Triangulating design science, behavioural science and practice for technological advancement in tele-home health

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Abstract: This study exemplifies the integration of information systems (IS) behavioural science in the area of technology adoption and diffusion into the design science paradigm. We first present a research framework for triangulating design and behavioural science paradigms. From the design science perspective, we introduce an intelligent interface (Model Of User's Emotions – MOUE) aimed at discerning emotional state from processing sensory modalities input. We contextualise MOUE within the tele-home healthcare setting as a means to provide the caregivers with an assessment of the patient's emotional state. We use an IS adoption model in an exploratory field study as theoretical foundation to integrate behavioural science into the design science process of adapting MOUE to the context. Data analysis indicates that future iterations of MOUE user interfaces for the tele-home health context should augment rather than replace the existing processes and interfaces. Data also indicates efforts related to adoption and implementation should address anxiety regarding artificial intelligence. To address the prototype phase of the research framework, we propose future work to expand the application of 'Wizard of Oz' type studies in which researchers simulate system interaction with subjects who believe they are interacting with the system to afford realism in prototypical experimentation.

Keywords: design science; tele-home health; telemedicine; behavioural science; affective computing; simulation study.

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Biographical notes: Dr. LeRouge represents the information systems (IS) behavioural science component of this research team. Dr. LeRouge's current research interests include socio-technical issues related to healthcare information systems (particularly telemedicine), IS personnel, and technology mediated learning. Dr. LeRouge won the best paper award in the Health Information Systems track at the 2004 Hawaii International Conference on Systems Sciences. Dr. LeRouge has served in consulting, training, controller, and analyst roles in the software, healthcare, public accounting, and petrochemical industries. She has publications in the *International Journal of Human Computer Studies, Journal of Computer Information Systems, and Journal of Informatics and Education Research* as well as chapter contributions to edited books.

Dr. Lisetti represents the design science component of this research team. Dr. Lisetti has won multiple awards including a NIH Research Service Award and the Nils Nilsson Award for Integrating AI Technologies at the AAAI 2000 Mobile Robot Competition. She focuses her research on the study of emotional intelligence and computational models of emotions and affective processes. The overall goals of her research are to enhance human-computer interaction by enriching it with affective contextual knowledge, as well as to develop more intelligent artificial agents by endowing them with functions of the emotional system. Her research has been granted support from US federally funded agencies such as National Institute of Health (NIH) and Office of Naval Research (ONR); and private companies such as Intel Corporation and Interval Research Corporation.

1 Design and behavioural science triangulation

Technologies that facilitate virtual primary care provide the promise of increasing the efficiency and effectiveness of communication between patient and caregiver. However, innovative technology alone does not provide a complete solution to achieve the promise. Many emerging technologies facilitating virtual primary care require human-computer interaction in the data capture or output process. The challenge is to design and introduce technologies that support medical staff in complex, collaborative work environments (between patient and doctor and among medical team members), which may already have well-established, successful work practices and little tolerance for error. The parallel challenge to virtual primary care is to design and introduce to patients innovative technologies which are relatively unobtrusive, self-explanatory, and easy to use. Hence, technologies that enrich the patient/caregiver information exchange are socio-technical systems. Furthermore, research indicates technologies that employ human-computer interaction tend to be co-adaptive, meaning people adapt to the technology, yet also adapt the technology for their own purposes (Mackay, 1990).

The opportunities for advancement within this co-adaptive context may best be met through triangulation of design science and behavioural science (particularly, information systems and human computer interface) paradigms. The integration of inductive and deductive approaches, where design scientists (creators), behavioural scientists (‘understanders’; theorists) and ‘real-world’ practitioners are engaged in the pursuit of these opportunities to advance medical care, may address some of the limitations of singular paradigms and research strategies. Specifically, the precision and control of the design science paradigm may be complemented by the existential realism of exploring practitioner settings and the generalisability in applying repetitively tested theories to a new context and hence enable research triangulation (Runkel and McGrath, 1972).

Design science is an iterative process of creation, improvement, and adaptation. The iterative nature of design science provides a viable forum for integrating practice and theory. The purpose of this paper is to introduce a research framework triangulating design science, behavioural science, and real-world observation/engagement suitable for the development of technologies that support virtual primary care. We fulfil this goal by first describing the model. We then describe a context, tele-home health, which currently deploys technology supporting virtual primary care. We exemplify design science techniques by discussing a Model Of User's Emotions System (MOUE), a design artifact under development that potentially could be used to model patient emotions. We then draw upon behavioural science by discussing the Chau and Hu technology acceptance model as our theoretical foundation (Hu, 2002). We allow the behavioural model to guide field study. Field study insights are presented using the theoretical framework as a guide to inform further iterative development of MOUE and application within this context.

