**Abstract (Summary)**

Voice recognition technology-enabled devices possess extraordinary growth potential, yet some research indicates that organizations and consumers are resisting their adoption. This study investigates the implementation of a voice recognition device in the United States Navy. Grounded in the social psychology and information systems literature, the researchers adapted instruments and developed a tool to explain technology adoption in this environment. Using factor analysis and structural equation modeling, analysis of data from the 270 participants explained almost 90% of the variance in the model. This research adapts the technology acceptance model by adding elements of the theory of planned behavior, providing researchers and practitioners with a valuable instrument to predict technology adoption. [PUBLICATION ABSTRACT]

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| ABSTRACT |
| Voice recognition technology-enabled devices possess extraordinary growth potential, yet some research indicates that organizations and consumers are resisting their adoption. This study investigates the implementation of a voice recognition device in the United States Navy. Grounded in the social psychology and information systems literature, the researchers adapted instruments and developed a tool to explain technology adoption in this environment. Using factor analysis and structural equation modeling, analysis of data from the 270 participants explained almost 90% of the variance in the model. This research adapts the technology acceptance model by adding elements of the theory of planned behavior, providing researchers and practitioners with a valuable instrument to predict technology adoption. |
| Keywords: technology acceptance model; theory of reasoned action; theory of planned behavior; voice recognition |

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Supported by the development of easy-to-use and inexpensive technology, the adoption of voice recognition technology (VRT)-enabled devices by businesses and consumers is slated to grow 17% per year, becoming a $52 billion market by 2007 (Business Communications Company, 2003). Studies in hospital settings illustrate average productivity gains of 30% with the introduction of VRT devices (MedQuist, 2003). Additionally, organizations garner cost savings and the potential for improved security, while consumers are attracted to hands-free operation of personal devices including cellular phones and personal digital assistants. Yet, despite improvements in the technology itself and the potential productivity gains, studies suggest that organizations and consumers are resisting VRT adoption (Costanzo, 2003).

Social psychology and information systems research have extensively explored the adoption of innovations including information technology. A variety of tools have been developed to explain the adoption process, including the widely referenced theory of reasoned action (Fishbein & Ajzen, 1975), theory of planned behavior (Ajzen, 198; Fishbein & Ajzen, 1975), and technology acceptance model (Davis, 1986). This study marks the first time that the adoption of VRT has been explored with these research tools.

The adoption process is explored in this study during the initial implementation of a voice recognition device by the U.S. Navy. The next section describes the situation and the system to be implemented and is followed by a review of the social psychology and information systems literature. Then the research model and study's hypotheses are presented. A description of the data and its analysis is presented followed by the discussion of the findings. The paper concludes with implications and suggestions for future research.

BACKGROUND

Coupling computer recognition of the human voice with a natural language processing system makes speech recognition by computers possible. By allowing data and commands to be entered into a computer without the need for typing, computer understanding of naturally spoken languages frees human hands for other tasks (Lai, 2000; Shneiderman, 2000). Speech recognition by computers can also increase the rate of data entry, improve spelling accuracy, permit remote access to databases utilizing wireless technology, and ease access to computer systems by those who lack typing skills (Boyce, 2002). The seamless integration of voice recognition technologies creates a human-machine interface that has been applied to consumer electronics, Internet appliances, telephones, automobiles, interactive toys, and industrial, medical, and home electronics and appliances (Soule, 2000). Applications of speech recognition technology are also being developed to improve access to higher education for people with disabilities (Goette, 2000; Leitch & Bain, 2000). Although speech recognition systems have existed for two decades, widespread use of this technology is a recent phenomenon.

Some of the most successful applications have been telephone based. Continuous speech recognition has been used to improve customer satisfaction and the quality of service on telephone systems (Charry, Pimentel, & Camargo, 2000; Goodliffe, 2000; Rolandi, 2000). Name-based dialing has become more ubiquitous, with phone control answer, hang-up, and call management (Gaddy, 2000a). These applications use intuitive human communication techniques to interact with electronic devices and systems (Shepard, 2000). BTexact Technologies, the Advanced Communications Technology Centre for British Telecommunications, uses the technology to provide automated directory assistance for 700 million calls each year at its UK bureau (Gorham & Graham, 2000). Haynes (2000) deployed a conversational interactive voice response system to demonstrate site-specific examples of how companies are leveraging their infrastructure investments, improving customer satisfaction, and receiving quick return on investments. Such applications demonstrate the use of speech recognition by business. The investigation of current customer needs and individual design options for accessing information utilizing speech recognition is key to gaining unique business advantages (Prizer, Thomas, & Suhm, 2000; Schalk, 2000). A long-awaited application of speech recognition, the automatic transcription of free-form dictation from professionals such as doctors and lawyers, lags behind other commercial applications (Stromberg, 2000).

