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ABSTRACT

The Technology Acceptance Model (TAM) has integrated behavioral theories from cognitive psychology to explain system usage by introducing the cognitive constructs of perceived usefulness and perceived ease of use. Later studies on TAM have found individual differences to be important determinants of system usage as well. In this study, we attempt to integrate the theories in second language learning literature into the TAM model to better explain the contribution of individual differences to technology acceptance. Specifically, we introduce the construct of computer user aptitude, defined as the ability to learn computer technology, as a potentially significant individual difference and show how the antecedents of user aptitude, such as tolerance of ambiguity, risk-taking tolerance, general aptitude and anxiety, affect this new construct. A measurement instrument is developed and tested. Preliminary results using exploratory factor analysis and path analysis are presented and future research directions are discussed.

Keywords

Technology acceptance model, individual differences, computer user aptitude, second language learning

INTRODUCTION

Theories of technology acceptance have integrated behavioral models from cognitive psychology to predict system usage by introducing cognitive constructs such as perceived usefulness (PU) and perceived ease of use (PEOU) found in the technology acceptance model (TAM) (Davis, 1989). TAM proposes to predict system usage (SU) by measuring behavioral intentions (BI), and to predict BI by measuring PU and PEOU. The antecedents to PU and PEOU are labeled external variables (EVs), which "provide the bridge between internal beliefs and intentions represented in TAM and the various individual differences, situational constraints and managerially controllable interventions impinging on behavior" (Davis, et al. 1989, p.988).

Although TAM has been widely studied, researchers are still trying to specify and test alternative EVs. A multitude of studies have been published introducing different EVs that extend the original TAM model by adding subjective norm (Venkatesh and Davis, 2000), intrinsic motivation (Thompson, Lim and Lai, 1999) and self-efficacy (Chau, 2001). With some notable exceptions (e.g., Argawal and Karahanna, 2000), there has been a paucity of studies that deal with the cognitive aspects of the perceptions inherent in the key constructs PU and PEOU. The concept of perception has been typically treated as a "black box", as if all users have the ability to interpret and understand the technology equally. Although this "black box" is central to the TAM model as a filter to determine usefulness and ease of use, little attention has been devoted to investigating when it might be a bridge and when it might be a barrier to the information leading to the determination of usefulness and ease of use.

We argue that a better understanding of the cognitive filter for the external stimuli is vitally important to any application of TAM. To address this issue, we propose computer user aptitude (CUA), defined as the ability to learn computer technology, as an important antecedent to the cognitive constructs PU and PEOU. Computer user aptitude derives its theoretical basis

from the learning literature, specifically literature on the success in secondary language learning. We postulate that those individuals who can learn computer technology successfully will have a greater propensity to perceive the technology as easier to use and useful compared to those individuals who have difficulties learning computer technology. Learning computer technology is posited as parallel to the learning of a second language, since any computer technology has its own vocabulary, i.e. a language that must be understandable prior to an individual determining whether the technology is useful or easy to use.

This study focuses on the development of the proposed computer user aptitude construct and its antecedents. The research question is twofold: 1) what are the dimensions of computer user aptitude? and 2) are the antecedents identified in second language learning significantly correlated to the computer user aptitude construct? The main contribution of this study is to synthesize previously unrelated theories, TAM and success in second language learning, as a foundation for introducing and developing a new external construct, CUA. This research should lay the foundation for future studies that incorporate CUA into the TAM model and test its contribution to the predictive capability of the TAM model.

THEORETICAL BACKGROUND

For more than a decade research has found support for TAM in a multitude of diverse situations and populations including telemedicine and medical support systems (Chau and Hu, 2002), business including senior executives (Pijpers, Bemelmans, Heemstra, van Montfort, 2001), and cultures as diverse as those of Arabic countries (Rose and Straub, 1998) and Hong Kong (Chau and Hu, 2002). Most recently, TAM has been applied to e-business applications (Koufaris, 2002; Gefen, Karahanna, Straub, 2003). Researchers have actively pursued validations and extensions of TAM to unveil more unspecified significant constructs in both more general and specific contexts. In this section, we review the relevant literature related to the development of the focal construct, *computer user aptitude*.