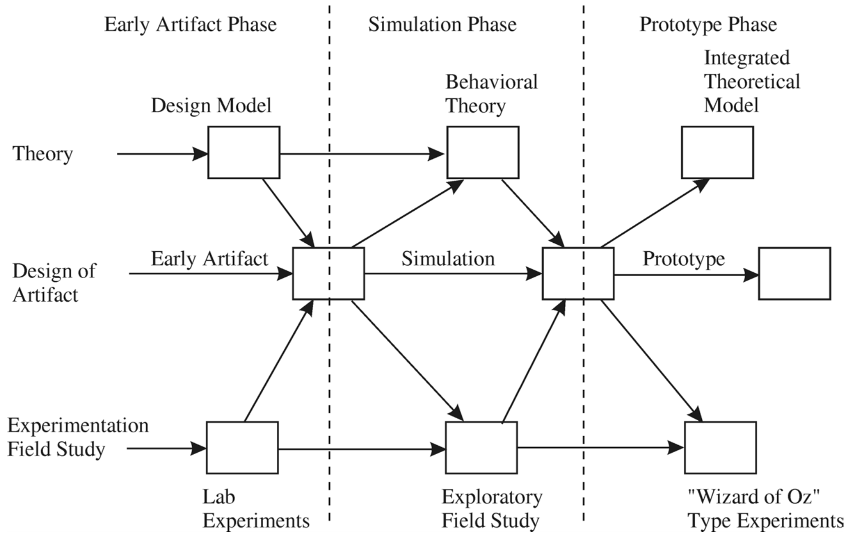
2 Framework for design and behavioural science triangulation for virtual primary care technologies

Computer science and information systems each borrow techniques from natural and social sciences as well as engineering. Also, the borders between these disciplines are often blurred. One means of distinguishing these disciplines seems to be research paradigms. Paradigms provide the overarching umbrella, which guide research questions and methods. Kuhn's work conveys a recurring theme that researchers act and think based upon their paradigms (Kuhn, 1996). It is rare to find one researcher or a research team composed of scientists within the same discipline manifesting the paradigms of multiple disciplines. Computer science often favours design-oriented questions and methods (e.g., creation and simulation), which are often of an inductive nature. Alternatively, information systems often favour theoretical development or a deductive approach to questions and methods. There is ample representation of quality research that has been done in each of these disciplines using a singular paradigm. As researchers seek to address problems of increasing complexity and as the pursuit of interdisciplinary research grows, the need for multiparadigmatic research frameworks is heightened. These frameworks provide a guide to address complex problems with both social and technical challenges to artifact development and deployment.

Additionally, there seems to be increasing pressure for researchers to attend to real- world problems if they want to increase the relevance of research efforts.

We adapt a framework originally presented by Makay and Fayard (see Figure 1) (Mackay and Fayard, 1997). Theory, design, and real-world field study instantiate various progressions of the technology under development. The first phase of the framework focuses on design science activities aimed at providing an early artifact of a solution to a problem. The second phase integrates behavioural science theory, design science, and exploratory field study aimed at further refining the initial artifact to a state suitable for simulation testing, preferably within a real-world context. The third phase of the model focuses on developing a prototype based upon socio-technical insights gained from design science innovation, behavioural theory, and user interaction with design artifacts. Any and all of the phases can be repeated as needed to work towards a beta version of the technology. The boxes on the diagram represent key points of interaction between the emerging technology and various constituencies (design science researcher, behavioural scientist, and/or end users).

Figure 1 Triangulation of behavioural and design science research framework



Source: Adapted from Mackay and Fayard (Lisetti *et al*., 2003a)

The overall objective of this research framework is to probe validity through triangulation and applicability to addressing real-world problems. We use an innovation in the tele-home health context to further clarify the model and begin with an introduction to this complex setting.

3 Tele-home health

Home care is currently 'the fastest-growing section of the healthcare market in the USA' and is also experiencing rapid growth in other venues such as the UK (Darkins and Carey, 2000). According to the National Association for Home Care, more than 20,000 medical professionals provided approximately 7.6 million people in the US home care services for acute illness, long-term health conditions, permanent disability, or terminal illness (National Association of Home Care, Basic Statistics About Home Care, 2003). Factors such as medical cost control and an aging population continue to seed the home healthcare industry (Warner, 1997; Darkins and Carey, 2000).

On average, non-chronic patients 'require home care for three months, often needing more than two visits per week' (Siwicki, 1996). Daily or frequent visits may be the ideal, but are not efficient or feasible due to healthcare reimbursement constraints and competing patient requirements for visit time, except in acute care situations. This requires healthcare professionals to make potentially difficult decisions in balancing quality ideals against the feasibility of frequent on-site visits. Longer durations between communications may potentially impede the open flow of relevant physical and mental health information (both verbal and non-verbal) between the home healthcare professional and patient, which may impact patient health.

In response to such home care issues, telecommunications began to establish a viable presence in the home healthcare industry in the 1990's in the form of telehealth. Tele-home healthcare is purported to cut on-site visit home healthcare costs and enhance the quality of home healthcare through increased monitoring (Siwicki, 1996). Tele-home health provides communication options between the medical professional and patient when hands-on care is not required. Advocates of telehealth in home healthcare contend that this means of interacting is patient-centered and promotes patient autonomy through education and improved communication (Warner, 1997).

