Information Systems Research

Publication details, including instructions for authors and subscription information:
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Much previous research has established that perceived ease of use is an important factor influencing user acceptance and usage behavior of information technologies. However, very little research has been conducted to understand how that perception forms and changes over time. The current work presents and tests an anchoring and adjustment-based theoretical model of the determinants of system-specific perceived ease of use. The model proposes control (internal and external—conceptualized as computer self-efficacy and facilitating conditions, respectively), intrinsic motivation (conceptualized as computer playfulness), and emotion (conceptualized as computer anxiety) as anchors that determine early perceptions about the ease of use of a new system. With increasing experience, it is expected that system-specific perceived ease of use, while still anchored to the general beliefs regarding computers and computer use, will adjust to reflect objective usability, perceptions of external control specific to the new system environment, and system-specific perceived enjoyment. The proposed model was tested in three different organizations among 246 employees using three measurements taken over a three-month period. The proposed model was strongly supported at all points of measurement, and explained up to 60% of the variance in system-specific perceived ease of use, which is twice as much as our current understanding. Important theoretical and practical implications of these findings are discussed.
(*Technology Acceptance Model*; *Perceived Ease of Use*; *Usability*; *Playfulness*; *Anxiety*; *Self-Efficacy*; *Enjoyment*)

Introduction

Information technology (IT) acceptance and use is an issue that has received the attention of researchers and practitioners for over a decade. Successful investment in technology can lead to enhanced productivity, while failed systems can lead to undesirable consequences such as financial losses and dissatisfaction among ememployees. Despite significant technological advances and increasing organizational investment in these technologies, the problem of underutilized systems plagues businesses (Johansen and Swigart 1996, Moore 1991, Norman 1993, Wiener 1993). For example, the Internal Revenue Service (IRS) invested about $4B on a system aimed at simplifying the processing of tax returns for 1996 by computerizing the process. However, reports in early 1997 (e.g., Johnston 1997) indicated that the IRS was forced to revert to the manual

Information Systems Research, © 2000 INFORMS
Vol. 11, No. 4, December 2000, pp. 342–365
1047-7047/00/1104/0342$05.00
1526-5536 electronic ISSN

method of processing returns. In this and other cases, users have found the system to be too difficult to use and have not been able to scale that hurdle to user acceptance and usage of the new system (e.g., Venkatesh 1999). Such low usage of installed systems has been suggested to be a possible key explanation for the "productivity paradox" (Landauer 1995, Sichel 1997). Thus, understanding user acceptance, adoption, and usage of new systems is a high priority item for researchers and practitioners alike.

A significant body of research in information systems (IS) (e.g., Davis et al. 1989, Venkatesh 1999) and human-computer interaction (HCI) (e.g., Gould and Lewis 1985) has accumulated supporting the importance of such perceived ease of use on initial user acceptance and sustained usage of systems. Although there is a large body of research on the perceived ease of use construct, very little work has been done to understand the determinants of this important driver of technology acceptance and use. Understanding the determinant structure of this key driver of user acceptance and usage is critical because it will provide leverage points to create favorable perceptions, and thus foster user acceptance and usage. The importance of such a line of inquiry has been highlighted by recent research (Taylor and Todd 1995) focused on the determinant structure of key constructs in the Theory of Planned Behavior (see Ajzen 1985, 1991).

The current research attempts to further our understanding of the determinants of perceived ease of use of a system by focusing on how these perceptions form and change over time with increasing experience with the system. Typically, researchers and practitioners have restricted their attention to system design characteristics (e.g., Davis et al. 1989) or training (e.g., Venkatesh 1999) when trying to enhance user perceptions of the ease of use of a system, thereby overlooking other controllable variables such as individual difference variables and variables that are a result of a system-user interaction. Based on an anchoring and adjustment framework, a theoretical model proposes that in forming system-specific perceived ease of use, individuals anchor on key individual and situational variables that relate to control, intrinsic motivation, and emotion. With increasing direct experience with the target system, individuals adjust their system-specific perceived ease of use to reflect their interaction with the system.

Background

There have been several theoretical models employed to study user acceptance and usage behavior of emerging information technologies. While many of the models incorporate perceived ease of use as a determinant of acceptance, the Technology Acceptance Model (TAM) (Davis 1989, Davis et al. 1989) is the most widely applied model of user acceptance and usage. TAM was adapted from the Theory of Reasoned Action (TRA) (Ajzen and Fishbein 1980, Fishbein and Ajzen 1975). TAM suggests that two specific beliefs—perceived ease of use and perceived usefulness—determine one's behavioral intention to use a technology, which has been linked to subsequent behavior (Taylor and Todd 1995; see Sheppard et al. 1988 for a meta-analysis of the intention-behavior relationship). Attitude towards using a technology was omitted by Davis et al. (1989) in their final model (pp. 995–996) because of partial mediation of the impact of beliefs on intention by attitude, a weak direct link between perceived usefulness and attitude, and a strong direct link between perceived usefulness and intention. This was explained as originating from people intending to use a technology because it was useful even though they did not have a positive affect (attitude) toward using. The omission of attitude helps better understand the influence of perceived ease of use and perceived usefulness on the key dependent variable of interest—intention.

Further, TAM posits that perceived usefulness will be influenced by perceived ease of use because, other things being equal, the easier a technology is to use, the more useful it can be. Consistent with TRA, TAM suggests that the effect of external variables (e.g., system design characteristics) on intention is mediated by the key beliefs (i.e., perceived ease of use and perceived usefulness). TAM has received extensive empirical support through validations, applications, and replications (Adams et al. 1992; Chin and Gopal 1993; Chin and Todd 1995; Davis 1993; Davis and Venkatesh 1996; Gefen and Straub 1997; Hendrickson et al. 1993; Igbaria et al. 1997; Mathieson 1991; Segars and Grover 1993; Subramanian 1994; Szajna 1994, 1996; Taylor and

Todd 1995; Venkatesh 1999; Venkatesh and Davis 1996; Venkatesh and Morris 2000) by researchers and practitioners[1], suggesting that TAM is robust across time, settings, populations, and technologies.

Perceived ease of use is the extent to which a person believes that using a technology will be free of effort. Perceived ease of use is a construct tied to an individual's assessment of the effort involved in the process of using the system (see Davis 1989 for a detailed discussion of the theoretical and empirical development of the construct). Although this research focuses on perceived ease of use in the context of TAM, it is worth noting that other theoretical perspectives studying user acceptance have also employed similar constructs—Thompson et al. (1991) use a construct called "complexity," and Moore and Benbasat (1991) employ a construct called "ease of use." Although perceived ease of use is associated with intention in TAM, the underlying objective is to predict usage behavior. In this context, it is important to highlight that a vast body of research in behavioral decision making (e.g., Payne et al. 1993) and IS (e.g., Todd and Benbasat 1991, 1992, 1993, 1994) demonstrate that individuals attempt to minimize effort in their behaviors, thus supporting a relationship between perceived ease of use and usage behavior, albeit through intention as suggested by TAM. In contrast, the other TAM belief (i.e., perceived usefulness) is defined as the extent to which a person believes that using a technology will enhance her/his productivity.

The parsimony of TAM combined with its predictive power make it easy to apply to different situations. However, while parsimony is TAM's strength, it is also the model's key limitation. TAM is predictive but its generality does not provide sufficient understanding from the standpoint of providing system designers with the information necessary to create user acceptance for new systems (Mathieson 1991). Specifically, it is important to emphasize that although perceived ease of use has been employed extensively in user acceptance research in general and TAM research in particular, very little has been done to understand the determinants of perceived ease of use. Davis' more recent work acknowledges this potential limitation: "While being very powerful in helping us predict acceptance, one of the limitations of TAM is that it does not help understand and explain acceptance in ways that guide development beyond suggesting that system characteristics impact ease of use. . . . This places a damper on our ability to meaningfully design interventions to foster acceptance. In order to be able to explain user acceptance and use, it is important to understand the antecedents of the key TAM constructs, perceived ease of use and usefulness" (Venkatesh and Davis 1996, pp. 472–473). Understanding the determinants of perceived ease of use is further underscored by the two mechanisms by which it influences intention: (1) perceived ease of use has a direct effect on intention, and an indirect effect on intention via perceived usefulness, and (2) it is an initial hurdle that users have to overcome for acceptance, adoption, and usage of a system (see Davis et al. 1989).

