The Effects of Personality Traits, Software Interface, and Computer Experience on Performance and Perceptions of Ease of Use and Usefulness

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ABSTRACT

THE EFFECTS OF GENDER PERSONALITY TRAITS, SOFTWARE INTERFACE, AND COMPUTER EXPERIENCE ON PERFORMANCE AND PERCEPTIONS OF EASE OF USE AND USEFULNESS

Camille Otrakji

Different computer competency, personality traits, gender and different types of software interface can influence a users' perception of the software usefulness, ease of use and hence performance. Understanding the relationships between a users gender, personality traits, computer competency, perceptions, and performance using different interfaces is necessary because these variables are significant for the end-user as well as for business managers in making software decisions. In this paper, a research model to explain the above relationships is proposed, based on the computer learning process and the technology acceptance model. A menu driven interface and an icon-based interface were used in the experiment. A survey methodology was used to measure computer competency and user perceptions. Analysis of the data was done for the measurement model and Structural model. The measurement model was assessed in terms of reliability measure, and factor analysis. The structural model and hypotheses were investigated by examining the regression analysis. Two-way repeated measured analysis of variance (ANOVA) was used to investigate the relationship among gender, interface and perception and performance. The results suggest that the relationships between computer competency, perceptions and performance are significant for both interfaces.

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1. Introduction

During the last decade, software applications have been undergoing significant changes with respect to their features and interface design. These changes occur within short periods of time. Driven by the rapid advancement in technology, organizations that develop and supply software products face major uncertainty as to their software's eventual acceptance and use. An integral component to the acceptance of any information technology (IT) is the software that allows for human-computer interaction. In turn, a major component of any software is its interface. The software interface is the front line between human and computer. Facilitating the way people use IT to perform tasks, while introducing a feeling of ease of use are two critical user interface design and human-computer interaction issues (Molnar et al., 1996).

Previous work has investigated the role of computer interfaces mostly within the context of end-user training (Davis et al., 1993, Brancheau et al., 1987, Cheney, et. Al., 1986, Rivard et. Al, 1988). Other research works also included studies on command-based (CBI), direct-manipulation (DMI), menu-based (MBI) (Davis et al., 1993) and voice based (Molnar et al. 1996) interfaces.

A widely accepted user interface design guideline provides end-users with consistent interface application programs (Satzinger and Olfman, 1998). This consistency in user interface is thought to facilitate ease of use. This is due to the point of view that if all applications look and operate the same way, a user can draw on existing knowledge (Borgman, 1986 and Sein et al., 1989) when learning to use a new application (Bennett, 1986). However, the issue of interface consistency remains a controversial one. Many researchers have challenged the desirability of interface design based on consistency guidelines (Satzinger and Olfman, 1998). They argue that too much emphasis on interface consistency can focus designer attention away from carefully studying and supporting the user's task (Satzinger and Olfman, 1998, Akscyn et al., 1988, Gerlach and Kuo, 1991 and Grudin, 1989). Inevitably, innovative interface devices and interaction techniques will require us to break away from consistent interface standards (Marcus, 1993, Morse and Reynolds, 1993 and Nielsen, 1993).

Information systems managers, designers and software developers need to understand end-users performance and perceptions as they relate to new and different types of interfaces. End-users' performance and acceptance, or resistance to the use of new technologies depend strongly on their computer background, perceptions and performance while test driving them. Although many studies have looked at evaluating direct manipulation type of interfaces (DMI), few have studied menu driven interfaces (MDI). To the best of my knowledge, none have investigated icon based interfaces (IBI) and the influence of MDI and IBI on performance.

The primary objective of this study is to investigate empirically the moderating effects of an image editing software interface on the influence of different computer skills and personality traits on performance and end-user beliefs. Task completion time was used to measure performance and a survey approach was used to measure end-user beliefs, different computer skills and personality traits. Effectiveness was measured through the number of successfully and accurately completed tasks.

2. Theoretical Background

The theoretical basis for the present work draws on the model for instruction guided exploration approach proposed by Bostrom et al. (1988) (figure 2.1) and the technology acceptance model (TAM) (Davis et al., 1989). In subsequent sections we give a review of prior research from those fields that are relevant to our study.

2.1 The computer learning process

Figure 2.1 shows the elements of the computer learning process proposed by Bostrom et al. (1988). In this figure, the variables (in boxes) and corresponding relationship between the variables are identified.

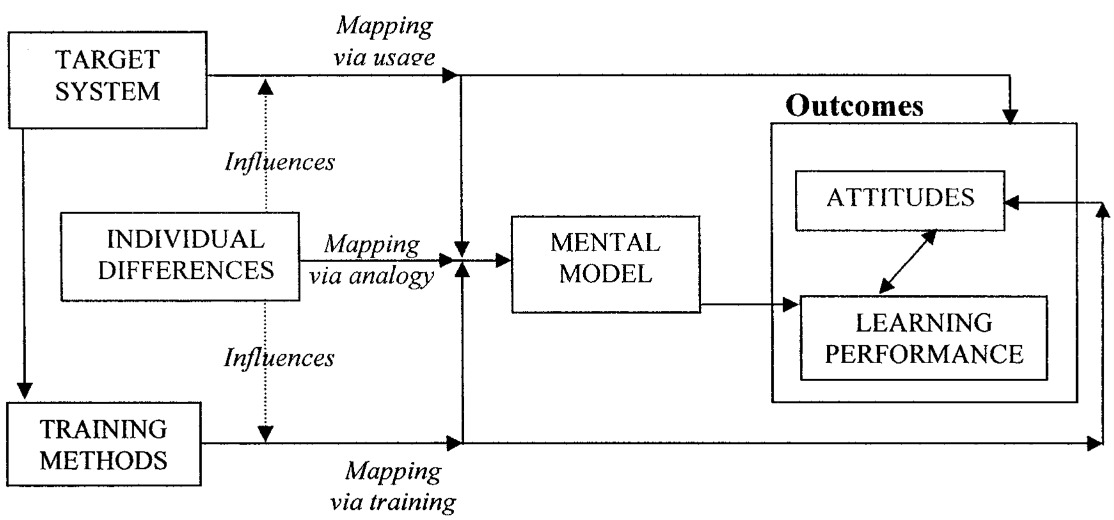


Figure 2.1: Research Framework for instruction guided exploration approach.

In Figure 2.1, five variables with their relationships are identified: The target system, individual differences, training methods, mental model, and outcomes. The target system may include a software package, a learning tool, or an interface. It is what the end user is interacting with and aiming to learn. In the case of a software application with a different type of interface, the user is adjusting his/her knowledge of previous interfaces to understand how the present one functions (Gould and Lewis, 1985). Individual characteristics such as computer competencies have been found to possibly influence learning outcomes (Egan, 1988). Training methods include primarily conceptual and procedural models. By providing a basis for reasoning about the target system, conceptual models facilitate the formation of mental models (Norman, 1983). Mental model describes an individual's internal representation of the system guiding the interaction with the system (Moran 1981, and Payne, 1991). Within the context of the systems interface, an individual having a correct mental model is necessary for accurate performance (Borgman, 1986). Individuals may form mental models by either using the system; by drawing analogies from similar systems they have previously had experience with and/or by training. Outcomes have been identified as being measured through performance and beliefs and attitudes towards the system (Sein et al., 1993). Understanding and learning to perform well indicates that the individuals' mental model is correct. Beliefs and attitudes towards the system can be elaborated using the technology assessment model.

2.2 The Assimilation Theory

During the early nineties there were three types of computer environments: Command-based, direct manipulation and menu-based (Davis et al., 1993). Command-based interfaces require the user to enter and read English-like commands; direct manipulation interfaces allow users to execute commands by clicking on cells on the screen, while menu-based interfaces require the user to run commands by selecting from a list of menus. These interfaces present a model of the computer system. The interface as a model suggests that individuals perceive and learn systems by actually using them (mapping via usage in figures 2.1 and 2.2).

The assimilation theory identifies two ways where an individual can learn: meaningful learning and memorization. Meaningful learning is a process and stored with existing knowledge. This process implies that the individual has gained knowledge. Memorization, on the other hand, utilizes new information in an arbitrary way such that little attention is given to its meaningful connection to existing knowledge. Knowledge that has been memorized is only retained for short periods of time because it is relegated to short-term memory rather than connected to long-term memory where knowledge exists (Ausbel, 1968). The assimilation theory suggests that meaningful learning occurs only if the processes of reception, availability and assimilation take place. First, the individual receives new information and transfers it into short-term memory. The individual then searches in long-term memory for the availability for related information and knowledge that may serve as appropriate anchors, which when found is then transferred from long-term to short-term memory for active usage (Davis and Bostrom, 1993).

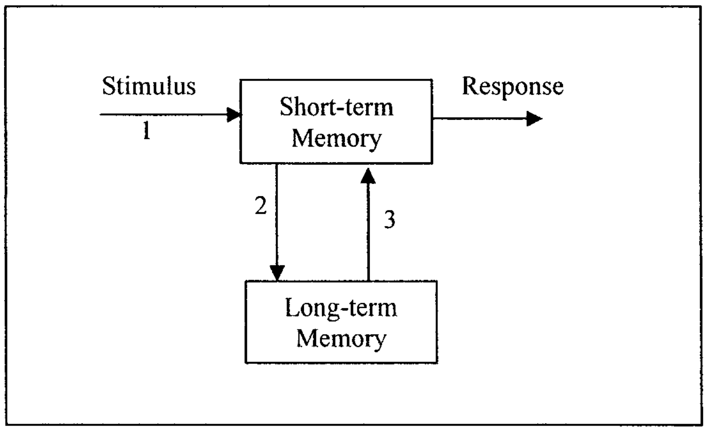


Figure 2.2: Process of Meaningful Learning

The assimilation theory can provide a basis to understand the responses and performance of individuals on the DMI and IBI. From one point of view, in order for an individual to perform well using a new interface, he/she need to access and search long-term memory to retrieve appropriate anchoring ideas and contexts which have been already assimilated as part of the existing knowledge structure. Studies have demonstrated the necessity to search and retrieve ideas from long-term memory for better performance. Providing cues to help retrieve appropriate information was found necessary. Not doing so was shown to result in the inability to retrieve appropriate concepts (Gentner and Gentner, 1983). Also, individuals given a conceptual model in advance of their use of a system performed better in executing the required tasks than those who did not receive a mode (Mayer, 1981).

Based on the propositions derived from the assimilation theory, one would expect that individuals more proficient in using DMI will perform better in executing some tasks using an IBI because the knowledge structure found in the long-term memory is more established, hence accessible for anchoring to those more proficient in using the DMI. The fact that a better DMI user can find and use appropriate anchoring ideas and concepts to perform better suggests that they have the capacity to reinforce, embed and relate (clarify) per-existing knowledge in long-term memory with knowledge of a new software interface.

This study focuses on the direct manipulation interface which we will refer to as an icon-based interface (IBI) and the menu driven interface (MDI) because they represent different views of how users interact with systems especially within graphical software. Research has reported on how the interfaces are superior (for MDI and CBI) however no studies (to the author's knowledge) have compared IBI and MDI in terms of their ease of use, performance and user perception of the target system.

There have been some studies that compared DMI with CBI but were scrutinized because they lacked a strong theoretical background (Hutchins et al. 1986, Davis et al., 1993). This study follows the reasoning of Davis and Bostrom (1993) as the theoretical background and uses the assimilation theory to explain the differences between the MDI and IBI interfaces. Our approach is based on sound and tested theories.

