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Adapting the Task-Technology-Fit Model to the Development and Testing of a Voice Activated Medical Tracking Application

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EXECUTIVE SUMMARY

The purpose of this study was to adapt the task-technology-fit (TTF) model to a voice activated medical tracking application (VAMTA). To accomplish this task, it was necessary to develop a valid instrument for obtaining user evaluations of the MTA. A pilot study was initiated in order to study the application with medical end-users. This phase of the study provided face validity. The study demonstrated that the perceptions of end-users can be measured and evaluation of the system from a conceptual viewpoint can be documented.

The pilot study survey results were analyzed using the Statistical Package for the Social Sciences (SPSS) data analysis tool to determine whether TTF, along with individual characteristics, will have an impact on user evaluations of VAMTA. The study modified the original TTF model for adequate domain coverage of medical patient care applications.

This study provides the underpinnings for a subsequent, higher level study of nationwide medical personnel. Follow-on studies will be conducted to investigate performance and user perceptions of the MTA system under actual medical field conditions.

BACKGROUND

As the medical community continues its quest for more efficient and effective methods of gathering patient data and meeting patient needs, increased demands are placed on IT to facilitate this process. The situation is further complicated by the segmented nature of healthcare data systems. Healthcare information is often encapsulated in incompatible systems with uncoordinated definitions of formats and terms. It is essential that the different parts of this organization, which have different data systems, find ways to work together in order to improve quality performance. The MTA has been developed to contribute to that effort by enhancing the electronic management of patient data.

Much has been written about end-user perceptions of IT (1, 3, 8, 22, 25), but few studies address user evaluations of IT as it applies to voice activated healthcare data collection. This study focuses on the development and testing of an instrument to measure the performance and end-user evaluation of the MTA in preventive healthcare delivery.

Related Work and Theoretical Framework

The TTF model (Figure 1) is a popular model for assessing user evaluations of information systems. The central premise for the TTF model is that "users will give evaluations based on the extent to which systems meet their needs and abilities." (13) For the purpose of our study, we define user evaluations as the user perceptions of the fit of systems and services they use, based on their personal task needs (13).

The TTF model represented in Figure 1 is very general, and using it for a particular setting requires special consideration. Among the three factors that determine user evaluations of information systems, technology is the most complex factor to measure in healthcare. Technology in healthcare is used primarily for reporting, electronic information sharing and connectivity, and staff and equipment scheduling.

Reporting is important in a healthcare setting because patient lives depend on accurate and timely information. Functional departments within the healthcare facility must be able to access and report new information in order to respond properly to changes in the healthcare environment (18).

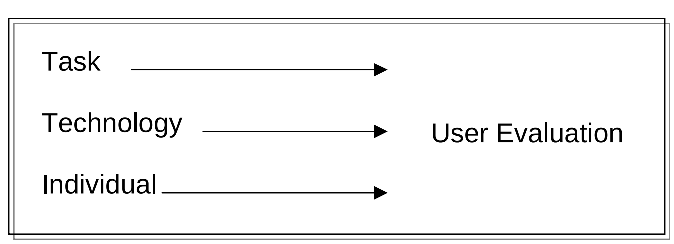
Four types of information are reported in a healthcare facility:

- Scientific and technical information
- Patient-care information
- Customer satisfaction information
- Administrative information (26).

Scientific and technical information provides the knowledge base for identifying, organizing, retrieving, analyzing, delivering, and reporting clinical and managerial journal literature, reference information, and research data for use in designing, managing, and improving patient-specific and departmental processes (17).

Patient-care information is specific data and information on patients that is essential for maintaining accurate medical records of the patients' medical histories and physical examinations. Patient-specific data and information are critical to tracking all diagnostic and therapeutic procedures and tests. Maintaining accurate information about patient-care results and discharges is imperative to delivering quality healthcare (4).

Figure 1. Task Technology Fit Model



Customer satisfaction information is gathered from external customers, such as a patient and his or her family and friends. Customer satisfaction information is gathered from surveys and takes into account socio-demographic characteristics, physical and psychological status, attitudes, and expectations concerning medical care, the outcome of treatment, and the healthcare setting (21).

The administrative information that is reported in a healthcare facility is essential for formulating and implementing effective policies both at the organizational and departmental level. Administrative information is necessary to determine the degree of risk involved in financing expansion of services (9).

Electronic Information Sharing and Connectivity

As the technological infrastructure of organizations becomes increasingly complex (15), IT is increasingly being used to improve coordination of activities within and across organizations (6). Computers and video networks provide long-distance healthcare through medical connectivity. Doctors interact with each other and ancillary medical personnel through e-mail, video, and audio means. A difficult patient case in a rural area, or on shipboard, can be given expert specialist attention simply by using "distance" medicine. Not only can patient records, text, and documents be transmitted instantaneously via electronic means, but live video, x-rays, and other diagnostic parameters can be discussed in an interactive manner with live discussions.