Perceived Usefulness and Perceived Ease of Use

The focus in the original presentation by Davis (1989) was on two constructs, PEOU and PU as "self-reported indicants of system usage". PEOU is defined as "the degree to which a person believes that using a particular system would be free from effort," and PU is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis 1989, p.320). Davis provided a broad theoretical foundation for these constructs using widely recognized theories such as research on self-efficacy (Bandura, 1982) and the theory of reasoned action (Fishbein and Ajzen 1975). Davis saw a convergence of the various theories providing support for PEOU and PU to be considered separately as key determinants of behavior. In the original model PEOU and PU are antecedents to attitude, and attitude is an antecedent to behavioral intention (BI) and ultimately system use (SU). Subsequently, attitude was dropped due to its lack of significance, leaving only three theoretical constructs.

Computer User Aptitude

Computer literacy, an extension of traditional literacy, has become increasingly important as competitive pressures highlight the fact that "business cannot afford technology-illiterate managers" (Keen 1991). However, the term traditional literacy is not limited to those who can read (called literates) from those who cannot (called illiterates). A theoretically rich view of literacy defines it as a continuous, multidimensional indicator of proficiency in using written language, with its higher levels reflecting an ability to draw logical inferences and think critically (Wallendorf, 2001). Applying this definition, computer literacy has a range of competence, with the higher range reflecting different abilities than the lower range. Bandura (1997) recognized the basis for cognitive competencies as being promoted by psychological and social processes, part of which might be the psychological processes that interact with user aptitude. Cognitive ability, i.e. aptitude, and learning are closely tied, with substantial literature providing evidence that cognitive aptitude is a universal predictor of learning (Witt and Burke, 2002). Aptitude may then be considered a predictor of literacy, as literacy is the specific focus of learning symbols and utilizing that knowledge. Thus, user aptitude is part of the learning mechanism for the cognitive competencies required to develop computer literacy. The higher the user aptitude, the more an individual can draw logical inferences and think critically. An example of this relationship in the IT realm has been demonstrated in a study by Szajna and Mackay (1995) in which computing aptitude is shown to be related to learning performance in software training.

The proposed computer user aptitude (CUA), which refers to *one's perception about being able or having the capacity to learn computer technology***,** is derived directly from the aptitude construct. We argue that it is relevant to the technology acceptance research based on two observations. First, since PU, PEOU and BI are all cognitive constructs, the most influential variables would be those that support the cognitive process. Thus, the focus is on individually distinct dimensions of cognition. Davis et al. (1989) observed that "[l]earning based on feedback is another type of external variable apt to influence usefulness beliefs" (p.987). Individual differences based on learning theory have been studied in the contexts of both TAM and second language learning. Agarwal and Prasad (1999) traced the relationship between individual difference

variables and the cognitive concept of beliefs to the theories of learning, "which suggests that beliefs are learned responses, and that individual differences play a pivotal role in learning" (p. 7). A related construct that has been shown as an external variable to TAM is computer self-efficacy (CSE) (Venkatesh and Davis, 1996; Igbaria and Iivari, 1995). CSE "refers to *a judgment of one's capability to use a computer* (Compeau and Higgins, 1995). Based on Bandura's (1986) definition of self-efficacy which "is concerned not with the skills one has but with the judgments of what one can do with whatever skills one possesses" (p.391), we distinguish CSE from CUA in that the former emphasizes one's perceived ability to perform computer related tasks and the later focuses on one's perceived ability to learn computer skills. We postulate that CUA reflects the innate aptitude of an individual to acquire and apply knowledge and precedes skill acquisition. The distinction is more evident when looking at these two concepts together. For example, one could have low computer learning ability and yet strong perception of using computers or vice versa.