Theoretical Framework and Model Development

This paper proposes a theoretical framework that describes the determinants of system-specific perceived ease of use as individuals evolve from the early stages of experience with the target system to stages of significant experience. Prior research in IS and psychology has established the importance of actual behavioral experience in shaping the evolution of beliefs such as perceived ease of use (Doll and Ajzen 1992; Davis et al. 1989; Fazio and Zanna 1978a, 1978b, 1981; Venkatesh and Davis 1996). The framework presents an anchoring and adjustment perspective on the formation and change of system-specific perceived ease of use over time with increasing experience with a target system. Behavioral decision theory suggests that "anchoring and adjustment" is an important general decision making heuristic that is often used by individuals (Slovic and Lichtenstein 1971, Tversky and Kahneman 1974, see Northcraft and Neale 1987 for an example). In the absence of specific knowledge, the heuristic suggests that individuals rely on general information that serves as an "anchor" and, in fact, individuals are often unable to ignore such anchoring

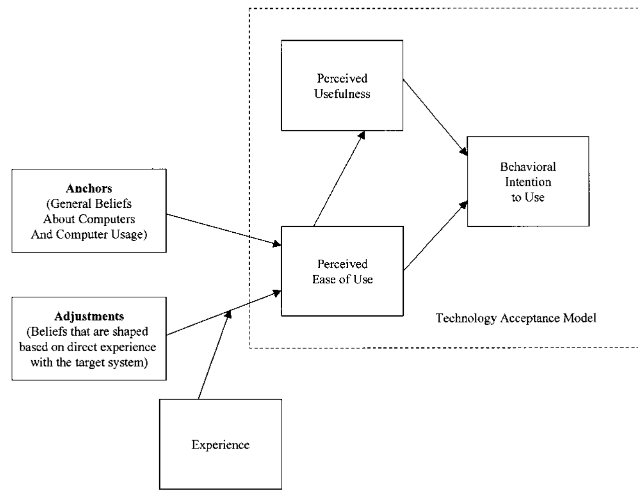
[1]The development and testing of TAM was based on studies conducted to examine potential acceptance of products of IBM, Canada.

information in decision-making processes. If additional information becomes available (typically following direct experience with the target behavior), individuals tend to adjust their judgments to reflect the new information but still rely on the initial anchoring criteria. Specifically, Helson (1964) suggests that a subject's response to a judgmental task is based on three aspects: (1) sum of the subject's past experiences, (2) the context or background, and (3) the stimulus (see also Streitfeld and Wilson 1986). To the extent that minimal context (i.e., specific system information) is given, the subject will make system-specific perceived ease of use evaluations based on prior experiences with systems. As more contextual information (i.e., system-specific information) becomes available, the more the judgment will be made within that context rather than based on previous experience.

Specifically, prior to direct experience with the target system, individuals are expected to *anchor* their system-specific perceived ease of use of a new system to their general beliefs regarding computers and computer use. With increasing experience with the system, individuals are expected to *adjust* their system-specific perceived ease of use to reflect their interaction with the system (Figure 1). The framework can also be explained in terms of the general-specific distinction from psychology and abstract-concrete distinction from marketing (Bettman and Sujan 1987, Mervis and Rosch 1981). In the absence of much knowledge about the target system and limited direct behavioral experience with the system, individuals will base their perceived ease of use of the target system on general, abstract criteria. With increasing learning and direct experience with the target system, user judgments about the ease of use of the system are expected to reflect specific, concrete attributes that are a result of an individual's direct experience with the system.

In addition to research in psychology, organizational behavior, and marketing that was discussed earlier, the basic arguments of anchoring and adjustment can also be supported from empirical evidence from prior user acceptance research. In the absence of much direct hands-on experience with new systems, user perceptions of ease of use of systems are not distinct across the different new systems, thus suggesting that in the early stages of user experience with new systems, there are a set of "common" determinants for system-specific perceived ease of use (Venkatesh and Davis 1996). Specifically, in the early stages of user experience, the initial anchors for system-specific perceived ease of use of a new/target system are expected to be individual difference variables and general beliefs regarding computers based on prior experience with computers/software in general and other systems in the organization. There is some evidence supporting this line of reasoning—general computer self-efficacy (Compeau and Higgins 1995a) has been shown to be a strong determinant of perceived ease of use before hands-on experience (Venkatesh and Davis 1996). As users gain experience with the target system, their assessment of the ease of use of the system, while still being anchored to individual difference variables and general beliefs, will adjust to reflect unique attributes of their interaction with the system and the system environment. Recent empirical research demonstrated low correlations between initial perceived ease of use and perceived ease of use after significant direct experience providing support for the idea that adjustments based on direct experience can be important in shaping perceived ease of use over time (Venkatesh and Davis 1996). Further, the original conceptualization of TAM presents an expectancy model, consistent with social cognitive theory (Bandura 1986) that dictates perceived ease of use (a process expectancy) and

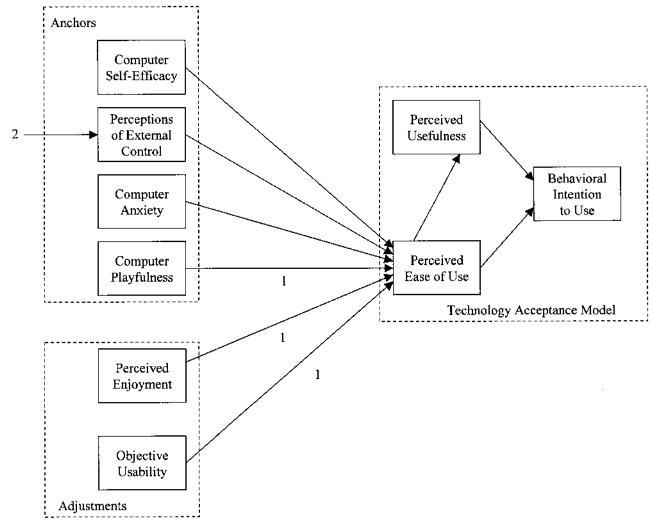
Figure 1 **Theoretical Framework for the Determinants of Perceived Ease of Use**



perceived usefulness (an outcome expectancy) would be key predictors of intention/behavior. Since the current research builds on TAM, there is an implicit assumption incorporating an outcome-process perspective that dictates other constructs would be "external variables" influencing key expectancies, thus lending support to the examination of other constructs as possible determinants of perceived ease of use.

A theoretical model based on the framework is proposed. Figure 2 presents the proposed model. Constructs related to control, intrinsic motivation, and emotion are proposed as general anchors for the formation of perceived ease of use regarding a new system. Specifically, control is divided into perceptions of internal control (computer self-efficacy) and perceptions of external control (facilitating conditions), intrinsic motivation is conceptualized as computer playfulness, and emotion is conceptualized as computer anxiety. Computer self-efficacy, facilitating conditions, computer playfulness, and computer anxiety are system-independent, anchoring constructs that play a critical role in shaping perceived ease of use about a new system, particularly in the early stages of user experience with a system. With increasing experience with the system, objective usability, perceptions of external control (facilitating conditions) as it pertains to the specific system,[2] and perceived enjoyment from system use are adjustments (resulting from the user-system interaction) that will have an added influence on system-specific perceived ease of use.

Figure 2 **Theoretical Modelof the Determinants of Perceived Ease of Use**



Anchors

Control: Computer Self-Efficacy and Facilitating Conditions. Control is a construct that reflects situational enablers or constraints to behavior (Ajzen 1985). In IS (Taylor and Todd 1995) and psychology (Ajzen 1991), control has been treated as a perceptual construct since that is of greater interest (from a psychological perspective) than actual control when understanding behavior (see Ajzen 1991). Specifically, control relates to an individual's perception of the availability of knowledge, resources, and opportunities required to perform the specific behavior. Perception of control was the key addition to the Theory of Reasoned Action (TRA) (Ajzen and Fishbein 1980, Fishbein and Ajzen 1975) to arrive at the Theory of Planned Behavior (TPB) (Ajzen 1985). Given that TAM was developed from TRA, the predecessor to TPB, the role of control was not explicitly incorporated in the theoretical development of TAM. Subsequent research also has not fully detailed the role of control in the context of TAM (cf. Venkatesh and Davis 1996).

Control has been shown to have an effect on key dependent variables such as intention and behavior in a variety of domains (see Ajzen 1991 for a review). In IS research, Mathieson (1991) applied TPB to a technology acceptance context and found that while control was a significant determinant of intention, TPB explained about the same variance as TAM. In a more recent study, Taylor and Todd (1995) found a similar pattern of results. However, the effect of control on intention over and above what is explained by the TAM constructs of perceived ease of use and perceived usefulness is not known. As mentioned earlier, the final model of TAM excludes the attitude construct and helps understand the explanatory power of perceived ease of use and perceived usefulness on intention. This final model of TAM was not tested in Mathieson (1991)

[2]Of the different adjustments, the adjustment for external control behaves differently. Specifically, general perceptions of external control serve as an anchor and the perceptions adjust in mean value with increasing user experience with the target system.

and Taylor and Todd (1995), thus not providing information about the effect of control on intention over and above TAM beliefs. Another point related to control is worthy of note—in IS research, perceived ease of use has been seen to be a determinant of attitude consistent with TPB (see Davis et al. 1989, Taylor and Todd 1995), while internal and external control have been related to perceived behavioral control in TPB. The current work relates control to perceived ease of use, thus departing from the basic framework of TPB. However, such "crossover effects" have been observed in prior research (Oliver and Bearden 1985, Warshaw 1980, Venkatesh and Davis 1996)

Although IS research has typically viewed control as unidimensional with a control belief structure that includes self-efficacy, technology facilitating conditions, and resource facilitating conditions (Taylor and Todd 1995), the unidimensionality of the construct has been challenged in psychology research. Azjen's (1985, 1991) conceptualization of control refers to internal and external constraining factors. Specifically, internal control relates to knowledge/self-efficacy and external control relates to the environment (Terry 1993). Empirical evidence confirms this bidimensionality—there has been evidence of low interitem correlations among measures of control based on the original conceptualization of the construct (see Beale and Manstead 1991, Chan and Fishbein 1993, Sparks 1994). Based on such results, it has been argued that individuals perceive internal and external control differently (Chan and Fishbein 1993; Sparks 1994; Sparks et al. 1997; Terry 1991, 1994; Terry and O'Leary 1995). The bidimensional conceptualization allows the role of the two control dimensions to be studied, understood, and managed separately (Terry 1993, Terry and O'Leary 1995, White et al. 1994) at the conceptual, operational, and practical levels. Despite the controversy about the conceptualization of control, both internal (e.g., de Vries et al. 1988, McCaul et al. 1988, Ronis and Kaiser 1989, Terry 1993, Wurtele 1988) and external control (e.g., Kimieck 1992, Schifter and Ajzen 1985) have an important role in shaping intention and behavior in a variety of domains.

