to work, he or she is more likely to adopt it. Moreover, Agarwal and Prasad (1997) and Plouffe *et al.* (2001a) found an influence of Compatibility on intention, which is antecedent to use. Thus, we propose:

H17. **The more the individual perceives that using the innovation is compatible with his or her preferred work style, the more intensively it will be used (Compatibility with Preferred Work Style → Use Intensity).**

3.8. Measurability

Measurability is expected to exert an influence primarily on Relative Advantage. Venkatesh and Davis (2000) observed a relationship between Result Demonstrability and Perceived Usefulness. They argued that individuals form more positive perceptions of the system if the relationship between use and performance is readily discernable. Extending this logic to the specific construct of Measurability, we argue that in those cases where impact is easily measurable, a stronger use-performance link will be found. If the impact cannot be measured (e.g., it is hard to see how much time is saved through using the innovation; or the impact is the potential to make better decisions rather than a direct improvement in decision making) then it will be more difficult to perceive the advantages of the innovation. Thus, we propose:

H18. **The greater the degree of Measurability of the innovation, the more the individual will see it as having Relative Advantage (Measurability → Relative Advantage).**

3.9. Communicability

Perceived Communicability is expected to influence Use Intensity directly. This view is different from how adoption antecedents are often viewed in the information systems literature. Most studies view Relative Advantage (or its close cousin, Perceived Usefulness) as mediator through which other variables operate. Yet, it is consistent with the innovation diffusion literature, which views communication as one of the central elements in the innovation decision process (Rogers 2003; Tornatzky and Klein 1982).

Potential adopters move closer to adoption by reducing uncertainty through communication. Thus, the ease with which the benefits of an innovation can be communicated should influence both the speed and level of adoption. Holak and Lehmann (1990) argue that innovation diffusion is faster if the benefits of the innovation are "perceived easily and expressed readily" (p. 61). In our study, we ask about the ability of the individual to communicate the benefits of the innovation as an assessment of the innovation property of Communicability. If the respondent can communicate about the innovation, then presumably others can as well. Thus, we argue:

H19. The more the individual perceives the Communicability of the innovation, the more intensively he or she will use it (Communicability → Use Intensity).

3.10. Voluntariness

Perceived Voluntariness reflects an important aspect of social influence. Such influences can operate through a mechanism of compliance (i.e., doing what is required *because it is required)* or internalization (Klein and Sorra 1996). When such influences are internalized, we would expect Voluntariness to influence Relative Advantage directly. This relationship was found by Aubert and Hamel (2001). It is similar to the effect proposed by Venkatesh and Davis (2000), where Subjective Norm was found to influence Perceived Usefulness. While Subjective Norm and perceived Voluntariness are not identical constructs, they both reflect normative pressure from one or more members of the individual's reference group (Agarwal and Prasad 1997; Karahanna *et al.* 1999). Thus, we suggest:

H20. The less the individual perceives use of the innovation to be voluntary, the more he or she will view it as having Relative Advantage (Voluntariness → Relative Advantage).

In addition, we hypothesize a relationship between perceived Voluntariness and Use Intensity. But here the evidence is mixed. Moore and Benbasat hypothesized that less Voluntariness results in greater use, but they found the opposite (more Voluntariness leads to more use), which they explained as cognitive dissonance reduction. Others have suggested a moderating effect of Voluntariness (though this is not tested here due to model complexity). However, the strongest empirical support is found for a negative relationship (Agarwal and Prasad 1997; Karahanna *et al.* 1999). Thus, we propose:

H21. The more the individual perceives that using the innovation is a voluntary decision, the less intensively it will be used (Voluntariness → Use Intensity).

3.11. Relative Advantage

The ability to communicate the benefits of an innovation's use will depend greatly on the benefits one perceives in the innovation. Communicability, in effect, is higher for a worthwhile innovation. Holak and Lehmann (1990) found a positive link between Relative Advantage and Communicability for entertainment products.

It is important to note here that the directionality of this relationship is different from the directionality for the other two elements of observability in our model (Others' use and Measurability). This will be examined in more detail in our discussion.

In sum, we propose:

H22. The more the individual perceives that the innovation has Relative Advantage, the more he or she will feel that its benefits can be readily communicated (Relative Advantage → Communicability).

Technology acceptance research has long demonstrated the influence of Relative Advantage (or Perceived Usefulness) on adoption behavior (Agarwal and Karahanna 2000; Bhattacherjee 2001; Chen *et al.* 2002; Davis *et al.* 1989; Igbaria *et al.* 1997; Plouffe *et al.* 2001a; Venkatesh 2000; Venkatesh and Davis 2000; Venkatesh *et al.* 2003). Thus, our final hypothesis is as follows:

H23. The more the individual perceives that the innovation has Relative Advantage, the more intensively it will be used (Relative Advantage → Use Intensity).

4. Field Study

The purpose of the field study was twofold: to validate the measures of the redeveloped PCI and to provide a preliminary test of the extended theoretical model. We collected data from 380 employees of a community hospital, focusing on their perceptions and use of a comprehensive hospital computer system. The system had been in place for approximately two years at the time of data collection, [5] and had facilities for maintaining patient records, ordering tests, reviewing test results, and emailing and scheduling. Use of the system was partly mandatory: all patient records were maintained on the system, so some level of use was required for the majority of employees. Nonetheless, there did seem to be opportunities to delegate direct use of the system for at least some employees, and the use of email and scheduling were clearly not universal. We viewed this system as typical of many technology innovations, in that some level of usage was likely required for all users, with a range of use possible depending on personal preference. Thus, while we expect that use will be less well predicted by the model (since some degree of use is constrained), we believe that the relationships will still hold as indicated.

[5] Some sites (this was a multi-site hospital organization) had been using the technology longer than others. The most recent implementation was six months prior to our survey.

4.1. Subjects

We mailed surveys through the hospital's internal mail system to all of the 2,113 non-physician employees at the hospital's three campuses. Physicians were not included in this aspect of the study, since the survey was lengthy (112 questions), and our contact at the hospital indicated that the response rate would be quite low. In total, we received 432 responses, a 20 percent response rate. While this is lower than would be desired, it is not unusual for large-scale surveys. We were unable to do a follow-up mailing with non-respondents, at the request of the organization. After removing surveys with a high percentage of missing responses, we were left with 380 usable responses. A comparison of the early responders to the late responders showed no significant differences on demographic variables (age, sex, years at the organization, years using computers) or any of the constructs in our research model. This approach to assessing non-response bias is based on the estimation procedure recommended by Armstrong and Overton (1977).

The respondents were, on average, 44 years of age. Ninety percent were women. They had worked at the organization for an average of 13 years and in their current job for eight years. Ninety-nine percent were full time employees. Over half worked straight days (54.6percent) while 40.6percent worked rotating shifts. The remainder was split between evening and night shift workers. The largest group of respondents (32.2percent) was Registered Nurses (RNs). Allied Health Professionals (physiotherapists, occupational therapists, etc.) represented 20.1percent of the respondents, and office staff represented 17.3percent. The remainder was a mix of managers, other patient care, and non-office staff. Table 1 shows the breakdown of respondents by job group.

Table 1. Staff Respondent by Group

Responses by Job Group	Percent
Director/Manager	6.9
Supervisor/Coordinator/Resource Nurse	8.8
RN	32.2
RPN	6.4
Other Patient Care	1.9
Allied Health Professional	20.1
Non-Patient Care (Office)	17.3
Non-Patient Care (Non-Office)	4.5
Other	1.9

The respondents reported using the system for an average of 2.5 hours per day. Reported use ranged from 0-11 hours, indicating a high degree of variability in intensity of use. Table 2 shows the descriptive statistics for the key constructs in our model.[6]

Table 2. Descriptive Statistics

	Mean	Std. Deviation
Others' Use – Peers	6.43	1.24
Trialability	4.60	1.35
Ease of Use	4.42	1.38
Compatibility with Prior Experience	4.34	1.49
Compatibility with Prior Values	5.12	1.22
Measurability	4.04	1.19
Image	3.83	1.51
Communicability	4.51	1.13
Voluntariness	1.76	1.13
Relative Advantage	4.33	1.60
Compatibility with Preferred Work Style	4.10	1.61
Use Intensity – Duration (minutes per day)	153.98	129.03
Use Intensity – Times	22.30	58.90
All items except Use Intensity were measured on a 7 point scale where 1 indicates a low value of the construct and 7 indicates a high value		

4.2. Data Analysis

Data were analyzed using SmartPLS (Version 2.0.M3). Each of the 12 constructs (11 from the PCI plus Intensity of Use) was measured by multiple items, so that estimates of the measurement and structural model performance could be obtained. Two of the constructs –

[6] For this table, we computed summed scores for the reflective constructs, using the items retained in our final model. For the formative constructs (i.e., Others Use, Use Intensity), the individual item values making up the construct are shown. Compatibility with preferred work style is shown in this table although it was subsequently dropped from the model.