2.3 The Technology Acceptance Model (TAM)

Based on the theoretical work (Theory of Reasoned Action) of Fishbein and Ajzen 1975, Davis 1986 developed the technology assessment model (TAM) which explains computer usage behavior. This work can be viewed as an extension of the outcome variable found in the research framework proposed by Bostrom et al., 1988 (see Figure 2.3). What is significant about TAM is that it identifies five key constructs that can explain user acceptance of a target system and hence actual use. These key constructs given in the TAM as shown in Figure 2.3 are: external variables, perceived ease of use, perceived usefulness, attitude, and behavioral intentions.

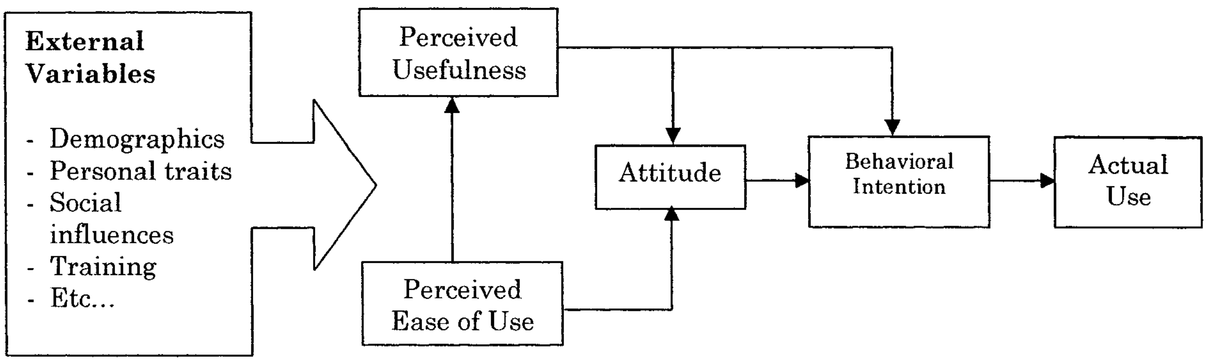


Figure 2.3: The Technology Acceptance Model (Davis et al. 1989)

The TAM (Davis 1989, Davis et al. 1989) explains user acceptance of a technology based on user perceptions (Venkatesh 1999). The goal of TAM (shown in Figure 2.3) is to explain the determinants that influence the attitude and behavior of a broad range of end users of computing technologies. Two beliefs are posited by TAM: (1) Perceived usefulness and (2) Perceived ease of use. Perceived usefulness is defined as subjective probability that using a specific target system will increase his or her job performance. Perceived ease of use refers to the degree to which the user expects the target system to be free from effort. TAM suggests that the actual use of the system is determined by the users' behavioral intention to use the system, which is in turn jointly determined by the users' attitude towards using the system and their perceived usefulness of the system (Davis et al. 1989).

2.4 Interfaces

The interface is the focal point of how users view an application. It consists of everything the user comes into contact with while using the system, whether that may be physically or conceptually (Moran, 1981). Through it, the user makes a judgment on the applications quality and usefulness (Frazier and Cannon, 1987). An interface that is difficult to use results in the inability of the user to interact with the application, hence hampering their efficiency in completing tasks (Kathleen et al., 1996). Software applications interface designs have been keyboard-driven, mouse driven, touch-screen driven or voice-driven. With the exception of keyboard-driven, interfaces have included the use of menus to support features structure.

Most PC users (or End User Computing – EUC) who are not programmers utilize a wide range of information technology (IT) applications to perform basic tasks. Evaluations of the interaction between IT and humans may take many forms ranging from consumer reaction to widespread adoption. The classical human computer interaction (HCI) approach to evaluation attempts to assess usability to describe the quality of IT that needs to be considered in the design process. The EUC domain exhibits a number of problems (Gururajan and Fink, 2002):

- Unsuitability of user experiences from manual systems in computer systems (Moran, 1981),
- Difficulty in recalling syntax (Sein et al., 1993) and interface maps,

- Using unstructured training material leading to negative influences (Gustafson and Branch, 1997) and
- Inability to recover from errors (Olfman and Madviwala, 1995).

End-user training has been argued to be the key factor responsible for EUC success (Sein et al., 1999). Currently, little is known about designing and evaluating effective and efficient end-user training programs. While the burden of success seems to fall onto end-user training, it is not necessarily the only factor of success. Gururajan and Fink (2002) argue that the computer interface is equally important to end-user training. Interfaces can be the difference between systems that are easy and enjoyable to use and systems that are frustrating and confusing, thereby resulting in not being used at all.

A widely accepted user interface design guideline is to provide end-users with consistent interface application programs (Satzinger and Olfman, 1998). This consistency in user interface is thought to facilitate ease of use (Borgman, 1986 and Sein et al., 1999) when using a new application (Bennett, 1986). However, many researchers have challenged the desirability of interface design based on consistency guidelines (Satzinger and Olfman, 1998). They argue that too much emphasis on interface consistency can focus designer attention away from carefully studying and supporting the user's task (Satzinger and Olfman, 1998, and Grudin, 1989). Inevitably, innovative interface devices and interaction techniques will require us to break away from consistent interface standards (Marcus, 1993, Morse and Reynolds, 1993 and Nielsen, 1993).

In this thesis, we investigate effectiveness and performance of two groups of participants such that one is using a menu-driven interface (MDI) while the other is using an icon-based interface (IBI). The MDI follows a consistent Microsoft standard interface, while the IBI uses icons to represent functions. It is worth at this point to review the concepts of consistent and iconic interfaces.

2.4.1 Consistent Interfaces

Consistent user interfaces for application programs has been widely accepted as a guideline to interface design (Nielsen, 1989). Consistent user interfaces across applications may facilitate ease of learning and use across different applications. This can be thought of in the sense that when one application looks and operates similar to another one, a user can draw on existing knowledge when learning the new application (Bennett, 1987). The user's knowledge of an application is often described as a mental model or schema (Borgman, 1989, Gentner and Steven, 1983, Sein et al., 1989) and the process of applying knowledge from one application to another is referred to as transfer of learning (Pelson, 1988).

Consistent user interfaces across applications have been so effective that application developers have attempted to copyright the look and feel of user interface designs (Samuelson, 1993 and 1993). Ease of learning and use has become a critical consideration for information systems managers (Sinha, 1992). At the same time, it has become evident that creating applications that are easy to learn and use is not as straight forward as originally thought of and found to be extremely difficult (Gerlach and Kuo, 1991).

The key to understanding how users perform using consistent interfaces is better understood by looking at the development process of the user's mental model. Learning each computer application is an ongoing process and changes in users knowledge as they interact with the software occurs with each use. To Moran (1981), the user interface consists of everything the user comes into contact with while using the system--physically, perceptually, and conceptually. Generally accepted models of the user interface are based on the concept of human computer interaction (Foley and Van Dam, 1982). Human-computer interaction is viewed as a form of communication between two parties that have quite different sending and receiving capabilities. In this case, the computer is limited to displaying messages and symbols on a screen and is quite limited in usability to receive and interpret information. The human on the other hand, is typically required to specify information for the computer using keys on a keyboard or clicks of the mouse.

Designing the user interface, then, involves designing two languages commonly referred to as the action language and the presentation language (Bennett, 1986). The action language, expressed by the user, is used to tell the computer which operations to perform on the objects in the application. The presentation language is used by the computer to ask about the objects and operations requested and to provide the resulting information. Both languages allow communication about a common task domain.

Foley and Van Dam (1982) developed a four-level model of the user interface. The first level, the conceptual model, defines the task domain about which the user and computer communicate (the objects manipulated, the relationships among objects, and the operations possible to manipulate objects). Levels 2, 3 and 4 define the semantic, syntactic, and lexical levels of the two related languages that are required for communication to occur, respectively.

The action language and the presentation language each have a semantic, syntactic, and lexical level. The semantic level refines the meaning of the words in the language. The semantic level also includes objects defined as part of the presentation language that control or support human interaction, such as a menu object, a dialog box object, or a prompt object. Therefore, the physical implementation details of the user interface begin with the semantic level. The syntactic level defines the grammar used to combine words into sentences. For the presentation language, syntax includes visual arrangement, such as shape and size, and temporal arrangement, such as when objects appear or disappear. For the action language, the syntax defines the sequence of user actions required to complete a message. The lexical level defines the way words in the language are actually expressed. For the presentation language, a word might be expressed by displaying text or symbols using various combinations of font, color, and line. For the action language, a word might be expressed by pressing a particular key or clicking the mouse over a particular object on the screen.

2.4.2 Icon-Based Interfaces

In recent years, imagery for the World Wide Web and e-commerce has become the most important communication medium for consumer product user interfaces. There are many different guidelines for building icon-based interfaces (examples include Easterby & Zwaga, 1980; Carrol & Thomas, 1982; Hemenway, 1982; Lodding, 1983; Gittins, 1986;

Shneiderman, 1987; Waterworth, Chignell & Zhai, 1993). Even though iconic interfaces are common and have distinct advantages (Paivio, 1971; Lodding, 1983; Rogers, 1989), the characteristics that make them attractive and appropriate are not well known (Gittins, 1986; Rogers, 1989; Blankenberger & Hahn, 1991; Garg & Plocher, 1999; Goonetilleke, Shih & Kurniawan, 2001). Icon designs are and can be limited by implementation constraints and sometimes are restricted by those that are in existence already, thereby lacking originality in some sense (Gittins, 1986). For the most part, elegance and simplicity have governed the selection of elements for visual design.

Icons have evolved from the concept of signs, which are defined as something that stands to someone for something in some respect or capacity' (Peirce, 1932). Hence, Peirce viewed a sign as a product of a three-way interaction between the representamen (that which represents), the sign's object (that which is represented) and its mental interpretant (the process of interpretation).

Horton (1994) indicated that icons alone are meaningless without a particular context and suggested the following relationship for icons:

Iconic → context → viewer (or interpretant) → meaning

The Interpretant-Object relationship is more difficult to penetrate since it is an inherent function of the person (intepretant) or culture. Interpretation also called expression is the process of understanding the meaning of a sign. It is the same as identifying the relationship between the object and the representament. Since each person (interpretant) is unique and possesses a certain cultural and social bias, the mental model to recall an object by the representamen can be very different for each person (Bourges-Waldegg & Scrivener, 1998; Choong & Salvendy, 1998).

The function of representation involves emphasizing the relationship between the representament and the object that is represented. In this relationship, the electiveness of the representation depends on what is represented and how it is represented. Waterworth et al. (1993) found that the icon design process is still artistic in nature. There are many different classification schemes for icons (e.g. Smith, Irby, Kimball & Verplank, 1982; Lodding, 1983; Jervell & Olsen, 1985; Gittins, 1986). Historically, in the context of what is to be represented, semiosis (the sign process) has been limited to representing only objects. The reasons may be two-fold:

- Firstly, an icon has been considered to be a graphical symbol to represent objects in a computer system (Gittins, 1986).
- Secondly, icons have evolved from pictorial representations of objects even though, in recent times, software developers have extrapolated the concept of an icon to go beyond object and encompass actions (Blankenberger & Hahn, 1991; Galitz, 1996).

