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Perceptual structure of the desired functionality of internet-based health information systems

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Abstract With the emergence of the Internet, new health information systems are being designed and implemented that focus on coordination between providers, patients, payors and other constituents. While the importance of end user input in identifying the desired functionality of systems has long been recognized, very little work focuses on how users perceive the desired functionalities of these new systems to group together, and the implications of these groupings for the organization of functionalities into program modules and associated user interfaces. In this paper, we advance the construct, user based perceptual structure of desired functionality, in the context of these new coordination-intensive health information systems. Perceptual structure depicts how users perceive different desired system functions to group together. A conceptual framework is advanced which links perceptual structure to two broad categories of components, external coordination and internal coordination, which are related to prospective beliefs about system value. The framework is tested empirically via two field studies conducted by a hospital chain focusing on two major user groups, physicians and office administrators. The setting involves a proposed Internet-based health information system that links various constituencies in the service delivery chain. The empirically generated perceptual structure is found to be largely supportive of its conceptual counterpart. Implications for the design and development of this new class of systems, and public policy implications of such new systems are presented.

Keywords Management information systems development · Health care · Perceptual structure

1. Introduction

In the face of rising healthcare costs and concerns about access and quality, the role of information technology has been assuming growing importance. President Bush has launched an initiative to create a seamless national health record for every American within 10 years. Gingrich et al. [1] recommend the widespread adoption of integrative healthcare information systems as a key initiative in transforming healthcare. David Brailer, the national coordinator for health-care information technology is building the National Health Information Network, a medical Internet designed to hold medical records and health histories for all Americans [2]. Medicare recently announced plans to provide physicians with free software to computerize their medical practices [3]. The Center for Information Technology Leadership [4] estimates that a national system for electronic health information could save as much as $78 billion,[1] but half of that value could be lost if

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[1] While this specific estimate has been disputed by others, the essential claim that information integration contributes substantially to the creation of value is not in dispute.

healthcare providers did not make their systems interoperable. Indeed, a key role of information systems in improving healthcare outcomes is to decrease information asymmetry with the environment, and to do so by availing ourselves of data and information from multiple sources.

The importance of interoperability, which is critical to achieving integrated healthcare systems, is evident when the flow of a patient through the medical system is considered (see Figure 1). Patients see primary care providers, who may prescribe medications, order diagnostic tests, and refer the patient to specialists, or a patient may require hospitalization and so on. In the healthcare context, interoperability pertains primarily to the flow of clinical and administrative data. The most common data flows are between providers such as hospitals and medical group practices and other providers, and between providers and laboratories, radiology centers, pharmacies, payors, and public health departments [4].

The potential benefits of these integrated healthcare systems are manifold: they reduce administrative costs, reduce the likelihood of redundant tests, provide clinicians with longitudinal test results, eliminate errors associated with oral reporting of results, make the costs of procedures more transparent, facilitate prescription writing, provide physicians with data about contraindications, facilitate the coordination of care across providers, save time associated with chart requests and referrals, help prevent errors of omission, reduce the costs and increase the timeliness of processing transactions with payors. Perhaps the most important benefits of these systems are the intangible improvements in improved patient safety and quality of care.

These integrative systems acquire and share information sourced from multiple functions, departments and organizations, and serve a multitude of users including providers, administrators and other professionals. They enable coordination within a provider organization and between a provider and its suppliers, partners and patients.[2] A system may "virtually integrate" many individual systems by using Internet technologies and standards for communication and information sharing. The value of an integrative system derives not just from its individual components, but from the additional benefits that accrue when these systems are used to coordinate both clinical and administrative aspects of patient care. What is unique about healthcare is the degree of interdependence between a large number of fragmented providers—including generalist and specialist physicians, laboratories, hospitals, payors etc.—which result in the importance of incorporating information from multiple sources.

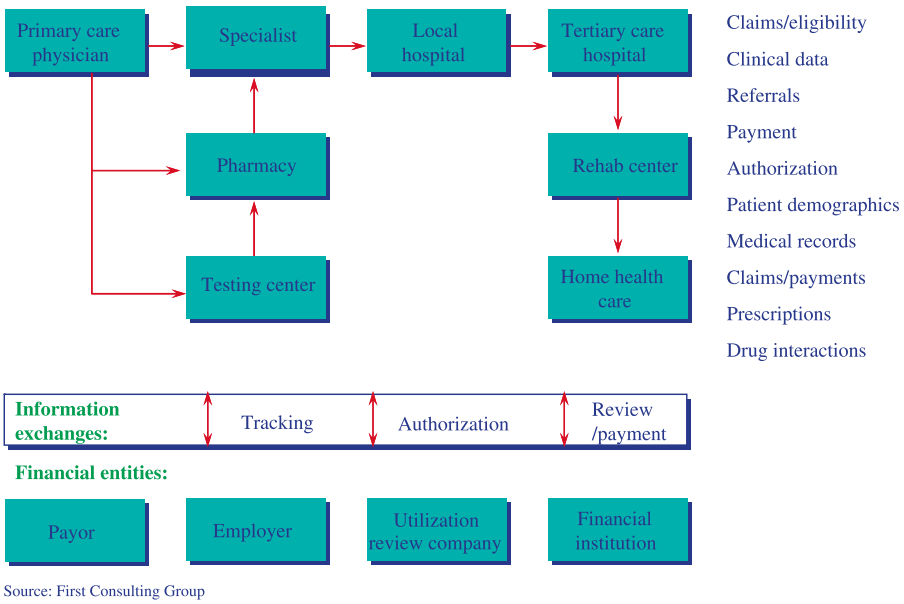
Current technology developments emphasize the increasing importance of integrative systems. The emergence of the Internet as a viable low-cost communications platform coupled with standards for data and information exchange has enabled the development of systems that facilitate communications within and between organizations.[3] Importantly, the development of the World Wide Web and its intuitive graphical user interface has made it easy for medical professionals to learn how to use these systems.

These systems are different from earlier, more traditional health information systems that focused on single functions such as claims processing, scheduling, or medical compliance (see Shiffman et al. [5] for a review of 25 studies) and on a single class of users, such as administrators or physicians. They are also different from earlier integrated systems such as enterprise resource planning systems which while multi-functional, typically focused on a single class of users per function and largely focused on a single enterprise. The new Internet-based systems are much more user-centric, and are often designed so that a specific function can be used by different users or by making many functions available to a single user through a single interface (e.g., a physician who is looking for information on clinical protocols or best practice information, as well as information on financial management of the practice). Moreover, while earlier healthcare systems were largely used by administrators, these new systems are used increasingly by both physicians and administrators. They focus on communications and coordination in addition to data processing, and simultaneously provide access to internal and external resources and organizations, frequently transcending organizational boundaries.

The potential benefits of these integrative systems will only be realized if provider organizations such as hospitals and physician groups adopt and use these systems effectively. A system's usability and its potential benefits are critical factors underlying successful adoption. To maximize effectiveness of healthcare professionals, the system design must incorporate an

[2] Note that it is not the Internet that enables coordination, particularly external coordination, but it is the proposed system that does. Use of the Internet, and its associated standard protocols, as the platform is simply a design choice.

[3] While national standards for healthcare information exchange have not been fully defined or adopted, standards are emerging that will further facilitate adoption.