Speech recognition systems are being tested for, or are already in use, in government and in private industry to the benefit of organizations and users. Speech technology has been applied to medical applications, particularly emergency medical care that depends on quick and accurate access of patient background information (Kundupoglu, 2000). The U.S. Defense Advance Research Projects Agency organized the Trauma Care Information Management System (TCIMS) Consortium to develop a prototype system for improving the timeliness, accuracy, and completeness of medical documentation. One outcome of TCIMS was the adoption of a speech-audio user interface for the prototype (Holtzman, 2000). The Federal Aviation Administration conducted a demonstration of how voice technology supports a facilities maintenance task. A voice-activated system proved to be less time consuming to use than the traditional paper manual approach, and study participants reported that the system was understandable, easy to control, and responsive to voice commands. Participants felt that the speech recognition system made the maintenance task easier to perform, was more efficient and effective than a paper manual, and would be better for handling large amounts of information (Mogford, Rosiles, Wagner, & Allendoerfer, 1997). Pilots must have good head/eye coordination when they shift their gaze between cockpit instruments and the outside environment. Boeing has investigated ways to free pilots from certain manual tasks and sharpen their focus on the flight environment. The latest solution includes the use of a rugged, lightweight, continuous-speech device that permits the operation of selected cockpit controls by voice commands alone. This technology is being applied in the noisy cockpit of the Joint Strike Fighter (Bokulich, 2000). Financial service organizations are beginning to explore the merits of speech recognition. Customers can use this technology to conduct "hands-free" banking. Such "customer-facing" applications are gaining popularity in the financial services industry (Costanzo, 2003).

Even though applications of speech recognition technology have been developed with increased frequency, the field is still in its infancy, and many limitations have yet to be resolved. For example, the success of speech recognition by desktop computers depends on the integration of speech technologies with the underlying processor and operating system and the complexity and availability of tools required to deploy a system. This limitation has had an impact on application development (Markowitz, 2000; Woo, 2000). Use of speech recognition technology in high-noise environments remains a challenge. For speech recognition systems to function properly, clean speech signals are required, with high signal-tonoise ratio and wide frequency response (Albers, 2000; Erten, Paoletti, & Salam, 2000; Sones, 2000; Wickstrom, 2000). One solution offered to reduce the negative consequences associated with noise-related errors is to implement a multimodal architecture. An example of a multimodal architecture is combining speech and pen input to reduce speech recognition errors (Oviatt, 2000). Oviatt suggests that " ... multimodal systems will help stabilize error-prone recognition technologies, while also greatly expanding the accessibility of computing for everyday users and real-world environments" (p. 45). In conjunction with the multimodal architecture, a microphone system is critical in providing the required speech signal, and, therefore, has a direct effect on the accuracy of the speech recognition system (Andrea, 2000; Wenger, 2000).

Interference, changes in the user's voice, and additive noise-such as car engine noise, background chatter, and white noise-can reduce the accuracy of speech recognition systems. In military environments, additive noise and voice changes are common. For example, in military aviation, the stress resulting from low-level flying can cause a speaker's voice to change, reducing recognition accuracy (Christ, 1984). The change in voice modulation to compensate for environmental dynamics such as increased noise levels is called the Lombard effect (Oviatt, 2000). Oviatt suggests that speech recognition accuracy degrades when a system processes Lombard speech, and recommends that this effect should therefore be considered when designing such systems.

Despite the growth of voice recognition systems, we found only one study that examined the adoption of this innovative technology in organizations. This study explored the adoption of speech recognition technology within a sample of people with disabilities (Goette, 2000). Specifically, the Goette study focused on the perception of individuals with disabilities toward the adoption of a speech recognition technology designed specifically to facilitate a "hands-free" work environment. She found that the ability to use the technology for a trial period was the major factor influencing successful adoption. The next section describes the environment and system the U.S. Navy is implementing followed by an examination of the theoretical research.

NAVAL VOICE INTERACTIVE DEVICE (NVID)

Shipboard medical and engineering personnel regularly conduct comprehensive surveys to ensure the health and safety of the ship's crew, equipment, and working environment. Currently, surveillance data are collected and stored via manual data entry, a timeconsuming process that involves typing handwritten survey findings into a word processor to produce a completed document. Typically, inspectors enter data and findings by hand onto paper forms and later transcribe these notes into a word processor to create a finished report. The process of manual note taking and entering data via keyboard into a computer database is time consuming, inefficient, and prone to error. To remedy these problems, the Naval Shipboard Information Program was developed, allowing data to be entered into portable laptop computers while a survey is conducted (Hermansen & Pugh, 1996). However, the cramped shipboard environment, the need for mobility by inspectors, and the inability to have both hands free to type during an inspection make the use of laptop computers during a walk-around survey difficult. Clearly, a hands-free, space-saving mode of data entry that would also enable examiners to access pertinent information during an inspection was desirable.