Others' Use and Intensity of Use – were modeled as formative, that is, as composed of their elements. Others' Use reflects the degree to which the system is used by different reference groups (e.g., peers, managers, etc.). The usage by different groups is thus understood to form the overall construct of Others' Use (Petter *et al.* 2007). This represents a formative indicator. For Use Intensity, we included two measures: the total amount of time spent using the system in a day and the number of times the system is accessed. Again, Use Intensity is defined as being formed by these two elements, and thus the construct was modeled as formative.

Assessing the measurement properties of formative indicators is a subject of recent academic interest (Diamantopoulos and Winklhofer 2001; Loch, Straub and Kamel 2003; Petter, Straub and Rai, 2007). In this paper, we adopted the process suggested by Loch *et al.* (2003) and built on by Petter *et al.* (2007). This involved creating a weighted score for each formative construct by multiplying the standardized scores of the items by the weights provided by PLS (i.e., in essence a weighted composite factor score). This weighted score was then correlated with the individual items making up the formative construct as well as all other constructs in the model. If the correlations between items of the formative construct and the item-to-construct correlations were significant, the measures were deemed to have achieved convergent validity. For discriminant validity, the items of the formative construct must have correlated more highly with their associated construct then they did with other constructs. For all of the remaining constructs, we viewed the items as being reflections of the underlying construct, and thus modeled them as reflective. For these reflective indicators, traditional measures of reliability and tests of construct validity are appropriate.

The choice to use PLS over other methods such as covariance structure analysis basically came down to a decision about whether to model some constructs as formative. Using the technique suggested by Diamantopoulos and Winklhofer (2001), we could model Others' Use as formative. However, the Diamantopoulos and Winklhofer technique does not work for endogenous constructs with no paths leading from them, necessitating that Use Intensity would have to be modeled as reflective if we wanted to use covariance-based structural modeling techniques. Recent evidence (Petter *et al.* 2007) suggests that inaccurately modeling constructs as reflective, when they are, in fact, formative, leads to an increase in Type 1 errors. Based on this evidence, we selected PLS for the data analysis.

4.2.1. Measurement Model Tests and Refinement

Our first PLS model indicated problems in the measurement of some reflective constructs. We assessed the loadings and cross-loadings, internal consistency reliability, average variance extracted, and discriminant validity following well-established guidelines (Barclay *et al.* 1995). Based on our results, we re-examined the items that performed poorly, and modified the scales. We dropped a total of 19 items at this stage. For some (e.g., EOU3 – "When I use the hospital computer system, it requires a lot of mental effort") we reasoned that the wording may have been ambiguous or awkward, thus resulting in lower reliability. For some of the negatively worded items (e.g. TRIAL9 – "A proper on-the-job tryout of the various uses of the hospital computer system was impossible") we felt that the negative item represented a much stronger sentiment than the positive items, and thus the meaning of the items was different. Relative Advantage and Compatibility with Preferred Work Style showed a lack of discriminant validity, as has been found in previous studies (e.g., Karahanna *et al.* 2006; Karahanna *et al.* 1999; Moore and Benbasat 1991). Given this significant problem, we chose to drop Compatibility with Preferred Work Style from our model. We return to this decision and its implications in our discussion.

There were also problems with the formative constructs. Although all three measures of Others' Use satisfied the criteria for convergent validity, there were issues with discriminant validity for two of the three measures (OU_MGR; OU_PEXT). These items were dropped from the analysis. Thus, our conclusions regarding the effect of Others' Use are confined to the use of the hospital computer system by one's peers. This is consistent with our view of Others' Use as reflecting group norms, as only the behavior of peers seems relevant to its formation. The two measures of Use Intensity were acceptable, and this construct was deemed to have met the standards for convergent and discriminant validity. Appendix 3 shows the items that were deleted from the analysis (marked with an x). Details of the analysis are available from the authors.

Once we had removed the items that appeared to be problematic, we re-estimated model parameters. The results substantially improved. Table 3 shows the internal consistency reliabilities for each of the reflective constructs, all of which exceed 0.7. To assess discriminant validity of the reflective constructs, we used two criteria. First, discriminant validity requires that the constructs share more variance with the items that measure them than with other constructs. In all cases, the shared variance between a construct and its measures is higher than the correlation between constructs (shown on the diagonal of Table 3), the test suggested by Gefen et al. (2000). Second, a look at the loadings and cross-loadings (available from the authors) did not reveal any overly problematic cross-loadings.

The net effect of our examination was to conclude that, as modified, the measures of the PCI were reliable and demonstrated both convergent and discriminant validity. The items that were removed from the scales were problematic in various respects and thus did not reflect the intended constructs well. With the measurement model satisfactory, we were now prepared to examine the structural model and evaluate the hypotheses regarding the influence of the PCI constructs.

4.3. Structural Model Tests

The path coefficients (shown in Table 4) represent standardized betas. Significance was assessed using bootstrapping, with 1,000 samples of size 380. The results show moderate support for the model. We dropped five of the original hypotheses when Compatibility with Preferred Work Style was omitted from the model. Of the remaining 18 hypotheses, 14 were significant.

Use by peers did not influence Trialability (H1). Ease of Use did not directly influence Use Intensity (H10); this is consistent with previous results, that has found the relationship between Ease of Use and Use Intensity to be fully mediated by Relative Advantage. The effect of Image on Use Intensity was also mediated; thus its direct effect was not supported (H14). Finally, the effect of Voluntariness on Relative

Table 3. Reliability and Discriminant Validity of Constructs (Revised Model)

		Construct (by Number)										
	ICR	OU	TRIAL	CEXP	EOU	CVAL	COMM	IMAGE	MEAS	RA	VOL	USE
OU	n/a	n/a										
TRIAL	.85	.08	**.70**									
CEXP	.80	.06	.31	**.71**								
EOU	.89	.15	.35	.46	**.75**							
CVAL	.83	.09	.33	.39	.43	**.74**						
COMM	.80	.19	.28	.34	.41	.30	**.71**					
IMAGE	.90	.14	.20	.14	.39	.32	.37	**.84**				
MEASUR	.82	.16	.25	.19	.39	.32	.56	.38	**.78**			
RA	.96	.21	.29	.35	.64	.59	.45	.63	.47	**.84**		
VOL	.88	-.34	-.19	-.11	-.04	-.18	-.12	-.10	-.06	-.11	**.77**	
USE	n/a	.32	.03	.23	.21	.10	.27	.20	.24	.31	-.22	n/a

ICR = Internal Consistency Reliability
The diagonal elements show the square root of the average variance extracted (indicating the average correlation between the construct and its measures). The off diagonal elements show the correlations between constructs

Table 4. Tests of Hypotheses

H#	Path	Path Coefficient	t-value (p)
H1	Others' Use – Trialability	.08	1.37 (ns)
H2	Others' Use – Ease of Use	.12	3.23 ($p < .01$)
H3	Others' Use – Image	.14	3.09 ($p < .01$)
H4	Others' Use – Relative Advantage	.07	2.14 ($p < .05$)
H5	Others' Use – Voluntariness	-.34	4.10 ($p < .001$)
H6	Trialability – Compatible with Prior Experience	.31	7.50 ($p < .001$)
H7	Compatibility with Prior Experience – Ease of Use	.46	11.78 ($p < .001$)
H8	Ease of Use - Compatibility with Preferred Work Style	Dropped	-
H9	Ease of Use – Relative Advantage	.32	7.90 ($p < .001$)
H10	Ease of Use – Use Intensity	-.01	.10 (ns)
H11	Compatibility with Values - Compatibility with Preferred Work Style	Dropped	-
H12	Compatibility with Values – Relative Advantage	.30	8.02 ($p < .001$)
H13	Image – Relative Advantage	.37	9.75 ($p < .001$)
H14	Image – Use Intensity	-.02	.24 (ns)
H15	Compatibility with Preferred Work Style – Communicability	Dropped	-
H16	Compatibility with Preferred Work Style – Relative Advantage	Dropped	-
H17	Compatibility with Preferred Work Style – Use Intensity	Dropped	-
H18	Measurability – Relative Advantage	.10	2.70 ($p < .01$)
H19	Communicability – Use Intensity	.15	2.78 ($p < .01$)
H20	Voluntariness – Relative Advantage	.02	.56 (ns)
H21	Voluntariness – Use Intensity	-.18	4.54 ($p < .001$)
H22	Relative Advantage – Communicability	.45	9.49 ($p < .001$)
H23	Relative Advantage – Use Intensity	.23	3.06 ($p < .01$)