Tele-home health systems transmit three basic types of information – text data, audio, and images (Crist, Kaufman and Crampton, 1996). Tele-home health possibilities include telephone reminder systems, wireless personal emergency response systems, vital sign monitoring devices, video conferencing, medication reminder systems, and web-based systems. Interactive communications may be either synchronous or asynchronous. Three common forms of interactive communication means include:

Video Telehealth System: Consists of a videophone, telephone with speakerphone, and electronic peripheral devices including a blood pressure cuff and pulse monitor, stethoscope-sending unit, and thermometer.

In-Home Messaging Device (see Health Hero Network, 2004 for demo of example device): Connects to a patient's existing home telephone line (uses plain old telephone service – POTS) and allows patients to view scripted questions and reminders from their healthcare provider on a brightly lit, high contrast LCD screen.

Health Chat Line: Requires the patient to log into a private internet site from their home computer at a designated time for private synchronous communication with a clinician. Certain home healthcare programmes may also support asynchronous communication. internet communication is used in instances when free-form communication is preferred rather than scripted communication (see next paragraph) and when the patient possesses the appropriate computer skills. Patient medical needs, and to a lesser degree, cost factors dictate the type of system recommended.

4 Need for affective computing in home healthcare

Though on-site presence may not be mandated, the home healthcare provider must still exhibit cognitive and observational skills to assess patient status from a distance when using tele-home health tools. Vital sign readings and medicine reminders may be effectively communicated through current physiological detection devices used in tele-home heath care, but effective state assessment (psychological state influenced by or resulting from the emotions) may prove a greater challenge in providing comprehensive, quality tele-home healthcare.

Current feasibility issues may not permit home healthcare professionals to consider factors such as communication flow and affective assessment (aside from mental health situations) when measuring requires on-site visit frequency. Unfortunately, none of the common forms of interactive communication used support the multi-modal richness of face-to-face communication, which provides 'body language', voice inflection, facial expression, and contextual clues to someone's affective state. As stated by Picard (1995),

> "…emotional states may be subtle in their modulation of expression….When affect communication is most important, then person-to-person contact carries the most information; email presently carries the least".

Literature indicates that emotional states may be conveyed through voice, facial expression and other physiological representations (Lisetti and Schiano, 2000). The ability to communicate emotion is enhanced through freedom of expression. As we decrease the modes of communication and freedom of expression, fewer affective clues pass through the communication process. As a result, affective assessment may be subject to misinterpretation of meaning as well as deceptive intent (patient trying to hide their emotional state via inaccurate textual representation). Of the devices described earlier, the in-home messaging devices exemplified both a reduction in modality as well as expressive freedom (in that it shrinks the vehicle of communication down to objective text-based responses). Within the tele-home health context, the computer mediated communication (CMC) may hamper affective assessment and ultimately the quality of care.

5 Early artifact phase: MOUE design model, early artifact, and lab experiments

A MOUE (Model Of User's Emotions) is a system currently under development, which builds a model of user's emotions during interaction from monitoring a user (e.g., patient) via multi-sensory devices. MOUE's functional scope aims at:

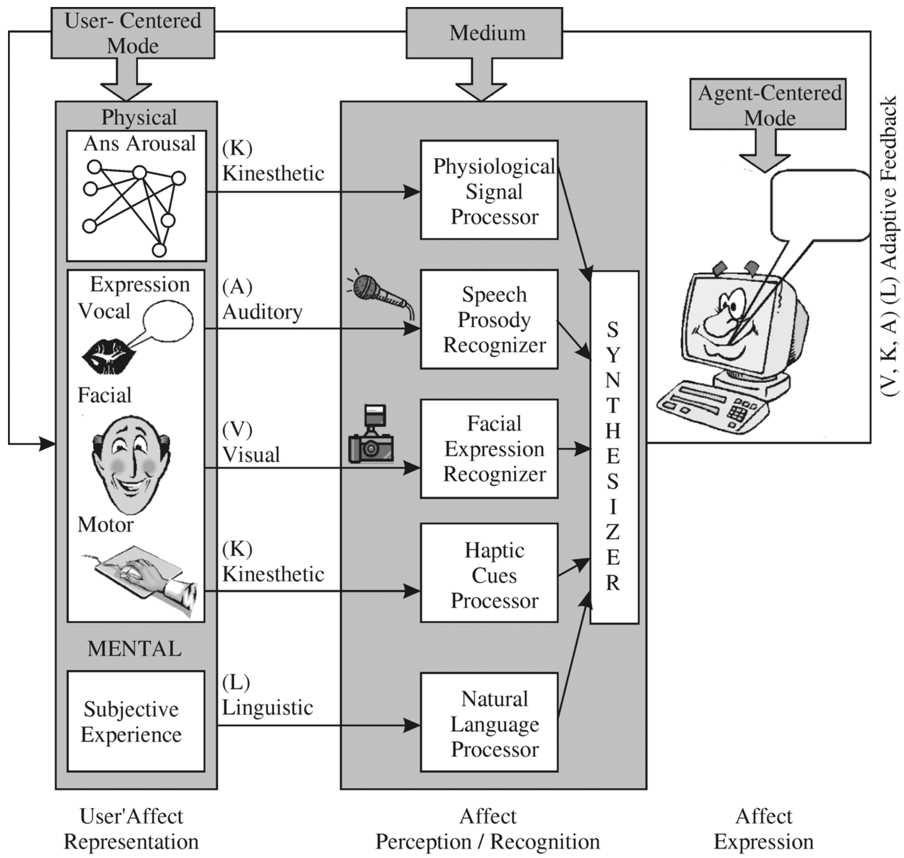
- identifying emotional components satisfied by its sensory observations
- having a database of emotion concepts for each of the most commonly experienced emotions of a given user
- providing feedback to the user about his or her state
- categorising similar emotions and inferring emotional trends
- instantiating its own emotion-like motivational state (future research)
- initiating some appropriate multi-modal adaptive action from that state (future research).