Second, we postulate that users interact with computer technology via languages that are theoretically processed in a similar manner as any human language. For example, there are syntactical rules and unique vocabularies associated with computer technologies. Although newer computer technologies are moving towards more intuitive geographical user interfaces (GUI), there are still rules and vocabularies that are unique to the use of any specific applications. Hence, we postulate that the variables influencing the successful learning of a second or foreign language might also dictate the successful learning of technology "languages". In the following sub-sections, we discuss these variables and develop our research hypotheses.

Antecedents of Computer User Aptitude

Aptitude

Aptitude is an "innate or acquired capacity for something" (Webster's 1994), which predisposes a person to perceive "something" as easier to understand and, by extension, easier to use. Here the "something" is technology. Ehrman and Oxford (1995) found cognitive aptitude to have the strongest correlation with second language proficiency. Cognitive aptitude in this case refers specifically to modern language aptitude. However, there is a recognized difference between measures of intelligence and measures of language aptitude. Thus, modern language aptitude tests should contribute incrementally over conventional ability tests to predict learning success (Grigorenko et al., 2000). In the current study, we argue that CUA should contribute incrementally over conventional ability tests to predict computer user success. If users are proficient or at least have the capacity to be proficient with regard to learning technology, they are apt to perceive new technology as easier to use and useful than otherwise. This line of discussion leads us to the follow research hypotheses:

H1a: *GA has a positive relationship with CUA.*
H1b: *GA has a significant positive relationship with PEOU, mediated by CUA.*
H1c: *GA has a significant positive relationship with PU, mediated by CUA.*

Computer Anxiety

Both language anxiety (AN) and computer anxiety (CA) have been studied extensively with varied results. While a comprehensive review of these studies is beyond the scope of this study, several observations are appropriate. AN is typically considered as "a form of performance anxiety" (Ehrman and Oxford 1995) and categorized as the debilitating kind of anxiety (Horwitz et al., 1986). CA, on the other hand, has been found to have a separate range for facilitating and debilitating behavior similar to the relationship between performance and stress where a moderate level is optimal and very high or very low is detrimental to performance (Desai, 2001). Two types of anxiety have been identified– state anxiety caused by a specific situation, and trait anxiety referring to a certain disposition that has a propensity to worry (Mikulincer, Kedem and Paz, 1990). In the current study, the focus is on measuring trait anxiety, since the focus is on individual differences and not situational factors. Research findings have also indicated that math and test anxiety may be related to computer anxiety (Desai, 2001). Heinssen, Glass, Knight (1987) took the various potential origins into account when they developed Computer Anxiety Rating Scale (CARS), noting that "cognitive factors [thus] appear to play an important role in computer anxiety" (p.57). Thus, cognitive factors are important dimensions to investigate in order to gain an accurate understanding of their impact on CA. Incorporating CA into TAM, studies have found a negative influence of CA on perceived ease of use (Venkatesh 2000), however the potential mediating effect of CUA has not been specifically included. It is important to understand the possible impact of CUA in order to understand how to better deal with CA. This line of discussion leads us to the follow research hypotheses:

H2a: *CA has a significant negative relationship with PEOU, mediated by CUA.*
H2b: *CA has a significant negative relationship with PU, mediated by CUA.*

Tolerance of Ambiguity and Risk-Taking

Tolerance of ambiguity (TA) and its related concept risk-taking (RT) are enablers of learning, as demonstrated by studies that "students who can tolerate moderate levels of ambiguity are more likely to persist in language learning than students who cannot" (Ehrman and Oxford, 1995, p.69). Additionally, "[t]hose who can tolerate ambiguity in language learning are more likely to take risks; and risk-taking is an essential for progress" (Ehrman and Oxford 1995, p.69). In recent studies of TAM, propensity to take risk has been researched indirectly through the construct of personal innovativeness in information technology (PIIT) (Argarwal and Karahanna, 2000; Argarwal and Prasad, 1998). PIIT may be a function of individuals' tolerance of risk (Bommer and Jalajas 1999). Research has also supported the belief that attitudes toward both risk and ambiguity are important determinants of decision-making (Ghosh and Ray, 1992). The importance of TA and RT for learning and decision-making suggests that they will also be significant to technology acceptance and usage, since learning, which is theorized to be a basis for beliefs and decision-making, is part of the process of accepting new technology and using it. This line of discussion leads us to the follow research hypotheses:

H3a: TA has a positive relationship with PEOU, mediated by CUA.
H3b: TA has a positive relationship with PU, mediated by CUA.
H3c: RT has a positive relationship with PEOU, mediated by CUA.
H3d: RT has a positive relationship with PU, mediated by CUA.

Proposed TAM Extension

The discussions on the TAM model and the CUA construct suggest that CUA may be an important external variable that could significantly increase the predictability of the TAM model by explicating a potentially important antecedent to perception, in this case perception of usefulness and perception of ease of use. The hypothesized relationships between the main construct, CUA, and its antecedents, as well as the proposed extension to the TAM mode, are depicted in Figure 1. In this paper we present the preliminary study of developing and validating the CUA construct.

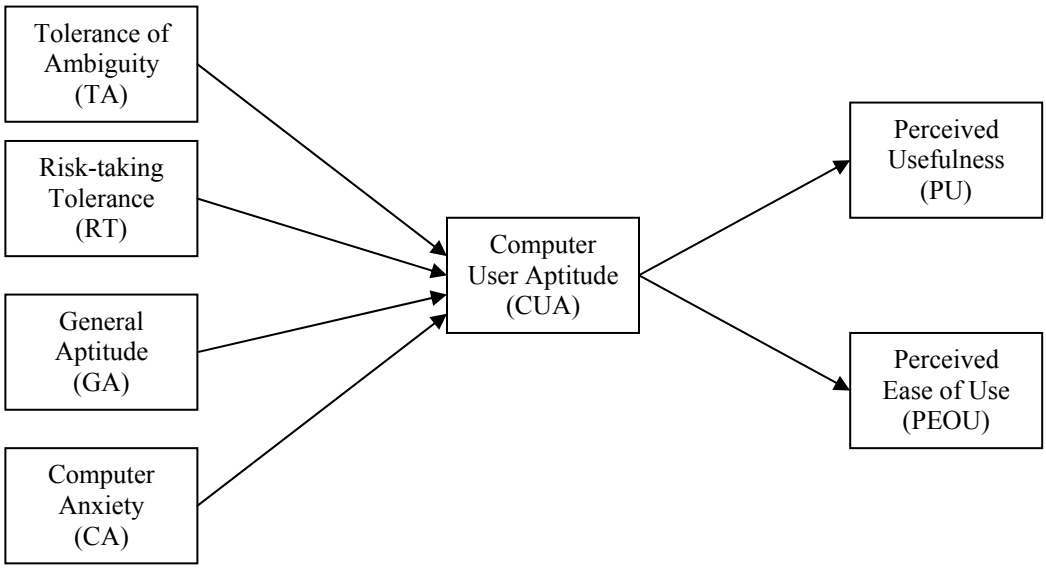

Figure 1: Proposed TAM Extension

RESEARCH METHODOLOGY

Data Collection

The proposed research model was operationalized through a field study using a survey methodology for data collection. Data was collected from students of various business majors enrolled in introductory MIS courses at a large state university. Given the nature of the sample, the Internet and Microsoft PowerPoint were chosen as the target technologies for the

measurement of self-reported usage. These technologies were considered appropriate for two reasons: 1) they are both voluntary in the school curriculum and students have access to both technologies throughout the campus in open computer labs, and 2) they are representative of software that would be used by the general public, not only technical specialists. While programming languages might appear to be the choice at first, since they are analogous to natural languages and have a more structured syntactic framework than graphical user interface (GUI) based technology, we believe they would target an overly biased sample through self-selection due to their specific technical orientation and thus not used in this study. An iterative process was used for the survey instrument development beginning with a pilot sample of 64 responses. The results of the pilot survey analysis were used to refine the survey instrument. A total of 150 surveys collected were used to complete the analyses presented in this study.