Table 5. Explained Variance in Endogenous Constructs

Construct	Explained Variance
Trialability	1.0%
Compatibility with Experience	9.8%
Ease of Use	23.1%
Communicability	20.2%
Image	2.0%
Voluntariness	11.8%
Relative Advantage	67.0%
Use Intensity	14.9%

Table 6. Direct, Indirect and Total Effects			
	Direct Effect	Indirect Effect	Total Effect
Others' Use			
…on Trialability	.08	-	.08
…on Compatibility with Prior Experience	-	.03	.03
…on Voluntariness	-.34	-	-.34
…on Ease of Use	.12	.02	.14
…on Image	.14	-	.14
…on Relative Advantage	.07	.09	.16
…on Communicability	-	.07	.07
…on Use Intensity	-	.11	.11
Trialability			
…on Compatibility with Prior Experience	.31	-	.31
…on Ease of Use	-	.14	.14
…on Communicability	-	.02	.02
…on Relative Advantage	-	.05	.05
…on Use Intensity	-	.01	.01
Compatibility with Prior Experience			
…on Ease of Use	.46	-	.46
…on Relative Advantage	-	.15	.15
…on Communicability	-	.07	.07
…on Use Intensity	-	.04	.04
Ease of Use			
…on Communicability	-	.15	.14
…on Relative Advantage	.32	-	.32
…on Use Intensity	-.01	.10	.09
Compatibility with Values			
…on Relative Advantage	.30	-	.30
…on Use Intensity	-	.09	.09
…on Communicability	-	.13	.13
Image			
…on Communicability	-	.17	.17
…on Relative Advantage	.37	-	.37
…on Use Intensity	-.02	.12	.10
Measurability			
…on Communicability	-	.04	.04
…on Relative Advantage	.10	-	.10
…on Use Intensity	-	.03	.03
Communicability			
…on Use Intensity	.15	-	.15
Voluntariness			
…on Relative Advantage	.02	-	.02
…on Use Intensity	-.18	.00	-.18
…on Communicability	-	.01	.01
Relative Advantage			
…on Communicability	.45	.00	.45
…on Use Intensity	.23	.07	.30

Advantage was not significant (H20). Thus, in this situation, pressure to adopt seemed to operate more through a mechanism of compliance (direct effect on Use Intensity) rather than internalization. The implications of these results will be discussed in the next section of the paper.

Table 5 shows the explained variance in the endogenous constructs in the model. The model explains nearly 15percent of the variation in Use Intensity. This is somewhat lower than previous research that includes the actual usage construct. But given the context of the study (the hospital system was at least to some extent mandatory), it is not surprising. Moreover, the fact that Relative Advantage, in addition to perceived Voluntariness, predicts extent of use reinforces our view that even for a supposedly mandatory use system, variations in intensity of usage do occur and are explainable by models of volitional behavior.

An assessment of the total effects of each construct on Use Intensity further demonstrates the value of a more complex model (Table 6). Relative Advantage has the largest total effect on Use Intensity (0.30). Yet several constructs that are either not hypothesized to have, or else do not turn out to have, significant direct effects on Use Intensity, do show significant indirect effects. Others' Use and Compatibility with Values are not hypothesized to have any direct effect on Use Intensity. Yet when all of the relationships in the model are taken into account, Others' Use has a total effect of 0.11 and Compatibility with Values has a total effect of .09. Ease of Use and Image were each hypothesized to have a direct effect on Use Intensity. Yet in the final model, they both showed small negative (and non-significant) direct effects. Their total effects, however, are positive (0.09 for Ease of Use and 0.10 for Image). These are still small effects, but they are important to consider, as they provide for a deeper understanding of the phenomenon.

In general, the model supports our view of inter-relationships among the perceived characteristics of innovating. We demonstrate that the effects are not simply additive influences on Use Intensity, but rather that the PCI constructs influence each other as well as Use Intensity. Modeling these more complex influences helps to better understand the factors that influence individuals' acceptance and use of IT. Moreover, modeling the relationships between Relative Advantage and the other PCI characteristics helps us to understand how this critical antecedent to Use Intensity is itself formed. This information will be valuable when trying to influence RA perceptions.

5. Discussion

Our reconsideration of the PCI constructs makes both theoretical and methodological contributions. Theoretically, our principal contribution is the demonstration of the value of richer theoretical models. Figure 3 shows the trimmed model, which was ultimately supported by our data. This more complex model demonstrates the potential for improved understanding that comes from considering a richer model. The assessment of total effects shows that we might draw different conclusions about the role of a construct if we fail to consider its indirect effects. In particular, we find that the impact of Ease of Use, Compatibility with Values, Image, and Others' Use would be underestimated if indirect effects are not taken into account. The organizational and social environment (e.g., Others' Use, Trialability, Voluntariness) influence perceptions of a technology's Ease of Use, Compatibility, Communicability, Image enhancing potential, and Relative Advantage) and ultimately the intensity with which it will be used. Our findings show that Relative Advantage, as conceptualized here, is a summary judgment that mediates or partially mediates the effects of many other variables on Use Intensity. It would be tempting to conclude, then, that the most important factor to understand is Relative Advantage. But simply knowing that Relative Advantage is the strongest influence on Use Intensity tells us little about how to influence that perception of advantage. If our goal is simply to predict Use Intensity, then focusing on Relative Advantage is appropriate. But if our goal is to develop means by which to influence Use Intensity, then understanding the myriad ways in which perceptions of an innovation's characteristics are formed and exert influence on Use Intensity becomes far more critical. This study provides a preliminary examination of one possible set of relationships. Further work should continue to examine the inter-relationships among these influences. What happens when these factors are mutually reinforcing? What happens when they are in conflict?