In an IT usage context, internal control is conceptualized as computer self-efficacy, an individual difference variable that represents one's belief about her/his ability to perform a specific task/job using a computer (see Compeau and Higgins 1995a, 1995b). There is experimental evidence supporting the causal flow from computer self-efficacy to system-specific perceived ease of use (Venkatesh and Davis 1996). The link was justified on the basis that in the absence of direct system experience, the confidence in one's computer-related abilities and knowledge can be expected to serve as the basis for an individual's judgment about how easy or difficult a new system will be to use.

While there has been some theoretical and empirical support for the influence of general perceptions of internal control (i.e., computer self-efficacy) on system-specific perceived ease of use, the role of general perceptions of external control in determining system-specific perceived ease of use has been overlooked. As Mathieson (1991) pointed out, external control issues are not explicitly included in TAM, or the perceived ease of use construct. Mathieson (1991) argued that while perceived ease of use could potentially encompass control over resources, this was not made explicit. For instance, an item such as "I would find ⟨particular system⟩ easy to use" (e.g., "I would find Word easy to use") could result in a response wherein the respondent has taken into account constraints placed not only by system characteristics but also by availability of knowledge, resources, and opportunities—i.e., the underlying elements of control. Given the broad conceptualization of perceived ease of use, we expect that user judgments of the difficulty of using a system will incorporate both internal and external dimensions of control. External control is expected to exert its influence in the form of individual perception of technology and resource facilitating conditions (see Taylor and Todd 1995). In the context of workplace technology use, specific issues related to external control include the availability of support staff, which is an organizational response to help users overcome barriers and hurdles to technology use, especially during the early stages of learning and use (e.g., Bergeron et al. 1990). In fact, consultant support has been conceptually and empirically shown to influence perceptions of control (e.g., Cragg and King 1993, Harrison et al. 1997). Users in organizational settings will have general perceptions of external control based on prior technology introductions in the organization. Prior to direct experience with the new system environment, such general perceptions of external control are essentially system-independent and serve as situational anchors in the formation of perceived ease of use of the new system. Thus, the model proposes that internal and external control will be important anchors in the formation of early system-specific perceived ease of use.

Intrinsic Motivation: Computer Playfulness. The next anchor proposed is related to intrinsic motivation. There are two main classes of motivation: extrinsic and intrinsic (Vallerand 1997). Extrinsic motivation relates to the drive to perform a behavior to achieve specific goals/rewards (Deci and Ryan 1987), while intrinsic motivation relates to perceptions of pleasure and satisfaction from performing the behavior (Vallerand 1997). In TAM, extrinsic motivation and the associated instrumentality are captured by the perceived usefulness construct (see Davis et al. 1989, Davis et al. 1992, Venkatesh and Davis 2000, Venkatesh and Speier 2000). TAM does not explicitly include intrinsic motivation. The current work proposes that the role of intrinsic motivation will relate to the perceived ease of use construct. In relating intrinsic motivation to general computer usage contexts, the construct of computer playfulness has been successfully applied and operationalized in prior research (Webster and Martocchio 1992). Computer playfulness is an individual difference variable defined as "the degree of cognitive spontaneity in microcomputer interactions" (Webster and Martocchio 1992, p. 204). There is a significant body of theoretical and empirical evidence regarding the importance of the role of intrinsic motivation on technology use in the workplace (Davis et al. 1992; Malone 1981a, 1981b; Webster and Martocchio 1992; Venkatesh and Speier 1999, 2000). Webster, Trevino, and Ryan (1993) called for research on important outcomes of computer playfulness as it relates to human-computer interaction. Although TAM predicts technology acceptance based on user perceptions following such interactions, research to date has not studied how computer playfulness fits into the nomological network of TAM. The current research addresses this issue by proposing computer playfulness as a system-independent, motivation-oriented anchor for system-specific perceived ease of use.

At the outset, it is important to address the basic rationale for such a causal flow.[3] Computer playfulness represents an abstraction of the openness to the process of using systems and such an abstract criterion is expected to serve as an anchor for the perceived ease of use of a specific new system. Computer playfulness is an individual difference variable that is system-independent. Those who are more "playful" with computer technologies in general are expected to indulge in using a new system just for the sake of using it, rather than just the specific positive outcomes associated with use. Such playful individuals may tend to "underestimate" the difficulty of the means or process of using a new system because they quite simply enjoy the process and do not perceive it as being effortful compared to those who are less playful. This implies that there is likely to be a positive relationship between general computer playfulness and system-specific perceived ease of use. Although individuals may not expect systems in organizational settings to necessarily prompt high levels of fun (on-task or off-task), computer playfulness is still expected to be a relevant factor influencing user perceptions about a system since the construct of computer playfulness not only includes the desire for fun but also involves exploration and discovery. Computer playfulness may also include challenge and curiosity (see Malone 1981a, 1981b). Thus, in general, more playful individuals are expected to rate any new system as being easier to use compared to those who are less playful.

Higher levels of computer playfulness lead to an internal locus of causality (Deci 1975, DeCharms 1968) that in turn lowers perceptions of effort. Gattiker (1992) suggested that motivation in general will have an impact on substantive complexity, a construct similar to perceived ease of use. More specifically, from a theoretical standpoint, research in psychology suggests that higher levels of intrinsic motivation typically

[3]It is possible to argue that perceived ease of use should influence intrinsic motivation (computer playfulness), rather than intrinsic motivation influencing perceived ease of use, as proposed. The causal flow from perceived ease of use to intrinsic motivation would be consistent with a motivational model where extrinsic and intrinsic motivation are the key predictors of intention/behavior, resulting in perceived ease of use being examined as a determinant of intrinsic motivation. However, given the focus on TAM, an outcome and process expectancy model, intrinsic motivation is expected to influence perceived ease of use.

lead to willingness to spend more time on the task (e.g., Deci 1975). We extend this argument to suggest that higher levels of computer playfulness will lead to lowered perceptions of effort—i.e., for the same level of actual effort/time invested, perceptions of effort/time will be lower in the case of a more "playful" user when compared to a less "playful" user. In the absence of much direct experience with the specific system, the user does not possess much information about the extent to which using the specific system is enjoyable, but one's desire to explore and play with a new system in general is expected to influence her/his perceived ease of use of the new system.

Emotion: Computer Anxiety. The anchors related to control capture knowledge and resource aspects, and the intrinsic motivation anchor captures computer playfulness. The emotional aspect of technology usage is expected to be captured via a construct called computer anxiety. Computer anxiety is defined as an individual's apprehension, or even fear, when she/he is faced with the possibility of using computers (Simonson et al. 1987). Computer anxiety, like computer self-efficacy and computer playfulness, relates to users' general perceptions about computer use. While computer self-efficacy relates to judgments about ability and computer playfulness relates to the spontaneity in an individual's interaction with a computer, computer anxiety is a negative affective reaction toward computer use. A significant body of research in IS and psychology has highlighted the importance of computer anxiety by demonstrating its influence on key dependent variables. For example, computer anxiety has been shown to have a significant impact on attitudes (Howard and Smith 1986, Igbaria and Chakrabarti 1990, Igbaria and Parasuraman 1989, Morrow et al. 1986, Parasuraman and Igbaria 1990, Popovich et al. 1987), intention (Elasmar and Carter 1996), behavior (Compeau and Higgins 1995a, Scott and Rockwell 1997, Todman and Monaghan 1994), learning (Liebert and Morris 1967, Martocchio 1994, Morris et al. 1984), and performance (Anderson 1996, Heinssen et al. 1987).

Given its important role in influencing key dependent variables, prior research has devoted much attention to the causes of anxiety in a variety of domains including computer use (Anderson 1996, Cambre and Cook 1985, Chu and Spires 1991, Igbaria and Chakrabarti 1990), and on prescriptions and potential interventions to reduce computer anxiety (Bohlin and Hunt 1995, Chu and Spires 1991, Crable et al. 1994, Emanuele et al. 1997, Keeler and Anson 1995, Leso and Peck 1992, Reznich 1996, Schuh 1996). From a pragmatic standpoint, with the increasing pervasiveness of computers in the workplace and homes, there may be some question about whether the construct of computer anxiety, which was of much significance over a decade ago when individuals in organizations exhibited such emotion (e.g., Zoltan and Chapanis 1982, see Maurer 1994 for a review), is still relevant—in fact, there is recent field evidence to indicate the existence of computer anxiety and high variability across individuals (Bozionelos 1996, Marcoulides et al. 1995). Although computer anxiety has been researched extensively in IS and psychology, its role in the nomological net of TAM has not been investigated.