However, actions (verbs) manipulate objects in specific ways and are not easily represented compared to their counterparts, the objects (nouns) (Apple Computer, 1996). Hence, what should be represented becomes difficult if the icon is to convey meaningful information in the simplest way so that the image possesses perceptual immediacy. In this respect, Mullet and Sano (1995) have suggested three principles for simplicity.

An established way to design icons is based on unifying individual icons into a collective metaphor (Gittins, 1986). Thus, icons are meant to correspond with real objects with which the users are familiar. Limitations may arise due to a lack of a direct mapping between the real objects and the system objects. An even greater problem arises if icon designers use the same or similar metaphor in different contexts thereby causing confusion for the users. Even though the same concept can be applied at a lower level to individual icons, unification to produce a coherent whole is generally perceived to result in an increase in the GUI density and thus, simplicity has been achieved only through a minimization of parts (or elements) rather than by true unification.

How the object is represented depends on the semantics (intended meaning of the sign), which addresses the direct relationship between the representamen and the sign object.

1. Representation icons that typically represent images of the object.

2. Abstract icons that attempt to visualize a concept that is not far from the concrete image.

3. Arbitrary icons that have no obvious reference to their intended meaning.

A fourth form of representation is the use of text. Apple Computer (1996) has suggested that text should not be used in icons, as text is often confusing. However, Horton (1994) has indicated that icons and words are not enemies and are not mutually exclusive. Kacmar and Carey (1991), and Egido and Patterson (1988) have shown that text and graphics together improve performance. In addition, the text in languages such as

Chinese and Japanese is somewhat graphical and its appropriateness is worthy of consideration (Choong & Salvendy, 1998; Goonetilleke et al., 2001).

What an icon represents may not be obvious when one encounters it the very first time even though it may be possible to guess the meaning. In this respect, a component that has somewhat been neglected in relation to icons, but could improve the represenatmin-interpretant relationship, is user training. Somberg (1987), Anderson (1990) and many others have shown that practice does improve user performance with menu-driven systems. Training can help impart the designer mental model for ease of understanding. Thus, we hypothesize that learning through the design process (or making the design process visible) with a short period of training can convey the designer mental model of the icon meaning quite electively. Galitz (1996) has indicated that getting accustomed to graphical user interfaces may require about 8 h of training while other experts estimate the learning time to be in the order of 20 or 30 h.

3. Theoretical Framework and Hypotheses

This study focuses on the effect of computer experience with two different types of interfaces on user task completion time and its influence on beliefs. The types of interfaces are the MDI and the IBI. These interfaces represent different views of how users interact with a target system. Some research has reported on how menu driven interfaces are superior however, to the best of the author's knowledge, no studies were found that have compared menu driven interfaces with the increasingly popular icon based interfaces. There have been some studies that compared direct manipulation interfaces with command based interfaces but were scrutinized because they lacked a strong theoretical background (Hutchins et al. 1986, Davis et al., 1993). This study follows the reasoning of Davis and Bostrom (1993) and uses the assimilation theory to explain interface-performance relationship.

Since the seventies, IS research has contributed to a better understanding of this process and its outcomes. The early efforts concentrated on the identification of factors that facilitated IS use. This produced a long list of items that proved to be of little practical value. It became obvious that, for practical reasons, the factors had to be grouped into a model in a way that would facilitate analysis of IS use (Legris et al., 2003).

In 1985, Fred Davis suggested the technology acceptance model (TAM). It examines the mediating role of perceived ease of use and perceived usefulness in their relation between systems characteristics (external variables) and the probability of system use (an indicator of system success). More recently, Davis proposed a new version of his model: TAM2. It includes subjective norms, and was tested with longitudinal research designs. Overall TAM and TAM2 explain about 40% of system's use. Analysis of empirical research done by Legris et al. (2003) using TAM, shows that results are not totally consistent. This suggests that significant factors are not included in the models. They conclude that TAM is a useful model, but has to be integrated into a broader one which would include variables related to both human and social change processes, and to the adoption of the innovation model.

The assimilation theory can provide a basis to understand the responses and performance of individuals on the MDI and IBI. In the context of our work, in order for an individual to perform well using a new interface, he/she needs to access and search long-term memory to retrieve appropriate anchoring ideas and contexts which have been already assimilated as part of the existing knowledge structure. Therefore, an individual who is using an IBI for the first time and has good overall computer graphics skills may complete a task relatively fast, in comparison to a less skilled user, because he/she is able to access and retrieve appropriate pre-existing anchoring ideas and concepts from long term memory. Studies have demonstrated the necessity to search and retrieve ideas from long-term memory for better performance. Individuals given a conceptual model in advance of their use of a system performed better in executing the required tasks than those who did not receive a model (Mayer, 1981). Therefore, individuals that have good overall computer skills or graphic skills using different software will perform better.

Based on the propositions derived from the assimilation theory, one would expect (as suggested by the assimilation theory) from individuals that have more experience with graphical software to perform better using the IBI used in this study. The fact that a better IBI user can find and use appropriate anchoring ideas and concepts to perform better suggests that they have the capacity to reinforce embed and relate (clarify) per-existing knowledge in long-term memory with knowledge of a new software interface.

According to Davis et al., there are some external variables that affect perceived usefulness and perceived ease of use. One of these external variables is "personal traits". One of the personal traits we selected in this study is "experimentation traits". The reason is, compared to the traditional MDI, IBI is more graphical and consists of new elements and new methods. Therefore individuals who like to experiment may find that using IBI is easier and IBI is more useful.

Gender, has been studied in many research as one of the key elements that influence the perception and performance in using technology. Women are narrowing the gender gap in science and math, but not in technology (Closing the Gender Gap: Gender Gaps Fact Sheet, 1997). Research has shown that perceptions begin to slowly change in upper elementary grades when girls tend to view the computer as a tool to complete a task, while boys begin playing games and establishing a "friendship" with their computer (Fiore, 1999). Besides the difference in perception on technology, the technical expertise required to establishing access to technology, and the interfaces users encounter when they are using technology can be significant deterrents to perception and performance for non-technical users. While graphical user interfaces can significantly ameliorate this problem, they are system specific, more straightforward and a situation which can hamper access for small or community organizations and lower income individuals who can only afford older and non-standard equipment, if at all. (Hoai-An Truong, 1993) According to the previous research, female should have higher positive perception in an icon base interface and with the graphical user interface, they should perform better.

Figure 3.1 shows the research model proposed by Bostrom et al. (1988) as it applies to our present research framework. The black boxes identify the components used in the present study. Figure 4 (black boxes considered only) describes the influence of the target system on the outcomes. In the context of our study, the following components apply:

The target system: The target system is a software interface. More specifically, we consider two different interfaces, a Menu Driven Interface (MDI) and an Icon Based Interface (IBI) for the same application.

Individual differences: Individual differences include two types of user computer competencies. Considering that individuals may be familiar with either MDI or IBI, the two types of computer competencies used in this study were overall computer skills and graphic skills.

Training methods: Training methods variable was not used in this study because it never took place. The study did not train individuals nor considered the training variable. The primary focus was on investigating the computer competencies, belief and performance relationships for the two interfaces.

Mental model: The mental model variable uses the assimilation theory to help us understand the differences in performances found based on user computer competencies and interface type.

Outcomes: The user-interface interaction is studied from the perspective of beliefs and performance. Beliefs are associated with the outcomes component of the research framework shown in figure 4 and is based on the technology assessment model described in the previous section. Performance is associated with the time a user takes to complete a predetermined task (task time).

This study focuses on the effect of two different types of interfaces, namely menu driven interface (MDI) and the icon based interface (IBI), on user performance. These interfaces represent different views of how users interact with a target system. Research has reported on how menu driven interfaces are superior. However, no studies (to the authors' knowledge) have compared menu driven interfaces with icon based interfaces in terms of user perceptions.

There have been some studies that compared direct manipulation interfaces with command based interfaces but were scrutinized because they lacked a strong theoretical background (Hutchins et al. 1986, Davis et al., 1993). This study follows the reasoning of Davis and Bostrom (1993) and uses the assimilation theory to explain interface-performance relationship.

The assimilation theory can provide a basis to understand the responses and performance of individuals on the MDI and IBI. In the context of our work, in order for an individual to perform well using a new interface, he/she need to access and search long-term memory to retrieve appropriate anchoring ideas and contexts which have been already assimilated as part of the existing knowledge structure. Therefore, an individual who is using an IBI for the first time and has good overall computer skills may complete a task relatively fast because he/she is able to access and retrieve appropriate pre-existing anchoring ideas and concepts from long term memory. Studies have demonstrated the necessity to search and retrieve ideas from long-term memory for better performance. Individuals given a conceptual model in advance of their use of a system performed better in executing the required tasks than those who did not receive a model (Mayer, 1981). Therefore, individuals that have a good overall computer skills or graphic skills using different software will perform better.

Based on the propositions derived from the assimilation theory, one would expect that individuals more proficient in using MDI will perform better in executing some tasks using an IBI because the knowledge structure found in the long-term memory is more established, hence accessible for anchoring to those more proficient in using the MDI. The fact that a better MDI user can find and use appropriate anchoring ideas and concepts to perform better suggests that they have the capacity to reinforce, embed and relate (clarify) per-existing knowledge in long-term memory with knowledge of a new software interface.

The assimilation theory may be useful in explaining performance in a learning context and where users undergo training. However, beliefs and how the interface is perceived can play an important role in the acceptance of the software as it is controlled by the software interface. In this study, we selected two external variables, overall computer skills and graphic skills, to demonstrate how users' experiences in using software with standard and non-standard interfaces can influence performance directly and indirectly via the beliefs constructs. It would be expected that users with a lot of overall computer skills (with standard menu driven interfaces) will perform better in the MDI and less well in the IBI. The reverse is true for users with graphic skills. The question that is interesting to ask is how better or worse do users perform with non-matching user interfaces? Specifically, what is the difference between H8 in MDI and H5 in IBI. The assimilation theory in this case could prove to be useful in shedding some light into interface characteristics and effectiveness. Finally, whether beliefs are shaped by overall computer skills and graphic skills important to understand due to the fact that beliefs in turn influence acceptance and hence possibly performance (a user that resists a new software for whatever the reason, will perform weakly).