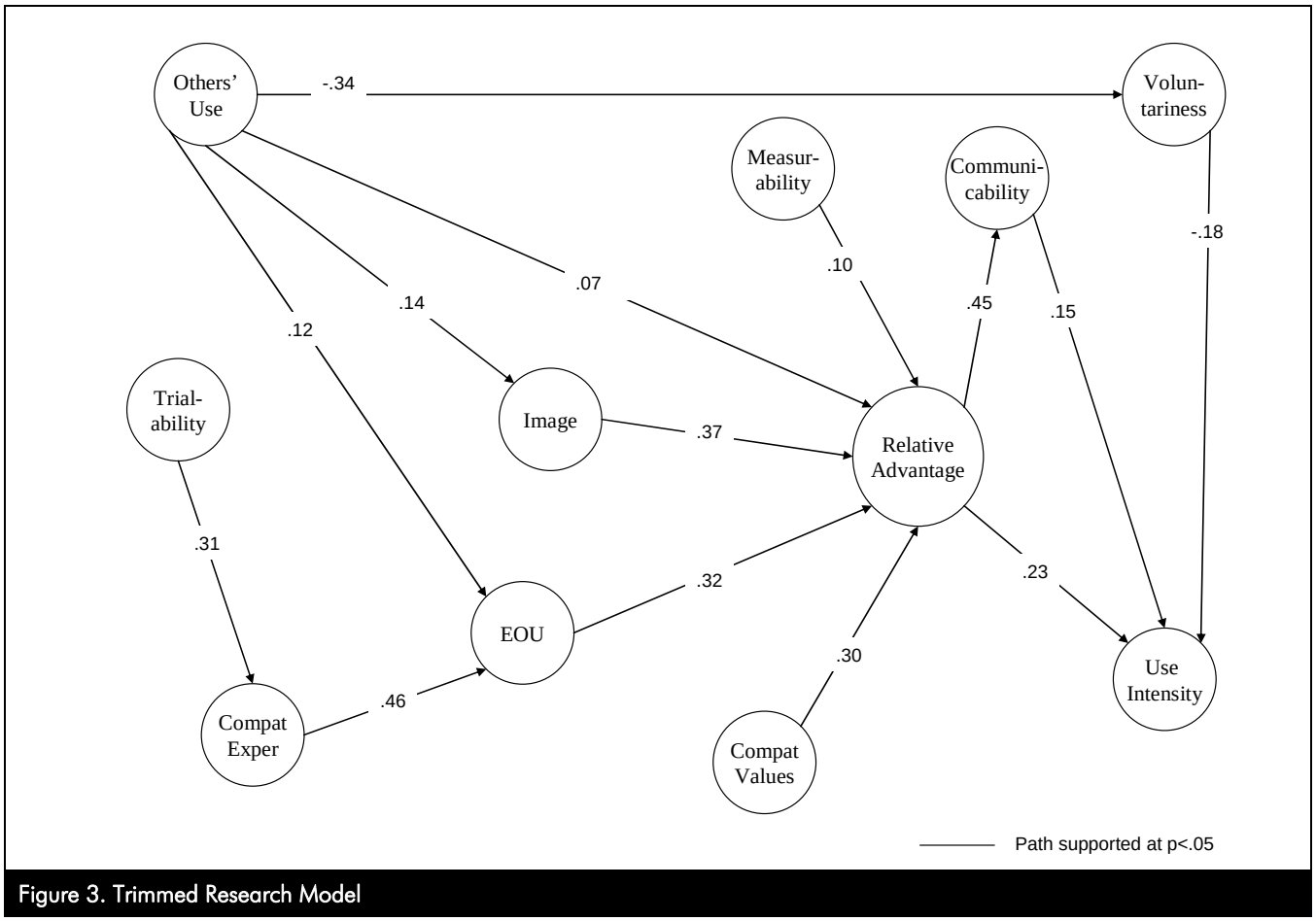

Figure 3. Trimmed Research Model

One particular theoretical avenue that requires additional attention is the directionality of the relationships. As we noted at the outset, we provide what we believe to be a logical case for the directionality of our relationships. Yet we acknowledge that many relationships are reciprocal in nature. Others' Use, for example, influences Use Intensity (indirectly). This individual's use, then, becomes part of the Others' Use for colleagues and influences their adoption, reinforcing the relationship further. In addition, Compatibility with Values influences Relative Advantage, since people are unlikely to see benefits in something they consider counter to their values. But at the same time, RA influences Compatibility with Values, as these values may be subject to change when confronted with truly beneficial technologies. Our study, being cross-sectional in nature, was unable to fully explore these bi-directional relationships. Thus, further exploration of these influences is necessary. This represents a significant opportunity for theoretical development. Such developments are likely to require more intensive research methods, however, to fully appreciate the processes by which technologies diffuse through the organization and the ongoing linkages between adoption antecedents.

A second key theoretical contribution comes from the separation of constructs into more precise elements. Following on the work of Karahanna *et al.* (2006), who did this for Compatibility, this study considers three elements of Rogers' observability construct: Others' Use, Measurability, and Communicability. Each of these elements had been present in prior literature, but little research had considered them collectively. By separating them out, we see that each element has different influences in the model. Others' Use directly influences Ease of Use, Image, Relative Advantage, and Voluntariness perceptions, while Measurability influences Relative Advantage directly (though the path is quite small). Communicability, on the other hand, was found to partially mediate the influence of Relative Advantage on Use Intensity, based on an assessment following the procedures outlined by Baron and Kenney (1986). This distinction between the roles of the three Observability elements demonstrates the value of conceptualizing this multi-dimensional construct more precisely. By separating out the different dimensions, we can observe relationships that might be masked if they were only viewed at the higher order level.

From a methodological standpoint, this paper shows that Moore and Benbasat's argument that "additional checks for validity and reliability would be prudent after rewording [to adapt to other contexts]" was more than just conservatism on the part of the authors. Instrument development truly is an ongoing process and, as argued by Straub (1989) and Boudreau *et al.*(2001), we need to continue to devote attention to this process at all stages of research. A key goal of our research was to extend the development of Moore and Benbasat's PCI constructs and to develop new, more robust measures. Our study was partly successful in this regard. We have developed new instruments, which have passed the basic tests of content validity through card sorts.

The scales we have developed continue to reflect the influence of Moore and Benbasat's (1991) work. Most of our items are the ones that they developed. Some of the items developed by Karahanna *et al.* (2006) have been incorporated, in order to reflect more recent conceptualizations of Compatibility as a multi-dimensional construct.[7] We added items to the existing sets from Moore and Benbasat in order to improve the wording of negatively oriented items (i.e., by making them harder to misread), to replace items that we had found consistently problematic in our earlier work, and to make the items more adaptable to a variety of technological contexts (including those representing hardware, software, and process innovations).

Most of the measures we developed show good psychometric properties and good coverage of the domain. The exceptions, which will be discussed shortly, are Relative Advantage and Compatibility, and the set of constructs that stem from Rogers' observability dimension.

Nonetheless in our model testing, we eliminated many items. Examination of the detailed results suggests at least a few reasons for the lower performance of some measures. First, many of the items that were deleted were negatively worded. In redeveloping our measures, we tried to minimize the possibility that careless reading of the items would result in erroneous responses. But we still see a lower level of consistency between positively and negatively worded items. This suggests that there are more fundamental problems in using a mixture of negatively and positively worded items. It can be argued that strongly disagreeing to a positively worded item does not necessarily equate to strongly agreeing with the item's opposite (Spector *et al.* 1997). For example, consider the Relative Advantage item "Using Microsoft Excel enables me to accomplish tasks more quickly." A respondent who strongly disagrees with this item does not necessarily mean that using Microsoft Excel means they complete tasks more slowly; they might simply feel strongly that it has no effect. Thus, this respondent would not necessarily strongly agree with an item worded in the negative. There are other potential reasons, however, for the lower reliability of negatively worded items. Weems *et al.* (2003) investigated differences in the characteristics of respondents who show the highest differences in absolute scores on negatively and positively worded items in a variety of measures. They found a mix of demographic (e.g., age, gender) and psychographic (e.g., hope, religiosity, lack of confidence) variables that predicted differences in means between the positively worded and negatively worded components of standardized tests. In some cases, the variables are argued to influence careless responding, thus reflecting higher error variance for some groups. In other cases, they are hypothesized to influence willingness to strongly (as opposed to weakly) agree or disagree with items, thus reflecting a difference in the meaning of the construct. Their final recommendation, with which we would agree, is that survey researchers need to examine additional means of minimizing non-attending behaviors. Negatively worded items are one way of doing this, but given the challenges associated with their reliability (in our study) and the systematic differences in scores (found by Weems *et al.* 2003), other means may be necessary. Further investigation of this issue in an Information Systems context is warranted.

The context of our study may also have influenced the performance of the measures in our study. For both Trialability and Compatibility with Prior Experience, the items included a mixture of clearly past tense items (I was given the opportunity to try it out) and more present tense items (I have had the chance to try it out). Since our data were collected after implementation, this combination of items may have

[7] We do not include all of the items developed by Karahanna *et al.*, as we collected our data before their final measures were developed.

produced error. For Compatibility with Prior Experience, for example, the difference in these items may have reflected a difference between Compatibility before implementation and now that the system is in place. The present-tense items were the ones deleted here, and this is consistent with a retrospective data collection. Context also may have influenced the performance of the items measuring Image. The items that were dropped related more to the innovation as a status symbol (vs. a contribution to one's perceived value as an employee). Perhaps for this technology – a relatively mandatory technology being used for day-to-day operational processing – does not represent a source of status, even though it might contribute to other aspects of an individual's image.

Given these reasons for the performance of the measures, the items that were kept in our model can be viewed as a recommended short form, with the caveat that in a different context (either in terms of adoption stage or technology status potential) some items might be productively re-assessed.

As noted earlier, and like many previous studies, our results continue to show problems of discriminant validity between Compatibility with Preferred Work Style and Relative Advantage. Our initial card sorting results suggested this problem, and our model testing results clearly show a lack of discriminant validity between these constructs. Such consistent findings, across studies and methods, suggest a need to reconsider the constructs' definitions and operationalizations. Our reading of Rogers suggests a possible interpretation that would explain these results. Rogers (2003) defined Compatibility in terms of consistency "with the existing values, past experiences and needs of potential adopters" (p. 14). Moore and Benbasat argued that Compatibility with needs was confounded with Relative Advantage, and thus omitted that aspect of Compatibility from their measure. They drew heavily on Davis' construct of Perceived Usefulness in developing their measure of Relative Advantage. As a result, it contains little clear comparison to a precursor technology. Moreover, consistency with needs is a different conceptual construct than a perception that an innovation is relatively better than its precursor. Karahanna *et al.* (2006), in further developing the components of Compatibility, began with Moore and Benbasat's more restricted definition. Perhaps the current measure of Relative Advantage actually captures the concept of Compatibility with Needs. If this were true, then the lack of discrimination between this construct and the two Compatibility constructs mentioned above could be seen as reflecting their membership in a multidimensional construct.

Our solution to the discriminant validity problem in this case was to drop Compatibility with Preferred Work Style. While this is a reasonable approach for dealing with discriminant validity problems among constructs, it is not entirely satisfactory from a theoretical standpoint. Van Slyke *et al.* (2003) present a detailed assessment of the implications of different approaches to modeling these constructs, and argue for the theoretical separation of these constructs. Taken together, our findings suggest the need for additional development of these two constructs, perhaps particularly of Relative Advantage. One additional aspect of the Relative Advantage construct that might be considered in further development is whether it is uni- or multi-dimensional. The items measuring Relative Advantage include items related to efficiency/productivity as well as work quality. These are different elements of work performance, and while the items all hang together – supporting the notion of unidimensionality – conceptually, the elements are quite different, and it is worth exploring whether a multi-dimensional characterization (similar to what we and others have proposed for Compatibility and Observability) is warranted.