Source: First Consulting Group

Fig. 1 The continuum of care: typical patient flow scenario

understanding of how these systems will be used, not just in terms of individual features and functions, but more comprehensively in terms of the multiple spheres of work that each user performs. Mark and Gonzalez [6] argue that "most current designs of information technology are based on the notion of supporting distinct tasks" while "people organize their work in terms of much larger and thematically connected units of work." They argue that "design of information technology needs to support people's continual switching of work spheres."

In this paper, we first propose a conceptual framework based in the information processing view of organizations that facilitates the analysis of work spheres. We then examine how users perceive the functionality of these new systems *to group together* with a view to understanding the implications of these *groupings* for system design (especially the organization of program modules and associated user interfaces into screens), system use, and public policy. Note the difference between system functionalities and the grouping of these functionalities. Functionalities refer to individual aspects such as patient diagnostic reports, online pharmacy services, clinical protocols and so on. *Groupings* of these functionalities, which we label *perceptual structure*, denote the *association* between functionalities as perceived by users and can be interpreted as spheres of work that users are engaged in. For example, users may perceive functionalities related to coordination with external suppliers and partners such as online pharmacy services and ordering laboratory tests to be grouped together, while perceiving functionalities related to internal coordination such as best practice information and outcomes measurement services to be grouped together. Further, the knowledge of perceptual structure is likely to be more useful in more complex settings wherein multiple users adopt a cross-functional orientation. Ozcan and Smith [7] have called for research on identifying the optimal nature of information systems. Since our work has implications for system design, especially the organization of program modules and associated user interfaces into screens, our work is viewed as a response to their call.

The importance of user involvement in successful development of information systems has long been recognized [8–17]. Software development methodologies have long incorporated user involvement to generate accurate assessments of desired functionalities. In addition, the effectiveness of different techniques and communication channels that link users and developers (e.g. facilitated teams, intermediaries, surveys and focus groups) have been studied [18]. In the health care context, Leonard [19] recognizes the role of physicians and patients in designing an electronic patient record. Kinzie et al. [20] provide an overview of a user-centered process to design a family health history website, including techniques for needs assessment of physicians and patients, goals/task analysis, and user interface design. Consequently, the contribution of this paper does not lie in suggesting user involvement in the software development process nor in the identification of desired functionalities. Rather it lies in theorizing and empirically determining how desired features and services in these new coordination systems are perceived by users

to group together in the *perceptual structure* of information systems functionality. This structure is particularly important in integrative health information systems which are multi-user and multi-functional.

This user-based construct can be of considerable value in several aspects of system design and development—the elicitation of user needs, the specification of functional requirements, the decomposition of a complex system into program modules and the associated user interfaces, specification of the system and presentation logic, and the definition of the conceptual schema of the underlying database systems—and is likely to enhance stakeholder acceptance and use. For example, assume that physicians perceive tasks associated with coordination with external constituencies such as laboratories and pharmacies to group together. Also suppose that these external coordination tasks are perceived to be different from tasks related to internal coordination between members of their own practices (tasks related to finance, human resources, etc.). Such knowledge would be useful in designing different interfaces grouped into external and internal coordination. Alternatively, a different categorization and interface would result if physicians perceive tasks related to operations to be different from those related to control, regardless of whether these tasks involved external or internal coordination. Further, if there is significant variation in the weight that different physicians apply to different functionalities, the interface can be designed to separate rather than integrate these functions. The development of user friendly systems resulting from the identification of perceptual structure is more likely to generate support from physicians which is so critical to system acceptance [21].

Perceptual structure is viewed as a key construct in the literature on design and marketing of new products or services [22]. Marketing scientists regularly employ factor analysis to develop perceptual maps that summarize the wants and gets of different customers, resulting in the identification of unmet needs, which in turn generate opportunities for designing and marketing new products and services. However, this construct has not been explored in the health care or information systems literatures to aid the design and use of Internet-based health information systems.

In this paper we ask the following fundamental questions. Is there a user based perceptual structure for desired functionality of these new coordination systems? That is, are desired functions of an Internet-based information system—intranets and extranets for example—perceived by users to be related or grouped in a structured manner so that they can be categorized into a set of distinct factors? If such a user based construct exists, what factors best specify the structure of system functionality? How are these factors related to a potential user's prospective belief about overall value derived from use of the system? Which factors are more important than others?

Our study is conducted in the context of a custom software development process for an Internet-based information system at a healthcare organization. The healthcare industry is one in which information technology is currently being deployed aggressively to improve efficiency of several constituencies involved in the delivery chain. Potential users of the system are identified before development begins in order to collect information on desired functions and services. Following Mumford [23], two groups of users, physicians and their office administrators are studied because they will be the end users of the system. As Keil and Carmel [18] recommend, we employ direct links such as focus groups of likely users to identify potential functions of the system, and surveys of likely users to measure the importance of the identified functions. The measured importance of system functions is subjected to a factor analysis. This analysis groups system functions into different factors. The empirically determined perceptual structure is contrasted with the theoretical structure posited.

This study contributes to the existing literature in several ways. First, we propose a new construct, the perceptual structure of the desired functionality of information systems, in the context of Internet-based health care coordination systems. Second, we develop a conceptual framework, based on an information processing model of organizational activities, that links the perceptual structure construct to a user's prospective belief about the overall value derived from use of the system, and posits that the effects of perceptual factors on belief about overall value will be moderated by user characteristics such as experience, type of work, and involvement. Next, we test the conceptual framework by conducting a factor analysis of data from two field studies conducted at a hospital corporation. We show that the factor analysis leads to an empirically determined perceptual structure for information system functionality, and that the resulting factors are empirically associated with the prospective belief about the overall value derived from use of the system. We investigate if the perceptual structure is distinct for different classes of users. We suggest ways in which our results can be utilized in the development process for such new Internet-based health information systems so that increased usage of such systems provides public benefits such as faster, more accurate diagnoses.

2. Conceptual framework

In order to develop an understanding of the perceptual structure of the desired functionality of coordination systems in a way that enables applicability across a variety of users and settings, it is useful to begin with a model of organizational activities from an information processing perspective. A review of the existing literature reveals several such approaches to modeling organizational activities.

One approach adopts a process-centric view of organizational activities [24, 25]. Porter [25] provides the basis for this approach in his depiction of an organization as a value chain. Davenport [24] classifies business processes into operational and management control processes. Operational processes embody the execution of tasks comprising the activities of an organization's value chain. Management processes focus on the control processes required to ensure the effectiveness and efficiency of the operational processes. This model has been adapted for the information systems context by researchers such as Mooney et al. [26]. In practice, enterprise resource planning systems like SAP/R3 are based on process-oriented models of organizational activities. In a health care setting, operations processes consist of tasks such as ordering imaging studies and laboratory tests, forwarding the received information to physicians, online delivery and editing of hospital transcriptions, etc. Management processes consist of control processes for medical process improvement (e.g., best practice information), financial management (e.g., capital contract management information and reconciliation), and human resource management (e.g., online participation in medical staff governance).