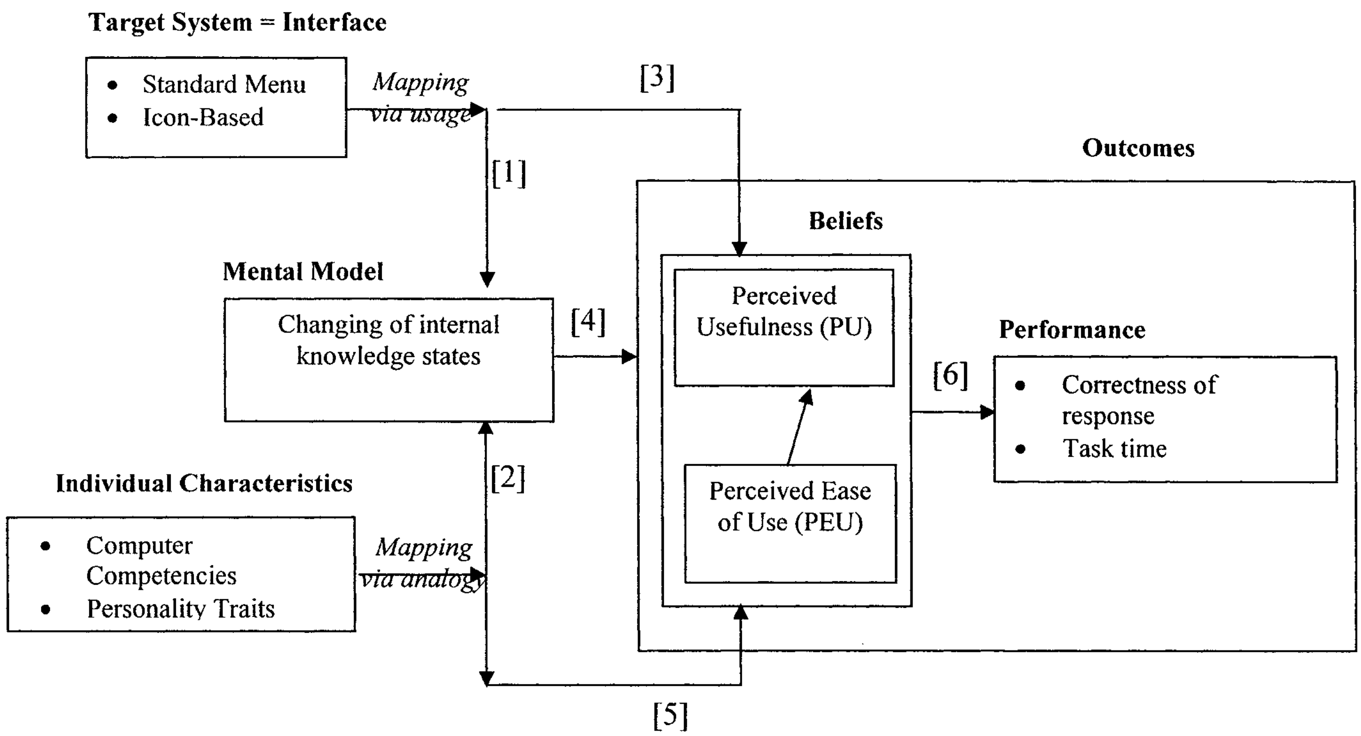


Figure 3.1: Research Framework for instruction guided exploration approach.

Based on the above discussion we posit the following hypotheses:

1. General computer skill has a significant positive influence on perceived ease of use for both MDI and IBI.

2. General computer skill has a significant negative influence on task completion time using MDI but not on task completion time using IBI.

3. Frequency of using Internet has significant influence on task completion time using both IBI and MDI.

4. Knowledge to general office software applications that usually have MDI as interface has significant influence on task completion time using MDI but not IBI.

5. Computer graphic skill it has a significant influence on perceived ease use for IBI but not for MDI.

6. Computer graphics skill has significant influence on task completion time using MDI and IBI.

7. Knowledge to software that has IBI as interface has significant influence on task completion time using IBI but not MDI.

8. Perceived ease of use has positive influence on perceived usefulness for both MDI and IBI.

9. An experimentation trait has more significant influence on Perceived Usefulness for IBI than for MDI.

10. An experimentation trait has more significant influence on Perceived Ease of Use for IBI than for MDI.

11. An experimentation trait has more significant influence on Performance for IBI than for MDI.

12. There is a significant interaction between gender and interface.

13. MDI improves Performance over IBI for the same application.

14. Males perform better (will have lower task completion times) than Females.

4. Methodology

The overall approach taken to investigate the hypotheses was via (1) the completion of tasks using the software that has the capability of switching between the two different interfaces (MDI and IBI) and (2) an empirical test using a survey instrument for data collection (experience with MDI and IBI, computer competencies and beliefs).

4.1 Subjects and Procedure

Students from Concordia University, John Molson School of Business, Montreal, Canada, were asked to use one of either the MDI or IBI. A coin was flipped to decide on the type of interface the participant would use. Upon completion of the computer tasks, the participants were asked to complete a questionnaire containing 28 questions. A total of 68 participants followed a set of instructions which required them to execute the following 5 tasks. These instructions are:

> Using the "menus on top of the screen only and without using the buttons on the left of the screen" try to perform the five simple tasks listed below. Your experiment supervisor will start the digital timer as soon as you are ready to start. Take as little or as long a time to finish the tasks properly. Please ask the supervisor to stop the timer as soon as you finish every task. If you absolutely cannot perform a specific task, please let the supervisor know about it then jump to the next task.

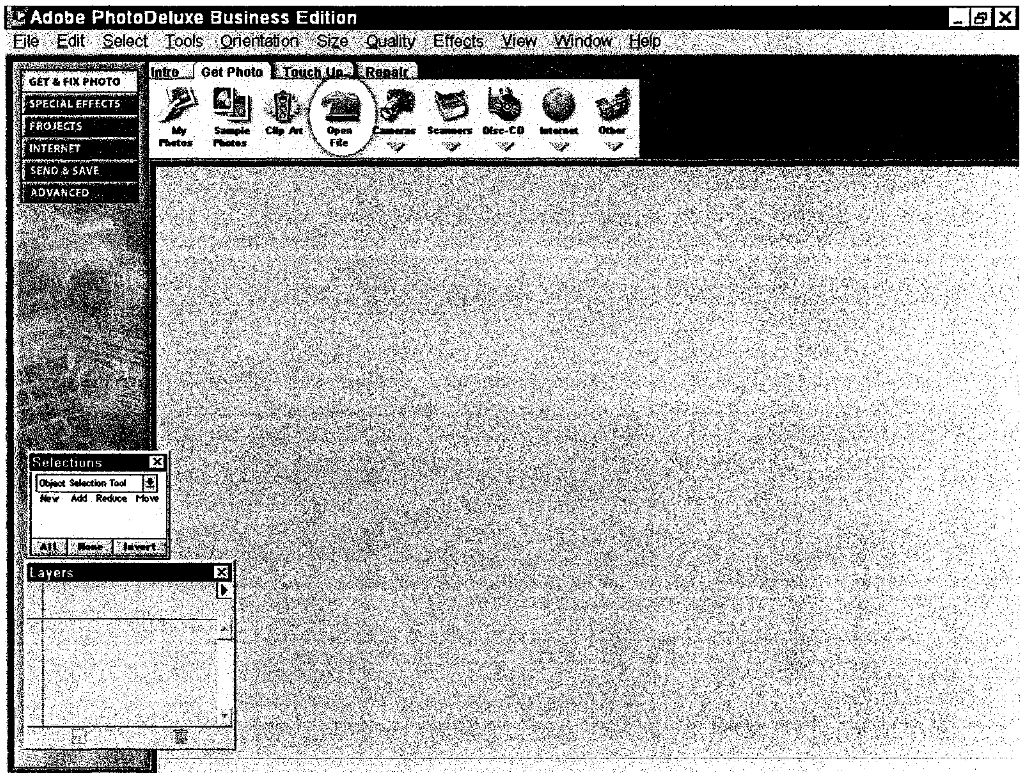
Table 4.1: Instructions to complete the five required tasks.

Task	Instructions
1	From the <Concordia> folder on the <C> hard drive (root directory) open a file named: corvette.jpg. Ask the supervisor to note the time.
2	Convert the picture to black and white. Ask the supervisor to note the time.
3	Flip the picture horizontally. Ask the supervisor to note the time.
4	Make the picture "grainy" by adding noise to it. Ask the supervisor to note the time.
5	Save your picture in the <experiment> directory on the <C> drive root directory. Save as JPEG format. Name it with your code. Ask the supervisor to note the time.

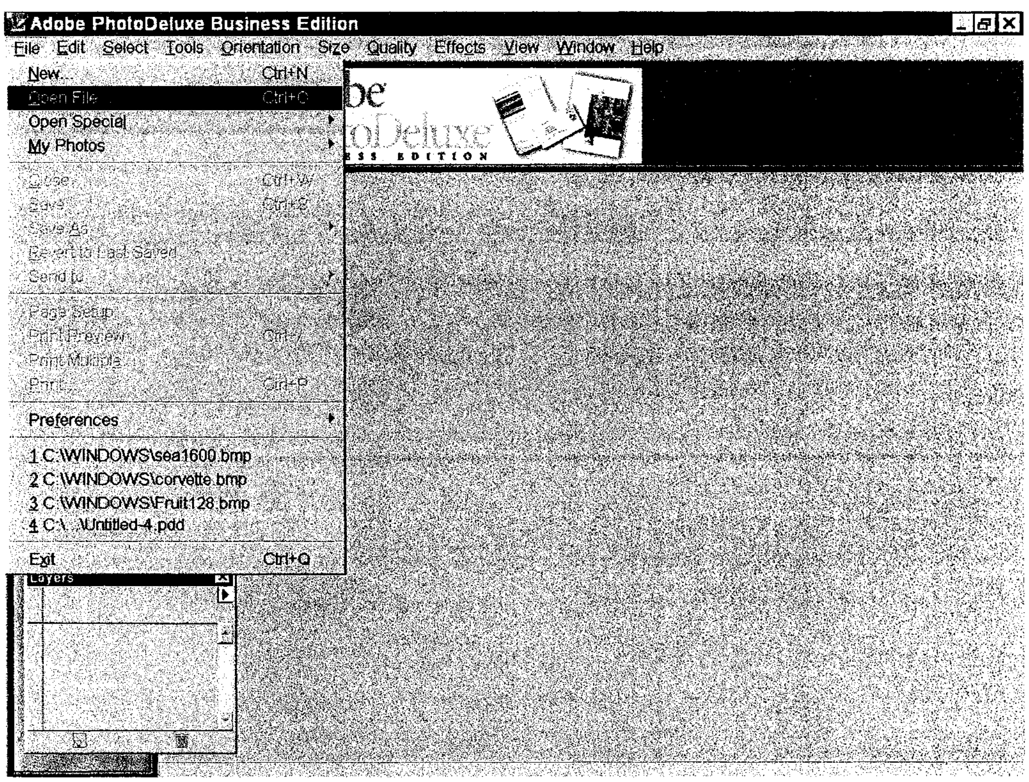
While the participants were doing the tasks, a research assistant logged the start of the session using a stopwatch and monitored their activities by logging the time of completion of each task. As a result, five time variables representing the completion time of each task were collected.