The Naval Voice Interactive Device (NVID) project was developed to replace existing, inefficient, repetitive survey procedures with a fully automated, voice-interactive system for voice-activated data input. In pursuit of this goal, the NVID team developed a lightweight, wearable, voice-interactive prototype capable of capturing, storing, processing, and forwarding data to a server for easy retrieval by users. The voice-interactive data input and output capability of NVID reduces obstacles to accurate and efficient data access and reduces the time required to complete inspections. NVID's voiceinteractive technology allows a trainee to interact with a computerized system and still have hands and eyes free to manipulate materials and negotiate his or her environment (Ingram, 1991). The NVID has been designed to allow voice prompting by the survey program, as well as voice-activated, free-text dictation. An enhanced microphone system permits improved signal detection in noisy shipboard environments. All of these capabilities contribute to the improved efficiency and accuracy of the data collection and retrieval process by shipboard personnel. A comprehensive description of the NVID device and its development can be found in Paper, Rodger, and Simon (in press).

THEORETICAL BACKGROUND

The theory of reasoned action (TRA) (Fishbein & Ajzen, 1975) remains one of the most influential models of behavior in social psychology. The model assumes that behavior can be predicted on the basis of a person's behavioral intention. In turn, intention is determined by two components, one personal and the other social. The theory was designed to model how any speci- fied behavior under volitional control is produced by beliefs, attitudes, and intentions toward that behavior. It further specifies that this intention is produced by both the individual's attitude toward performing that behavior, and the individual's perception of social pressures to perform that behavior, or the social norm. The TRA has been empirically tested in over a hundred studies, in a diverse range of fields including health, fitness, drug use, extraterrestrial beliefs, and social and consumer behaviors, and it has demonstrated strong support for the proposed determinants of intention (Sheppard, Hartwick, & Warshaw, 1988). Results of meta-analyses and quantitative reviews of TRA and its enhanced version theory of planned behavior (see below) indicate that attitude, subjective norm, and perceived behavioral control explained 40-50% of variance in intention, with intention explaining 19-38% of variance in behavior (Sutton, 1998).

The TRA assumes that human beings usually behave in a sensible manner so that they might obtain favorable outcomes and meet the expectations of others (Fishbein & Ajzen, 1975). According to the theory, behavioral intention is an immediate predecessor of a behavior and it is determined by attitude toward behavior and subjective norm. Attitude toward behavior is obtained by summing the products of behavioral beliefs to certain outcomes. Behavioral beliefs refer to the probability that a behavior leads to certain outcomes; the evaluation of outcomes is the extent to which the consequences of the behavior are favorable. Subjective norms are the summed products of normative beliefs and motivations to comply. Normative beliefs represent an individual's perceptions of a person's tendency to behave in a manner consistent with their reference group's belief.

Theory of planned behavior (TPB) was developed by Ajzen, who extended the TRA by introducing an additional construct-perceived behavioral control- to account for situations in which individuals lack complete control of the target behavior (Ajzen, 1985; Fishbein & Ajzen, 1975) (see Figure 1). Perceived behavioral control (PBC) is held to influence both intention and behavior. The rationale behind the addition of PBC is that it allows prediction of behaviors that are not completely under volitional control. While TRA can predict behaviors that are relatively straightforward, there are certain circumstances in which constraints on actions confounded its accuracy. The inclusion of PBC provides insights about the potential constraints on action by the actor, and is held to explain why intentions do not always predict behavior. A variety of studies have provided support for TPB (Ajzen, 1991; Blue, 1995; Conner & Sparks, 1996; Godin, 1993; Godin & Kok , 1996; Hausenblas, Carron, & Mack et al., 1997; Van den Putte, 1991; Armitage & Conner, 2001; Jonas & Doll, 1996; Manstead & Parker, 1995; Sparks, 1994).

From TRA, TPB retained the two other antecedents of intention: subjective norm and attitude toward behavior. Subjective norm refers to the individual's perceptions of general social pressure to perform a given behavior. If an individual perceives that significant others endorse the behavior, they are more likely to intend its performance. Attitude toward the behavior reflects the individual's global positive or negative evaluations of performing the behavior. Generally, the more favorable the attitude toward the behavior, the stronger the individual's intention to perform it (Fishbein & Ajzen, 1975).