As the availability of external consultative services increases, information sharing and connectivity are becoming increasingly important. Connectivity allows diagnoses to be made in remote locations using electronic means, and information sharing decreases the chances that mistakes will be made in a healthcare setting. Connectivity leads to shared care that comprises the continued, coordinated, and integrated activities of different people from different institutions applying different methods in different time frames, all in a combined effort to aid patients medically, psychologically, and socially in the most beneficial ways (10). In addition to reporting and electronic information sharing and connectivity, IT is used extensively for staff and equipment scheduling in healthcare settings. IT-based scheduling can lower healthcare costs and improve the utilization of physical and human resources. Scheduling using statistical, time series, and regression analysis is conducted to achieve lower costs through rationing assets (e.g., ambulatory service and real-time forecasting of resources) (23).

SETTING THE STAGE

The purpose of this study was to develop and test a valid survey instrument for measuring user evaluations of VAMTA in preventive healthcare. The findings of a pilot study testing the instrument were used in a preliminary assessment of the effectiveness of the VAMTA system and the applicability of TTF to the VAMTA. The development of the instrument was carried out in two stages. The first stage was item creation. The objective of this first stage was to ensure face and content validity of the instrument. An item pool was generated by interviewing two end-users of IT, obtained from a pool of medical technicians. The end-users were given training on the module for two days and invited to participate in the study. These subjects were selected for reasons of geographical proximity of the sample and, in many cases, the existence of personal contacts onboard ship.

An interview was also conducted with one of the authors of this study, who has approximately 10 years of experience as an IT end-user. In addition, the domain coverage of the developed pool of items was assessed by three other end-users from three different ship environments covered in the survey. None of the end-users, who were a part of the scale development, completed the final survey instrument. All the items were measured on a five-point Likert scale ranging from "strongly agree" to "strongly disagree."

Next, the survey instrument was utilized in a pilot study in which end-users tested the VAMTA. This pilot study provided face validity, in that the perceptions of end-users could be measured, and evaluation of the system from a conceptual viewpoint could be documented. A total of 33 end-users were used in this phase to test the VAMTA. They reported their perceptions of the MTA in the survey instrument, which was provided after their training and testing. The pilot study results were analyzed using SPSS and Microsoft Excel to determine whether TTF, along with individual characteristics, had an impact on user evaluations of the VAMTA. For the study, the original TTF model was modified to ensure adequate domain coverage of medical and preventive healthcare applications.

Instrument Development and Measurement of Variables

The IT construct used in the pilot study focused on the use of VAMTA to support preventive medicine applications. A summary of the questions presented in the survey instrument is provided in Appendix A, VAMTA *Follow-Up Questionnaire*. Construction of the survey instrument was based in part on Akaike's (2) information criterion (AIC) and Bozdogan's (5) consistent information criterion (CAIC).

CASE DESCRIPTION

Testing of the VAMTA required started on 8 March 2002 and ended on 1 April 2002. The purpose of this pilot study was to test the survey instrument designed to measure user evaluations of VAMTA in preventive healthcare, as well as to collect data for use in a preliminary assessment of VAMTA and the applicability of TTF to the system.

Participants

Thirty-three individuals participated in testing of the VAMTA, including 11 females and 22 males with various levels of experience and education. Experience ranged from test subjects who had never seen the application before they tested it to developers who built the application. A number of test subjects had limited medical backgrounds. Education ranged from high school graduates to PhDs.

Hardware and Operating System

Fujitsu 3400S pen tablet computers with the Microsoft Windows 98 operating system were used for all testing. CAT 51 microphones were used. CAT 51 microphones allow for hands-free, voice-activated computer operation in high-noise environments.

Testing Procedure

Each test subject was shown a demonstration of the VAMTA application prior to testing. Test subjects were then required to build a new user account and speech profile. Subjects ran through the application once using a test script to become familiar with the application. Next, the test subjects went through the application again while being videotaped. No corrections were made to dictated text during the videotaping. This allowed the tracking of voice dictation accuracy for each user with a new speech profile. Test subjects completed the entire process in an average of two hours.

Afterward, each test subject completed a questionnaire to determine user demographics, utility and quality performance, system interface, hardware, information management, and overall system satisfaction and importance. This survey instrument also allowed the test subjects to record any problems and suggest improvements to the system. Problems recorded by test subjects in the survey instrument were also documented in the Bug Tracking System by the test architect for action by the VAMTA development team.

Pilot Study Test Results

The performance of VAMTA during testing was measured in terms of voice accuracy, voice accuracy total errors, duration with data entry by voice, and duration with data entry by keyboard and mouse. Viewed together, these statistics provide a snapshot of the accuracy, speed, and overall effectiveness of the VAMTA system.

Each test subject's printout was compared with a test script printout for accuracy. When discrepancies occurred between the subject's printout and the test script, the printouts were compared with the video recordings to determine whether the test subjects said the words properly, stuttered or mumbled words, and/or followed the test script properly. Misrecognitions occurred when the test subject said a word properly and the speech program recorded the wrong word. The accuracy of voice recognition, confirmed by videotaped records of test sessions, averaged 97.6%, with 6 misrecognitions. The minimum average voice recognition was 85%, with 37 misrecognitions. The maximum average voice recognition was 99.6%, with 1 misrecognition. Median voice recognition was 98.4%, with 4 misrecognitions.