MOUE has three main components:

- A sensory-motor apparatus performing distributed low-level processing and integrating the result into a 'perceptual interpretation of facial expression',
- An ontology of emotion concepts based on schema theory, built as a distributed semantic network, in which each active node represents a characteristic of the current emotion
- An active interface which externalises to the user the perceived emotional state and reciprocally allows the user to correct and fine-tune the systems interpretation of his/her own internal emotional states. MOUE is described in detail in work by Bianchi-Berthouze and Lisetti (2002).

The overall model for MOUE (Model Of User's Emotions) is shown in Figure 2 (Lisetti *et al.*, 2003). Emotion seems to be best accounted for and represented by including *both* physiological and subjective components in a model of user's emotions (Lisetti, Douglas and LeRouge, 2001). Accordingly, MOUE is set up to be able to take as input both mental and physiological compoentns associated with a particular emotion experience by the user.

Figure 2 MOUE paradigm: combining AI and *HCI* for affective computing



Source: (Lisetti *et al*., 2003b)

Using the same terminology as Maybury and Wahlster (1998), physiological components are to be identified and collected from observing the user via receiving sensors or medium (e.g., camera, mouse, microphone) through the human senses employed to express emotion. The associated modalities or modes are: Visual (e.g., captured via camera), Kinesthetic (e.g., captured via mouse), and Auditory (e.g., captured via microphone) abbreviated as *V*, *K*, *A*.[2]

The system is also designed to be able to receive textual input in the form of linguistic terms for emotion concepts, which describe the subjective experience associated with a particular emotion. Utilisation of facial expressions is an appropriate indicator of subjective components as research on automatic facial expression recognition has shown very promising results (Lisetti and Schiano, 2000b).

Because of the multi-modal nature of the MOUE system and its simple natural language processing abilities, it will be possible to map out the user's inner states more accurately with the system's growing sensing abilities.

The *output* of the system is given in the form of a synthesis for the most likely emotion concept corresponding to the sensory observations. The synthesis constitutes a descriptive feedback about the user's current state, derived from the user's ongoing video stream, and a selected sequence of still images. The emotional state concepts include neutral, angry, frustrated, sad, and afraid. Recent experiments captured physiological readings as input for MOUE assessment, indicated promising results (Lisetti *et al*., 2003). Specifically, results indicated 70% success in categorising neutral, 80% success in categorising anger, 80% success in categorising fear, 70% success in categorising frustration, and 90% success in categorising sadness.

It is our proposition that MOUE has the potential to address the affective communication paradox challenges experienced in the tele-home healthcare setting that we identified in the previous section.

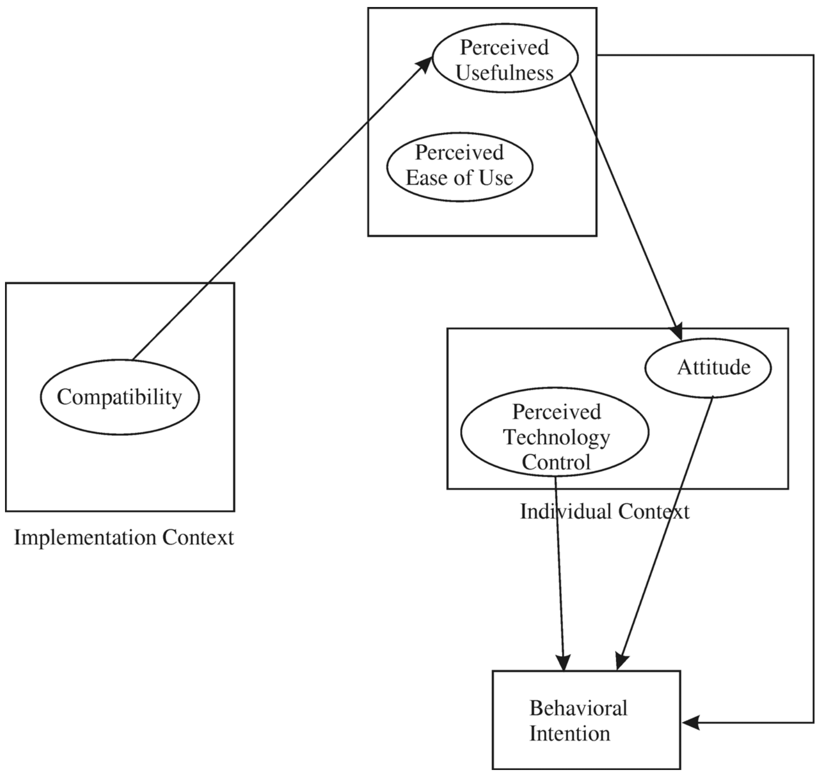
6 Simulation phase: behavioural theory, exploratory field study, and simulation prototype