The technology acceptance model (TAM) developed by Davis (1986) is grounded in both TRA and TPB. The goal of TAM is to "provide an explanation of the determinants of computer acceptance that is general, capable of explaining user behavior across a broad range of end-use computing technologies and user populations" (Davis, Bagozzi, & Warshaw, 1989, p. 985). This model (see Figure 2) seeks to identify a small number of fundamental variables that impact both behavioral intention to use computers and actual system use. The TAM has proven to be a robust model. The validity of TAM's predictive power was demonstrated by Mathieson (1991). He established that both TAM and TPB were good predictors of intention to use an information system, with TAM demonstrating a slight empirical advantage. He also commented that TAM was easier to apply while working with generalized users' opinions.

The original TAM posits that two particular beliefs, perceived usefulness and perceived ease of use, are critical for computing acceptance (Davis et al.,1989). An examination of the model indicates that computer use is determined by behavioral intention, with intention viewed as mutually determined by the individual's attitude and perceived usefulness of the computer system. Attitude, in this model, is in- fluenced by perceived usefulness and perceived ease of use. During the development of TAM, subjective norm-a critical element of TRA and TPA-was deleted due to theoretical and measurement issues (Davis et al., 1989), despite the psychology literature's finding that the construct was an important determinant of intention and behavior. A number of studies have found subjective norm to significantly contribute to the strength and predictability of the model (Mathieson, 1991; Hartwick & Barki, 1994; Taylor & Todd, 1995b; Gefen & Straub, 1997; Venkatesh & Morris, 2000l; Venkatesh & Davis, 2000).

Since its introduction, TAM has been modified and compared with other theories. Attitude has been removed as a means to simplify the model (Adams, Nelson, & Todd, 1992; Igbaria, Guimaraes, & Davis, 1995; Chau, 1996; Szajna, 1996). Other studies have added system use as a dependent variable, with subjects self-reporting their results (Davis et al., 1989; Adams et al., 1992; Igbaria et al., 1995). Additionally, behavioral intention has been used as a dependent variable (Davis, 1989; Chau, 1996). External variables have also been introduced into the model to explain situational factors that impact technology acceptance. In a study of microcomputer usage, Igbaria et al. (1995) added training, support, and organizational factors. Other studies (Thompson, Higgins, & Howell, 1991; Davis, 1993) removed behavioral intention from the model and directly link attitude to system use. These studies argue that the goal of the model is to determine factors of system use, not the intention to take part in future behavior. Results indicate that TAM is a valid model for predicting user acceptance of information technology. Perceived usefulness of a technology has been consistently identified as an integral predictor of attitude formation, while substantiation for perceived ease of use has been inconsistent or less significant. The leading explanation for the weak results for perceived ease of use as a predictor of attitude is that intention to use a technology may decrease as exposure to technology expands (Chau, 1996).

THIS STUDY

This is the second study in a twophase examination of the development and introduction of NVID, an interactive voice operated device used in shipboard environments by the U.S. Navy. The first study (Paper, Rodger, & Simon, in press) explored the creation of a focus group, its requirements and issues for development, and the prototype device's initial testing. This study uses the information gathered during the first study to create and test an instrument that assists the Navy in the examination of intentions of sailors and their use of the device during its initial rollout. This phase of NVID's implementation was conducted with enlisted members-restricted to two job classification codes (healthcare specialists and machinists)-from the medical and engineering departments on a deployed (at sea) aircraft carrier. The NVID's use was voluntary since the Navy was still refining the device and did not feel that it was ready for full-scale adoption.

Sailors were introduced to NVID before the deployment. The device was demonstrated to participants from both departments, explained as experimental and voluntary, and presented as a means to improve their productivity and make their tasks easier. Training was then conducted on how to use the device and download the information into their department's computer, and then time was given to each sailor to practice and experiment with an actual unit. Additional opportunities for training and experimentation were provided before the ship deployed. Upon culmination of the department's training, sailors completed a questionnaire.

During the NVID implementation experiment, each sailor participating in the study was given a randomly generated code that he/she was required to input to activate the device. To use the NVID, a sailor would check it out from the department's office, input their assigned code, and then use the device while they were conducting their assigned tasks. When the sailor returned to the department's office, the NVID was connected to a workstation and the collected information, along with the user's code, was downloaded and saved for tracking. At the end of the implementation experiment, the researchers and the Navy were able to compile the number of times and when each sailor used the device as well as what tasks were performed. This provided a reliable means to determine system use without relying on self-reported measures that can be biased.