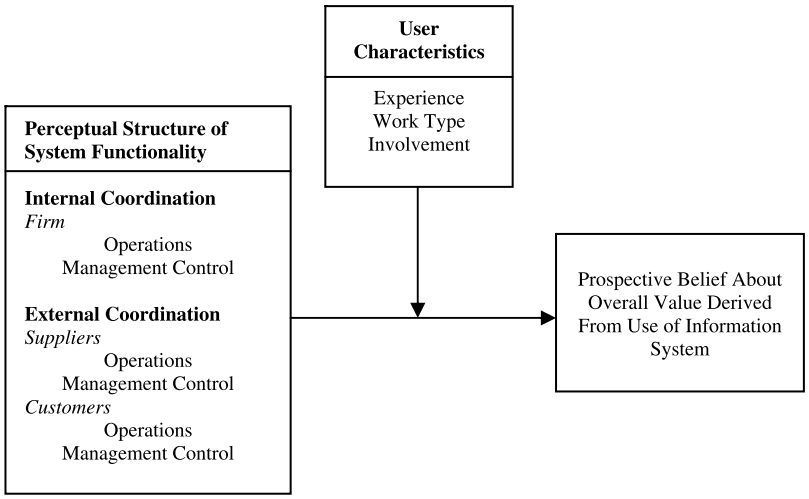
A second approach has been adopted in the literature on the impact of information systems on the structure of organizations. This research stream has adopted an economic perspective focusing on internal and external activities related to coordination within and between firms [27–29]. Gurbaxani and Whang [28] developed a model that has three components—internal coordination, external coordination, and operations.

Internal coordination consists of activities within an organization that are related to its operations. Internal coordination can be categorized further into two major groupings. The first category *directly* relates to the operations activities of a firm (e.g., ordering image studies and laboratory tests, forwarding the received information to physicians, etc.); the second consists of the control activities associated with the management of the organization's operations (e.g., medical process improvement, and financial and human resource management). External coordination focuses on the activities involved in using an outside firm or market on the supply side (e.g., laboratories and pharmacies), and on the activities involved in dealing with customers (e.g., patients and payors) on the demand side. On the supply side, their model includes both management control and operations activities. Gurbaxani and Whang [28] were primarily focused on the change in organization structure. Consequently, their focus was on the supply side of external coordination and not on customer-facing activities. In contrast, the new Internet-based health care coordination systems involve customer-facing activities as well.

In this paper, we draw on the economic model developed by Gurbaxani and Whang [28] and the model put forward by Mooney et al. [26] to provide the theoretical basis for the perceptual structure of the desired functionality of an Internet-based coordination system. We hypothesize that such a perceptual structure exists. Based on this model, we predict that the structure will consist of two major components of activities—internal coordination within the firm, and external coordination with suppliers and customers (see Figure 2). We further expect that internal coordination will consist of two major subsets of activities: those associated with the operations, and management control activity of an organization. Similarly, external coordination with suppliers will consist of two main components—operations and management control activities.

We extend the model to include external coordination with customers. While, it may seem that coordination with customers will focus primarily on operations related activities since management has little control over customers, there are several potential control processes related to customers, such as patient eligibility and credit verification, and monitoring of patient satisfaction. Operations activities with customers include activities such as communications with and scheduling of patients. Accordingly, we predict that the factor model will consist of six factors—two factors (operations and management control) each for internal coordination, external coordination with suppliers, and external coordination with customers. It is important to note that this model employs higher level constructs because it is intended as an inclusive framework within which desired functionalities of an Internet-based coordination system can be grouped; naturally the specific factors that emerge in any specific system or application setting will depend upon the scope of the system being developed. For example, a system that computerizes drug prescriptions only will primarily

Fig. 2 Conceptual framework



facilitate external operations and a system that computerizes medical records only will primarily facilitate internal operations. In general, we expect that Internet-based information systems that are better aligned with users' perceptual structure will be perceived by the user to have higher overall value, making it more likely that these systems will be used.

In addition, there is likely to be heterogeneity among users based on user characteristics such as experience, type of work, and involvement. Such heterogeneity could have the following effects. First, the relationship between perceptual structure and prospective belief about overall value derived from use of the system could vary for different user groups within a population; that is the importance of factors in explaining variation in overall value might vary. For example, less experienced physicians may be more concerned or involved with medical process improvements, while more experienced or senior physicians may be more concerned or involved with financial and human resource management issues. Second, it is also possible that perceptual structure could vary for different user groups, implying that the factors identified for different user groups (e.g., physicians vs. their office administrators) may differ in their composition (functionalities desired) and the amount of variation explained.

Prior approaches have described information system contexts in terms of internal versus external entities, engaged distinctly in operations and management control processes. We examine whether the Internet blurs the physical boundaries of organizations, by facilitating coordination between external and internal constituents. We also investigate whether contemporary technology, claimed to be a tool of empowerment, facilitates the integration of operations and management control activities. Consequently, we report the results of exploratory analysis (in which the factor structure is unconstrained in that it allows for blurring between external and internal constituencies and integration of operations and management control activities), followed by a confirmatory analysis (in which the factor structure is constrained by a theoretically predefined structure that does not permit such blurring or integration).

3. Empirical analysis

The conceptual framework advanced in the previous section is tested using two field studies conducted by a Southern California hospital corporation (consisting of six hospitals) for the possible development of a pilot medical intranet and extranet within their integrated delivery system. The main purpose of the studies was to provide an assessment of the priorities for system functionality of two main groups of users of the potential system, physicians and their office administrators. A majority of physicians in our study have stand alone offices in close proximity to the hospitals. Studies 1 (physicians) and 2 (office administrators) are descriptive studies employing larger samples and structured questionnaires designed to elicit quantitative information on functional priorities. These questionnaires were designed based on exploratory research comprising focus groups of a smaller sample of physicians and their office administrators. In addition, focus groups were conducted subsequent to the two field studies in order to get additional qualitative insights.

3.1. Survey of physicians (Study 1)

The physician survey instrument was structured in three sections. In the first section of the survey, physicians were queried about their use of computers and the

Internet. In the second section, physicians were asked to indicate the strength of their belief about the use and value of computerization in their practice. Physicians were also asked questions about their experience, type of practice and specialty. In the third section, physicians were asked to rate on a five-point scale (1 = not interested, 5 = very interested) each of 28 functionalities (see Table 1 for a complete list) identified in the focus groups that preceded questionnaire design. In the survey instrument, measurement of the dependent variable (belief about use and value) was conducted prior to the measurement of the independent variables (interest in system functionalities) to avoid contamination of the dependent variable [30].

The survey was sent to all 2,007 physicians on the medical staff of the six hospitals in the corporation, of which 983 completed questionnaires were received. This higher than expected response rate of 49% was attributed to the survey letter being signed by all Medical Directors, the growing knowledge and use of the Internet by members of the hospital community, and the inclusion of a $1 bill as an attention getter.

Study respondents displayed considerable variation on several dimensions. Respondents included a mix of specialties, and capitated and fee-for-service providers. They varied considerably on the number of years in practice. On the type and primary area of practice, and experience (number of years after residency) this sample was judged to be representative of the hospital chain's population of physicians. The interest in IT is also evident in the mean interest ratings for the 28 functionalities, 25 of which had a mean interest rating greater than or equal to three (1 = not interested, 5 = very interested). Details on the sample, representation, and mean interest ratings are available from authors. While the mean importance ratings provide information on the strength of preference for system functionalities, this information is much too idiosyncratic to provide a conceptual understanding of the underlying perceptual structure.

To test the suitability of factor analysis in our application we conducted three diagnostics, Bartlett's test (chi-square = 15,988, $p < 0.00001$), the anti-image correlation (361 of 378 coefficients were less than 0.3), and the Kaiser-Meyer-Olkin (KMO = 0.95) measure [31]. All three diagnostics independently indicated very high suitability of the factor model.