The 68 participants consisted of 41% females and of 59% males. Table 2 shows the basic characteristics of the participants. On average, the students sample represents a group: with an average age of around 26 years, comfortable in English and finish junior CEGEP.

plate 1: step 1 screen shots from MDI and IBI interfaces

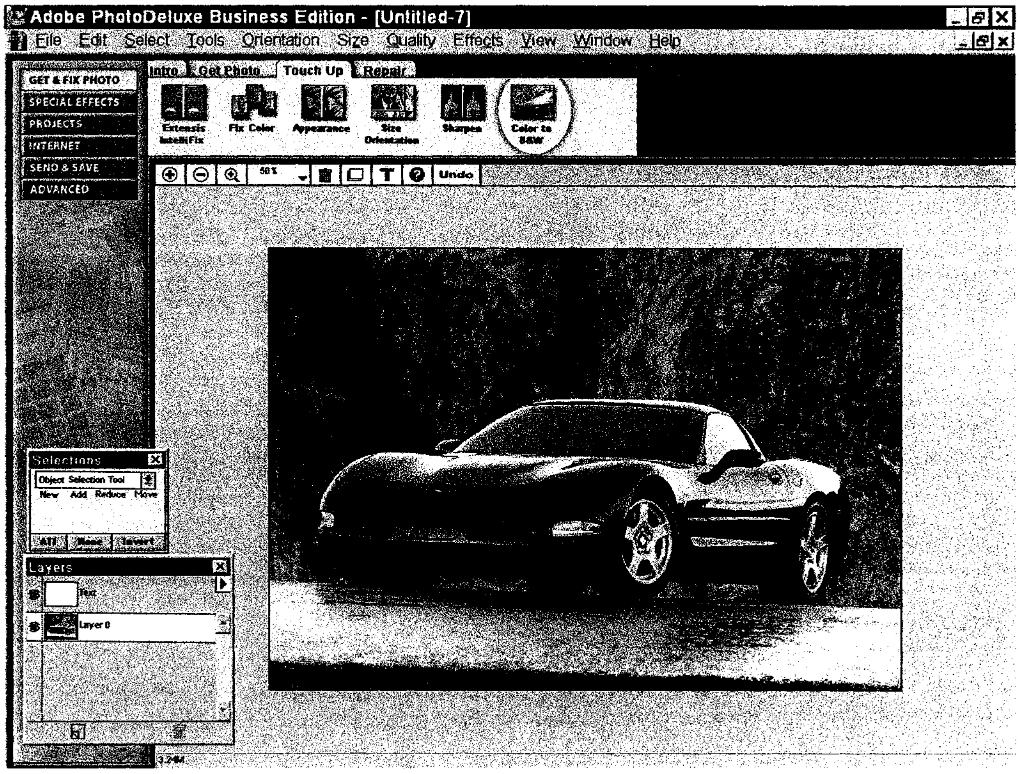


To Open a file in the IBI: Click on the <get and Fix photo> category button. Followed by <Get Photo> tab on top, followed by <Open File> Icon.

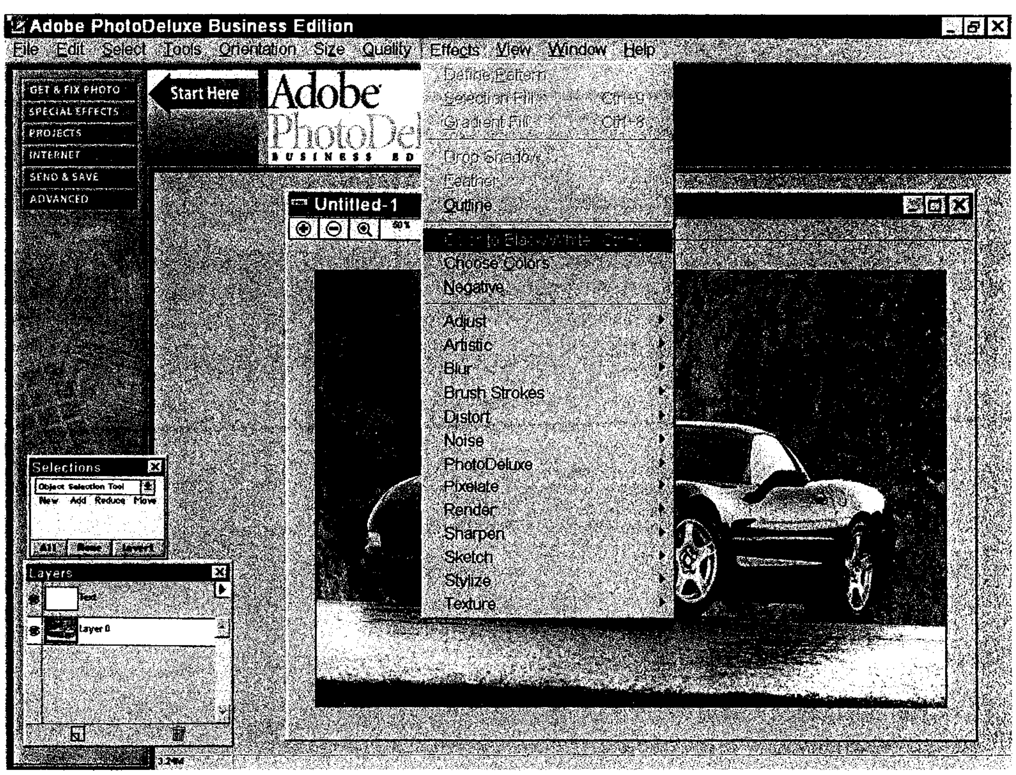


To open a file in the MDI: from the <File> menu choose <Open File>.

plate 2: step 2 screen shots from MDI and IBI interfaces

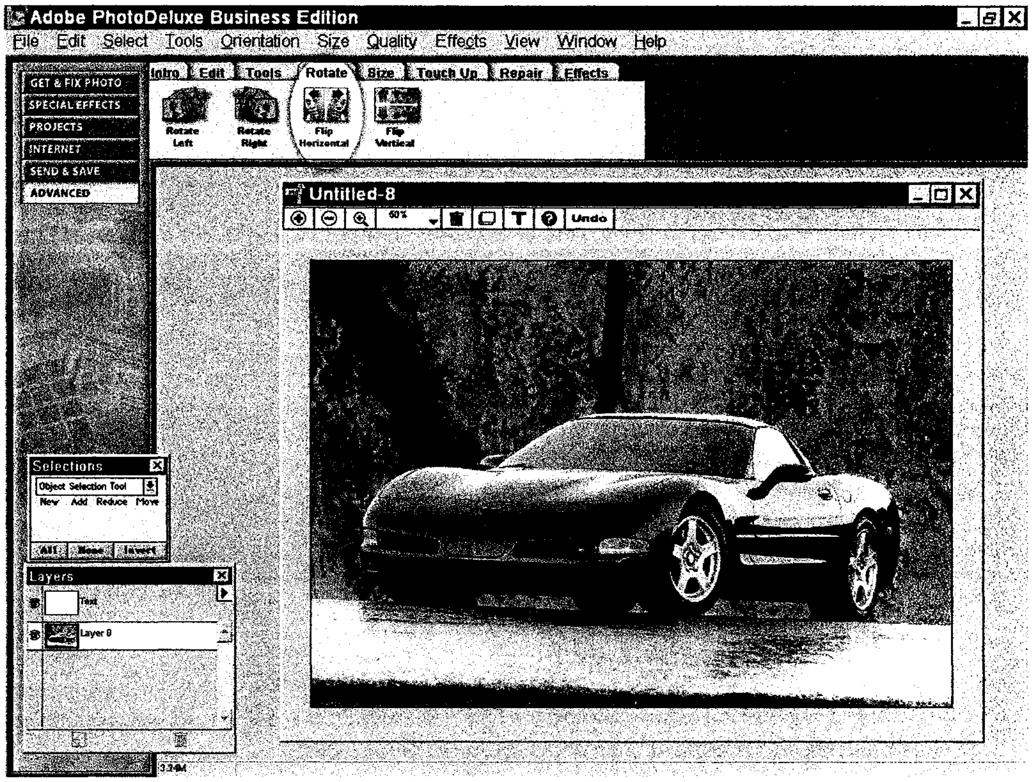


To convert the picture to Black and White in the IBI: Click on the <get and Fix photo> category button. Followed by <Touch up> tab on top, followed by <Color to Bl&W> Icon.

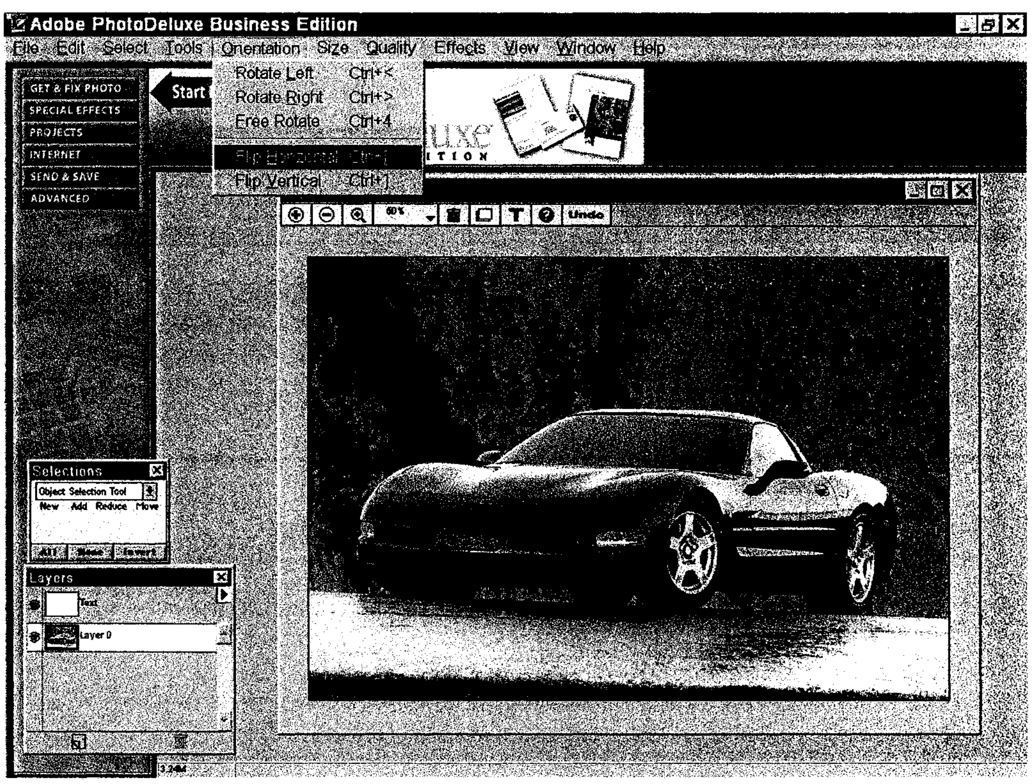


To convert the picture to Black and White in the MDI: from the <Effects> menu choose <Colo to Black/White>.

plate 3: step 3 screen shots from MDI and IBI interfaces

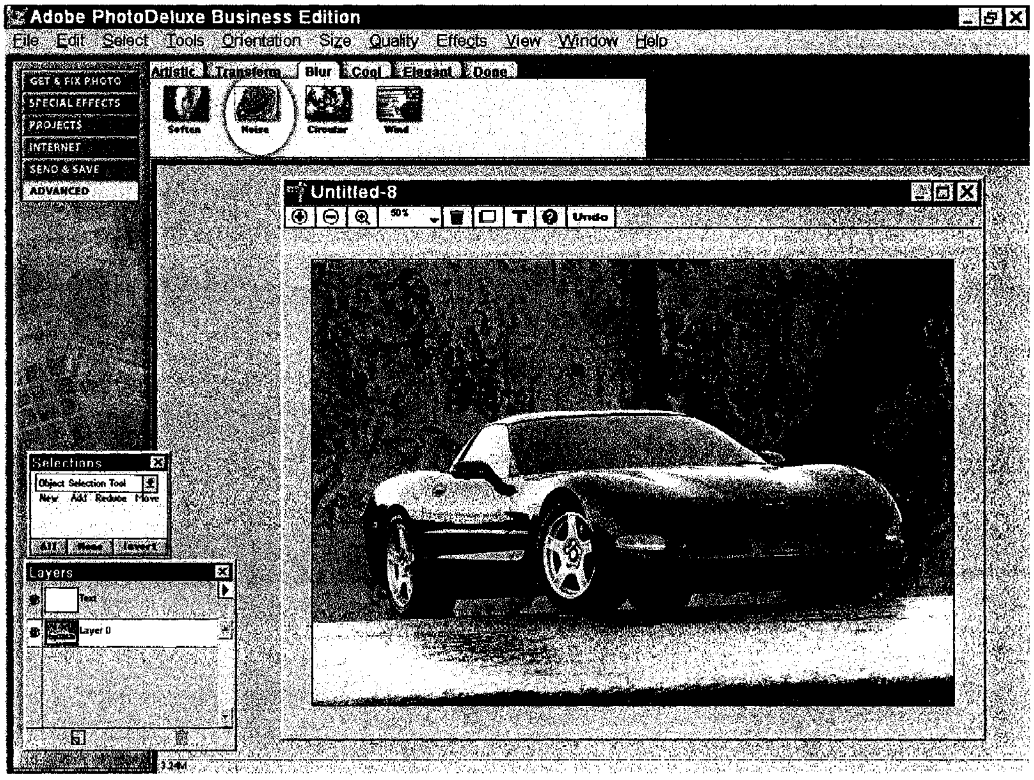


To Flip the picture horizontally in the IBI: Click on the <Advanced> category button. Followed by <Rotate> tab on top, followed by <Flip Horizontal> Icon.