RESEARCH MODEL AND INSTRUMENT

The proposed modified TAM consists of the traditional TAM envisioned by Davis and the addition of subjective/social norm. The study's dependent variable remains system use for two reasons. The first reason is that the Navy was primarily interested in NVID's acceptance, and the second, to provide additional validity to TAM under this organizational situation. The extension of TAM is a result of the input from the focus groups during the first phase of this study. Members of these groups impressed upon the researchers that factors such as those used in the TAM instrument and the social norms measurements would impact the intention and ultimate decision to use NVID1. Subjective/social norm as indicated in earlier sections is derived from the referent TRA/TPB and was eliminated from TAM for theoretical and construct reasons.

The members of the focus group strongly suggested the inclusion of the additional factor because the Navy's goal was to implement NVID in the shipboard environment. A Navy ship's crew lives and works in very close quarters during deployment, when the ship sails from her home port for up to six months. Small ships have over 200 people, while an aircraft carrier has a crew of over 5,500. During the deployment, members of the crew become an extended family with sailors of specific departments, working, playing, eating, and sharing quarters together. The focus group felt that as a result of these "family" ties, there would be strong social pressure to adopt or reject the NVID. Hence, the inclusion of subjective/social norm, which as indicated earlier has strong validity in predicting intent, was recommended. Since sailors using NVID have similar educational and organizational backgrounds (the experiment was limited to two ratings-job classifiers-within two departments), our model purposefully excludes any external variables. Our research model is illustrated in Figure 3.

The instrument used to investigate technology adoption in this study is derived from well-researched and validated measures. Nineteen items were culled from the literature and were formulated into question items using a 7-point Likert scale, with 1 designated "strongly agree" and 7 designated "strongly disagree." The researchers later added the use numbers collected from the ship's servers. The instrument was first validated by the focus group review panel plus a small number of potential users from departments not involved in NVID's test. They independently reviewed the instrument and suggested minor changes that were incorporated into the final design. The instrument was then balanced and randomized by the researchers.

The completed instrument was then evaluated for construct validity and reliability (Straub, 1989). Construct validity is concerned that the instrument actually operationalizes the constructs it purports to measure. Reliability is an index that refers to the respondents' ability to answer the same question in a similar manner over time. To test the instrument, a pretest was conducted with approximately 50 randomly selected groups of sailors from ship-based commands at a large Navy base. The results indicated acceptable Cronbach's alpha values (all above .80) and higher covariation among items for the same factors than among those for different factors. These results suggest that the instrument was of acceptable measurement reliability and had sufficient convergent and discriminate validity. Participants were instructed to consider their NVID experiences when completing this instrument. A copy of the final instrument is found in Table 1.

OPERATIONAL MEASURES Of THE STUDY VARIABLES AND HYPOTHESES

Perceived Usefulness

This factor is defined as "the prospective user's subjective probability that using a specific application system will increase his/her job performance within an organizational context" (Davis et al., 1989). User acceptance of computer systems is driven by perceived usefulness due to the reinforcement of value outcomes (Adams et al., 1992; Davis et al., 1989). The factor is similar to a component of relative advantage (Rogers, 1983) and identified by Dearing, Meyer, and Kazmierczak (1994) as the degree to which an innovation is more capable of achieving an ideal end-state. Six items were used to construct the perceived usefulness scale and are similar to those used in previous studies (Hu, Chau, Sheng, & Tam, 1999; Venkatesh & Morris, 2000; Al-Gahtani & King, 1999; Igbaria et al., 1995; Igbaria, Zinatelli, Cragg, & Cavaye, 1997).

H1a: Perceived usefulness is positively related to intentions toward NVID.

H1b:Perceived usefulness is positively related to NVID's use.

Perceived Ease of Use

Ease of use refers to the degree to which users expect the information system to be easy to understand and use (Davis et al., 1989). Some studies suggest that perceived ease of use will have a direct impact on attitude and behavioral intention and an indirect effect on perceived usefulness (Venkatesh & Morris, 2000). The direct effect should increase a user's acceptance of the system and lead to high levels of system use, while the indirect effect suggests that a system that is perceived as easier to use will be used more than one perceived harder to use (Davis et al., 1989). This study elects to retain only the direct effect given there is only a single system under testing with a key goal in NVID's development to create an easy-to-operate and user-friendly device. The items for this factor were also derived from previous studies (Hu et al., 1999; Venkatesh & Morris, 2000; Al-Gahtani & King, 1999; Igbaria et al., 1995; Igbaria et al., 1997). Participants were asked to indicate their agreement with six statements rated on a 7-point Likert scale.