Based on the general framework proposed, we hypothesize that general computer anxiety will be an anchor exerting a negative influence on the perceived ease of use of a new system. The theoretical underpinnings for such a link are drawn from classical theories of anxiety (Philipi et al. 1972) that suggest the consequences of anxiety include a negative impact on cognitive responses, particularly process expectancies. In related research, Morris et al. (1984) suggest that there are two key components of anxiety: cognitive and emotional. The cognitive component leads to negative expectancies while the emotional element leads to negative physiological reactions. Tobias (1979) argued that even though anxiety is an affective state, its effects on behavior and performance are mediated by cognitive processes.

Social cognitive theory suggests that anxiety and expectancies (e.g., efficacy, ease of use) are reciprocal determinants (Bandura 1986). Specifically, depending on which of the two variables serve as the stimulus, an effect on the other may be observed. Within the context of the current work since the effects on perceived ease of use are being studied, anxiety is viewed as a determinant of the process expectancy—i.e., perceived ease of use. Further evidence for the impact of computer anxiety on perceived ease of use comes from prior research demonstrating an anxiety-attitude link (e.g., Igbaria and Parasuraman 1989). On this basis, the current research argues that the role of computer anxiety in the context of TAM will play out as an effect on perceived ease of use, a belief shown to be closely related to attitude (e.g., Davis et al. 1989). In this context, the other belief of TAM (i.e., perceived usefulness) may have outcome-oriented anchors (see Venkatesh and Davis 2000), but perceived ease of use is expected to have a process-oriented anchor (i.e., computer anxiety), with increasing levels of general computer anxiety leading to lowering of system-specific perceived ease of use.

The impact of anxiety on individual attentional resource allocation strategies provides additional causal bases for the negative influence of computer anxiety on perceived ease of use. Anxiety, typically, has an adverse effect on the attention devoted to the task at hand (Eysenck 1979, Tobias 1979). From the perspective of resource allocation theory (e.g., Kanfer et al. 1994), it can be argued that some of the attentional resources will be directed to the off-task activity of anxiety reduction, thus increasing the effort required to accomplish tasks. Given that perceived ease of use is an individual judgment about the ease of behavioral performance based on effort, higher levels of general computer anxiety are expected to cause lowering of system-specific perceived ease of use.

Interrelationships Among Anchors. Prior research has established interrelationships among the different anchors, particularly among internal control (computer self-efficacy), computer playfulness, and computer anxiety. Computer self-efficacy and highly similar constructs (e.g., perceived knowledge, computer confidence) have been related to computer playfulness (Webster and Martocchio 1992) and computer anxiety (Compeau and Higgins 1995a, Hunt and Bohlin 1993, Igbaria and Ilvari 1995, Loyd et al. 1987, Martocchio 1994, Heinssen et al. 1987). Although anxiety in a variety of domains, including computer use, has been negatively related to self-efficacy, there is empirical evidence to suggest that computer anxiety and computer self-efficacy are distinct constructs (e.g., Compeau and Higgins 1995b). Also, the two constructs have been shown to explain unique variance in key dependent variables such as behavior (e.g., Compeau and Higgins 1995b). Similarly, there is evidence to suggest that computer playfulness is related to anxiety (Bozionelos 1997, Webster and Martocchio 1992). Due to the extensiveness and complexity of the proposed model of determinants, the interrelationship among the different constructs is not expounded upon.[4] Thus, the current work is interested in the interrelationships among the constructs from a rather limited perspective of discriminant validity across the constructs and the unique variance in perceived ease of use explained by each construct.

Anchors and Adjustments Over Time: The Role of Experience

What will the role of anchors be over time? What will the adjustments be? Prior user acceptance research has shown experience to have an important influence on several key constructs and relationships (e.g., Davis et al. 1989, Taylor and Todd 1995, Szajna 1996). Similarly, in the proposed model also, experience is expected to have direct and moderating effects on constructs and relationships. In this regard, the impact of experience on the different anchors and adjustments is expected to be different.

Prior research has shown that perceptions of internal control (computer self-efficacy) will continue to be a determinant of perceived ease of use of a specific system even after significant direct experience with the system (Venkatesh and Davis 1996). Building on this finding, the current research expects that even though individuals may have acquired significant system specific knowledge and experience, their perceived ease of use of the target system will continue to draw from their general confidence in their computer-related abilities. Similarly, even with increasing experience, general computer anxiety is expected to continue to have an effect on system-specific perceived ease of use. As user experience with the specific system increases, the knowledge and anxiety related adjustment is expected to be **objective usability**. Prior TAM research (Venkatesh and Davis 1996) has defined and operationalized objective usability consistent with its conceptualization in human-computer interaction research (Card et al. 1980). Objective usability is a construct that allows for a comparison of systems based

[4]Please see the correlations reported in the results section.

on the actual level (rather than perceptions) of effort required to complete specific tasks. The role of direct behavioral experience and results of such experiences are expected to be important in shaping system-specific perceived ease of use over time. This also follows from attitude/intention theories (Doll and Ajzen 1992; Fazio and Zanna 1978a, 1978b, 1981) and anxiety research (Cambre and Cook 1985), which suggests that actual behavioral experience shapes beliefs such as perceived ease of use. For instance, even if an individual possesses low computer self-efficacy and high computer anxiety which shaped initial perceived ease of use, with increasing direct experience with the target system, s/he is expected to perceive the system to be easy or hard to use partly depending on the extent to which the system is easy to use from an objective standpoint.

The next adjustment with experience relates to external control. Before direct behavioral experience with the actual system environment issues (e.g., login/access time, response time, etc.) and organizational environment as it relates to the specific system (e.g., support staff), the general perception of external control (facilitating conditions) was expected to serve as an anchor. Since perceptions of external control are not directly related to the user interface of the system, individuals will simply modify/change their original perceptions of external control to reflect the organizational environment as it relates to the specific system and other aspects of the system environment. In operational terms, the adjustment is expected to be quite simply a **change in the mean value of the perceptions of external control**, thus suggesting that experience will have a direct effect on perceptions of external control. Over the long term, the relationship between external control and perceived ease of use is expected to continue as individuals are expected to factor in external control when judging the ease of use of a system.

The role of intrinsic motivation as a determinant of system-specific perceived ease of use is expected to change over time. Early perceptions of system-specific ease of use were said to be anchored to general computer playfulness. With increasing experience, perceived ease of use is expected to reflect the unique attributes of enjoyment as it relates to the user-system interaction. A conceptualization of intrinsic motivation that is system-specific is **perceived enjoyment**. Perceived enjoyment is adapted from Davis et al. (1992) and defined as the extent to which the activity of using a specific system is perceived to be enjoyable in it's own right, aside from any performance consequences resulting from system use. With increasing direct experience with the target system, the role of general computer playfulness as a determinant of perceived ease of use of the target system is expected to diminish, and system-specific perceived enjoyment is expected to dominate. In many Windows-based systems, software manufacturers are attempting to provide interfaces that are fun, "cute," and tie into social functioning (e.g., the "animated assistant icons" in Office 97). Such design features aim to create enjoyment albeit with the goal of enhancing perceived ease of use of the specific system. We expect that with increasing experience, system use may become more routinized, less challenging, and less discovery-oriented. In such cases, the lack of enjoyment may cause system use to be perceived to be more effortful.

Often, researchers have manipulated task difficulty and examined its effect on intrinsic motivation (e.g., Hirst 1988) and concluded causal flow from perceptions of ease to intrinsic motivation, consistent with Davis et al. (1992). In marked contrast to these prior findings, there is some recent evidence that favors a causal flow from perceived enjoyment to perceived ease of use (Venkatesh 1999). By manipulating the level of system-specific enjoyment through training, not only was it found that perceived ease of use could be enhanced but also the salience of perceived ease of use as a determinant of intention increased (Venkatesh 1999), thus suggesting that perceived ease of use could certainly be influenced by system-specific perceived enjoyment. The current research argues for a causal flow in keeping with this recent empirical evidence. Thus, depending on the extent to which actual system use is perceived to be enjoyable or boring, perceived ease of use of the target system may increase or decrease over time.

Summary. The current research proposed a theoretical framework (Figure 1), based on an anchoring and adjustment perspective, to explain the determinants of perceived ease of use, a key driver of user acceptance and usage of information technologies. The theoretical model (Figure 2) based on the framework proposes control—internal (computer self-efficacy) and external (facilitating conditions), intrinsic motivation (computer playfulness), and emotion (computer anxiety) as general anchors that influence early perceptions of ease of use of a new system. With increasing experience with the target system, an individual is expected to adjust her/his perceived ease of use of the system. Specifically, the role of computer self-efficacy and computer anxiety are expected to continue. The role of computer playfulness is expected to diminish over time, giving way to system-specific perceived enjoyment. In addition, objective usability is expected to serve as an adjustment for internal control and computer anxiety. Finally, facilitating conditions will undergo a shift from being general perceptions and expectations of the system and organizational environment to being system-specific.