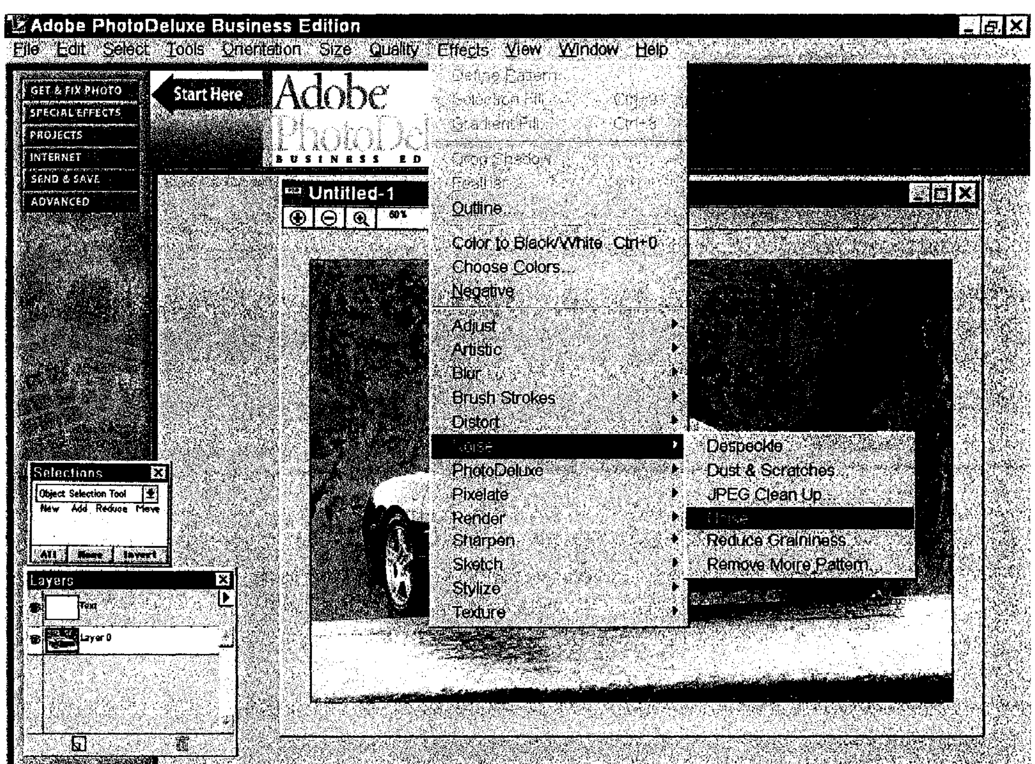


To Flip the picture horizontally in the MDI: from the <orientation> menu choose <Flip Horizontal>.

plate 4: step 4 screen shots from MDI and IBI interfaces

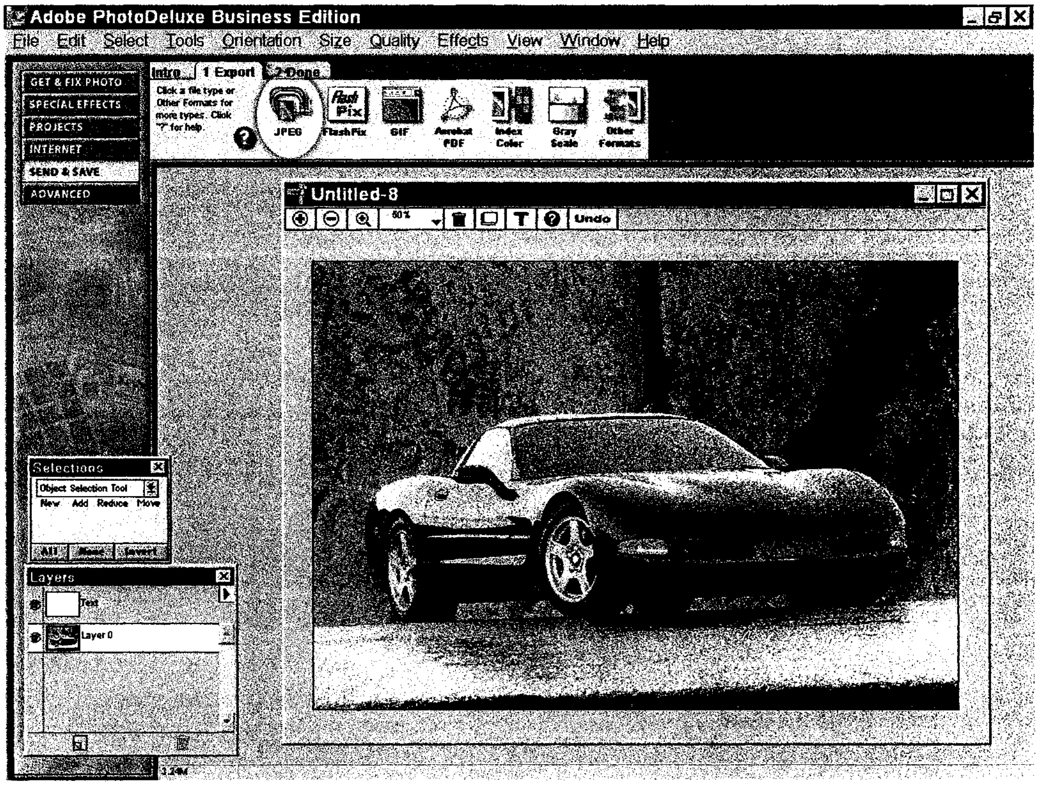


To add noise to the picture in the IBI: Click on the <Advanced> category button. Followed by <Blur> tab on top, followed by <Noise> Icon.

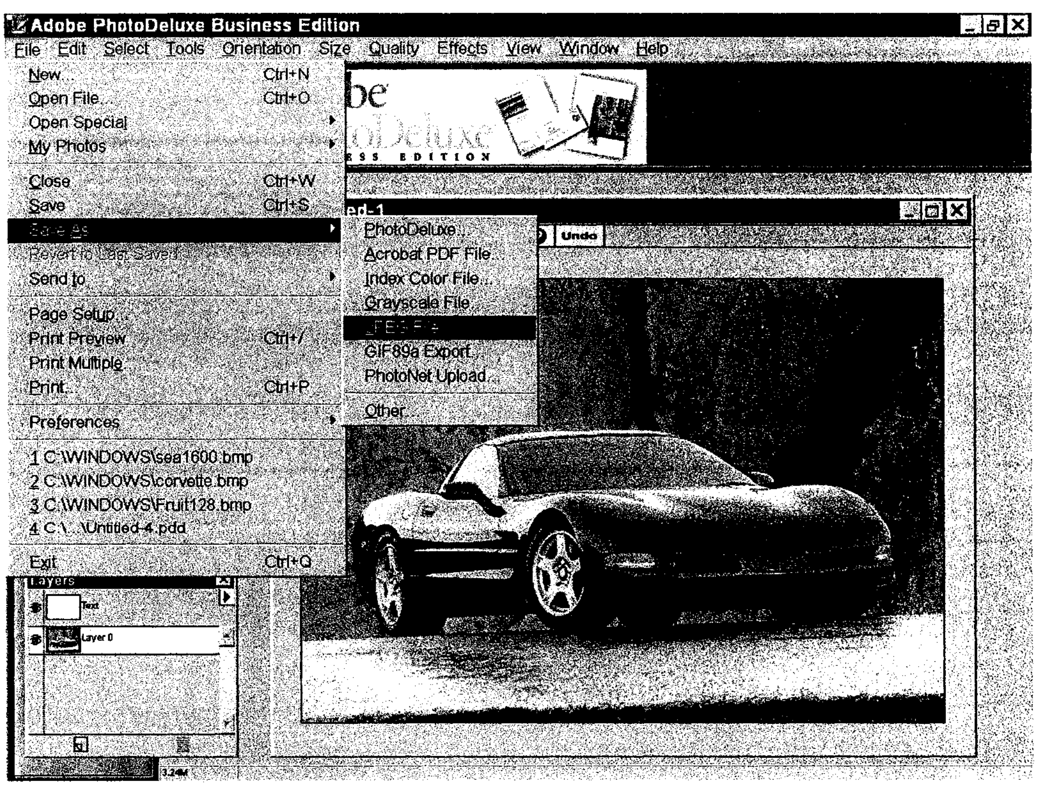


To add noise to the picture in the MDI: from the <Effects> menu choose <noise> followed by <noise> again from the submenu.

plate 5: step 5 screen shots from MDI and IBI interfaces



To save the picture as JPEG in the IBI: Click on the <Send and Save> category button. Followed by <Export> tab on top, followed by <JPEG> Icon.



To save the picture as JPEG in the MDI: from the <File> menu choose <save as> followed by <JPEG file> from the submenu.

4.2 The Software

Adobe Photo Deluxe 1.0 was used for both types of interfaces (Figure 4.1 and 4.2). This consumer photo editing software has the rare, if not unique, ability to let the user chose between a standard menu-driven interface, and a more graphical icon-based interface. Functionality of the software is not affected by switching between the two interfaces. Therefore, this software allowed the authors to study the effects of variations of interface type on constructs of interest, while keeping all other variables constant.

The MDI shown in figure F.1 is a standard type of interface consistent with Microsoft software products. All participants are familiar with the MDI due to their use of Microsoft Office. The menu component of the interface includes Microsoft standard menus such as file, edit, view, tools, window and help as well as image editing specific menus such as select, orientation, size, quality, and effects.