The introduction of an intelligent affective interface into a tele-home healthcare setting holds the potential of providing improved capabilities for affective state assessment and monitoring to potentially increase the quality and possibilities of tele-home healthcare in a cost-effective manner. A patient's affective risk level may be objectively monitored according to individual emotions and/or aggregated for overall emotional risk assessments. Additionally, the clinician can have a reading of the patient's emotional state during synchronous communication to compensate for the loss of modalities.

However, research findings and personal accountings demonstrate that the development and availability of promising technology does not necessarily beget the successful utilisation of the technology (DeLone and McLean, 2002). The potential for improvements in the affective assessment are contingent upon development in conjunction with appropriate use of innovations. A primary issue in enabling the application of MOUE to tele-home healthcare is *acceptance,* which has long been recognised as a critical success factor in information systems (IS) literature (e.g. Davis, 1989; Brancheau, Janz and Wetherbe, 1996). Bellotti *et al*., (1995) concluded that theoretically grounded HCI design artifacts could be effective, but only 'if the end-user requirements of the design are properly understood, and the value of such techniques can be demonstrated'.

Requirements may be best understood by integrating design efforts with behavioural theory and field study observation. Given the cost and effort in developing innovative technologies, such as MOUE, there exists additional cause to evaluate acceptance into proposed contexts during the development process. Though there is a strong IS technology acceptance research stream (Agarwal, 2000), little research investigates the exploration integration of IS acceptance constructs into the development of innovations (i.e., design science). We use significant relationships found in the Chau and Hu technology acceptance model (see Figure 3) developed in consideration of the broad context of telemedicine as a means to integrate insights from IS behavioural science research in the area of technology adoption to further MOUE development for the tele-home health context. We develop these insights based on prior research and qualitative field study. The field study included ten semi-structured interviews with tele-home health providers employed by three leading tele-home health organisations and 21 hours direct observation of tele-home health providers at various sites in the process of performing their jobs.

Figure 3 Chau and Hu model of information technology acceptance by individual professionals – significant relationships



Source: Chau and Hu (2002)

Both patient and medical provider acceptance are desired. The tele-home health case managers (e.g., nurse, nurse practitioner, dietitian) and, ultimately, the physician in charge of the case are responsible and accountable for establishing the direction and execution of tele-home healthcare and the introduction of various technologies into the tele-home health context. Without adoption by healthcare professionals, the successful utilisation of MOUE in the tele-home health context is severely inhibited, if not impossible. Past research has demonstrated that healthcare professionals have unique characteristics as a user group, which may impact the nature and propriety of commonly proposed antecedents to acceptance in this context (Hu *et al*., 1999). In fact, without adoption by caregivers, it is possible tele-home health patients may not even be exposed to MOUE on a broad-scale level. Hence, we primarily focus this discussion on MOUE acceptance from the perspective of healthcare professionals using the Hu model constructs as a guide for discussion. Additionally, we acknowledge patient acceptance as a future research topic.

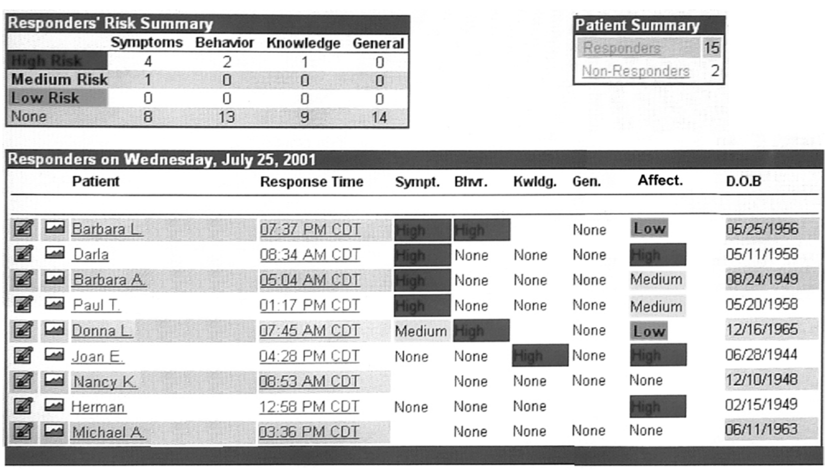
6.1 Implementation context

Compatibility: Compatibility refers to the degree to which the use of telemedicine technology is perceived by a clinician to be consistent with their current work practices or preferences. Prior research indicates physicians may become entrenched in a style or routine of practice in which they categorise a patient's needs and then select '…appropriate standard programmes (such as, treatments or protocols) from a repertoire, and subsequently execute them (Chau and Hu, 2002; p.200).