Method

Three longitudinal field studies were conducted to test the model of determinants of perceived ease of use. The studies were designed to sample for heterogeneity (see Cook and Campbell 1979) in terms of industry and target system being introduced to end-users. In all three studies, the use of the system was voluntary. Three measurements of user reactions were made over a three-month period of time in each of the three studies. The first measurement was following initial training (T1), the second measurement was after one month of use (T2), and the third measurement was after three months of use (T3). All constructs were measured at T1, T2, and T3 with one exception—objective usability was measured only at T1 because of the involved nature of measurement that requires about 45 minutes of the subject's time. Table 1 presents a summary of the measurement.

Table 1 Measurement

Post-training (T1)	One month post-implementation (T2)	Three months post-implementation (T3)
BI, U, EOU	BI, U, EOU	BI, U, EOU
VOL	VOL	VOL
CSE, PEC, PLAY, CANX[a]	PEC[b]	PEC[b]
OU, ENJ	ENJ	ENJ

[a]Although CSE, PLAY, CANX were measured at T2 and T3, measures taken at T1 were used to examine the extent to which EOU was anchored to those beliefs. Interestingly, the pattern of results was identical even when CSE, PLAY, and CANX measures from T2 and T3 were used.

[b]Although PEC is an anchor, the process of anchoring and adjustment (change in mean value over time) for the construct required the use of the different measures over time.

Study 1

The subjects were 70 employees in a medium-sized retail electronic store. They were being introduced to a new interactive online help desk system, which was to be used in responding to customer queries received in-person and via telephone. Fifty-eight subjects completed the study and provided usable responses at all three points of measurement. Prior to the training, none of the subjects possessed specific knowledge about the system or how it worked. The training was conducted by a group of three individuals unaware of the research or its objectives.

Study 2

The subjects were 160 employees in a large real estate agency. They were being introduced to a new multimedia system for property management, which was to be used to manage all information related to new properties available for sale, properties sold in the past, and to help customers. One-hundred and forty-five subjects completed the study and provided usable responses at all three points of measurement. The subjects possessed no prior (pre-study) knowledge about the system. Similar to the first study, the subjects participated in a training program. The training was conducted by a group of three individuals who did not know about the research or its objectives.

One point worth noting is that there were two separate groups of subjects in this organization in that the two groups were introduced at different points in time. Forty-nine subjects were introduced to the system first, and 41 of them provided completed responses at all points of measurement (Study 2a). One-hundred and eleven subjects in two different branch offices were introduced to the system about a year after Study 2a, and 104 subjects in this group completed the study (Study 2b) at all three points of measurement.

Study 3

The subjects were 52 employees in a medium-sized financial services firm. The payroll department of the organization was moving from a proprietary IBM-mainframe environment to a PC-based (Windows95) environment for the company payroll application. Forty-three subjects completed the study and provided usable responses at all three points of measurement. As in the previous two studies, the subjects possessed no prior knowledge about the system and were trained to use the system by three trainers unaware of the research or its objectives.

Measurement

As mentioned earlier, all three studies in this research measured user reactions related to a new system. User reactions were tracked over time as users progressed from being novices to fairly experienced users of the system (see Table 1). The instrument primarily used validated items from prior research (see Appendix 1 for list of items employed in this research). The TAM constructs of perceived ease of use (EOU), perceived usefulness (U), and behavioral intention to use (BI) were measured using scales adapted from Davis (1989) and Davis et al. (1989). Perceived voluntariness of use (VOL) was measured using a scale adapted from Moore and Benbasat (1991). This measure was treated as a check to ensure that the study contexts were perceived to be voluntary by the users.

The anchors measured were perceptions of internal control (computer self-efficacy; CSE), perceptions of external control (facilitating conditions; FC), intrinsic motivation (computer playfulness; PLAY), and emotion (computer anxiety; CANX). Internal control (computer self-efficacy) was measured by adapting the scale of Compeau and Higgins (1995a), consistent with previous work on the determinants of perceived ease of use (Venkatesh and Davis 1996). Perceptions of external control (facilitating conditions) were measured using the scale adapted from Mathieson (1991) and Taylor and Todd (1995). Intrinsic motivation (computer playfulness) was measured using the scale adapted from Webster and Martocchio (1992). The only anchor for which a scale was not readily adaptable was emotion (computer anxiety). Although there are several scales available to measure computer anxiety, the reliability and validity of prior scales, including the widely used Computer Anxiety Rating Scale (CARS) (Heinssen et al. 1987), have been challenged (Compeau and Higgins 1995a, Ray and Minch 1990). Given some of the concerns regarding the multidimensionality of CARS, a new scale (Brown and Vician 1997) is employed in this research. While their scale builds on CARS, it addresses some of the problems of reliability and validity of the older scale.

The two adjustments measured were objective usability (OU) and perceived enjoyment (ENJ). Objective usability was operationalized consistent with the keystroke model from human-computer interaction research (Card et al. 1980) and prior user acceptance research (Venkatesh and Davis 1996). The suggested guideline for operationalization of this construct is to compute a novice to expert ratio of effort. Specifically, the time taken by an expert to perform a set of tasks using the system in an error-free situation is compared with the time taken by a novice (subject). In this research, following each training program, subjects were assigned a set of tasks to be completed. The time taken by each individual subject to complete the tasks was recorded by the system, which was then compared to the time taken by an expert to arrive at a ratio that would serve as the measure of objective usability for the particular subject. The higher the objective usability estimate (novice to expert ratio), the harder the system is to use from an objective standpoint. Perceived enjoyment was measured using the scale adapted from Davis et al. (1992); this scale was also used recently in organizational behavior research (Venkatesh and Speier 1999) and HCI research (Venkatesh and Speier 2000).

A pre-test of the instrument was conducted to ensure that the items were adapted appropriately to the current context. A group of 30 undergraduate students was chosen at random to participate in the pre-test of the instrument. The reliability and validity of the scales were consistent with prior research. Of particular interest to us was the reliability and validity of the new computer anxiety scale. The Cronbach alpha estimate for reliability was 0.81. Exploratory factor analysis using principal components analysis with direct oblimin rotation and an extraction criterion of eigenvalue greater than one was conducted—the computer anxiety items loaded on one factor with loadings greater than 0.70 and cross-loadings less than 0.25 on factors related to the other anchors (i.e., computer self-efficacy, facilitating conditions, and computer playfulness). In contrast, the scale of Heinssen et al. (1987) had a Cronbach alpha estimate of 0.43 and loaded on three separate factors.

Next, a focus group of five business professionals evaluated the instrument. The reaction to the instrument was largely positive. The key change made to the instrument following the two pre-tests was the inclusion of titles for each of the constructs in Study 1, Study 2a, and Study 3. While research on the topic of intermixing vs. grouping of items has suggested that grouping of items may lead to inflated reliability and validity estimates (e.g., Budd 1987), there is some work, including Budd (1987), that suggests that there is a possibility that intermixing of items in the case of validated scales leads to measurement errors, confusion, and irritation among the respondents (see Davis and Venkatesh 1996). Thus, in this research, items related to each construct were grouped to avoid possible measurement errors, particularly since validity and reliability of the different scales had been established by prior research and such a validation was not a focus of this work. While there is empirical evidence in other contexts suggesting that grouping and titling causes no negative consequences (Davis and Venkatesh 1996), this research sought to eliminate the possibility of biases empirically as well. Therefore, construct titles were not included in Study 2b that was conducted after the three aforementioned studies were completed. The objective of intermixing items in Study 2b was to examine possible artifactual inflation of reliability/validity, and path coefficients (because of grouping and titles) in Studies 1, 2a, and 3.

Results

Prior to analyzing the data, we examined support for the assumption that the technology introduction contexts were indeed voluntary, one of the boundary conditions of TAM. In all studies at all points of measurement, the mean score of perceived voluntariness was greater than 6.0 on a 7-point scale with a standard deviation less than 0.5, supporting the idea that the users indeed saw the usage contexts to be voluntary.

The structural equation modeling technique of Partial Least Squares (PLS) was used to analyze the data. PLS analyzes measurement and structural models with multi-item constructs that include direct, indirect, and interaction effects. There are several excellent examples of the use of PLS in IS research (see Barclay et al. 1995; Chin et al. 1996; Compeau and Higgins 1995a, 1995b; Sambamurthy and Chin 1994). The software package used to perform the analysis was PLS-Graph, Version 2.91.03.04.

The measurement model was assessed separately for each of the studies (1, 2a, 2b, and 3) at each of the three points of measurement, thus resulting in 12 models. All constructs in all models satisfied the criteria of reliability and discriminant validity, therefore, no changes to the constructs were required. This pattern was very consistent with expectations since all measurement scales, with the exception of computer anxiety, had been tested and validated in prior research. Since PLS-Graph does not produce loadings and cross-loadings, the DOS version of PLS was used and the procedure LVPC was employed to generate the factor structure. Appendix 2 reports the results of the *measurement model* for the data pooled across organizations at T1 (the rationale for presenting pooled data is presented in the next paragraph). The basic factor structure indicated all cross-loadings were lower than 0.35 in all studies at all three points of measurement. This basic pattern was found in all studies at all points of measurement. The reliability and discriminant validity coefficients were examined, and the pattern of results in all studies at all points of measurement were supportive of high reliability within constructs, and discriminant validity across constructs (square root of the shared variance across items measuring a construct was higher than correlations across constructs). The results pertaining to the measurement model are reported based on the data pooled across studies in the next paragraph.