Total errors include both misrecognitions and human errors. Human errors occurred when a test subject mispronounced a word, stuttered, or mumbled. The total accuracy rate of the VAMTA was 95.4 %. Human error accounted for 2.2% of the total errors within the application.

The duration of each test subject's voice dictation was recorded to determine the average length of time required to complete a medical encounter while using the VAMTA. The average time required to complete a medical encounter in which data entry was conducted by voice was 8 minutes and 31 seconds. The shortest time was 4 minutes and 45 seconds, and the longest time was 23 minutes and 51 seconds.

While the majority of test subjects entered medical encounter information into the VAMTA only by voice, several test subjects entered the same medical encounter information using a keyboard and mouse. The average time required to complete a medical encounter in which data entry was conducted with keyboard and mouse was 15 minutes and 54 seconds. The shortest time was 7 minutes and 52 seconds, and the longest time was 24 minutes and 42 seconds.

The average duration of sessions in which data entry was performed by voice dictation was compared to the average duration of sessions in which data entry was performed with a keyboard and mouse. On average, less time was required to complete the documentation of a medical encounter using VAMTA when data entry was performed by voice instead of with a keyboard and mouse. The average time saved using voice versus a keyboard and mouse was 7 minutes and 52 seconds per medical encounter. The duration of each medical encounter included the dictation and printing of the entire Chronological Record of Medical Care form, a Poly Prescription form, and a Radiologic Consultation Request/Report form.

Survey Response Analysis

While the effectiveness of the VAMTA during the pilot study testing can be estimated from statistics on voice accuracy and duration of medical encounters, the applicability of the TTF model to the VAMTA system can be determined by an analysis of the end-user survey instrument responses. Multiple regression analysis reveals the effects of VAMTA utility, quality performance, task characteristics, and individual characteristics on user evaluations of VAMTA (Table 1).

The results indicate that overall end-user evaluations of VAMTA are consistent with the TTF model. The F value was 6.735 and the model was significant at the p=0.001 level of significance. The R-square for the model was .410. This indicates that model-independent variables explain 41% of the variance in the dependent variable. The individual contributions of each independent variable factor are shown in Table 2.

Table 1. One-Way ANOVA Table for Regression Analysis

Degrees of Freedom	Source	Sum of Sq.	Mean Sq.	F Value	P>F
4	Regression	2.664	.666	6.735	.001
29	Residual	2.867	.099		
33	Total	5.531			

** significant at p=.001*

Table 2. Individual Contribution of the Study Variables to the Dependent Variable

					P>F
Source	**Degrees of Freedom**	**Sum of Sq.**	**Mean Sq.**	**F Value**	**0.022****
Ease of Use	1	1.577	1.577	5.834	0.007**
Navigation	1	2.122	2.122	8.459	0.0000*
Application	1	0.211	3.80	4.59	0.0000*
Operation	1	0.912	0.912	3.102	0.008**
Understandable	1	0.965	0.965	3.196	0.0085**

** significant at p=.001, ** significant at p0.05*

While the Table 10 data reveals the suitability of the TTF model, Table 11 reveals another finding. Based on the data shown in Table 11, according to pilot study user evaluations of VAMTA, utility and quality performance are the major factors that affect the management of information by VAMTA.

CONCLUSIONS

The VAMTA pilot study revealed findings related to the effectiveness of the survey instrument and the VAMTA itself. As a result of the pilot study, the VAMTA follow-up questionnaire has been proven to be a valid survey instrument. By examining end-user responses from completed surveys, analysts were able to measure multiple variables and determine if the TTF model was applicable to the VAMTA system. The survey's effectiveness should extend to its use in future studies of VAMTA's performance in preventive healthcare in a national setting.

Analysis of the actual end-user responses supplied during the pilot study confirmed that the TTF model does apply to VAMTA. In pilot study survey responses, the VAMTA system received high ratings in perceived usefulness and perceived ease of use. This suggests that the VAMTA shows promise for medical applications.

The survey responses also revealed that utility and quality performance are the major factors affecting the management of information by VAMTA. In future, end-users who want to improve the management of healthcare information through use of VAMTA will need to focus on utility and quality performance as measured by perceived usefulness and perceived ease of use of the VAMTA system.

In addition to providing findings related to TTF and the utility and quality performance of VAMTA, the pilot study demonstrated ways in which the VAMTA system itself can be improved. For example, additional training with the application and corrections of misrecognitions will improve the overall accuracy rate of this product.

The combined findings resulting from the pilot study have laid the groundwork for further testing of VAMTA. This additional testing is necessary to determine the system's performance in an actual medical setting and to define more clearly the variables affecting the TTF model when applied in that setting.

In the pilot study, efforts were focused on defining the information technology construct for preventive healthcare applications. Limited work was done to define tasks and individual characteristics. To complete this work, future research should focus on defining the task and individual characteristics constructs for the TTF model for measuring user evaluations of IT in preventive healthcare.

REFERENCES

Available upon request.