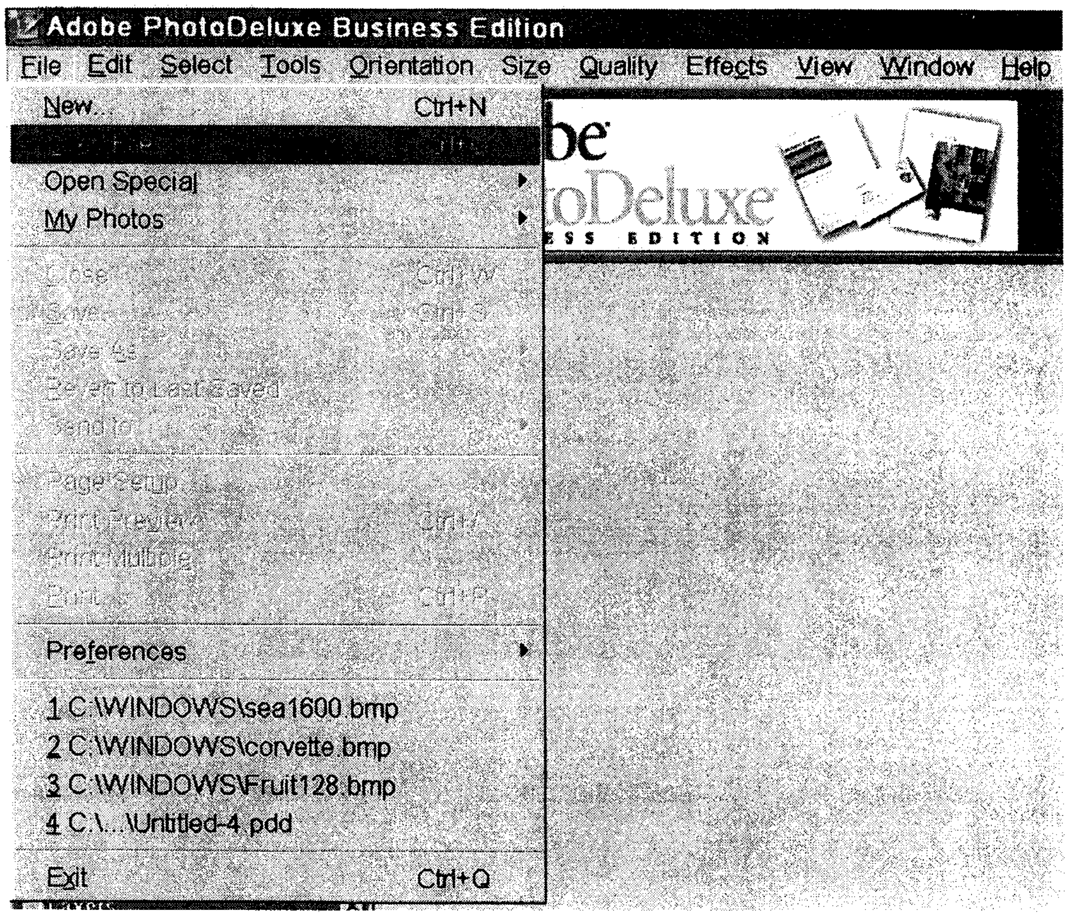


Figure 4.1: The Menu-Driven Interface.

The interface of PhotoDeluxe is strongly task-based. As shown in Figure 4.2 below, at the top-left hand corner is a panel containing six buttons. These buttons represent the major workflow components in the correct sequence, from getting a photo into the software to printing it in the desired format. By clicking on a button, the software guides you through a set of tasks shown as thumbnail choices across a horizontal top panel. Relevant help and access to necessary tools and commands are made available throughout the process. In effect, the IBI is designed to guide you through each activity rather than leave you to hunt through the menus and help system.

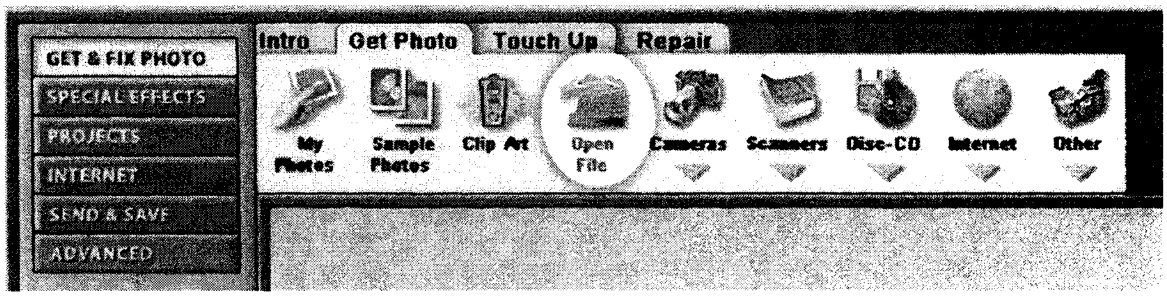


Figure 4.2: The Icon-Based Interface

It is important to point out that compared to the MDI, the IBI provides guidance to the user at the cost of creative freedom. This is not necessarily disadvantageous for all users. One could argue that for businesses, users are less interested in experimentation and are more focused on completing a predetermined objective for their image manipulation, which makes the IBI more appropriate for them.

4.3 The Questionnaire

The items included in the post-experiment questionnaire fall under one of the following four categories: (1) Demographics, (2) Computer competencies (3) TAM based belief constructs and (4) construct representing personality traits used in psychology research and which were used here for exploratory analysis.

Table 4.2 Demographic variables and choices

Variable	Choices
Age	1. 18-24, 2. 25-34, 3. 35-49, 4. 50-65
Education	1. Finished high School, 2. Finished CEGEP, 3. Finished University, 4. Finished Graduate studies (masters, Ph.D.)
Proficiency in English	From 1 (I manage) to 7 (I'm very comfortable)

The descriptive statistic on the demographic variables is attached in Appendix A.

(2) Computer competencies

Table 4.3: Computer competencies construct items.

Construct	Code	Item
Computer Skills (CS)	CS1	My general computer skills are: (Novice – Expert)
	CS2	I used at least one of the following software (never – everyday): Lotus 123 for DOS, word perfect for DOS, dBase III, DOS WordStar for DOS.
	CS3	The number of Internet sites I usually visit is (small – very large)
	CS4	I have (little – considerable) knowledge about at least on of the following software products: MS Word for windows, MS Excel, Word Perfect for windows, Visual Basic.
Graphic Skills (GS)	GS1	My computer graphics skills are: (Novice – Expert)
	GS2	I am (little – very) familiar with at least one of the following software: MS Encarta (or other encyclopedias), Kai's power tools, Fractal Design Painter, Factal Design Dabbler, Softimage Digital Studio.

(1) TAM-based belief constructs

Validated constructs adopted from different relevant prior research work (Davis and Venkatesh, 1996) were operationalized such that the wording of items was changed to account for the context of the study. All items shown in table 3 were measured using a 7-point Likert-type scale with anchors for most of the questions from "Strongly disagree" to "Strongly agree". The questionnaire included items worded with proper negation and a shuffle of the items to reduce monotony of questions measuring the same construct.

Table 4.4: TAM belief constructs items.

Construct	Code	Item
Perceived Usefulness (PU)	PU1	Using ADOBE PHOTO DELUXE would reduce my efficiency in basic photo editing. (Strongly disagree -- Strongly agree)
	PU2	Using ADOBE PHOTO DELUXE would reduce my ability to do basic photo editing. (Strongly disagree -- Strongly agree)
	PU3	Using ADOBE PHOTO DELUXE would make basic photo editing interesting. (Strongly disagree -- Strongly agree)
	PU4	Using ADOBE PHOTO DELUXE would let me feel that I control the basic process of photo editing. (Strongly disagree -- Strongly agree)
Perceived Ease of Use (PEU)	PEU1	I would find it easy for me to use ADOBE PHOTO DELUXE to finish my basic photo editing. (Strongly disagree -- Strongly agree)
	PEU2	It would be easy for me to become skillful at using ADOBE PHOTO DELUXE. (Strongly disagree -- Strongly agree)
	PEU3	I think that the process of using ADOBE PHOTO DELUXE to do photo editing is clear and understandable. (Strongly disagree -- Strongly agree)
	PEU4	I would find ADOBE PHOTO DELUXE easy to use. (Strongly disagree -- Strongly agree)

(2) Psychological constructs representing personal traits

The second group of questions was composed with the objective to measure personal experimentation traits.

Table 4.5: Personality traits construct items.

Construct	Code	Item
Experimentation Traits	ET1	In general, when I travel, I like to always go back to the same places I tried and known before. (Strongly disagree -- Strongly agree)
	ET2	I like to meet new people and make new friends, when I have the time. (Strongly disagree -- Strongly agree)
	ET3	I would be motivated to try the latest version of my favorite software, or even a different company's version. (Strongly disagree -- Strongly agree)
	ET4	I would feel uncomfortable if I wear the latest in fashion clothing. (Strongly disagree -- Strongly agree)
	ET5	In general, I enjoy trying different types of international cuisine. (Strongly disagree -- Strongly agree)

4.4 Analytical technique

The analytical techniques used in this study are Exploratory Factor Analysis, Confirmatory Factor Analysis, Regression, and ANOVA.

Exploratory factor analysis (EFA).

EFA is used to create factor model from the data. EFA is applied to constructs ET, CS and GS. Correlation matrix is used in the EFA to summarize the relationships between pairs of observed variables. The unrotated factor pattern matrix then represents the factor model without rotation, and the adequacy of this factor model is determined by examining the scree plot of the eigenvalues. Then, rotation is applied to the first factor model to generate a second factor model with items identified more strongly with one or the other factor. Finally, those items with low factor loading are dropped from the model and the remaining items are tested again by using EFA.

Confirmatory factor analysis (CFA).

CFA is applied to construct PU and PEU. The Cronbach's Alpha was used to assess scale reliability and confirmatory factor analysis was used to assess construct validity for the variables used in this research. This type of analysis lets researchers statistically control for the influences of other variables in the model so that they can examine the unique contribution made by each variable of interest (Morris, G. M. and Dillon, D., 1997)

Regression

The analytical technique used in this study to test the TAM model hypotheses was single regressions.

ANOVA

Finally, for the data, a 2 (gender) x 2 (interface) and a 2 (ET) x 2 (interface) -- two-way repeated measure analysis of variance (ANOVA) were conducted. The ANOVA is used to examine how the gender and experimentation traits affect PU, PEU, and P in the different interfaces.

5. Results and Analysis

5.1 Exploratory Factor Analysis

Exploratory factor analysis (EFA) mathematical criteria based on the previously outlined assumptions are used to create factor models from the data. It simplifies the structure of the data by grouping together observed variables that are intercorreclated under one "common" factor.

It is important to choose a proper FA method to conduct the EFA effectively. Although principal axis factoring has been the most widely used method in the past, maximum likelihood (ML) has a number of desirable features that make it the currently preferred method for conducting exploratory factor analysis. ML estimation methods have been shown to be robust to mild to moderate departures from normality in generating appropriate factor solution (Boomsma, 1987). It attempts to find the most likely population parameter estimates that produced the observed correlation matrix, assuming that the observed correlation matrix is from a sample drawn from a multivariate normal population (Lawley and Maxwell, 1963). Therefore in this study, we apply ML in the factor analysis.

5.1.1 Correlation Matrix

A matrix is a two-dimensional representation of correlation among a set of observed variables. EFA generally proceeds from a correlation matrix summarizing relationships between pairs of observed variables. By eyeballing a correlation matrix, often one can partially determine a common factor structure by seeing what observed variables clump together as one possible factor and which ones may form another factor.

Table 5.1 consists of 13 questionnaire items regarding the personality traits, computer skills and computer graphic skills of the participants.