3.1.1. Description of factors

Principal component analysis was selected as the extraction method because it explained the highest amount of variance of several extraction methods considered. The rotation method, Varimax, was selected because it provided the greatest clarity of factor interpretation among several rotation methods attempted. Five factors were selected based on a Scree plot of Eigenvalues. The five factors explained a cumulative of 69% of the variation in the data on the importance of system functionalities. The incremental variation explained by subsequent factors was small. Four factors had Eigenvalues greater than or equal to one while the fifth factor had an Eigenvalue very close to one (0.9). Subsequent factors had Eigenvalues much lower than one (0.6, 0.5, etc.).

Factor 1 is interpreted as "External Coordination: Supplier (and Partner) Operations." In the medical context, suppliers and partners include providers of image studies and transcriptions, laboratories and diagnostic facilities, and pharmacies. As can be seen in Table 1, the items that comprise factor 1 deal mainly with operations activities such as the ordering, receipt, and forwarding of related medical services. Except for online pharmacy services, the variables that load most heavily on factor 1 have lower loadings (by more than 0.1) on the other four factors, indicating that factor 1 is well identified. The only exception is that when pharmacies go online it impacts the external coordination between the physician's office and the pharmacy (factor loading of 0.524), and the electronic record impacts internal coordination of operations and management control (factor 2) because it allows more efficient checking of health plan formularies and costs of prescriptions (factor loading of 0.459). This is one example of how the internet blurs the traditional boundaries between external and internal coordination. We decided to not conduct item purification because we were interested in exploring for the presence of such blurring. This factor explains 50% of the variance in physicians' priorities for functionalities.

In contrast, *factor 2* involves activities that are interpreted as "Internal Coordination: Operations and Management Control." The functionalities that comprise this factor are aimed at generating process improvement within the organization. Process improvement activities are generally initiated and carried out by "staff" of the firm, an internal constituency. Process improvement requires a system to measure and generate feedback through the application of benchmarks, and standards on outcomes. In the medical context, process improvement includes the development and use of clinical protocols and best practice information, protocol implementation, online medical information, outcome measurement services and online patient scheduling. Note that some functionalities such as online consultation/follow-up sched-

Table 1 Factor analysis results for physicians (Study 1)

	Factors[a]				
	1 External coordination: supplier (and partner) operations	2 Internal coordination: operations and management control (process improvement)	3 Internal coordination: management control (finance and control)	4 Internal coordination: management control (human resources)	5 External coordination: customer operations
Order imaging studies	0.781	0.255	0.228	0.178	0.017
Receive image transcription	0.752	0.218	0.217	0.218	0.029
Online delivery and editing of hospital transcriptions	0.681	0.210	0.143	0.214	0.406
Online electronic signature	0.679	0.231	0.143	0.176	0.234
Forward received labs, transcription to other MDs	0.656	0.324	0.275	0.115	0.283
Patient diagnostic reports (lab, radiology, etc.)	0.616	0.143	0.140	0.063	0.500
Transcription service (w. electronic delivery of reports)	0.615	0.364	0.199	0.045	0.310
Online ordering inpatient/ outpatient diagnostic	0.605	0.497	0.252	0.160	0.151
Online pharmacy services (formulary, costs, RX, drugs)	0.524	0.459	0.197	0.173	0.151
Clinical protocols, best practice information	0.307	0.735	0.126	0.170	0.170
Protocol implementation while ordering (alerts, reminders)	0.338	0.720	0.219	0.192	0.112
Online medical information (medline, CME, etc.)	0.259	0.608	0.058	0.189	0.397
Online consultation/ follow up scheduling with other MDs	0.440	0.574	0.359	0.225	0.082
Outcomes measurement services (HEDIS, patient satisfaction)	0.232	0.551	0.221	0.475	0.172

Table 1 (Continued)

	Factors[a]				
	1 External coordination: supplier (and partner) operations	2 Internal coordination: operations and management control (process improvement)	3 Internal coordination: management control (finance and control)	4 Internal coordination: management control (human resources)	5 External coordination: customer operations
Microsoft office or equivalent	0.229	0.529	0.247	0.252	0.275
Online patient scheduling (for your office)	0.306	0.511	0.456	0.132	0.047
Capital reconciliation	0.179	0.081	0.743	0.404	0.046
Capital contract management information	0.177	0.075	0.732	0.403	0.051
Financial practice management services (billing, A/R, etc.)	0.080	0.326	0.715	0.108	0.087
Eligibility inquiry	0.165	0.033	0.660	0.090	0.488
Online referral management system	0.259	0.168	0.623	0.068	0.427
Online encounter form (DX, services)	0.408	0.338	0.610	0.135	0.038
In-office document routing/ accountability	0.447	0.358	0.554	0.137	0.025
Online participation in medical staff governance	0.187	0.225	0.238	0.827	0.102
Online participation in IPA/MSO governance	0.186	0.225	0.334	0.812	0.068
Online viewing of scheduling (hospital, on call, etc.)	0.278	0.464	0.186	0.575	0.143
E-mail (to/from professionals/ patients)	0.247	0.356	0.094	0.082	0.660
Receive patient demographic information	0.315	0.217	0.445	0.204	0.501
Cumulative percent of variance explained	50	57	62	65	69
Eigenvalue	13.9	2.0	1.4	1.0	0.9

[a] Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalization.

uling with other MDs, and protocol implementation while ordering (alerts and reminders) are operations activities while others such as clinical protocols or best practice information, and outcomes measurement services are management control activities. Accordingly, this factor demonstrates that users perceive some operations and management control activities within a single factor, which is suggestive of integration of these two classes of activities in system design. Except for outcome management services and online patient scheduling, the functionalities that load most heavily on factor 2 have lower loadings (by more than 0.1) on the other four factors, indicating that factor 2 is quite well identified. Outcomes measurement services impact process improvement (factor loading of 0.551) as well as management and control of human resources (factor loading of 0.475 with factor 4). Online patient scheduling impacts process improvement (factor loading of 0.511), and finance and control (factor loading of 0.456 with factor 3). These are examples of how the internet integrates across traditional boundaries between operations (outcomes, patient scheduling) and control (human resources, finance) activities. This factor explains 7% of the variance in physician priorities for functionalities, so that both factors 1 and 2 explain a cumulative variance of 57%.

Factor 3 involves activities related to the management control processes initiated and carried out largely by internal constituencies; correspondingly we label this factor as "Internal Coordination: Management Control (Finance and Control)". In our medical context, these include finance and control activities such as capital reconciliation, capital contract management information, financial practice management services, online referral and encounter management system, online encounter forms, and in-office document routing and accountability. Note that eligibility inquiry, a control activity related to customers appears here, perhaps because eligibility inquiry is perceived by physicians to be a key aspect of management control. The functionalities that load most heavily on factor 3 have lower loadings (by more than 0.1) on the other four factors, indicating that factor 3 is well identified. This factor explains 5% of the variance in physician priorities for functionalities, so that factors 1, 2, and 3 explain a cumulative variance of 62%.