Tele-home health case managers operate in the same categorisation process under the direction of a physician. Our interviews and direct observations indicated clinicians spend much of their time reviewing integrated data from multiple indicators of patient status in a manage-by-exception manner to guide caseloads of up to 250 patients per tele-home health clinician. Tele-home health literature supports these observations and in fact, provides accounts of even higher patient/clinician ratios (e.g., Crist, Kaufman and Crampton, 1996). Past literature, interviews, and direct observation indicate that clinicians are comfortable with current output format and styles, which seems to accommodate the process of contingency categorisation.

Hence, it is of no surprise that clinicians queried regarding MOUE output options expressed the preference for integration within the current presentation format, and specifically preferred the use of tables, graphs, and colour-coded schemas to avoid disruption of established patterns of practice. To reflect the influence of these issues into the design process, we present a prototype of aggregated summary/alert patient status information that emulates the interface motifs currently in use for one popular tele-home health system embodying MOUE output in Figure 4.

Figure 4 Proposed prototype of aggregated summary/alert patient status



Responders' Risk Summary

	Symptoms	Behavior	Knowledge	General
High Risk	4	2	1	0
Medium Risk	1	0	0	0
Low Risk	0	0	0	0
None	8	13	9	14

Patient Summary

Responders	15
Non-Responders	2

Responders on Wednesday, July 25, 2001

Patient	Response Time	Sympt.	Bhvr.	Kwldg.	Gen.	Affect.	D.O.B
Barbara L.	07:37 PM CDT	High	High		None	Low	05/25/1956
Darla	08:34 AM CDT	High	None	None	None	High	05/11/1958
Barbara A.	05:04 AM CDT	High	None	None	None	Medium	08/24/1949
Paul T.	01:17 PM CDT	High	None	None	None	Medium	05/20/1958
Donna L.	07:45 AM CDT	Medium	High		None	Low	12/16/1965
Joan E.	04:28 PM CDT	None	None	High	None	High	06/28/1944
Nancy K.	08:53 AM CDT		None	None	None	None	12/10/1948
Herman	12:58 PM CDT	None	None	None		High	02/15/1949
Michael A.	03:36 PM CDT		None	None	None	None	06/11/1963

6.2 Individual context

Perceived technological control: Perceived control refers to the healthcare professional's assessment of perceived ability to use telemedicine technology. Perceived control in the tele-home health context refers to both technological capability and autonomy. Healthcare professionals (particularly physicians) are thought to exercise considerable autonomy in their work process and accordingly, considerable control over the use of technology in the patient care context (Chau and Hu, 2002). Though home healthcare case managers may be subject to greater levels of control imposed by home healthcare organisations and/or attending physicians, they are the home healthcare patient's 'front-line' care decision makers and possess elements of autonomy in their work process.

MOUE adds data to the present context with no data costs. The use of this additional data will likely be volitional. Research indicate both nurses and patients may promote innovations that provide the possibility of improved patient care (Darkins and Carey, 2000; Whitten, Mair and Collins, 2001; Telemedicine Goes Mainstream, 2001). Given the trend toward the use of multiple and increasingly sophisticated devices, including wearable biochemical sensors that track a multitude of physiological measurements in tele-home healthcare (Crist, Kaufman and Crampton, 1996)[3], the introduction of new sensors or added application of currently existing sensors to affective state interpretation may not seem foreign or disruptive to the existing tele-home healthcare atmosphere. Based upon the aforementioned, it seems tele-home health professionals will manifest perceived ability to use MOUE and possess motivations for use, assuming issues surrounding technological context and implementation context are satisfied.

Attitude: The general attitude regarding tele-home health and innovation in this area seems favourable. In a 2001 Report to Congress on Telemedicine, the Office for the Advancement of Telehealth indicated generally high patient and provider satisfaction in summarising over forty telemedicine studies measuring satisfaction (Department of Health and Human Services, Health Resources and Services Administration, Office for the Advancement of Telehealth, Rockville, 2001). Indications are that clinicians, particularly home care nurses, and patients have not been daunted by the introduction of new technologies.[3] However, individuals generally rely on their human senses to provide indicators of another's emotional state rather than external devices, even when communication is taking place via distance. Two of our interviewees seemed to have some anxiety with MOUE spawned by fears of artificial intelligence. MOUE innovators and implementers should acknowledge the introduction of MOUE might require some degree of conceptual shift for some potential users. As such, proactive change management efforts (e.g., education on the positive uses and limitations of MOUE) may be warranted.