Given that the measurement models were found to be acceptable, we conducted tests to examine whether the data could be pooled across studies. There were two key differences across the studies that needed to be examined before pooling: (1) Was there any difference in the path coefficients across each of the different studies given that different systems were being introduced in each of the organizations? (2) Studies 1, 2a, and 3 employed an instrument with titles whereas

Study 2b had items intermixed across constructs—did the titles result in any artifactual inflation of path coefficients? To address the first issue, the data were then pooled across the four studies (1, 2a, 2b, and 3) and dummy variables (DUMMY1, DUMMY2, and DUMMY3) were introduced and coded as (0,0,0), (1,0,0), (0,1,0), and (0,0,1) to represent each of the studies. The models were analyzed including interaction terms of all constructs with the dummy variables—e.g., CSE X DUMMY1, CSE X DUMMY2, etc. (see Chin 1996 for a discussion). Nonsignificant interaction terms suggested that the models were statistically equivalent across sites at each of the three points of measurement (Pindyck and Rubenfeld 1981). To address the second issue, the data were pooled across sites, and one dummy variable, STUDY_DUMMY, was introduced—0 to represent Studies 1, 2a, and 3 (i.e., where the instrument was administered with titles) and 1 to represent Study 2b (i.e., where the instrument was administered with items being intermixed). The models were analyzed including interaction terms of all constructs with the variable STUDY_DUMMY—e.g., CSE X STUDY_DUMMY, PEC X STUDY_DUMMY, etc. Nonsignificant interaction terms suggested statistical equivalence across Studies 1, 2a, 3, and 2b at each of the three points of measurement. Therefore, the data were pooled across the different sites and the measurement model was re-estimated. The reliability and discriminant validity coefficients are reported in Tables 2(a), 2(b), and 2(c).

Once the measurement model corresponding to the pooled data set was found to be acceptable, the structural model results were examined at all three points of measurement. Figures 3(a), 3(b), and 3(c) summarize the results at each time period. TAM was strongly supported at all three points of measurement, consistent with the vast body of prior research on the model, with perceived ease of use and perceived usefulness explaining about 35% of the variance in intention. In order to examine full mediation by perceived ease of use, additional models were tested by including direct links from the proposed determinants to intention.[5] The effects of all proposed determinants of perceived ease of use at all points of measurement were fully mediated (by perceived ease of use) and no direct effects were observed on intention. Of particular interest from the perspective of this research is that perceived ease of use was found to have a direct effect and indirect effect (via perceived usefulness) on intention at all three points of measurement. The results indicated that the proposed framework and model of determinants of perceived ease of use were strongly supported.[6] It is particularly worth noting that perceptions of external control not having any direct effect on intention runs counter to TPB, although it is consistent with the proposed model. As expected, at T1, the proposed anchors were the only determinants of perceived ease of use, with the variance explained being 40%. With increasing experience (i.e., T2 and T3), adjustments were found to play a key role in determining perceived ease of use, with the variance explained increasing to up to 60%. The current work thus explains twice as much variance in perceived ease of use when compared to Venkatesh and Davis (1996), the previous model of the determinants of perceived ease of use.

Discussion

Several key findings emerged from the current work. There was significant support for the model of the determinants of perceived ease of use with the hypothesized determinants playing a role as expected over time with increasing experience with the target system. We found that control (internal and external conceptualized as computer self-efficacy and facilitating conditions respectively), intrinsic motivation (computer playfulness), and emotion (computer anxiety) serve as anchors that users employ in forming perceived ease of use about a new system. With increasing direct experience with the target system, the adjustments playing a role were objective usability, perceptions of external control as it related to the specific system environment, and perceived enjoyment from system use. Interestingly, with increasing experience, although adjustments played an important role in determining system-specific perceived ease of use, the general beliefs regarding computers and computer use

[5]The results of the additional models are not reported here due to space constraints.

[6]The effect of experience on perception of external control was observed via a significant mean shift over time.

Table 2(a) Reliability and Discriminant Validity Coefficients at T1

	ICR	1	2	3	4	5	6	7	8	9
BI	0.92	0.94								
U	0.93	0.52***	0.91							
EOU	0.92	0.34***	0.33**	0.88						
CSE	0.84	0.24**	0.08	0.39**	0.82					
PEC	0.82	0.21*	0.19*	0.35**	0.30***	0.84				
PLAY	0.88	0.26**	0.12	0.32***	0.35**	0.13	0.88			
CANX	0.91	0.07	−0.20*	−0.40***	−0.30**	−0.17	−0.31***	0.85		
ENJ	0.90	0.10	−0.16*	0.06	0.20*	0.19*	0.39***	−0.23**	0.89	
OU	N/A	0.10	0.15*	0.17*	0.19	0.19	0.10	−0.21*	0.10	1.0

Table 2(b) Reliability and Discriminant Validity Coefficients at T2

	ICR	1	2	3	4	5	6	7	8	9
BI	0.90	0.92								
U	0.91	0.55***	0.89							
EOU	0.93	0.30***	0.35***	0.91						
CSE	0.90	0.29***	0.13	0.43***	0.84					
PEC	0.88	0.20*	0.11	0.40***	0.27***	0.87				
PLAY	0.85	0.12	0.18	0.22**	0.28***	0.21**	0.86			
CANX	0.88	0.11	−0.26**	−0.35**	−0.33***	0.06	−0.30**	0.89		
ENJ	0.92	0.19*	−0.19*	0.25**	0.15	0.22**	0.40***	−0.25**	0.89	
OU	N/A	0.14	0.12	0.22**	0.22*	0.20*	0.18*	−0.20*	0.17	1.0

Table 2(c) Reliability and Discriminant Validity Coefficients at T3

	ICR	1	2	3	4	5	6	7	8	9
BI	0.90	0.95								
U	0.91	0.56***	0.92							
EOU	0.96	0.24**	0.39***	0.87						
CSE	0.80	0.20*	0.19*	0.46***	0.79					
PEC	0.85	0.22**	0.20*	0.49***	0.29***	0.74				
PLAY	0.81	0.20*	0.14	0.15	0.30***	0.10	0.82			
CANX	0.83	−0.19*	−0.12	−0.33***	−0.31***	0.05	−0.33***	0.84		
ENJ	0.93	0.18*	0.08	0.29***	0.28**	0.12	0.40***	0.09	0.85	
OU	N/A	0.20*	0.21*	0.39***	0.22**	0.26*	0.14	−0.23**	0.06	1.0

Note. Diagonal elements are the square root of the shared variance between the constructs and their measures.
Off-diagonal elements are the corelations between the different constructs.
ICR = Internal Consistency Reliability
$^*p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

continued to be important factors driving system-specific perceived ease of use. In fact, certain general anchors (computer self-efficacy and facilitating conditions) were stronger determinants than were adjustments resulting from the user-system interaction.

Theoretical Contributions and Implications

From the perspective of user acceptance, the current research significantly expands our understanding of factors influencing user acceptance. Research on the Technology Acceptance Model has led to various