Factor 4 is interpreted as "Internal Coordination: Management Control (Human Resources)." In our medical context, this involves human resource issues such as online participation in the governance of medical staff, and online participation in the IPA/MSO, activities that relate to management of staff—an internal constituency. Online participation in the IPA/MSO has similarities to the human resource coordination activities required between different divisions of a company. Except for online viewing of scheduling, the functionalities that load most heavily on factor 4 have lower loadings (by more than 0.1) on the other four factors, indicating that factor 4 is well identified. Online viewing of scheduling impacts human resource control (factor loading of 0.575) because it allows for computation of utilization, and impacts process improvement (factor loading of 0.464 with factor 2) because it simplifies scheduling. This is another example of how the internet integrates across traditional boundaries between different functional areas within the company (e.g., human resources and operations). This factor explains 3% of the variance in physician priorities for functionalities, so the four factors taken together explain a cumulative variance of 65%.

Finally, we label *factor 5* as "External Coordination: Customer Operations." In our medical context, this involves communication (to/from professionals and patients), and receiving patient demographic and background information, mainly operational aspects. Interestingly, this group of physicians viewed e-mail correspondence with professionals and patients as different from the ordering and receipt of medical information. Factor 5 is less well identified because receiving patient demographic information (e.g., whether employed, income) is relevant for billing (e.g., to the Sate of California MEDICAL program) and hence finance and control activities as well. The five factors explain a cumulative 69% of the variance in physicians' desired functionalities of the system.

In summary, it is clear that a perceptual structure exists given that all the proposed information system functions did not load on a single factor. While factor 1 explains 50% of the variation, factors 2 through 5 explain incremental variation of around 20%. External and internal coordination load on different factors. Interestingly, external coordination (factors 1 and 5) explains about 54% of the variance in the underlying data. Internal coordination (factors 2, 3, and 4) explains about 15% of the variance. As a result, external coordination explains over three times the variation explained by internal coordination. Traditional information systems in this setting have focused on internal coordination activities such as financial accounting and billing, while other functionalities classified as external coordination were delegated to non-automated approaches (mail and telephone). The new Internet-based systems now allow these important functionalities for external coordination to be computer-supported.

We had hypothesized that the factor structure would consist of separate factors for internal and

external coordination. Our empirical analysis is quite consistent with that hypothesis. External and internal coordination activities load on distinctly different factors. Except for online pharmacy services there is no significant blurring between internal and external coordination activities, so that the coordination view of organizational activities (as reviewed under the second approach in the Conceptual Framework section) is supported. In our health care context, participating organizations are focused physician groups so that most suppliers are external to the organization. The main difference is that management control aspects of internal coordination are represented by three different factors (process improvement, finance, and human resources). Moreover, there is integration between operations and management control activities and some integration between different functional areas within the company, so that the process-centric view of organizational activities (as reviewed under the first approach in the Conceptual Framework section) which views operational activities as distinct from control activities receives less support. Further, as expected, external coordination with customers is found to consist mainly of operational activities.

The empirical analysis reported above was based on exploratory factor analysis which is useful when a field is not well understood. Exploratory analysis is unconstrained regarding assignment of functionalities to factors. Exploratory analysis can be useful to look both for potential blurring (e.g., between external and internal coordination) or integration between factors (e.g., operations and management control) as we observed above in factor 2. Exploratory analysis also permits specific functional areas (e.g., medical process improvement, finance, and human resources) to be separately associated with specific factors as we observed above in factors 2, 3, and 4.

In addition to the exploratory factor analysis, we estimated a confirmatory factor analysis based on the theoretical model in Figure 2. The theoretical model does not permit blurring or integration in that external and internal constituents and operations and management control activities are considered distinct, nor does it permit specific functional areas to be separately associated with certain factors. Three judges familiar with health care information systems and the classification proposed in Figure 2 classified the 28 functionalities in Table 1 under the six factors hypothesized to comprise perceptual structure (Figure 2). Of the 28 functionalities, 22 were classified similarly under both analyses, and six were classified differently. The inter-judge reliability was high (0.9). Both exploratory and confirmatory factor analysis models were compared in a structural equations modeling framework with similar degrees of freedom (159) on six measures of fit. The fit of the exploratory model was found to be better than that of the confirmatory model on two of six fit measures (Consistent Akaike's Information Criterion (CAIC) of 2,038 vs. 2,076; chi-square of 159 vs. 197), and equivalent on the other four measures (Root Mean Square Residual (RMR), Standardized RMR (SRMR), Adjusted Goodness of Fit Index (AGFI), and Normalized Fit Index (NFI)). The fit of the exploratory model was also found to be better (parsimony adjusted fit of 0.79) than three other theoretical models, one in which functionalities were classified only as external vs. internal (parsimony adjusted fit of 0.57), another in which functionalities were classified only as operation vs. control (parsimony adjusted fit of 0.58), and a third in which functionalities were classified based on four constructs, external vs. internal and operations vs. control (parsimony adjusted fit of 0.58).

3.1.2. Relationship between factors and prospective belief about use and value

We calculated factor scores for each physician respondent on the five factors described above. We estimated the association between factor scores and potential users' prospective beliefs about using and valuing the system by specifying a regression equation as follows. The dependent variable was defined as the answer to the following question. Rate the strength of your belief in the following statement: "If meaningful medical, financial, and clinical data were available on a computer, and I received adequate training, I would use and value the computer in my medical practice." The respondent provided a score on a five-point scale (1 = Don't Believe, 5 = Strong Belief). The independent variables were the factor scores for each of the five factors described above. Principal component analysis generates factors that are non-collinear with each other. As a result, hypothesis testing of the association between each factor and the dependent variable is facilitated. Results are presented in Table 2.

All five factors are found to be statistically associated with the prospective belief about use and value of the system, indicating that the user requirements are well defined. Factor 5 "External Coordination: Customer Operations" is found to be most strongly related to the prospective belief about use and value that physicians place on the system (highest standardized beta), followed by factors 1 and 2 "External Coordination: Supplier (and Partner) Operations," and "Internal Coordination: Operations and Management

Table 2 Regression between prospective belief about use and value of information system and factor scores for physicians (Study 1)

r^2 0.1435			Adjusted r^2 0.1367		
Factors	Unstandardized coefficients		Standardized coefficients	t	Sig.
	β	Std. error	β		
(Constant)	4.14	0.0433		95.5	0.00
1	0.23	0.0432	0.18	5.33	0.00
2	0.22	0.0431	0.17	5.06	0.00
3	0.12	0.0433	0.09	2.66	0.01
4	0.099	0.0431	0.08	2.29	0.02
5	0.33	0.0431	0.26	7.57	0.00

Factor 1. External coordination: supplier (and partner) operations.
Factor 2. Internal coordination: operations and management control (process improvement).
Factor 3. Internal coordination: management control (finance and control).
Factor 4. Internal coordination: management control (human resources).
Factor 5. External coordination: customer operations.

Control," and factors 3 and 4 "Internal Coordination: Management Control (of finance and human resource functions)." This indicates that in our medical context, from the perspective of using and valuing such a new Internet-based information system, external coordination activities are viewed to be most important followed by internal coordination activities. This result is consistent with the factor analysis result based on the relative magnitude of variance explained by external and internal coordination factors and underscores the importance of and difficulty in coordinating with parties in a company's value network which are outside the immediate organization.

3.2. Study of office administrators (Study 2)

Since functions performed by office administrators are different from those of physicians, a separate survey was designed for office administrators. The office administrator instrument was structured in three sections. In Section 1, administrators were asked questions about their office, such as the number of physicians and non-physicians, and about the office information system environment. In Section 2, they were asked how a number of functions were performed such as claims, eligibility/insurance verification, referrals, authorization, credentialing, accessing clinical results, etc. In Section 3, administrators rated each of a list of 22 system functionalities (see Table 3) on a five-point scale (1 = not interested, 5 = very interested) to reflect the importance of these aspects in their daily work routine and activities. These functions were identified from focus group analyses of office administrators conducted prior to the development of the questionnaire.