Rogers' Observability dimension also reflects a multidimensional construct. In our work, we have decomposed this concept into three elements: Others' Use, Communicability, and Measurability. We have explored a variety of ways to conceptualize Others' Use. In the course of our studies, we have examined this construct using labels based on specific job categories, as well as on reference group-based categories (i.e., peers, managers, subordinates, etc.). Our final model is based on reference group categories. In this context we found that the behavior of peers is the only significant influence. In other contexts, it is possible that other categories will be more important. Thus, continued examination of the role of others' behavior is needed.

Communicability and Measurability were two dimensions present in Moore and Benbasat's Result Demonstrability. We believe both are relevant to consider. However, as we noted earlier, there is still something missing. The notion of Measurability presupposes a degree of precision – and quantification – of the results of using the innovations that are not always present. Focusing on Measurability, then, limits the applicability of the scales. Further development is needed to move this construct away from this narrow focus. In order to accomplish this, we recommend incorporating three items, the first of which comes from Moore and Benbasat's Result Demonstrability construct:

- The results of using [the innovation] are apparent to me
- Benefits from using [the innovation] can be directly attributed to it
- The real advantages of using [the innovation] are hard to prove (R).

The remaining items should be reworded as much as possible to remove the elements that imply quantitative measurement:

- It is hard to measure the results of using [the innovation] ➔ change to "hard to see"
- The effects of using [the innovation] can be assessed precisely ➔ change to "readily assessed"
- It is easy to determine the impact of [the innovation] ➔ leave as is

5.1. Limitations

These contributions must be qualified, given the limitations of the research. The first relates to the importance of context. While we have incorporated multiple innovation types in our card sorting process, in an effort to achieve greater robustness to changes in the innovation context, our three types still represent only specific instances. Including three types is an improvement over a single type, but it is possible that characteristics of the three specific instances we chose (an ergonomic keyboard, Microsoft Excel, and online expense claim

submission) were unique enough to create problems moving to still different contexts. In addition, our empirical test of the revised scales was conducted in a single organization with only a single software innovation. In this organization, use was mandatory for at least some aspects of the system. The respondents were predominantly female, with an average age of 44. Since Voluntariness, age, and gender have been shown to moderate one or more relationships in technology acceptance models, the specific results from our model may not generalize. In order to fully assess the robustness of the scale and the model, a more substantial empirical test is needed, in which a hardware, software, and process innovation would be compared across a larger number of more diverse subjects. It is also possible that a single, generalized model of the factors that influence the adoption of *any* technology is simply not possible. Rather, we should be looking to theorize how our broad frameworks (such as the PCI model) might be expected to differ based on characteristics of the technology. This would respond to calls such as that made by Orlikowski and Iacono (2001) to more fully theorize the technology artifact.

The second set of limitations relates to data collection. As with most, but not all, studies in the area of technology acceptance, our data come from self-reports of both the PCI and usage intensity. Common method bias becomes an issue in such cases. We ran an assessment using Harman's single factor test, and found no evidence of a significant common method effect.

Third, our model considers only Use Intensity as the outcome variable. Jasperson *et al.* (2005) suggest numerous other post-adoption behaviors that could be investigated. To truly understand the relationship between the PCI and technology acceptance, broadly speaking, examination of a wider set of outcome variables (such as scope of use and satisfaction with the technology) need to be considered.

Use Intensity was also measured with what Burton-Jones and Straub (2006) refer to as "lean" measures of use. Our measures were perfectly consistent with past research practice, but it might be desirable for future researchers to consider "richer" measures, especially in that only 15percent of the variance in use was explained by antecedents in our model.

Our arguments regarding the importance of social factors need further exploration. We draw extensively on findings regarding Subjective Norm in developing our theorizing for the role of perceived Voluntariness. Tsai *et al.* (2004) distinguish between Intended Voluntariness, Perceived Voluntariness, and Realized Voluntariness. They argue that Perceived Voluntariness is perhaps closer in definition to the notion of Subjective Norm in the literature. However, this is a function of the way in which the constructs have been measured in the literature. The intent of the Voluntariness construct, as proposed by Moore and Benbasat and as further investigated by a variety of authors, including Venkatesh and Davis (2000), is quite different and relates more closely to Realized Voluntariness. Since we did not measure Subjective Norm in our study, we cannot specifically examine this overlap. Further investigation of the different types of social influence proposed in the literature is necessary to better understand this important factor in technology acceptance.

In terms of our model test, we also believe that further theorizing is necessary. Our trimmed model shows which paths were supported in the model, but it is important to consider other possible paths that we did not examine. Moreover, and as noted earlier, several of the paths we proposed can be argued to operate in both directions; our study did not examine this directionality of influence and is thus limited in its ability to draw firm conclusions about the exact influences of the constructs.

A final limitation of our study is that the measurement modifications that were made were driven by the empirical results, and while they can be explained theoretically (in terms of negatively worded items, timing and technology context), they were not tested on a separate sample, and thus there is the possibility that we have over-fit the measures to the context.

6. Conclusions

In summary, this paper presents a refined conceptualization of the perceived characteristics of innovating, and develops a more complete theoretical model of their influences on Use Intensity. This is important both to future research on technology acceptance and to the practice of technology deployment in organizations. More precise conceptualizations of our constructs are necessary to capture the subtle nuances of individual perceptions, and a more complete theoretical model is necessary to understand the multiple means through which users' behavior can be influenced.

Acknowledgements

We would like to thank Detmar Straub, senior editor, and the review team for their insightful and helpful suggestions throughout the review process. We would also like to thank Michael Medeiros for his help in the instrument development phase of the work. Finally, we acknowledge the financial support of the Social Science and Humanities Research Council of Canada (grant #410-98-0979).

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Appendix 1

PCI Definitions	
Construct	Definition
Relative Advantage	the degree to which the innovation is perceived as being better than the other options – the comparison may be explicit (A is better than B) or implicit (A is better)
Compatibility with Preferred Work Style	the degree to which the innovation is perceived as being consistent with the way the potential adopter *would like to work*, even if that is not the way they work now
Compatibility with Prior Experience	the degree to which the innovation is perceived as being consistent with the prior experience of potential adopters
Compatibility with Values	the degree to which the innovation is perceived as being consistent with the existing values of potential adopters
Ease of Use	the degree to which an innovation is perceived as being easy to use
Image	the degree to which using the innovation is perceived to enhance one's image or status in the organization
Communicability	the degree to which the results of using the innovation can be easily communicated to others
Trialability	the degree to which the innovation may be experimented with before adoption
Voluntariness	the degree to which adoption of the innovation is viewed as a matter of personal choice, rather than external pressure
Others' Use	the degree to which potential adopters are aware of other people using the innovation

Appendix 2

Details of Instrument development

Item Generation

We adopted and modified items for the revised constructs from previous work (Karahanna *et al.* 2006; Moore 1989; Moore and Benbasat 1991). We reexamined the negatively worded items to ensure that the negation was dependent on something more than the word "not," following the recommendations of Spector (1992). We also reworded the Image item discussed earlier to "In my organization, people gain prestige through the use of Personal Workstations," which more clearly identifies the innovation as a status enhancing mechanism. Other minor wording changes were made to aid transferability of items to the software or process innovation context. In total, we modified 8 of Moore and Benbasat's 47[8] items.

New items were generated for several of the categories. In some cases we felt that some aspect of the construct wasn't fully covered. In other cases, we felt that additional reverse coded items would be beneficial to avoid response carelessness. Finally, some of the scales had very few items. In total we generated 21 new items. Table A-1 shows the number of items from each source that made up the original pool of 76 items.

Card Sorts and Instrument Revision

Once the item pool was complete we began assessing the dimensionality of the PCIs using card sorting. We followed the procedures used by Moore and Benbasat for confirmatory sorts. Judges (students, faculty and knowledge workers) were asked to independently sort the items into the 12 categories. Three additional categories were added for items that (a) didn't fit with any of the categories, (b) fit in multiple categories or (c) didn't make sense. This ensured that judges would not be force-fitting items. In each round, we conducted sorts for 3 different types of innovation (hardware, software, process). As one motivation for revising the instrument was to make it more robust for application in a variety of contexts, we felt it was important to use multiple contexts throughout the development process. As a result, each of our sorting phases includes multiple types of innovations (Appendix 3 shows the different wordings used for the constructs in the card sorting, and the subsequent field study).

[8] Not all 47 items were used; some related to Compatibility with Current Work Practices and visibility. These items were omitted.