H2: Perceived ease of use will positively influence users' attitudes toward NVID.

Subjective/Social norm

Subjective norm relates to perceptions of general social pressure; the underlying normative beliefs are concerned with the likelihood that specific individuals or groups with whom the individual is motivated to comply will approve of the behavior. Subjective norm is considered to be a function of salient normative beliefs. Subjective norm was the last component added to the TRA and several authors have argued that it is the weakest component. As a result, studies have deliberately removed subjective norm from analysis, as was the case with the development of TAM. On the other hand, Trafimow and Finlay (1996) found evidence to suggest a distinction between individuals whose actions are driven primarily by attitudes and those who are driven by subjective norms. Their findings are confirmed across different behaviors where subjective norms have been found to be independently predictive of intentions (Venkatesh & Davis, 2000; Venkatesh & Morris, 2000; Conner & Sparks, 1996; Conner&& Armitage, 1998). These studies suggest that the explanation for the poor performance of the subjective norm component lies in its measurement with a number of studies using single, as opposed to more reliable multi-item, scales. The construct is composed of three adapted statements derived from previous studies (Venkatesh & Morris, 2000; Donald & Cooper, 2001).

H3: Social/subjective norms will positively influence attitude.

System Usage

The actual amount of usage by participants and the tasks they performed were logged by the NVID, uploaded to the department's server, and later collected by the researchers. Items collected included a date/time stamp, the number of times a sailor logged onto NVID, the particular tasks he/she performed, and the length of time used. Sailors were instructed to use only their assigned login code and when to log into and out of the NVID. Since sailors were required to check out the NVID unit, the researchers were confident that the user controls were sufficient, but realized that errors in length of time could still occur. Despite this limitation, the researchers believed that this system was superior to self-reported measures or user logs. Even though self-reported measures have been validated in past studies (Blair & Burton, 1987) their measures are not precise and are subject to user bias. Since each sailor had an equal opportunity to use NVID, the researchers created a metric of use by multiplying the number of times a user logged onto the device by the number of tasks he/she performed. The number of times the user logged on was matched to the date/time stamp to insure no errors in logging in. The length of time a sailor was logged on was not used since there was no control over an individual's routine.

DATA ANALYSIS AND RESULTS

A total of 270 sailors participated in the NVID trial. The participants had an average age of 20.4 years, an average enlistment time of 3.3 years, and an average time onboard the aircraft carrier of 17 months (standard shipboard assignment is 3 years).

Reliability and construct validity of the instrument was evaluated using Cronbach's alpha with all values exceeding 0.80. Construct validity was evaluated by examining convergent and discriminant validity using both correlation analysis and exploratory factor analysis. Principal component factor analysis using a promax rotation procedure resulted in a 4-factor solution using the Eigen greater-than-one rule. The four factors yielded by the factor analysis procedure matched those proposed by the theoretical model. The analysis provided the researchers with sufficient justification to believe the ability of the items used to support this study's model. A copy of the factors, their item loadings, and Cronbach's alpha scores are found in Table 2, while the correlation matrix is present in Table 3.

TESTING THE MODEL

An examination of the proposed model was conducted using structural equation modeling (SEM) in the SAS statistical package, CALIS procedure, using maximum likelihood estimation. SEM has been found superior to other techniques including multiple regression analysis (Hankins, French, & Horne, 2000), and is used to test for whether the proposed model successfully accounts for the actual relationships observed in the sample. The proposed model was examined for overall goodness of fit and explanatory power, plus the individual causal links (paths) to test the study's hypotheses. The literature suggests seven indices be examined as a measure of the overall model's fit (Hoyle, 1995; Segars & Grover, 1993; Hatcher, 1994). All recommended indices were used in this study, including chi-square, goodness of fit index (GFI), adjusted goodness of fit index (AGFI), normalized fit index (NFI), nonnormalized fit index (NNFI), comparative fit index (CFI), and root mean square residual (RMSR). All indices provided justification to support the model's fit. The indices and their recommended values are presented in Table 4. Once the model's overall fit was satisfied, the individual constructs of the model were examined.

The constructs of interest in this study, behavior intention and system use, were examined using the adjusted R2 for each dependent construct. Together the constructs explained 86% of the variance observed in the sailors' intention and use of the NVID device. As indicated in Figure 4, system use contributed the overwhelming amount of observed explanatory power of the model, with over 60%. During this phase of analysis the individual paths (hypotheses) were also examined. Using the standardized estimates, each path (hypothesis) was examined for its contribution to the model and level of statistical significance. All paths were found to be statistically significant, although the direct effect of perceived usefulness on system use was marginal. The strongest effect demonstrated was the .90 path coefficient between behavior intention and system use. This finding suggests that a one-unit increase in a sailor's intention results in a .90 unit in system use. The exogenous variables (perceived usefulness, ease of use, and social/subject norms) paths to behavior intention were retained during the analysis with statistically significant coefficients of .21, .16, and .26 respectively.