Of the 420 physician offices contacted, 122 surveys were completed for a response rate of 29%. A structured survey approach was employed, utilizing a well-scripted telephone interview. Each interview lasted approximately 15–20 min. The telephone interview methodology was chosen to facilitate participation.

About half of the administrators managed groups comprising 2–20 physicians while the other half managed solo practices. These proportions were judged to be representative of the physician groups associated with the hospital chain. About half of the offices had Internet access while more than half had networked computers. A large percentage of offices reported using software systems for practice management. A smaller percentage reported using software systems for managed care and medical records. We observed that 19 of 22 system functionalities had mean interest ratings greater than or equal to three (1 = not interested, 5 = very interested), indicating a high interest in IT. As in the previous study, this information was too idiosyncratic to provide insight into perceptual structure. To assess the suitability of the factor model we used Bartlett's test of sphericity (chi-square = 1,724.05, $p < 0.00001$), and the KMO measure (0.866); both measures indicated very high suitability of the factor model.

Once again, we started with an exploratory factor analysis to explore for blurring and integration between factors (internal vs. external, operations vs. control). Principal component analysis was selected as the extraction method because it explained the highest amount of variance of many extraction methods considered. The rotation method, Varimax was selected because it provided the greatest clarity of factor interpretation among several rotation methods attempted. Five factors were selected based on a Scree plot of Eigenvalues (see Table 3). The five factors explained a cumulative of 76% of the variation in the

data on the importance of information system functionalities. Four of five factors had Eigenvalues greater than one while the fifth factor had an Eigenvalue very close to one (0.96). The incremental variation explained by the subsequent factors was small. Subsequent factors had Eigenvalues much lower than one (0.7, 0.6, etc.).

3.2.1. Description of factors

Factor 1 is interpreted as "External Coordination: Supplier (and Partner) Operations" involving suppliers and partners such as pharmacies, transcription services, allied outpatient facilities, skilled nursing facilities, home health organizations and laboratories, aspects of external coordination. The specific interactions encompass administrative tasks such as ordering of prescriptions, patient and physician scheduling, delivery of transcriptions, and data gathering from outpatient facilities. Except for online orders from labs, the functionalities that load most heavily on factor 1 have lower loadings (by more than 0.1) on the other four factors, indicating that factor 1 is well identified. The only exception is that online orders also affects internal coordination (factor loading of 0.357 with factor 3), and other aspects of external coordination such as the patient examination record (factor loading of 0.398 with factor 4) and communications with patients (factor loading of 0.368 with factor 5). This is another example of how the internet blurs the traditional boundaries between external and internal coordination and integrates across traditionally separate functional areas (administrative vs. clinical). This primary factor explained 51% of the variance in the office administrators' importance of online functionalities.

In contrast to factor 1, which deals with managing interactions with contracted clinical care entities, *factor 2* is interpreted as "External Coordination: Customer Operations." In the healthcare context, a payor such as an insurance company or a large employer is also viewed as a customer. This factor consists of the routine work of the office administrator, to ensure that patients are eligible to receive care and that referrals and billing are processed in a timely manner. Office administrators currently spend hours each day on the telephone with several payors checking eligibility and benefits, requesting authorizations, making referrals, and submitting claims, consequently the importance of system functionality that improves efficiency. The functionalities that load most heavily on factor 2 have lower loadings (by more than 0.1) on the other four factors, indicating that factor 2 is well identified. This factor explained 9% of the variance in office administrators' importance of online services and functionality so that factors 1 and 2 taken together explained 60% of the variance.

While factors 1 and 2 deal with coordinating interactions with external constituencies such as partners, suppliers, and customers, *factor 3* is interpreted as "Internal Coordination: Operations and Management Control." Activities in this factor include managing contractual and capitation data, outcomes tracking, organizational information, best practices data and scheduling. Except for clinical protocols, the functionalities that load most heavily on factor 3 have lower loadings (by more than 0.1) on the other four factors, indicating that factor 3 is well identified. Clinical protocols affect external coordination of operations with suppliers (factor loading of 0.494 with factor 1) as well. This happens because clinical protocols need to be followed both internally and externally. Like factor 2 in the previous study on physicians, this factor consists of both operational and managerial control activities related to internal coordination. This factor explained 6% of the variance in office administrators' importance of online services and functionality so that factors 1, 2, and 3 taken together explained 66% of the variance.

Factor 4 is also interpreted as "External Coordination: Supplier (and Partner) Operations"; however, this factor focuses primarily on the patient examination record in both inpatient and outpatient settings, while factor 1 focuses on administrative tasks such as ordering, scheduling, etc. This is clearly a critically important system function in the health care context. This factor includes diagnostic reports for inpatients and outpatients, and patient administrative data from the hospital. Except for the heath plan specific directory of ancillary service providers, the functionalities that load most heavily on factor 4 have lower loadings (by more than 0.1) on the other four factors, indicating that factor 4 is well identified. The only exception is the health plan specific directory which loads on the internal coordination factor (factor loading of 0.376 with factor 3), and other external coordination factors (correlations of 0.396 and 0.369 with factors 2 and 5, respectively). This happens because such a directory is important for the selection of providers (internal operations and management control) as well as billing (claims). This is another example of how the internet blurs the traditional boundaries between external and internal coordination. This factor explained 5% of the variance in the office administrators' importance of online functionalities so that factors 1, 2, 3, and 4 taken together explain 71% of the variance.

Finally, *factor 5* is interpreted as "External Coordination: Customer (and Professional) Operations,"

Table 3 Factor analysis results for office administrators (Study 2)

	Factors[a]				
	1 External coordination: supplier (and partner) operations administrative	2 External coordination: customer operations patient eligibility and claims	3 Internal coordination: operations and management control	4 External coordination: supplier (and partner) operations patient examination record	5 External coordination: customer (and professional) operations research/ e-mail
Pharmacy online (ability to order prescriptions/refills)	0.825	0.233	0.201	0.139	0.021
Pharmacy-economic data; prescription costs and costs per physician	0.728	0.175	0.370	0.068	0.226
Online scheduling for your office or inpatient	0.695	0.120	0.167	0.249	0.294
Online delivery and editing of transcriptions	0.605	0.308	0.106	0.422	0.195
Data from allied outpatient facilities; SNF/home health, etc.	0.540	0.190	0.364	0.194	0.395
Online orders inpatient/outpatient (lab, radiology, etc.)	0.445	0.242	0.357	0.398	0.368
Online eligibility/ benefits checking to health plans	0.164	0.865	0.130	0.221	0.263
Online eligibility/ benefits checking to MSO	0.088	0.847	0.164	0.158	0.218
Online authorization and referral	0.187	0.776	0.090	0.377	0.156
Online claims submission	0.293	0.724	0.284	0.097	0.068
IPA/MSO organizational information	0.101	0.223	0.823	0.148	0.099
Contractual and capitation data, information and issues	0.251	0.375	0.756	0.186	0.012
Outcomes tracking (i.e. clinical, HEDIS, patient satisfaction etc.)	0.405	0.145	0.675	0.156	0.293
Schedules; hospital, on-call, medical staff	0.425	−0.021	0.615	0.238	0.250
Clinical protocols, best practices information	0.494	0.057	0.513	0.243	0.351