Operationalization of Construct Variables

General Aptitude

The general aptitude (GA) construct is a new scale developed considering that the strongest indicator of second language learning success was cognitive aptitude (Ehrman and Oxford, 1995) and a positive relationship was found between successful second language learning and higher SAT-Verbal scores (Cooper, 1987). Thus the scale includes general cognitive aptitude indicators such as GPA and SAT scores.

Computer Anxiety

Items used for this construct were taken from a frequently cited instrument by Heinssen, et al.(1987) known as the Computer Anxiety Rating Scale (CARS). A recent study of a four-item subset instrument (Thatcher and Perrewe, 2002) showed a composite reliability of 0.94. This subset as well as several of the generally worded items was included.

Tolerance of Ambiguity

Items based on a tolerance of ambiguity instrument developed specifically for second language learning (Ely, 1989) and derived from the general scales of Budner (1962) and Norton (1975) were adapted for the information technology context.

Risk-taking

Attitude toward risk-taking was measured using a combination of a previously developed instrument known as the Choice Dilemma Questionnaire (CDQ) by Kogan and Wallach (1964). The CDQ instrument includes[redacted]ve situations that describe a choice between two alternative courses of action. Due to the length of the questionnaire, three representative situations were included in the pilot of which one was dropped due to poor psychometric properties.

Computer User Aptitude

We developed the scales to measure computer user aptitude in a multi-stage iterative approach. First, an initial set of items was constructed based on the underlying conceptualization. Then the pilot study was completed. The results of the pilot study aided in refinement of items establishing convergent and discriminant validity. The current scale consists of 21 items with seven relating to software, six relating to hardware, six relating to the Internet and two relating to a combination of the Internet and software.

RESULTS

Construct validity and reliability of the instrument

Discriminant validity was assessed using factor analysis with the extraction method of principal components and oblimin rotation method. Each construct was factor analyzed individually. It was determined that each construct had multiple factors representing the construct's multiple dimensions. An iterative process was employed where items that cross-loaded or did not load above 0.4 were analyzed for both their unique contributions to content validity and levels of loading. Those items that were considered to be problematic were removed one at a time with a reassess[redacted]of the factor loading. Once a stable factor loading was obtained for each construct, the reliability of each resulting dim[redacted]n was analyzed. The majority of the items exceed the .60 item-to-total correlations threshold recommended by Hair, Anderson, Tatham and Black (1998) for exploratory analysis. In the two cases where Cronbach's alpha did not exceed the .60 threshold, further examinations provided evidence that the lower values could be due to the fact that only two items comprise the GPA construct and three comprise the Overall Philosophy dimension. It was then deemed appropriate to keep those items at this stage of the study. Finally, the antecedents to CUA were factor analyzed together to ensure discriminant validity (see Table 2). Only one item cross-loaded (TA9R) and this level of cross loading is considered as acceptable during exploratory analysis with a smaller

sample. The CUA construct was also factor analyzed with four dimensions resulting (see Table 3). As a result, the scales were refined to seventeen items for CUA, four items for GA, five for RT, eleven for TA and five for CA. The Cronbach's alphas of all dimensions are presented in Table 1.

The multiple factors were assessed for content validity by reviewing the items comprising each factor. The items and the resulting dimensions can be found in Table 2. Upon review of the individual questionnaire items, the cohesiveness of like items was confirmed, with subdimensions identified.