DISCUSSION

This study analyzed an adapted TAM using the introduction of a voice recognition device with a homogeneous sample of 270 deployed U.S. Navy sailors. The results suggest that the adapted TAM, using the additional factor social/subject norm, is a robust model with excellent ability to predict system use while performing almost exactly as predicted by the literature. Contributing to the success of the adapted TAM is the setting in which the experiment was conducted. A military environment is generally regarded as one in which activities such as computer usage is mandatory, yet this study was successfully carried out as a voluntary experiment, which suggests that user acceptance/usage should be high given either circumstance.

The exogenous variables-perceived usefulness, perceived ease of use, and social/subject norm-were all statistically significant predictors of attitude/ behavior intention. The literature provided very strong support for the first two variables, although social/subject norm had received weaker support since it was dropped from the original TAM. Under the circumstance of this experiment we find that the variable provided similar if not stronger results than a recent study (Venkatesh & Davis, 2000) in which it was also included. Interestingly, both perceived usefulness and social/subject norm explained more variance (.22 and .26 respectively) than perceived ease of use (.15). The researchers suspect that given that all subjects in this experiment had ample computer experience and the NVID device was designed with ease of use in mind, the variable was considered less important. Additionally, the NVID was designed and tested specifically for shipboard use and to preserve the routine of its users. This may have contributed to the support for its usefulness, as time saved by using the device could be devoted to sailors' primary duties or advancement. The only surprise yielded by the study was the marginal direct influence of perceived usefulness on system use (.04).

The study's key finding is the adapted TAM's ability to predict sailors' intention and system use. The two factors (behavior intention and system use) predicted almost 90% of the model's explained variance, with system use contributing 62%. The findings clearly extend the literature's suggestions that attitude/behavior intention is an excellent predictor of system use (Venkatesh & Davis, 2000; Hu et al., 1999; Mathieson, 1991; Taylor & Todd, 1995; Szajna, 1996; Davis et al., 1989; Davis, 1986). Of some surprise was the relative weakness of attitude/behavior intention to explain more of the model's variance. The exogenous variables (perceived usefulness, perceived ease of use, and social/subject norm) accounted for only 26%of attitude/behavior intention, which is somewhat lower than in previous studies. Despite this less than expected result, the overall predictive power of the adapted TAM is excellent and should thereby incorporate the subject/social norm factor.

Although we provided evidence of the efficacy of the adapted TAM, the rapidly evolving nature of speech recognition technology (Boyce, 2002; Lai, 2001; Spring, 2003) may influence our model's predictive capability. As speech recognition technology becomes less error prone, more sophisticated, more powerful, and (hopefully) more userfriendly, perceptions of usefulness, ease of use, and social norm may fluctuate dramatically. As a result, their impact on intention and system use may also change. Given the potential rapid evolution of technology, future replications of this study may reveal that the adapted TAM is either more or less effective. However, we believe that the adapted TAM will prove even more effective in predicting system use because the future popularity of such technology hinges on its ability to attract new customers and retain current customers by providing a robust, reliable, and effective product (at least in terms of customer perceptions). A natural extension of the current study will be to replicate with the adapted TAM within the next 2 or 3 years.

The findings of this study make a contribution to theory by extending the exogenous variables of TAM with the inclusion and validation of subjective/ social norms. The researchers felt that since the factor was part of the referent literature and the original TRA/TPB models, its inclusion was warranted. Moreover, the inclusion of subjective/ social norms was empirically shown to be relevant with our sample. Since this study was conducted under somewhat unique conditions, we suggest that future research in other environmental settings also include subjective/social norms to further validate its applicability and explanatory ability. Additional research should also be conducted into the continued inclusion of perceived ease of use. Despite this study's finding of significance, its predictive power appears to be decreasing as this research stream continues. Information systems are more widely used than ever before and their design and user interfaces are created to improve and simplify user interaction. As a result, many users expect systems to be easy to use and simple in design and function. A trend is seen in the design and use of multifunction applications in today's mobile telephones, which contain planners once found in PDAs, Internet capabilities, and the original phone functions, all operated by voice or touch-screen. If this trend proves to be the future case and perceived ease of use is a less effective predictor of user intention and use, then the TAM model must be adapted accordingly. Either way, it appears that subjective/social norms will be an important influence on system use and hence our adaptation offers a contribution to the literature.