Table A-1. Origins of Items for Initial Pool					
	Number of Items from Each Source				
Construct	Moore & Benbasat Original	Moore & Benbasat Reworded	Karahanna *et al*	Moore 1989	New Items
Relative Advantage	8	1			6
Image	3	2		3	3
Compatibility - Prior Experience			3		
Compatibility - Preferred Work Style	2	1	2		
Compatibility with Values			2		
Ease of Use	8				
Others' Use	1‡	1‡			7
Measurability	5†			1	1
Communicability	1	1		1	
Trialability	10				3
Voluntariness	1	3		2	1

‡ These two items were presented by Moore and Benbasat as Visibility items, but they more closely reflect the definition of Others' Use used in this study.

† These items came from Moore and Benbasat's Result Demonstrability construct.

First Round Sorting and Item Revisions

In the first round, 12 judges completed the sorting task: four each for hardware (an ergonomic keyboard), software (a spreadsheet) and process (online submission of expense claims) innovations. Cohen's Kappa was computed to assess agreement among the judges as to item placement. Jarvenpaa (1989) suggests that Cohen's Kappa in excess of 0.65 represents acceptable consistency between the judges. The overall Kappa was 0.56, an unacceptable fit (Table A-2).

Table A-2. Cohen's Kappa from Card Sorting		
	First Round	Second Round
Hardware	0.62	0.75
Software	0.47	0.71
Process	0.62	0.86
ALL	0.56	0.77

We also computed the number of correct placements of the items and the number of incorrect placements, and used these results to refine the definitions and the items[9]. By considering the specific items that were misplaced and where they were misplaced, we were able to identify sources of confusion in the constructs.

The worst construct in the sorting was Relative Advantage (RA). Only 37.8percent of the RA items were correctly placed into the RA category. Several items were mistakenly classified as Compatibility with Preferred Work Style. Other overlap was observed with Compatibility with Values and with Ease of Use. In addition, there were a relatively high number of items classified as "no fit" and "fits more than one category." The weakness of the Relative Advantage items was surprising to us, since studies that have used the instrument have found it to be reliable. The only weakness found in previous research is a tendency for Relative Advantage to group together with Compatibility. After reviewing the items and the definitions, and talking with some of the subjects, we concluded that the problem is largely in the definition and title of the construct. The Relative Advantage definition[10] makes an explicit comparison to the innovation's precursor. Yet the items themselves make only implicit comparison. Examination of each item reveals a comparison that is implicit in the item (for example, "the innovation will make me more productive" implies that previously one was less productive). However, it is likely that the comparison is not sufficiently obvious to be seen in the card sorting process; thus we clarified the definition in round 2 to include either explicit or implicit comparisons.

In addition to item modifications to address areas of confusion, twelve new items were written to address weaknesses in the item pool. Items were also dropped if they were deemed as being inaccurate and beyond repair. What resulted was a new set of items, trimmed down from 76 to 68.

[9] The details of this analysis are available from the authors.

[10] the degree to which an innovation is perceived as being better than its precursor

Second Round

In the second round, we followed similar procedures and used the same innovations as exemplars. Eighteen judges completed the sorting task: 6 for hardware, 6 for software and 6 for process. Cohen's Kappa was 0.76 overall, an acceptable fit (Table A-2). Kappas by innovation type ranged from 0.71 for software to 0.86 for process[11].

The detailed results (Table A-3) show an improvement in hit rates in the second round card sorts. Most are over 85percent, and the lowest is 70percent. The areas in which problems occurred, in both the overall and innovation type sorts, were the same as for Round 1, though much less pronounced. Relative Advantage continued to be confounded with Compatibility (particularly Compatibility with Preferred Work Style).

Thus, the second round sorts confirmed that the changes improved the fit of items to their categories. The card sorting process shows that, in general, the revised PCI categories are clearly distinguishable as separate factors, and that the items reasonably relate to the categories as hypothesized. There are some areas where discrimination is less than perfect, but these are either situations where there is a strong causal link between the constructs, such as Compatibility with Preferred Work Style to Relative Advantage) or where the constructs are part of a higher order factor (e.g., the 3 dimensions of Compatibility).

Table A-3. Item Placements for the Second Round of Card Sorts

	Category Place In (number of items)												Target
	RA	PRE	EXP	VAL	EOU	IMAGE	COM	MEAS	TRIAL	VOL	OU	XXX‡	%
	(8)	(4)	(4)	(4)	(8)	(7)	(5)	(5)	(9)	(7)	(7)		
RA	101	10			5	1		19				8	70.1%
PRE	1	51		2	2					2		14	70.8%
EXP	2		63		2				2			3	87.5%
VAL				71								1	98.6%
EOU	2	3	3	1	134							1	93.1%
IMAGE	4			1		114		1				6	90.5%
COM	1	1					80	7				1	88.9%
MEAS							2	86				2	95.6%
TRIA			1		1			1	153	4		2	94.4%
VOL		1				1				120	1	3	95.2%
OU		2	2			1				1	105	15	83.3%

Total Placements	1296
Hits	1141
Overall Hit Ratio	88%

‡ This category includes items placed as "doesn't fit", "confusing" or "fits more than one category".

Preliminary Field Test of Instrument

As a final step in our revision process, we conducted a pre-test with the revised instrument. The subjects for the survey were 56 students in a full-time MBA program. They were recruited by their membership in a Change Management course, and were given class time to complete the survey. We assessed the reliability of the measures and their correlations with intensity of use of a Personal Digital Assistant (PDA)[12]. The results were satisfactory. Only Compatibility with Prior Experience demonstrated low reliability (Cronbach's alpha = 0.53). We could not see any clear reasons for this low reliability, and given the small sample size for this pilot study decided to leave the measure unchanged; however, we noted this reliability for future consideration. Relative Advantage Compatibility with Preferred Work Style, Compatibility with Values, Ease of Use, Trialability, Image and Communicability were significantly related to the intensity of use of the PDAs. On the other hand, Compatibility with Prior Experience, Voluntariness of Use and Others' Use were not significantly correlated with intensity of use. While we do not want to read too much into these results, since the data come from a specific hardware innovation, and reflect a small (n=56) sample size, they do support our reconceptualization of the PCIs into finer categories. Two of the three Compatibility sub-constructs were related to intensity of use, but not the third. Furthermore, Others' Use reflects one part of the conceptualization of visibility as defined by Moore and Benbasat. With this data, however, this component is not significantly related to

[11] It should be noted that these Kappa values are lower than those reported by Moore and Benbasat. We believe that one of the reasons for this has to do with the timing of the assessment. In Moore and Benbasat's procedure, judges met to reconcile their findings after they had independently sorted them. This allowed the judges to adjust item placements and provided a basis for understanding the emerging dimensionality of the items. Cohen's Kappa was computed after this process (Moore 1989). Because we were building off the established base of Moore and Benbasat's work, we did not include a reconciliation process among judges, and thus Cohen's Kappas were computed on the unreconciled placements.

[12] Each student had been given a PDA when they entered the program but use was strictly voluntary.

intensity. Again, we advise caution in the interpretation of these results, but suggest that failure to separate the constructs into their more precise factors may result in erroneous conclusions about the strength of the relationships between the PCIs and usage.