Construct	Dimensions	Abbreviation	Cronbach's Alpha
CUA	1-General hardware/software	CUA-D1	.88
	2-Internet chat/file transfer	CUA-D2	.84
	3-Programming	CUA-D3	.81
	4-Internet browsing	CUA-D4	.79
GA	1-SAT verbal/math	GA-D1	.91
	2-GPA, high school/college	GA-D2	.51
TA	1-Computer specific	TA-D1	.85
	2-Overall philosophy	TA-D2	.59
	3-Problem-solving	TA-D3	.63
CA	1-Enjoyment	CA-D1	.71
	2-Performance	CA-D2	.75
RT	1-Propensity	RT-D1	.80

Table 1: Descriptive Statistics

Scale Items	Factor 1	Factor	Factor	Factor	Factor	Factor	Factor	Factor 8
TA1R	.541							
TA2R	.828							
TA3R	.835							
TA4R	.834							
TA5R	.691							
RT4		.813						
RT5		.867						
RT6		.891						
TA10R			.651					
TA11R			.690					
TA12R			.807					
TA9R			.415			.406		
GA4				.925				
GA5				.908				
CA5R					.679			
CA6R					.795			
CA7R					.761			
TA6R						.643		
TA7R						.690		
TA8R						.775		
CA1							.808	
CA2							.767	
GA2								.800
GA3								.687

Rotation Method: Oblimin with Kaiser Normalization, loadings <.400 suppressed

Table 2: Factor Loadings

Scale Item	Factor 1	Factor 2	Factor 3	Factor 4
CUA1	.610			
CUA2	.663			
CUA3	.600			
CUA8	.559			
CUA9R	.625			
CUA11	.674			
CUA12	.634			
CUA15		-.708		
CUA16		-.733		
CUA17		-.822		
CUA18		-.733		
CUA4			.905	
CUA5			.915	
CUA7			.645	
CUA14				.625
CUA20				.948
CUA21				.879