Table 3 (Continued)

	Factors[a]				
	1 External coordination: supplier (and partner) operations administrative	2 External coordination: customer operations patient eligibility and claims	3 Internal coordination: operations and management control	4 External coordination: supplier (and partner) operations patient examination record	5 External coordination: customer (and professional) operations research/ e-mail
Patient diagnostic reports; outpatient including lab, radiology, etc.	0.195	0.197	0.158	0.889	0.222
Patient diagnostic reports; inpatient including lab, radiology, etc.	0.185	0.203	0.231	0.840	0.234
Patient administrative data and information from the hospital	0.248	0.321	0.188	0.649	0.097
health-plan-specific directory of ancillary service providers (lab, radiology, pharmacy, etc.)	0.118	0.396	0.376	0.469	0.369
Personal librarian	0.100	0.341	0.153	0.153	0.796
Online research/ medline, grateful med, etc.	0.318	0.217	0.233	0.203	0.741
E-mail (from professionals and/or patients)	0.372	0.112	0.088	0.355	0.637
Cumulative percent of variance explained	51	60	66	71	76
Eigenvvalue	11.2	1.9	1.4	1.1	.96

[a] Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalization.

involving communication with professionals and patients, including both research and e-mail correspondence. Research may take the form of requesting journal articles and books from hospital, university, and group librarians, or finding such information online. Communication is between professionals associated with the practice and between such professionals and patients. Factor 5 focuses on research and e-mail while factor 2 focuses on patient eligibility for reimbursement purposes. The functionalities that load most heavily on factor 5 have lower loadings (by more than 0.1) on the other four factors, indicating that factor 5 is well identified. The five factors taken together explain 76% of the variance in office administrators' priorities on functions desired in this new class of Internet-based information systems.

In summary, like the results from study 1 of physicians, it is again clear from study 2 of office administrators that a perceptual structure exists for system functionality. While factor 1 explains 51% of the variance, factors 2 through 5 explain 25% incremental variance. In study 2, like study 1, except for online orders and clinical protocols, external coordination is largely distinct from internal coordination. External coordination factors (factors 1, 2, 4, and 5) explain 70% of the variation while the internal coordination factor (factor 3) explains only 6% of the variation, so that external coordination factors for this sample explain more than ten times the variance explained by internal coordination factors. As in the physician study, traditional information systems in this setting usually focused on internal coordination activ-

ities such as a scheduling system for patients and medical personnel (factor 3) with other external coordination functions delegated to non-computer assisted approaches. The new Internet-based systems facilitate the automation of these other important functions that permit external coordination. In that there are differences between physicians and office administrators in the relative importance of factors, such comparative information could be employed to design some differences in the interface screens [23] for different constituencies.

We had hypothesized that the factor structure would consist of six factors; two factors associated with internal coordination, and four factors associated with external coordination. The empirical results of study 2 are quite consistent with some of the theoretical predictions. While there is some blurring in the type of coordination offered by certain functionalities, external and internal coordination are found to load on distinctly different factors. The main difference is that both operations and managerial control activities associated with internal coordination appear in a single factor, likely because office administrators usually have joint responsibilities involving both tasks. Consequently, like as in study 1 on physicians, in study 2 on office administrators we find more support for the coordination view of organizational activities (as reviewed under the second approach in the Conceptual Framework section) than the process-centric view of organizational activities (as reviewed under the first approach in the Conceptual Framework section) which views operational activities as distinct from control activities. In addition, like the result of study 1, external coordination involves mainly operational aspects.

In addition to the exploratory factor analysis reported above we conducted a confirmatory analysis based on the theoretical framework in Figure 2. As in the previous study, three judges classified the 22 functionalities in Table 6 under the six factors hypothesized to comprise perceptual structure (Figure 2). Of the 22 functionalities, 15 were classified similarly under both analyses, seven were classified differently indicating blurring or integration. The inter-judge reliability was high (0.8). Both exploratory and confirmatory factor analysis models were compared in a structural equations modeling framework with similar degrees of freedom (172) on six measures of fit. The fit of the exploratory model was found to be better than that of the confirmatory model on two of six fit measures (CAIC of 648 vs. 701; chi-square of 199 vs. 252), and equivalent on the other four measures (RMR, SRMR, AGFI, and NFI). The fit of the exploratory model was also found to be only marginally better (parsimony adjusted fit of 0.73) than three other theoretical models, one in which functionalities were classified only as external vs. internal (parsimony adjusted fit of 0.71), another in which functionalities were classified only as operation vs. control (parsimony adjusted fit of 0.71), and a third in which functionalities were classified based on four constructs, external vs. internal and operations vs. control (parsimony adjusted fit of 0.71).

3.3. Assessment of heterogeneity across studies 1 and 2

Next, we explored whether the factor structures, and their relationship to system value were different across users within the same user group. For example, we grouped physicians by experience (below and above the median) and percentage of inpatients (below and above the median) because senior physicians may have more administrative responsibility and practices with a smaller number of inpatients (in the hospital) deal with lower acuteness of illness. We grouped office administrators (by solo or multi-physician practices) because practices with multiple physicians involve more transactions with external and internal constituencies. We did not have specific hypotheses regarding differences in the factor structure that might result. We estimated separate factor and regression analyses for each subgroup.

Importantly, across the several segmentation analyses, the perceptual structures were largely similar on the composition and meaning of the factors. While there were some differences in the variance explained by factors these differences were small. We found larger differences in the contribution of factors to the explanation of using and valuing the system. For example, for senior physicians, financial and control aspects of internal coordination (factor 3) was more strongly associated with using and valuing computers than external coordination with suppliers (factor 1) and process improvement (factor 2). And for physicians with practices with a smaller percentage of inpatients, process improvement from internal coordination of operations and management control (factor 2) was more strongly associated with using and valuing computers than external coordination with suppliers (factor 1). These results depict the differential drivers of value for distinct user groups within a single population of physicians. Office administrator subgroups were found to be more homogeneous.

3.4. Summary of results from studies 1 and 2

The empirical results of both studies indicate that a perceptual structure for desired information system

functionality exists which is consistent with some aspects of its theorized counterpart. As theorized, external coordination activities are perceived to be largely different from internal coordination activities. Functionalities that relate to external coordination enabled by the Internet explain between three and ten times the variance explained by those related to internal coordination. Physicians, because of their ownership role, appear to be more balanced in their interest for external and internal coordination while office administrators appear to be more interested in external coordination. Our empirical results suggest an integration of operations and managerial control activities.

3.5. Focus group analysis

Subsequent to studies 1 and 2, eight focus groups comprising 50 physicians and five focus groups consisting of office administrators (working for the 50 physicians) were conducted. The objective was to get qualitative insights to substantiate the quantitative insights accumulated from the factor analyses. For example, we wanted to learn whether any important functionalities were missing, or how system functionalities could be made more powerful, etc. All participants were new in that they had not participated in previous focus groups.

Participants were presented with the factor labels from the corresponding factor analysis. Such a presentation facilitated a discussion of system functionality and how these could be enhanced, relative to focus groups conducted prior to the field studies. Participants generated a number of ideas to increase the effectiveness of system functions. For example, in factor 1, administrators identified several ancillary service providers (physician specialists) for appointment scheduling. While some additional functions were identified, no functions were identified which caused us to rethink the labeling of factors identified in studies 1 and 2. As a result, these focus group studies increased our confidence about the robustness of the factor solutions uncovered in studies 1 and 2.