Appendix 3

Items used							
	R	Item Code	Source	Hardware Wording	Software Wording	Process Wording	Survey Wording
		RA1	M&B	Using an ergonomic keyboard enables me to accomplish tasks more quickly.	Using Microsoft Excel enables me to accomplish tasks more quickly.	Submitting expense claims online enables me to accomplish tasks more quickly.	Using the hospital computer system enables me to accomplish tasks more quickly.
		RA2	M&B	Using an ergonomic keyboard improves the quality of work I do.	Using Microsoft Excel improves the quality of work I do.	Submitting expense claims online improves the quality of work I do.	Using the hospital computer system improves the quality of work I do.
		RA3	M&B	Using an ergonomic keyboard simplifies my work tasks.	Using Microsoft Excel simplifies my work tasks.	Submitting expense claims online simplifies my work tasks.	Using the hospital computer system makes it easier to do my job.
		RA4	M&B	Using an ergonomic keyboard improves my job performance.	Using Microsoft Excel improves my job performance.	Submitting expense claims online improves my job performance.	Using the hospital computer system improves my job performance.
		RA5	M&B	Overall, I find using an ergonomic keyboard to be advantageous in performing my job.	Overall, I find using Microsoft Excel to be advantageous in performing my job.	Overall, I find submitting expense claims online to be advantageous in performing my job.	Overall, I find using the hospital computer system to be advantageous in performing my job.
	R	RA6	Revision of M&B (reversed)	Using an ergonomic keyboard reduces my effectiveness on the job.	Using Microsoft Excel reduces my effectiveness on the job.	Submitting expense claims online reduces my effectiveness on the job.	Using the hospital computer system reduces my effectiveness on the job.
		RA7	M&B	Using an ergonomic keyboard gives me greater control over my work.	Using Microsoft Excel gives me greater control over my work.	Submitting expense claims online gives me greater control over my work.	Using the hospital computer system gives me greater control over my work.
		RA8	M&B	Using an ergonomic keyboard makes me more productive.	Using Microsoft Excel makes me more productive.	Submitting expense claims online makes me more productive.	Using the hospital computer system increases my productivity.
X		PRE1	Revision of M&B	Using an ergonomic keyboard fits with my preferred work style.	Using Microsoft Excel fits with my preferred work style.	Submitting expense claims online fits with my preferred work style.	Using the hospital computer system fits with my preferred work style.
X		PRE2	M&B; KAA	Using an ergonomic keyboard fits well with the way I like to work.	Using Microsoft Excel fits well with the way I like to work.	Submitting expense claims online fits well with the way I like to work.	Using the hospital computer system fits well with the way I like to work.
X		PRE3	New Item	Using an ergonomic keyboard lets me work the way I would like.	Using Microsoft Excel lets me work the way I would like.	Submitting expense claims online lets me work the way I would like.	Using the hospital computer system lets me work the way I would like.
X	R	PRE4	New Item	It is hard to employ my preferred work style when using an ergonomic keyboard.	It is hard to employ my preferred work style when using Microsoft Excel.	It is hard to employ my preferred work style when submitting expense claims online.	It is hard to employ my preferred work style when using the hospital computer system.
		EXP1	Revision of KAA	The use of an ergonomic keyboard is compatible with my past experience.	The use of Microsoft Excel is compatible with my past experience.	Submitting expense claims online is compatible with my past experience.	The use of the hospital computer system is compatible with my past experience.
	R	EXP2	KAA	Using an ergonomic keyboard is a new experience for me.	Using Microsoft Excel is a new experience for me.	Submitting expense claims online is a new experience for me.	Using the hospital computer system was a new experience for me.

Items used							
	R	Item Code	Source	Hardware Wording	Software Wording	Process Wording	Survey Wording
	R	EXP3	Revision of KAA	Using an ergonomic keyboard is different from everything that I've done before.	Using Microsoft Excel is different from everything that I've done before.	Submitting expense claims online is different from everything that I've done before.	Using the hospital computer system was different from everything that I'd done before.
	R	EXP4	New Item	I lack experience when it comes to things like using an ergonomic keyboard.	I lack experience when it comes to things like using Microsoft Excel.	I lack experience when it comes to things like submitting expense claims online..	I lack experience when it comes to things like using the hospital computer system.
	R	VAL1	Revision of KAA	An ergonomic keyboard provides capabilities that run counter to my values.	Microsoft Excel provides capabilities that run counter to my values.	Submitting expense claims online provides capabilities that run counter to my values.	The hospital computer system provides capabilities that run counter to my values.
	R	VAL2	Revision of KAA	Using an ergonomic keyboard is inappropriate for a person with my values regarding the role of technology.	Using Microsoft Excel is inappropriate for a person with my values regarding the role of technology.	Submitting expense claims online is inappropriate for a person with my values regarding the role of technology.	Using the hospital computer system is inappropriate for a person with my values regarding the role of technology.
	R	VAL3	New Item	My values are in conflict with the use of an ergonomic keyboard.	My values are in conflict with the use of Microsoft Excel.	My values are in conflict with the use of online expense claim submission.	My values are in conflict with the use of the hospital computer system.
		VAL4	New Item	Using an ergonomic keyboard is completely consistent with my values.	Using Microsoft Excel is completely consistent with my values.	Submitting expense claims online is completely consistent with my values.	Using the hospital computer system is completely consistent with my values.
	R	EOU1	M&B	I believe that an ergonomic keyboard is cumbersome to use.	I believe that Microsoft Excel is cumbersome to use.	I believe that submitting expense claims online is a cumbersome task.	I believe that the hospital computer system is cumbersome to use.
		EOU2	M&B	It is easy for me to remember how to perform tasks associated with using an ergonomic keyboard.	It is easy for me to remember how to perform tasks associated with using Microsoft Excel.	It is easy for me to remember how to perform tasks associated with submitting expense claims online.	It is easy for me to remember how to perform tasks associated with using the hospital computer system.
X	R	EOU3	M&B	When I use an ergonomic keyboard, it requires a lot of mental effort.	When I use Microsoft Excel, it requires a lot of mental effort.	When I submit expense claims online, it requires a lot of mental effort.	When I use the hospital computer system, it requires a lot of mental effort.
X	R	EOU4	M&B	Using an ergonomic keyboard is often frustrating.	Using Microsoft Excel is often frustrating.	Submitting expense claims online is often frustrating.	Using the hospital computer system is often frustrating.
		EOU5	M&B	I believe that it is easy to get an ergonomic keyboard to do what I want it to do.	I believe that it is easy to get Microsoft Excel to do what I want it to do.	I believe that it is easy to get what I want out of submitting expense claims online.	I believe that it is easy to get the hospital computer system to do what I want it to do.
		EOU6	M&B	Overall, I believe that an ergonomic keyboard is easy to use.	Overall, I believe that Microsoft Excel is easy to use.	Overall, I believe that submitting expense claims online is easy to do.	Overall, I believe that the hospital computer system is easy to use.
		EOU7	M&B	Learning to operate an ergonomic keyboard is easy for me.	Learning to operate Microsoft Excel is easy for me.	Learning to submit expense claims online is easy for me.	Learning to operate the hospital computer system was easy for me.
		EOU8	New Item	An ergonomic keyboard is user friendly.	Microsoft Excel is user friendly.	Online expense claim submission is user friendly.	The hospital computer system is user friendly.

Items used							
	R	Item Code	Source	Hardware Wording	Software Wording	Process Wording	Survey Wording
		IMAGE1	M&B	Using an ergonomic keyboard improves my image within the organization.	Using Microsoft Excel improves my image within the organization.	Submitting expense claims online improves my image within the organization.	Using the hospital computer system improves my image within the organization.
X	R	IMAGE2	New Item	Using an ergonomic keyboard does little to improve my image within the organization.	Using Microsoft Excel does little to improve my image within the organization.	Submitting expense claims online does little to improve my image within the organization.	Using the hospital computer system does little to improve my image within the organization.
		IMAGE3	M&B	Because of my use of an ergonomic keyboard, others in my organization see me as a more valuable employee.	Because of my use of Microsoft Excel, others in my organization see me as a more valuable employee.	Because of my submitting expense claims online, others in my organization see me as a more valuable employee.	Because of my use of the hospital computer system, others in my organization see me as a more valuable employee.
		IMAGE4	Revision of M&B	In my organization, people gain prestige by using an ergonomic keyboard.	In my organization, people gain prestige by using Microsoft Excel.	In my organization, people gain prestige by submitting expense claims online.	In my organization, people gain prestige by using the hospital computer system.
X		IMAGE5	Revision of M&B	People in my organization who use an ergonomic keyboard have a higher profile.	People in my organization who use Microsoft Excel have a higher profile.	People in my organization who submit expense claims online have a higher profile.	People in my organization who use the hospital computer system have a higher profile.
X		IMAGE6	M&B	Having an ergonomic keyboard is a status symbol in my organization.	Having Microsoft Excel is a status symbol in my organization.	Submitting expense claims online is a status symbol in my organization.	Using the hospital computer system is a status symbol in my organization.
		IMAGE7	Moore	Because of my use of an ergonomic keyboard, I see myself as a more valuable employee.	Because of my use of Microsoft Excel, I see myself as a more valuable employee.	Because of my submitting expense claims online, I see myself as a more valuable employee.	Because of my use of the hospital computer system, I see myself as a more valuable employee.
		COM1	Revision of M&B	I would find it easy to tell others about the results of using an ergonomic keyboard.	I would find it easy to tell others about the results of using Microsoft Excel.	I would find it easy to tell others about the results of submitting expense claims online.	I would find it easy to tell others about the results of using the hospital computer system.
	R	COM2	M&B	Explaining the advantages and disadvantages of an ergonomic keyboard would be difficult.	Explaining the advantages and disadvantages of Microsoft Excel would be difficult.	Explaining the advantages and disadvantages of submitting expense claims online would be difficult.	Explaining the advantages and disadvantages of the hospital computer system would be difficult.
		COM3	Moore	I think that I could very easily describe the effects of using an ergonomic keyboard.	I think that I could very easily describe the effects of using Microsoft Excel.	I think that I could very easily describe the effects of submitting expense claims online.	I think that I could very easily demonstrate the results of using the hospital computer system.
X		COM4	New Item	A person with experience using an ergonomic keyboard could explain its impact to me.	A person with experience using Microsoft Excel could explain its impact to me.	A person with experience submitting expense claims online could explain its impact to me.	A person with experience using the hospital computer system could explain its impact to me.
		COM5	New Item	I believe I could communicate to others the consequences of using an ergonomic keyboard.	I believe I could communicate to others the consequences of using Microsoft Excel.	I believe I could communicate to others the consequences of submitting expense claims online.	I believe I could communicate to others the consequences of using the hospital computer system.
	R	MEAS1	New Item	It is hard to measure the results of using an ergonomic keyboard.	It is hard to measure the results of using Microsoft Excel.	It is hard to measure the results of submitting expense claims online.	It is hard to measure the results of using the hospital computer system.