Figure 3(a) Results at T1

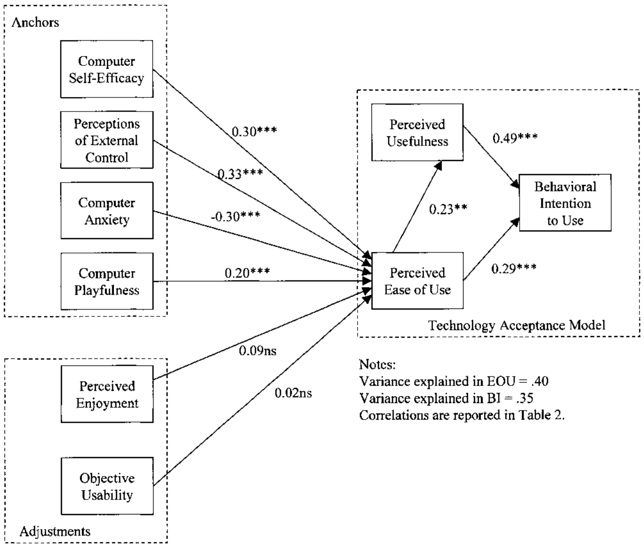


Figure 3(c) Results at T3

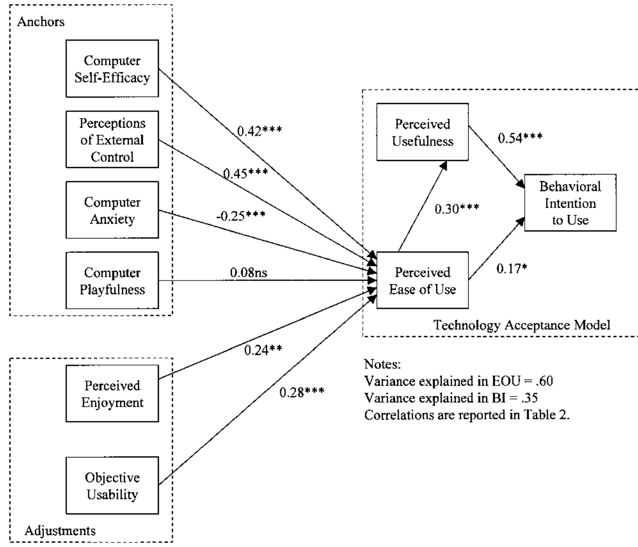
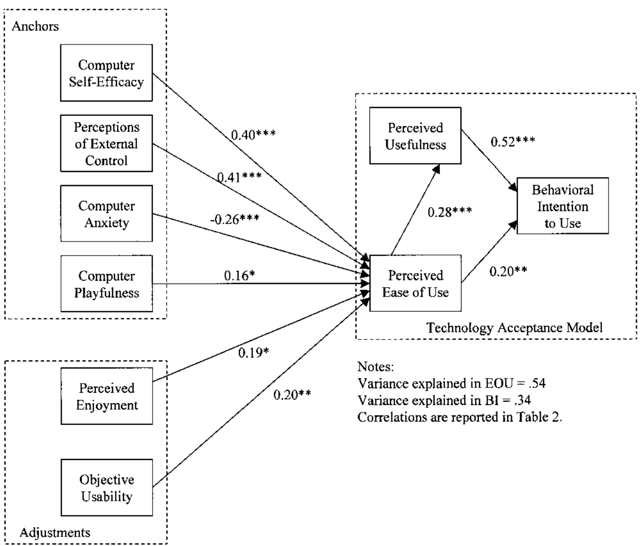


Figure 3(b) Results at T2



applications and replications. However, with the exception of some of Davis' work (e.g., Venkatesh and Davis 1996), research has not focused on understanding the determinants of TAM's key constructs. In this research, we attempt to go beyond the determinants of perceived ease of use identified by Venkatesh and Davis (1996). The determinants of perceived ease of use were developed and justified from a theoretical standpoint and validated empirically in three separate longitudinal field studies. By significantly increasing the variance explained in perceived ease of use, a much clearer picture of the factors influencing user judgments of system-specific ease of use has now emerged. Specifically, the proposed model of determinants explained up to a total of 60% variance in perceived ease of use, thus doubling our current understanding. The model presents an exposition of how the different determinants influence perceived ease of use and how their influence is affected by increasing user experience with a target system, thus providing researchers and practitioners with an in-depth understanding of the dynamics underlying the formation and change of perceived ease of use of a specific system.

The findings suggest that initial drivers of system-specific perceived ease of use are largely individual difference variables and situational characteristics, whose effect becomes stronger with experience. With increasing user experience with the target system, characteristics of the user-system interaction play a role in driving perceived ease of use of the target system, although their effect is still not as strong as the system-independent constructs. This is a very powerful result because it suggests that long-term perceived ease of use of a specific system is strongly anchored to general beliefs about computers that are system-independent and can be measured without much experience with the target system. This pattern of findings runs somewhat counter to what would be predicted by attitude/intention theories that suggest that experience will play a very key role in shaping attitudinal beliefs. One potential explanation for the current findings is that in the case of perceived ease of use about a specific system, individuals are driven by their general beliefs, even after significant direct experience with the system, as long as the specific system fits with the individual's broad expectations and industry-standard user interface conventions. It is, therefore, possible that adjustments will play a more important role in influencing perceived ease of use of the new system if one's continuing experience is inconsistent with the anchors. When experiences are consistent with expectations, there is no adjustment necessary (see also Szajna and Scamell 1993). It is also possible that the users under-adjusted and did not fully take their experiences into account, thus explaining the relatively weak influence of adjustments. Such an under-adjustment could be attributed to the short time-frame (three months) of the current research. In understanding the relative influence of anchors and adjustments, given the nascent state of research on determinants of perceived ease of use, we examined anchors and adjustments as main effects, something that is consistent with prior work in this area (Venkatesh and Davis 1996). Future work should examine possible moderation of anchors by adjustments.

The proposed theoretical framework and model of determinants of perceived ease of use integrates important constructs from other user acceptance models/research into the nomological net of TAM by positioning them as determinants of perceived ease of use. By demonstrating that constructs used in prior user acceptance research are indeed determinants of perceived ease of use, the current research presents a more complete, coherent, and unified view of user acceptance with TAM as the focal point. Also, by validating one of TAM's fundamental assumptions of mediation of external variables by perceived ease of use, the robustness of TAM as a powerful model to understand and predict user acceptance is further established. This represents an important theoretical contribution since there has been limited research (e.g., Davis et al. 1992, Venkatesh and Davis 1996) focused on testing the core assumption of mediation of the effect of other constructs on intention by the TAM constructs of perceived ease of use and perceived usefulness. The current work focused on the determinants of perceived ease of use, one of the two key drivers of acceptance per TAM. In related work, the determinants of perceived usefulness have been identified (Venkatesh and Davis 2000). It is important to test these two models in one study in order to present an integrated view of TAM and its determinants.

Limitations and Additional Future Research Directions

While this research possesses the advantage of field data from three different organizations, one potential direction for future research is to test the model in experimental settings as a way to provide internal validity for the model emerging from this work. The current work presented a cross-sectional analysis of the data, thus relying to a great extent on the theory to support causality. Future work should focus on a longitudinal analysis in order to strengthen the direction of causality proposed by the model. The current work was conducted in voluntary settings, which is quite suitable to the type of models/theories typically employed in user acceptance research. However, future research should examine mandatory usage contexts to test the boundary conditions of the proposed model.

There are some limitations related to measurement that should be noted. Although most scales employed in this work have been validated in prior research, the computer anxiety scale has not been previously used. The scale exhibited high reliability and validity in all studies at all points of measurement, but additional work is certainly warranted to further validate the scale and the role of the construct using this scale in more traditional anxiety research and other user acceptance research. In the current work, objective usability was operationalized using only one measurement during training, and the operationalization was consistent with prior human-computer interaction and user acceptance research. Future research should devise methods of measuring objective usability over time. However, even as it stands now, objective usability measured in the very early stages of user interaction appears to serve as a very useful predictor of long term perceptions of ease of use of a target system. Another limitation relates to the measurement of intention. The scales do not specify a time frame for use, largely because participating organizations were not specific at the outset about when subsequent administrations of the survey could be conducted. Also, usage behavior was not measured. One of the fundamental assumptions of research in the area of user acceptance is that the determinant constructs being studied are good predictors of usage behavior. There has been some concern about the predictive ability of TAM (see Straub et al. 1995). However, given that there is a significant body of research in IS (Taylor and Todd 1995), organizational behavior (Morris and Venkatesh 2000, Venkatesh and Morris 2000, Venkatesh and Speier 1999, Venkatesh et al. 2000), and psychology (see Sheppard et al. 1988 for a meta-analysis) supporting intention as a predictor of actual behavior, the issue is somewhat less critical. Future research should nevertheless examine the findings of the current work in a context where usage can be measured in order to add additional credibility to the model.

Practical Implications

System designers typically attempt to build systems that are easy to use while providing the functionality that the users need to accomplish their tasks. While user interface design is the typical focal point to enhance user acceptance, this research shows that there are multiple factors not directly related to the user-system interaction that are perhaps more important (e.g., computer self-efficacy). While a large amount of time during system design and development is typically spent on the user interface, this research suggests that practitioners should spend more time creating a favorable impact on system-independent factors, which have clearly been shown to be more important than user perceptions that relate to the user-system interaction in determining perceived ease of use of a specific system. This is particularly important since at all stages of user experience with a system, general, system-independent constructs play a stronger role than constructs that are a result of the user-system interaction.

The next steps should focus on designing and testing interventions to enhance perceived ease of use by targeting the identified determinants with an eye toward fostering increased technology acceptance in the workplace. As discussed earlier, there exists extensive research in IS and psychology that describes methods of enhancing self-efficacy and reducing anxiety—practitioners should attempt to adapt such interventions to end-user training contexts. Similarly, research should focus on designing managerial interventions that will provide facilitating conditions that favor the creation of positive perceptions about the ease of use of a specific system via perceptions of external control. Researchers and practitioners should attempt to better leverage the individual difference variable of computer playfulness and system-specific perceived enjoyment during the design and development phases of system building, and attempt to incorporate it into end-user training situations. In general, practitioners should design interventions directed at the various determinants of perceived ease of use that go beyond traditional training methods, which typically aim to impart only conceptual and procedural knowledge about a specific system. Organizations should consider putting in place general computer training programs that target increasing computer awareness, enhancing computer self-efficacy, and reducing computer anxiety among employees. Such training programs combined with appropriate facilitating conditions should pave the path for acceptance and usage of new systems. In fact, organizations will benefit particularly from system-specific training interventions that enhance user perceptions about the specific system and their general beliefs about new information technologies (see Compeau 1992).