Rotation Method: Oblimin with Kaiser Normalization, loadings < .40 suppressed

Table 3: CUA Factor Analysis

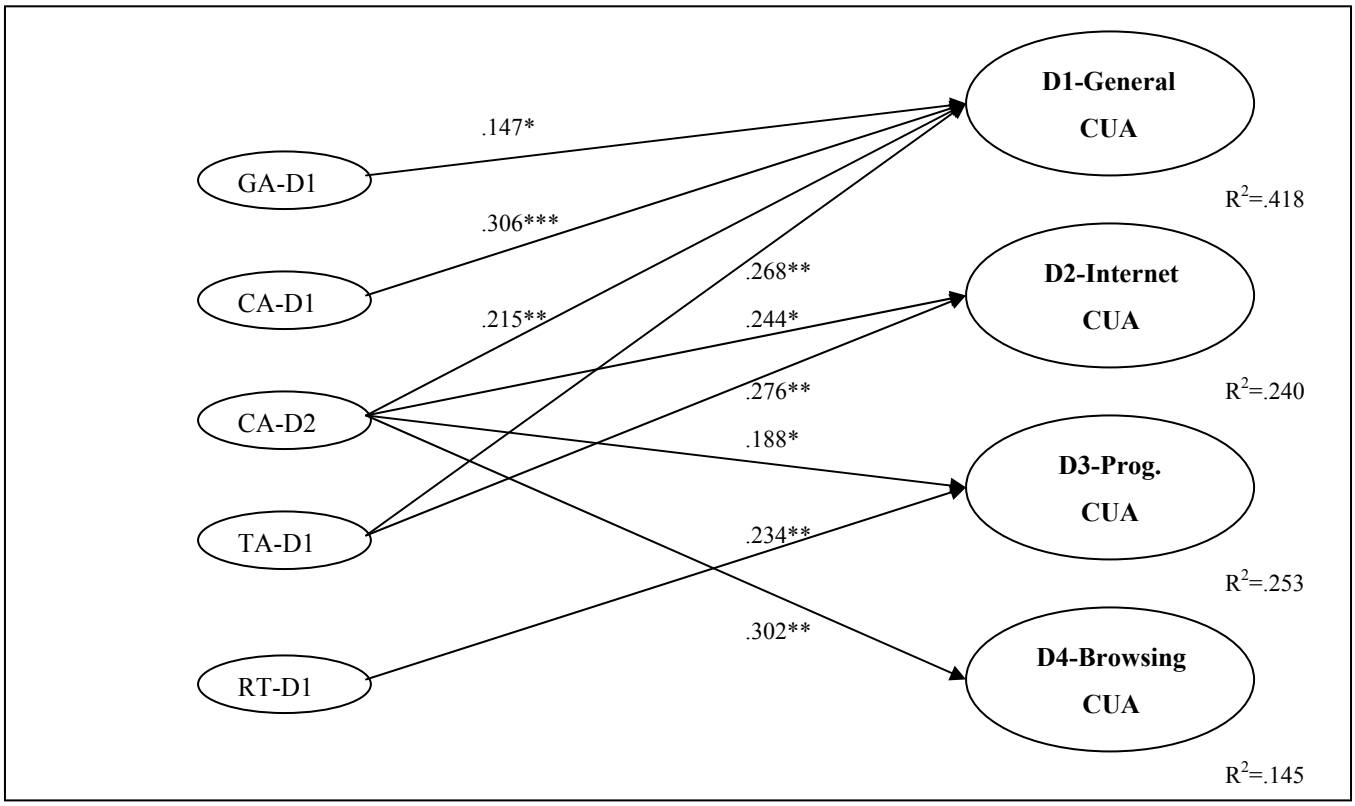

Figure 2: Path Analysis for CUA – Dimensions 1-4

Path Analysis

Given that the main construct being developed (CUA) was determined to be comprised of four dimensions, a series of ordinary least squares regression was performed to obtain the path coefficients and R^2s for each submodel. The results are summarized in Figure 2, where * denotes for p≤ .05, ** for p≤.01, and *** for p≤.001.

The results of segmenting CUA into the four indicated dimensions are significant and interesting for two reasons. First, it points to inherent differences in individuals as they navigate the perception process. Second, it clearly presents evidence that the IT artifact itself may be a critical piece of the research puzzle, following Orlikowski and Iacono's (2001) call to theorize about the IT artifact.

Tests for multicollinearity were completed for all regression equations using the variance inflation factor (VIF). The VIF values ranged from 1.09 to 1.6 for all regression equations, which are well below the threshold of 10 suggested by Hair et al. (1998). Thus, there are no indications of multicollinearity in the regression models.

CONCLUSION

In this study we have proposed and tested a new external variable construct, computer user aptitude (CUA), for the TAM model based on the literature of language learning in order to explicate the process by which individuals perceive the usefulness and ease of use of information technology. The results indicate that there are four distinct dimensions to computer user aptitude and each has a different combination of significant antecedents. The antecedents, derived from second language learning theories, represent individual differences that are hypothesized to impact the cognitive process of perception as an individual evaluates a computer technology for intention to use. We find that the general hardware/software dimension of CUA correlates the highest with the antecedents CA, TA and GA. CA is highly correlated with most of the dimension in a positive manner, which suggests that computer anxiety may be facilitating, particularly if an individual has some degree of ambiguity tolerance.

This study has several implications for research and practice. For research, honing the concept of individual differences and cognition within the TAM model will help to explicate the external variables "black box" which is the collection of all antecedents to perceived usefulness and perceived ease of use. Additionally, bringing in concepts that indicate success in another cognitive process, i.e. second language learning, provides an avenue for understanding success in technology acceptance. For practice, understanding technology acceptance by users is critically important in many contexts such as small business (Riemenchneider, Harrison and Myktyn, Jr.2003) and wireless Internet (Yu and Yao, 2003).

The development of an acceptable measurement instrument for the proposed construct is a first step in the analysis process. The next phase of this research project is to incorporate the proposed construct into the TAM model and show that CUA indeed has direct impact on PU and PEOU and significantly improves the TAM model in predicting user acceptance of new technologies.

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