Items used							
	R	Item Code	Source	Hardware Wording	Software Wording	Process Wording	Survey Wording
X		MEAS2	Moore	I believe that if a person knew how to do it, he or she could actually measure the benefits of using an ergonomic keyboard.	I believe that if a person knew how to do it, he or she could actually measure the benefits of using Microsoft Excel.	I believe that if a person knew how to do it, he or she could actually measure the benefits of submitting expense claims online.	I believe that if a person knew how to do it, he or she could actually measure the benefits of using the hospital computer system.
X	R	MEAS3	New Item	It is difficult to gauge the impact of using an ergonomic keyboard.	It is difficult to gauge the impact of using Microsoft Excel.	It is difficult to gauge the impact of submitting expense claims online.	It is difficult to gauge the impact of using the hospital computer system.
		MEAS4	New Item	The effects of using an ergonomic keyboard can be assessed precisely.	The effects of using Microsoft Excel can be assessed precisely.	The effects of submitting expense claims online can be assessed precisely.	The effects of using the hospital computer system can be assessed precisely.
		MEAS5	New Item	It is easy to determine the impact of an ergonomic keyboard.	It is easy to determine the impact of Microsoft Excel.	It is easy to determine the impact of submitting expense claims online.	It is easy to determine the impact of the hospital computer system.
		TRIAL1	M&B	I have had many opportunities to try out an ergonomic keyboard.	I have had many opportunities to try out Microsoft Excel.	I have had many opportunities to try out online expense claims submission.	I have had many opportunities to try out the hospital computer system.
		TRIAL2	M&B	I know where I can go to satisfactorily try out an ergonomic keyboard.	I know where I can go to satisfactorily try out Microsoft Excel.	I know where I can go to satisfactorily try out online expense claims submission.	I know where I can go to satisfactorily try out the hospital computer system.
	R	TRIAL3	New Item	I am unsure as to where I can go to satisfactorily try out an ergonomic keyboard.	I am unsure as to where I can go to satisfactorily try out Microsoft Excel.	I am unsure as to where I can go to satisfactorily try out online expense claim submission.	I am unsure as to where I can go to satisfactorily try out the hospital computer system.
		TRIAL4	M&B	An ergonomic keyboard was available to me to test adequately.	Microsoft Excel was available to me to test adequately.	Submitting expense claims online was available to me to test adequately.	The hospital computer system was available to me to test adequately.
X		TRIAL5	M&B	Before deciding whether to use any ergonomic keyboard applications, I was able to properly try them out.	Before deciding whether to use any Microsoft Excel applications, I was able to properly try them out.	Before deciding whether to use any applications of submitting expense claims online, I was able to properly try them out.	Before deciding whether to use the hospital computer system, I was able to properly try it out.
		TRIAL6	M&B	I was permitted to use an ergonomic keyboard on a trial basis long enough to see what it could do.	I was permitted to use Microsoft Excel on a trial basis long enough to see what it could do.	I was permitted to submit expense claims online on a trial basis long enough to see what it could do.	I was permitted to use the hospital computer system on a trial basis long enough to see what it could do.
X	R	TRIAL7	New Item	I was permitted to use an ergonomic keyboard on a trial basis for only a short period of time.	I was permitted to use Microsoft Excel on a trial basis for only a short period of time.	I was permitted to submit expense claims online on a trial basis for only a short period of time.	I was permitted to use the hospital computer system on a trial basis for only a short period of time.
		TRIAL8	M&B	I can have an ergonomic keyboard for periods long enough to try it out.	I can have Microsoft Excel for periods long enough to try it out.	I can submit expense claims online for periods long enough to try it out.	I had access to the hospital computer system for periods long enough to try it out.

Items used							
	R	Item Code	Source	Hardware Wording	Software Wording	Process Wording	Survey Wording
X	R	TRIAL9	M&B	A proper on-the-job tryout of the various uses of an ergonomic keyboard is impossible.	A proper on-the-job tryout of the various uses of Microsoft Excel is impossible.	A proper on-the-job tryout of the various uses of submitting expense claims online is impossible.	A proper on-the-job tryout of the various uses of the hospital computer system was impossible.
	R	VOL1	Revision of M&B	Managers in my organization expect me to use an ergonomic keyboard.	Managers in my organization expect me to use Microsoft Excel.	Managers in my organization expect me to submit expense claims online.	Managers in my organization expect me to use the hospital computer system.
X		VOL2	M&B	My use of an ergonomic keyboard is voluntary (rather than required by my manager or job description).	My use of Microsoft Excel is voluntary (rather than required by my manager or job description).	Submitting expense claims online is voluntary (rather than required by my manager or job description).	My use of the hospital computer system is voluntary (rather than required by my manager or job description).
X		VOL3	Revision of M&B	My manager allows me to decide whether to use an ergonomic keyboard.	My manager allows me to decide whether to use Microsoft Excel.	My manager allows me to decide whether to submit expense claims online.	My manager allows me to decide whether to use the hospital computer system.
		VOL4	Revision of M&B	Although it might be helpful, using an ergonomic keyboard is optional in my job.	Although it might be helpful, using Microsoft Excel is optional in my job.	Although it might be helpful, submitting expense claims online is optional in my job.	Although it might be helpful, using the hospital computer system is optional in my job.
		VOL5	Moore	My decision to use an ergonomic keyboard is entirely up to me.	My decision to use Microsoft Excel is entirely up to me.	My decision to submit expense claims online is entirely up to me.	My decision to use the hospital computer system is entirely up to me.
	R	VOL6	New Item	The use of an ergonomic keyboard is mandatory in my organization.	The use of Microsoft Excel is mandatory in my organization.	Submitting expense claims online is mandatory in my organization.	The use of the hospital computer system is mandatory in my organization.
	R	VOL7	New Item	My organization requires me to use an ergonomic keyboard in performing my job.	My organization requires me to use Microsoft Excel in performing my job.	My organization requires me to submit expense claims online in performing my job.	My organization requires me to use the hospital computer system in performing my job.

X – item was dropped after initial model run
(R) – item should be reverse scored

Item Code	Hardware Wording	Software Wording	Process Wording
OU1	My manager uses an ergonomic keyboard.	My manager uses Microsoft Excel.	My manager submits expense claims online.
OU2	Several of my peers in this organization use ergonomic keyboards.	Several of my peers in this organization use Microsoft Excel.	Several of my peers in this organization submit expense claims online.
OU3	Several of my peers in other organizations use ergonomic keyboards.	Several of my peers in other organizations use Microsoft Excel.	Several of my peers in other organizations submit expense claims online.
OU4	People in my department use ergonomic keyboards.	People in my department use Microsoft Excel.	People in my department submit expense claims online.
OU5	In my organization, one is aware of many people using an ergonomic keyboard.	In my organization, one is aware of many people using Microsoft Excel.	In my organization, one is aware of many people submitting expense claims online.
OU6	Many people outside my organization are using ergonomic keyboards.	Many people outside my organization are using Microsoft Excel.	Many people outside my organization are submitting expense claims online.
OU7	Many of my friends use ergonomic keyboards.	Many of my friends use Microsoft Excel.	Many of my friends submit expense claims online.

The items were reformatted for the field study to simplify the presentation. In addition, specific reference groups from the hospital environment were used. This procedure is recommended in future studies to capture the salient influences. The version used in the survey was as follows:

To what extent is the hospital computer system used by each of the following groups of people:

* OU_PEER the people with whom you regularly work.
X OU_MGR your supervisor or manager.
* To what extent are similar hospital computer systems used by your peers at other hospitals. (OU_PEXT)

Abbreviations Used:
RA = Relative Advantage
PRE = Compatibility with Preferred Work Style
EXP = Compatibility with Prior Experience
VAL = Compatibility with Values
EOU = Ease of Use
IMAGE = Image
COM = Communicability
MEAS = Measurability
TRIAL = Trialability
VOL = Voluntariness
OU = Others' Use

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Journal of the Association for Information Systems
ISSN: 1536-9323

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