The development of technology, such as MOUE, that may involve conceptual shift may benefit from recognising that such things as attentive participant education may be necessary as developmental experiments are staged. Additionally, experimentation exploring change management possibilities may provide direction on addressing future use situations where conceptual shift may be necessary. Concerns also indicate patient acceptance may influence healthcare provider acceptance. Specifically, if experimentation and use indicate patients are comfortable, caregivers' concerns regarding intrusion on patients may subside. It is to be noted that participants in MOUE studies using BodyMedia SenseWear© (BodyMedia, 2004) (a small wireless wearable computer that patients cuff to their upper arm that can measure galvanic skin response, skin temperature, ambient temperature, heat flow, and movement MOUE physiological input) responded they were comfortable, emotionally and physically, wearing the device (Lisetti *et al*., 2003).

This furthers the call for experimentation related to patient acceptance during the development process and the propagation of those results to healthcare providers.

6.3 Technological context

Perceived ease of use: A second acceptance issue relates to the cognitive load of the tele-home health clinician in assimilating a variety of patient data. As such, technology output provided in these settings must support user-processing efficiencies. Efficiencies can be achieved through interfaces that promote quick absorption of data and present data in a form that harmonises with accepted systems currently in use. Output from currently deployed devices typically utilise tables and charts to allow clinicians to quickly digest status and drill down to observe more detailed information. Alert signals (e.g., colour codes and audio sounds) are also used to improve processing efficiency while appropriately focusing attention (Crist, Kaufman and Crampton, 1996).

MOUE has the capability of producing very rich graphical output including simulated facial expressions. In discussing the rich potential graphic output possibilities, participants expressed concern regarding cognitive efficiency and the desire to integrate output with existing information. Many participants specifically stated a preference for simple tables and graphs.

In response to this issue, we developed screen prototypes, which exemplify colour-coding schema, quick absorption of high-level data, table and chart formats, and drill down capabilities. Figure 4, previously discussed, introduces a patient summary/alert menu screen utilising colour-coding. Figure 5 provides a prototype of a 'drill-down' MOUE output, providing affective state information in graphic form of the general nature currently used to present physiological information.

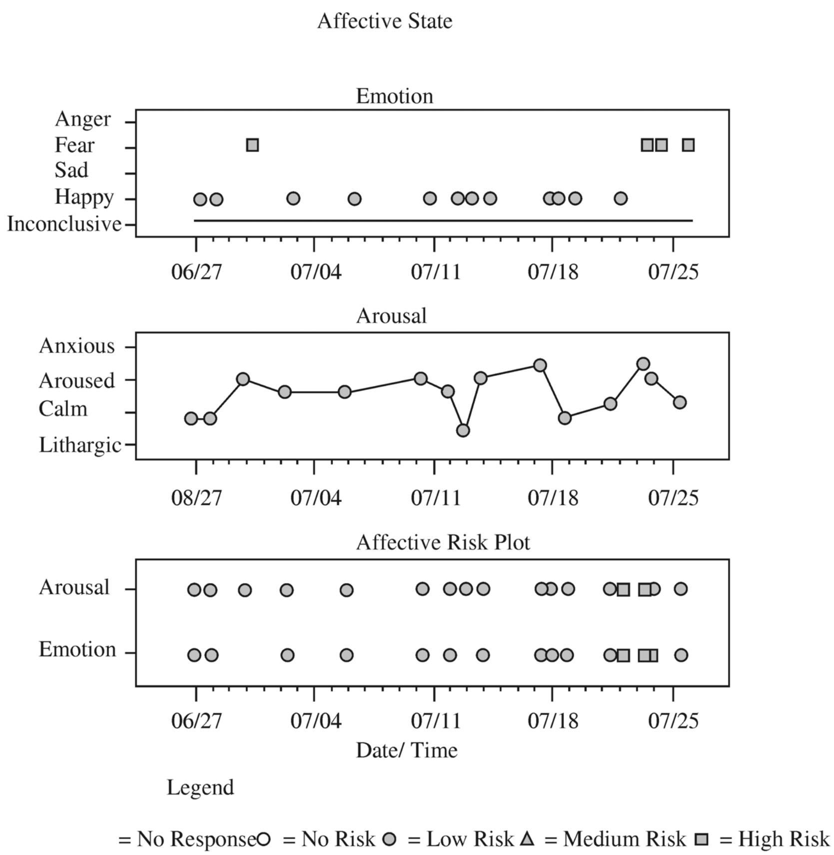
Perceived usefulness: This issue centres on beliefs and the perceived value of technology providing indicators of emotional state. MOUE must be seen as 'encompassing sufficient utilities for supporting or facilitating …core patient care services' (Chau and Hu, 2002; p.199). Interviewees concurred that affective state is a relevant factor in most health conditions. As stated by one interviewee:

There are very few health problems in which the emotional state does not play a factor. As a result the emotional state is a real concern whether there is visualisation or not. This makes the Care Coordinator (home healthcare case manager) a key component in using the appropriate clinical judgement when choosing the technology. Certainly in the mental health population the affective/emotional state is more fragile.