One of the areas that has not been exploited in practice is the potential for intrinsic motivation to enhance user acceptance and usage. Much prior research (Davis et al. 1992; Malone 1981a, 1981b; Webster and Martocchio 1992; Venkatesh and Speier 1999) has found intrinsic motivation to be an important factor influencing user acceptance and learning. This research has further refined our understanding in this regard by suggesting that general computer playfulness and perceived enjoyment are determinants of perceived ease of use. One example is "fun icons" like the ones introduced in MS-Office 97. A similar example is the use of "warm and fuzzy" screen savers (e.g., flashing cartoons on the screen, some action related to your favorite basketball team, etc.) as a way to cause perceived ease of use of specific systems (used by the individual) to be more favorable. Recent work in IS (Venkatesh 1999) and organizational behavior

(Venkatesh and Speier 1999) suggests that training environments can be tailored to exploit intrinsic motivation with a view toward enhancing acceptance and usage of new systems. This may be important from the standpoint of breaking the monotony in the extensive use of software in today's workplace.

Conclusions

This research investigated the determinants of perceived ease of use, a key driver of technology acceptance, adoption, and usage behavior. Based on a field investigation in three different organizations, strong support was found for the anchoring and adjustment model of determinants. We found that an individual's general beliefs regarding computers were the strongest determinants of system-specific perceived ease of use, even after significant direct experience with the target system. The findings of the current work point to the need for an increased focus on individual difference variables in order to enhance user acceptance and usage, rather than over-emphasizing system-related perceptions and design characteristics as has been done in much prior information systems and human-computer interaction research. The current work calls for practitioners to develop and implement general training programs on computer skills as they will have a strong influence on the acceptance and sustained usage of new systems.

Acknowledgments

The author would like to thank the Editors, Izak Benbasat, John King, and Chris Higgins, and the three anonymous reviewers for their invaluable comments and suggestions on earlier versions of this paper. The author would like to acknowledge the important input of Fred Davis, Gordon Davis, Shawn Curley, Phillip Ackerman, and Ruth Kanfer during the various stages of this research project. Last but not least, Tracy Ann Sykes' editorial help greatly improved the presentation and readability of this paper.

Appendix 1 Questionnaire Items

Behavioral Intention to Use

Assuming I had access to the system, I intend to use it.
Given that I had access to the system, I predict that I would use it.

Perceived Usefulness

Using the system improves my performance in my job.
Using the system in my job increases my productivity.
Using the system enhances my effectiveness in my job.
I find the system to be useful in my job.

Perceived Ease of Use

My interaction with the system is clear and understandable.
Interacting with the system does not require a lot of my mental effort.
I find the system to be easy to use.
I find it easy to get the system to do what I want it to do.

Perceptions of Internal Control (Computer Self-Efficacy)

(Note: Additional instructions were provided per Compeau and Higgins 1995a, 1995b)
I could complete the job using a software package. . .
. . . if there was no one around to tell me what to do as I go.
. . . if I had never used a package like it before.
. . . if I had only the software manuals for reference.
. . . if I had seen someone else using it before trying it myself.
. . . if I could call someone for help if I got stuck.
. . . if someone else had helped me get started.
. . . if I had a lot of time to complete the job for which the software was provided.
. . . if I had just the built-in help facility for assistance.
. . . if someone showed me how to do it first.
. . . if I had used similar packages before this one to do the same job.

Perceptions of External Control (Facilitating Conditions)

I have control over using the system.
I have the resources necessary to use the system.
I have the knowledge necessary to use the system.
Given the resources, opportunities and knowledge it takes to use the system, it would be easy for me to use the system.
The system is not compatible with other systems I use.

Computer Anxiety

Computers do not scare me at all.
Working with a computer makes me nervous.
I do not feel threatened when others talk about computers.
It wouldn't bother me to take computer courses.
Computers make me feel uncomfortable.
I feel at ease in a computer class.
I get a sinking feeling when I think of trying to use a computer.
I feel comfortable working with a computer.
Computers make me feel uneasy.

Computer Playfulness

The following questions ask you how you would characterize yourself when you use computers:

. . . spontaneous	. . . playful
. . . unimaginative	. . . unoriginal
. . . flexible	. . . uninventive
. . . creative	

Perceived Enjoyment

I find using the system to be enjoyable.

The actual process of using the system is pleasant.
I have fun using the system.

Objective Usability
No specific items were used. It was measured as a ratio of time spent by the subject to the time spent by an expert on the same set of tasks.

Experience
Was not explicitly measured—was coded based on point of measurement.

Perceived Voluntariness of Use
My superiors expect me to use the system.
My use of the system is voluntary.
My supervisor does not require me to use the system.
Although it might be helpful, using the system is certainly not compulsory in my job.

Note. All items were measured on 7-point Likert scale, except computer self-efficacy which was measured using a 10-point Guttman scale.

Appendix 2 Factor Structure Based on Pooled Data at T1

	1	2	3	4	5	6	7	8
BI1	**0.95**	0.08	0.07	0.05	0.03	0.01	0.09	0.19
BI2	**0.91**	0.05	0.09	0.09	0.07	0.12	0.09	0.17
U1	0.33	**0.88**	0.10	0.14	0.10	0.12	0.01	0.08
U2	0.28	**0.90**	0.13	0.19	0.11	0.07	0.03	0.19
U3	0.21	**0.91**	0.21	0.21	0.09	0.03	0.12	0.10
U4	0.18	**0.93**	0.05	0.10	0.17	0.07	0.12	0.11
EOU1	0.10	0.02	**0.94**	0.15	0.09	0.09	0.14	0.10
EOU2	0.02	0.07	**0.96**	0.17	0.01	0.03	0.02	0.14
EOU3	0.06	0.02	**0.91**	0.20	0.13	0.17	0.14	0.17
EOU4	0.11	0.10	**0.90**	0.21	0.08	0.05	0.11	0.19
CSE1	0.10	0.12	0.21	**0.99**	0.00	0.02	0.19	0.12
CSE2	0.20	0.02	0.03	**0.88**	0.02	0.03	0.23	0.20
CSE3	0.14	0.14	0.09	**0.87**	0.08	0.05	0.10	0.13
CSE4	0.15	0.01	0.00	**0.75**	0.09	0.08	0.11	0.15
CSE5	0.12	0.03	0.03	**0.71**	0.01	0.04	0.03	0.08
CSE6	0.03	0.00	0.10	**0.79**	0.02	0.06	0.05	0.15
CSE7	0.08	0.03	0.07	**0.85**	0.03	0.10	0.08	0.13
CSE8	0.10	0.12	0.02	**0.89**	0.04	0.11	0.03	0.15
CSE9	0.11	0.02	0.04	**0.90**	0.05	0.14	0.09	0.12
CSE10	0.07	0.08	0.03	**0.82**	0.01	0.15	0.02	0.10
EC1	0.05	0.02	0.07	0.03	**0.81**	0.10	0.04	0.22
EC2	0.02	0.13	0.17	0.06	**0.80**	0.09	0.01	0.13
EC3	0.06	0.09	0.19	0.14	**0.77**	0.07	0.09	0.12
EC4	0.15	0.00	0.09	0.11	**0.70**	0.02	0.01	0.14
EC5	0.19	0.12	0.10	0.10	**0.72**	0.19	0.03	0.04
ANX1	0.04	0.04	0.19	0.14	0.09	**0.71**	0.02	0.07
ANX2	0.05	0.09	0.14	0.13	0.03	**0.79**	0.09	0.29
ANX3	0.03	0.12	0.23	0.11	0.09	**0.80**	0.07	0.01
ANX4	0.09	0.01	0.08	0.12	0.08	**0.77**	0.10	0.20
ANX5	0.09	0.15	0.09	0.17	0.02	**0.70**	0.08	0.14
ANX6	0.04	0.03	0.11	0.22	0.08	**0.77**	0.14	0.18
ANX7	0.17	0.12	0.22	0.28	0.10	**0.70**	0.02	0.14
ANX8	0.18	0.03	0.03	0.05	0.08	**0.80**	0.08	0.19
ANX9	0.01	0.05	0.02	0.19	0.18	**0.81**	0.03	0.11
PLAY1	0.14	0.12	0.20	0.11	0.02	0.08	**0.90**	0.30
PLAY2	0.02	0.05	0.06	0.08	0.09	0.10	**0.73**	0.21
PLAY3	0.02	0.07	0.19	0.23	0.10	0.11	**0.79**	0.22
PLAY4	0.11	0.09	0.10	0.11	0.03	0.12	**0.71**	0.11
PLAY5	0.10	0.09	0.11	0.20	0.00	0.19	**0.73**	0.17
PLAY6	0.11	0.14	0.04	0.06	0.20	0.11	**0.80**	0.10
PLAY7	0.13	0.16	0.16	0.19	0.09	0.12	**0.70**	0.07
ENJ1	0.03	0.07	0.10	0.13	0.03	0.14	0.07	**0.80**
ENJ2	0.13	0.09	0.05	0.14	0.19	0.17	0.25	**0.79**
ENJ3	0.12	0.02	0.25	0.13	0.03	0.03	0.20	**0.71**

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Chris Higgins, Associate Editor. This paper was received on March 20, 1998, and was with the author $13\frac{1}{2}$ months for 3 revisions.