Future research should also continue to examine the external factors that impact a user's decision process to adopt and use an information system. While this study held the external factors constant, the researchers understand that in other settings these factors could significantly impact the intention and adoption process. Theoretical constructs should thereby extend the identification of these external factors and translate them into actionable steps implementers can take to improve and expedite the adoption/implementation process. For instance, if training and learning are critical external factors, researchers should identify how and by what steps these factors can be enhanced to correct deficiencies in deliverables. Additionally, researchers should examine TAM and adoption in a variety of multitiered settings. The vast majority of research samples encountered during this study, while drawn from different organizations, examined only one part or subsample of the organization's population. For experimental purposes this provides the researchers with stronger findings but is less applicable to the practitioner. Samples drawn from workers and managers throughout the organization could shed insight into variations required by the implementation and adoption process.

Limitations

The study set out to address the limitations of previous studies. The researchers were careful to incorporate into the work 1) a large sample of 270 participants, 2) a measurement scale that used at least three items per factor with Cronbach alphas of .80 or higher, 3) a structural equation model as an analysis technique, and 4) a direct measurement of system use to avoid self-reported system usage numbers. Yet despite this effort, the study did have some limitations that should be considered when interpreting the results. The sample in this study, U.S. Navy sailors, was a relatively homogeneous group as indicated by the selection of the two ratings (job classifications) in two departments. The experiment was conducted under conditions that were somewhat unique when compared to other studies. Specifically, subjects were all living and working in close conditions, involved with testing a new computer-based system, and were voluntary users. The researchers, however, recognize that while the subjects had unique characteristics and participated under unique conditions, they are not so different from other sample groups. Any study participant that belongs to an organization is subject to a certain degree of social pressure, be it positive or negative. This is true for student samples as well as those in business settings. Further, more recent studies have investigated TAM using unique or newly introduced systems. For instance, Hu et al. (1999) examined TAM with physicians using telemedicine and Venkatesh and Davis (2000) used four situations with subjects examining new systems.

Given these disclaimers, the researchers realize that sailors deployed onboard a military ship possess unique characteristics and a unique culture when compared with other potential subjects. As a result, we suggest that this circumstance could potentially bias the results of this experiment (at least in terms of generalizability to less unique contexts). Despite voluntary participation, it is possible that sailors believed that they were under pressure from their departments to use the NVID and that in turn might have influenced and perhaps inflated their system usage statistics. However, this did not appear to be the case when reviewing the data gathered from a limited number of interviews at the conclusion of the experiment. Another potential limitation was that this study purposefully controlled for any external factors, such as training, computer experience, image, and so forth, which might have influenced the participants. This may not always be the case in the general population and should be taken into consideration.

CONCLUSION

This study yielded several practical findings. First, subjective/social norms proved a significant factor when investigating the adoption of an information system, at least within the conditions of this experiment. Second, assuming that these findings are generalizable to other organizational settings, subjective/ social norm could have similar implications to adopters as perceived usefulness. That is, a socially acceptable technology may very well be similar to (or the same as) a perceptually acceptable one. If this is the case, information systems departments and those implementing the systems should be able to increase behavioral intention to use a system and ultimately system use itself by manipulating the organization's social environment. Third, social norms can be directly influenced by tweaking the reward system, technology training, and top management vision and participation. This suggestion is no different from actions undertaken by organizations to promote systems before implementation. For instance, a number of organizations involved in large-scale system implementation, such as ERP systems, actively "sell" the system to users through meetings, pep rallies, and promotional materials such as CDs and t-shirts. This in essence changes the organizational environment and creates social pressure for users to adopt the system. Once a critical mass of adopters is reached it becomes dif- ficult for users to refuse or delay their adoption process.

Technology acceptance in organizations has been widely studied yet still continues to be a topic of interest to both researchers and practitioners. Despite gains made by TAM and other models, there is no "holy grail" that succinctly predicts and explains user intentions and use. Perhaps this is due to the complexity of the topic and the dynamic nature of organizations. However, by offering a model that explains almost 90% of the variance with regard to system use, we are confident that the adapted TAM provides strong inroads toward explaining the complicated relationship between intention and use. The combined organizational experiences of the researchers match the study results. In many organizational settings, we have found that social pressure is a great contributor to intention and system use. It is difficult, if not impossible, for organizational members to dismiss the allure of peer and managerial pressure if the adoption/implementation of a system is mandatory and made part of the organizational culture. We thereby believe that our work extends and advances previous theoretical gains on this critical issue.