Additionally, those interviewed indicated some current concern over the ability to pick up affective clues while trying to manage large caseloads using current forms of communication. Though there is an increasing level of awareness, especially in the medical profession that physiological readings can provide indications of emotional state, there seems to be little formalised capture and integration of this data into medical practice. As such, the introduction of MOUE into tele-home health may be perceived as providing some remedy to this need, which may enhance perceived usefulness.

However, we acknowledge perceived usefulness is dependent on the quality of the technology (i.e., MOUE indicators show accurate and understandable output) and may be influenced by compatibility and attitude. Particularly, regarding attitude, participants indicated a challenge to determine usefulness until they were actually in a care-giving situation receiving patient communication.

Figure 5 MOUE drill-down output prototype for tele-home health context



Medication	Dosage	Frequency	Start Date	Stop Date
Lasix	20 mg	qd	06/16/2000	

Notes

7 Prototype phase: future work

The aforementioned exploratory qualitative analysis provides foundation, need, and direction for future experimentation to further adapt MOUE to the tele-home health context in the simulation phase of our framework. Given the costs and effort required to fully develop and implement complex systems such as MOUE, a 'Wizard of Oz study' integrating interface prototyping (Dahlback, Jonsson and Ahrenbert, 1998) seems an appropriate means for investigation of many of the potential adoption and implementation issues discovered through the qualitative study to somewhat of a simulated environment. Wizard of Oz (WOZ) (Dahlback, Jonsson and Ahrenbert, 1998) studies are studies where subjects are told they are interacting with a computer (HCI) system (and perhaps receiving 'real' information) through a multi-modal interface, though in fact they are not. In reality, a human operator (simulating CMC), the wizard, mediates the interaction. The desired consequence is that the subject can be given more freedom of expression, or be constrained in more systematic ways, than is the case in existing multimodal affective intelligent interfaces.

Such experiments permit avoidance of 'the chicken or the egg' problem: *how can one evaluate the usefulness and importance of intelligent affective feedback and readings before they exist?* Qualitative field study indicates a problem such as this may exist in introducing MOUE into the tele-home healthcare setting. Wizard of Oz studies can allow researchers to develop some grounded understanding of how relevant artificial intelligence research in affect recognition will promise to be in the adoption/implementation phase within a given context.

Wizard of Oz studies have been developed in the field of natural language processing (Dahlback, Jonsson and Ahrenbert, 1998) and we extend their paradigm to the evaluation of the potential of multi-modal affective intelligent interfaces. Based upon the potential integration issues as discussed using the Chau and Hu model (Chau and Hu, 2002), we claim Wizard of Oz experiments are most appropriate to provide a simulated environment to test MOUE interfaces in light of adoption and diffusion issues (at least in tele-home healthcare), and to therefore establish the motivation and need for further research in affect recognition and models of user's emotions.

Data collection from WOZ experimentation should be used to further the integrated theoretical model (incorporating design and behavioural science) and to inform the development of an operational prototype that can be used in pilot studies. Further development and testing of the integrated theoretical model may include ways in which MOUE may help the patient become more aware of his/her own affective states, when seen as a beneficial treatment method) by providing affective feedback to the patient.

8 Conclusions

The premise of this study is that information systems theory and practice can inform product creation as well as the intended or actual utilisation of finished product. We exemplify the integration of IS behavioural science and user participation into the design science process by addressing adoption and diffusion variables found significant in an adoption and diffusion model studied in the general telemedicine context with MOUE, an intelligent interface aimed at improving affective distance communications between a patient and healthcare provider and patient emotional state monitoring in a tele-home healthcare context. It seems tele-home healthcare settings provide a rich landscape for research and application of affective computing to improve the quality of patient care and MOUE has the potential to make a significant contribution to this need. The realisation of MOUE to fulfill this promise may be contingent upon the various interface, adoption, and implementation issues discerned through qualitative field methods. The underlying theme of introducing IS theory and field study to the design science process is that future iterations of MOUE, input and output user interfaces and related processes should augment rather than replace the existing reality and systems that presently exist and seem to work for other purposes in the tele-home health context.

The ability of MOUE to address identified issues in a cost and time-effective manner may best be addressed through preliminary experimentation using 'Wizard of Oz' type experiments. Our proposed methodological innovation expands the application of 'Wizard of Oz' type studies (Dahlback, Jonsson and Ahrenbert, 1998) to computer mediated communication (CMC) environments to investigate how MOUE assessments influence responses from healthcare professionals and how MOUE can be accepted into the healthcare environment.

Future research may instantiate the remaining phases of our framework, test the viability of various rapid prototyping techniques in the prototyping stage, and integrate patient fieldwork findings. Additionally, it is our hope that researchers will find our model useful in the development of effective and efficient technology suited to the needs of virtual primary care.

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Notes

1 Part of this work was accomplished when the author was at the University of Central Florida.

2 We limit ourselves to the three modalities (V, K, A) because we currently have found more emotion-relevant literature on those modalities than on the other two modes: Olfactory and Taste (O, T).

3 E-Health and This Generation of Home Health Care Patient, (2001) tie.telemed.org/homehealth/kinsella4_FT.asp