4. Discussion

This paper advances and empirically explores the theoretical construct of a user based perceptual structure for desired information system functionality in the context of new Internet-based coordination systems. While the importance of end user input in identifying the desired functionality of systems has long been recognized, very little work focuses on how users perceive the desired functionalities of these new systems to group together in spheres of work, and the implications of these groupings for the organization of functionalities into program modules and associated user interfaces [32]. While our study is conducted in a healthcare setting, we believe that our conceptual framework can be applied in a variety of settings where coordination and processing tasks are being computerized in an integrative system.

Perceptual structure is viewed as a key construct in the literature on design and marketing of new products or services [22]. However, to the best of our knowledge, this construct has not been explored in the health care or information systems literatures to aid the design and use of Internet-based health information systems. Results of two large sample studies indicate that a perceptual structure exists which explains between 69% (study 1) and 76% (study 2) of the total variation in the data on importance of system functionalities. Perceptual structure is found to be related to the prospective belief about value and use of the information system. External and internal coordination are perceived to be more distinct with the former playing a more significant role. Operations and management control functionalities are less distinct indicating that contemporary technology has empowered users in a way that blurs traditional boundaries between operations and management control.

The key implication for practice [33] is that knowledge of a perceptual structure in any application setting offers a theory-based addition to existing approaches to designing coordination systems. That is, we believe that when developing Internet-based information systems which emphasize coordination in addition to program functionality, software designers would benefit from incorporating a conceptual model of coordination into their structured development methodologies. Specifically, a development team could (1) segment users (e.g., physicians, office administrators), (2) employ the conceptual framework in an aided recall setting to generate functionalities from each user segment in a focus group, (3) measure the importance of the functionalities in a survey, and (4) factor analyze the importance ratings to generate an empirical perceptual structure. Knowledge of the perceptual structure will generally offer potential advantages in three key areas, (a) more comprehensive elicitation of required system functions, (b) better organization of functions into program modules and associated user interfaces, and (c) more effective promotion of the use of the system by different users. Perhaps, most importantly, from a policy perspective,

if the use of information systems becomes more pervasive in health care, this could result in substantial improvements in the costs and quality of care. The knowledge of an empirical perceptual structure and the resulting organization of functionalities into program modules and associated user interfaces are likely to generate user bases of support which are critical to the acceptance and use of any new system.

4.1. Elicitation of system functionality

Knowledge about a perceptual structure of information system functionality facilitates elicitation of system functionalities. For example, the physicians and office administrators participating in confirmatory focus group studies run subsequent to studies 1 and 2 that identified the empirical perceptual structure suggested system functionalities more easily than their counterparts who had participated in the exploratory focus groups conducted prior to studies 1 and 2. In the confirmatory focus groups that were run subsequent to studies 1 and 2, facilitators conducting the focus groups employed the factor labels in Tables 1 and 3 in an aided recall based setting to generate the functionalities. Both physician and office administrator participants appeared to easily generate insights about enhancement of functionalities. In addition, it is possible that knowledge of the theoretical perceptual structure as posited in Figure 2, if used in an aided recall based setting in the exploratory focus groups could have facilitated the generation of system functionalities, although this was not done in this application.

4.2. Design of system functionalities

By structuring domain knowledge, our theoretical framework complements research conducted in the field of computer-supported cooperative work, which focuses on general design guidelines for Internet-based systems [32]. Moreover, a coordination-based perceptual structure of system functionality can aid a system designer's decisions regarding organization of program functionalities into modules, the tradeoff between customizing the system for different sets of users and cost, and resource allocation decisions across system functionalities. First, the factor solutions (e.g., which functionalities load on a certain factor) can aid system design decisions regarding the organization of functionalities into modules. Second, by analyzing the impact of heterogeneity in user groups, system designers can determine whether to provide standard or custom interfaces for different user groups. Finally, the amount of variation explained by a factor and the extent of its association with overall usefulness can guide resource allocation decisions across functionalities.

4.3. Promoting the use of the information system

Clearly, a critical aspect of success of an information system is its use. A perceptual structure for system functionality can be employed to differentially promote the use of the system to different users. For example, in study 1 we found that for experienced physicians finance and control functionalities were more strongly associated with use and valuing the system than process improvement. This would suggest that the use of the system by more experienced physicians might be made more likely by promoting finance and control functionalities. In contrast, for less experienced physicians, external coordination with suppliers and partners was found to be more important than external coordination with customers in explaining using and valuing the computer. This suggests that the use of the system by this constituency might be made more likely by promoting the functionalities related to external coordination with suppliers and partners.

4.4. Public policy implications

Health care is the largest sector of the American economy. There is a strong belief at the policy level that there is a significant gap between the health care Americans ought to receive and what they do receive, and that this gap can be closed by increasing efficiency through the use of information systems [1, 2].

While numerous healthcare organizations have achieved significant levels of computerization, many health care providers in the United States, in particular physicians' offices, still operate with paper-based medical records and drug prescriptions. Moreover, health care providers (e.g., physicians, laboratory facilities, pharmacies, etc.) are frequently not connected electronically nor is it the norm for patients to be electronically connected with their health care providers. Electronic coordination offers significant potential to reduce costs and increase benefits. However, this potential is only likely to be realized if the use of such systems becomes pervasive. This study has shown a link between perceptual structure and users' prospective belief about use and value.

4.5. Limitations and future research

A limitation of this study is that the concept has been tested using data in a single industry (health care) with a single chain of hospitals (there are six hospitals in

this chain). The choice between a study of multiple systems (at multiple organizations) versus a single system (at a single organization) involves tradeoffs between external and internal validity. Single system studies [34–38] can offer greater internal validity. These studies allow the researcher greater control over the choice of respondents and offer reasonable assurance that common definitions are understood. This is because the questionnaire can usually be tailored to fit the terminology of the system and/or organization under study [13]. Multiple system studies may offer greater external validity in cases wherein internal validity can be assumed. In this first study, wherein we are trying to show existence of a perceptual structure, internal validity is particularly important. Consequently, we chose a single system design.

Another potential limitation is that some information providers, such as laboratory personnel, were not queried to the same extent as physicians and office administrators. The chain of hospitals at which this work was conducted is a physician-centric setting, and given resource constraints, decisions were made to focus on certain key constituencies over others. In some instances, however, the effects of this decision are mitigated since specialty physicians, who did provide input, often head laboratories.

In the conceptual framework, we focused on how user characteristics would moderate the relationship between perceptual structure of system functionality and overall perceived value of the system. We did not hypothesize differences in perceptual structure between different sets of users (e.g., physicians vs. office administrators). While the major empirical effect of user characteristics was as a variable influencing the association between perceptual structure of system functionality and overall value of the information system, we did find some small differences in perceptual structure between physicians and office administrators. It is possible that in other applications different users may have somewhat different perceptual structures so that conceptually, user characteristics may also affect perceptual structure in addition to influencing the association between perceptual structure and overall value of the system. Finally, the question related to using and valuing the computer at work which served as a dependent variable for the regression analysis conducted for physicians was dropped from the office administrator questionnaire (among other questions) to keep the length of that questionnaire manageable. Future research is required on testing the theoretical notion of a user based perceptual structure for system functionality across different industries and firms so that one can determine the extent of communality and heterogeneity. We hope our work encourages such efforts.

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