Table 5.1: Correlation Matrix

	ET1	**ET2**	**ET3**	**ET4**	**ET5**	**CS1**	**CS2**	**CS3**	**CS4**	**GS1**
ET2	0.067									
P-Value	0.710									
ET3	0.098	0.137								
P-Value	0.588	0.446								
ET4	0.302	-0.033	0.571							
P-Value	0.087	0.854	0.006							
ET5	0.13	0.266	0.041	0.169						
P-Value	0.471	0.135	0.820	0.347						
CS1	-0.014	-0.001	0.302	-0.031	0.081					
P-Value	0.940	0.995	0.088	0.862	0.653					
CS2	-0.151	-0.159	0.356	-0.074	-0.032	0.341				
P-Value	0.401	0.378	0.042	0.681	0.861	0.052				
CS3	-0.167	0.056	0.094	-0.178	-0.12	0.485	0.201			
P-Value	0.352	0.759	0.604	0.323	0.504	0.004	0.262			
CS4	0.111	-0.094	0.105	0.07	0.05	0.313	-0.215	0.566		
P-Value	0.539	0.603	0.561	0.698	0.784	0.076	0.229	0.001		
GS1	0.013	-0.018	-0.021	-0.154	0.185	0.653	0.17	0.374	0.218	
P-Value	0.942	0.919	0.907	0.392	0.302	0.000	0.345	0.032	0.222	
GS2	-0.036	-0.147	0.203	0.101	0.098	0.292	-0.057	0.212	0.382	0.506
P-Value	0.841	0.414	0.257	0.576	0.586	0.100	0.753	0.235	0.028	0.003

As one can observe from Table 5.1, for example, the correlation value between ET3 and ET4 is 0.571, which is fairly strong. Similarly, their relationships with the other variables in the matrix are relatively weak. This pattern of interrelationships may suggest that these two observed variables result from an underlying "Experimentation traits" factor.

5.1.2 Communalities and factor Pattern Matrix

Table 5.2 summarizes the relationship among the factors and their observed indicators.

We can immediately see that some variables are well defined with a factor (ET3 and ET4 with Factor 2; CS1 and CS3 with Factor 3; GS1 and GS2 with Factor 1). For some variables, however, the relationships are not very clear. For example, CS4 appears to load on Factor 1 (0.37) and factor 3 (-0.41). It is important to note that this initial factor matrix is unrotated. Later, we rotate the matrix to improve our ability to interpret the loadings, that is, to maximize the high loading of each observed variable on one factor and minimize the loading on the other factors.

An eigenvalue may be defined as the sum of the squared loadings of the indicators on the factor with which the eigenvalue is associated. The factor with the largest eigenvalues contains the most common variance among the observed indicators; those with small or negative eigenvalues are then dropped from the factor solution.

Table 5.2: Factor loading before rotation

Variable	Factor1	Factor2	Factor3	Communality
ET1	0.0130	-0.2400	-0.0350	0.0590
ET2	0.1370	-0.2530	-0.0300	0.0840
ET3	0.1460	-0.5800	-0.1580	0.3820
ET4	-0.1050	-0.5700	0.0950	0.3450
ET5	0.2380	-0.1850	0.1990	0.1300
CS1	-0.1600	-0.2670	-0.6950	0.5790
CS2	0.1910	-0.1210	-0.0660	0.0560
CS3	0.4410	0.0360	-0.8460	0.9110
CS4	0.3720	-0.2800	-0.4130	0.3880
GS1	1.0000	0.0000	0.0000	1.0000
GS2	0.6430	-0.1540	-0.0530	0.4400
Eigenvalue	2.3731	1.0058	0.9948	4.3738

The adequacy of the model can be determined by examining the scree plot in Fig 5.1. After three factors are retained, the eigenvalues of the additional factors attain a horizontal line (scree). Therefore, additional factors would add little to the model.

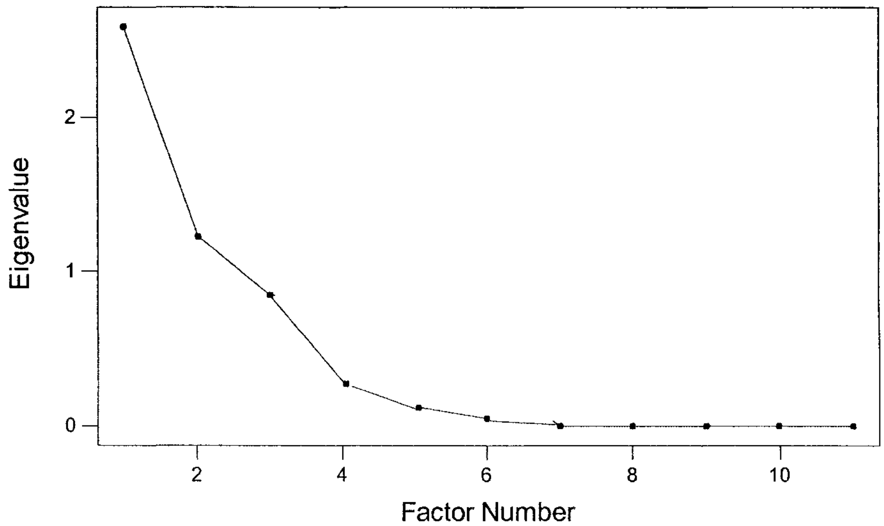


Fig 5.1: Scree plot before rotation

5.1.3 Method of Rotation

Although an initial pattern in the data can be seen from the varies loading in Table 5.2, some variables are not yet clearly defined as belonging with one underlying factor. We may be able to clean up the solution some, making the interpretation of the factor structure a bit easier. Some of these problems can be shown visually by plotting the factor loadings along a set of axes representing the factors.

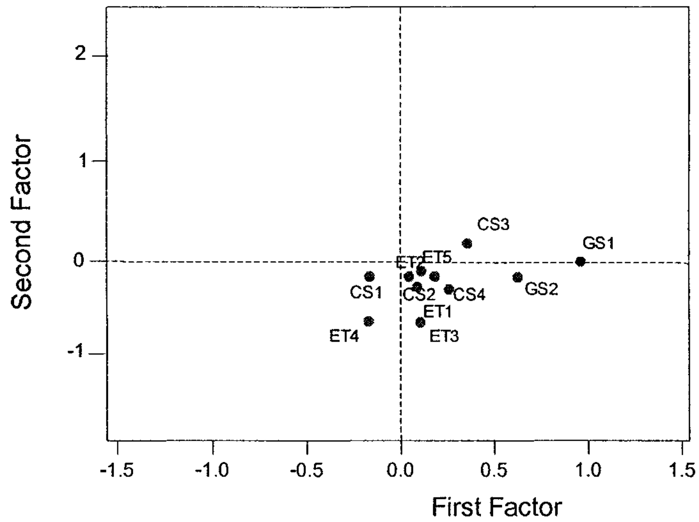


Fig 5.2: Score plot before rotation

We can easily identify the cluster of variables representing computer graphic skill (e.g.: GS1, GS2). These are loaded highly on Factor 1. But some of the items, like CS4, is a bit near to Factor 1 and also Factor 2.

Through rotation, we would like to get items to be identified more strongly with one or the other factor. There are three basic approaches to rotation including (a) graphic, which is difficult to apply when clustering of variables is unclear or there are more than two factors (Kim & Mueller, 1978), (b) analytic, which consists of orthogonal and oblique schemes, and (c) rotation to a target matrix, where the researcher has a pattern of relationships already in mind. In this research, we concentrate on analytic rotation, as it is the most widely used method. And we will use Orthogonal rotation which tends to maximize the loadings on one factor and minimize the loading on the other factor or factors. The most commonly used rotation scheme for orthogonal factors is Varimax, which attempts to minimize the number of variables that have high loadings on one factor. The rotated factor matrix is represented in Table 5.3.

Table 5.3: Factor loading after rotation

Variable	Factor1	Factor2	Factor3	Communality
ET1	0.0280	-0.0340	-0.2390	0.0590
ET2	0.1490	-0.0610	-0.2400	0.0840
ET3	0.1580	-0.1830	-0.5690	0.3820
ET4	-0.0180	0.1260	-0.5730	0.3450
ET5	0.2990	0.1310	-0.1530	0.1300
CS1	-0.3350	0.6520	-0.2050	0.5790
CS2	0.1790	-0.1130	-0.1040	0.0560
CS3	0.1980	-0.9330	0.0450	0.9110
CS4	0.2770	-0.5940	-0.2590	0.3880
GS1	0.9600	-0.2640	0.0950	1.0000
GS2	0.6190	-0.2190	-0.0940	0.4400
Eigenvalue	2.0149	1.4284	0.9304	4.3738

Fig 5.3 presents the graphic results of the orthogonal (Varimax) rotation. As one can see, after rotation, the two indicator of computer graphic skills still load very strongly on Factor 1. Notice that trough rotation, CS1, CS3 and CS4 now have higher loadings on Factor 2 and have move λ closer to the axis.

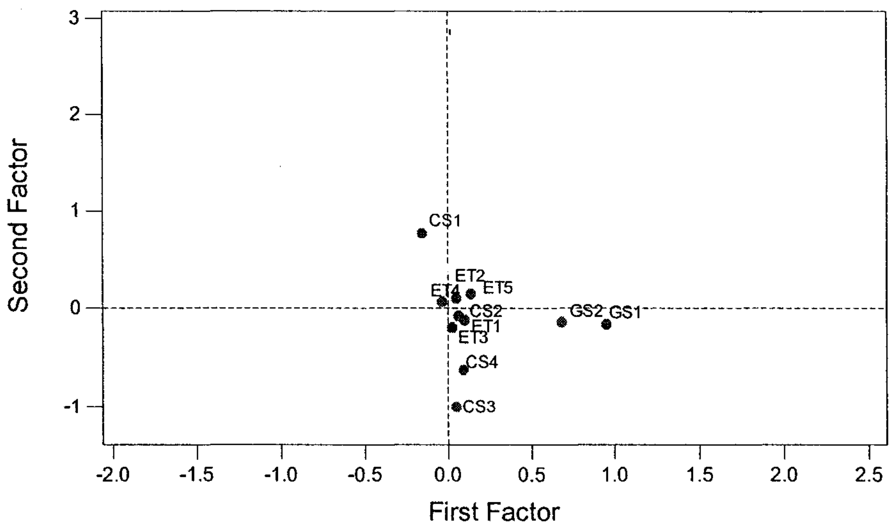


Fig 5.3: Score Plot after rotation

5.1.4 Final Solution

Due to the low correlation and low factor loading, the following items are rejected: ET1, ET2, ET5 and CS2. After rejection, the analysis based on the new selected items is done as following.

- CORRELATION MATRIX

Table 5.4 is the correlation matrix consists of 7 selected questionnaires after rejecting the low factor loading items.

Table 5.4: Final Solution: Correlation matrix

	E3	E4	CS1	CS3	CS4	GS1
E4	0.4710					
P-Value	0.0060					
CS1	0.3020	-0.0310				
P-Value	0.0880	0.8620				
CS3	0.0940	-0.1780	0.4850			
P-Value	0.6040	0.3230	0.0040			
CS4	0.1050	0.0700	0.6530	0.5660		
P-Value	0.5610	0.6980	0.0000	0.0010		
GS1	-0.0210	-0.1540	0.4530	0.3740	0.2180	
P-Value	0.9070	0.3920	0.0760	0.0320	0.2220	
GS2	0.2030	0.1010	0.2920	0.2120	0.3820	0.5060
P-Value	0.2570	0.5760	0.1000	0.2350	0.0280	0.0030

One can observe from the correlation matrix that the correlations between some items are fairly strong. For example, the correlation value between E3 and E4 is 0.47. Also, the correlation between CS1 and CS3 is 0.49 and the one between CS1 and CS4 is 0.65, the one between CS3 and CS4 is 0.57 and the one between GS1 and GS2 is 0.51. These high correlation values may suggest that these items belong to the same factors.

- COMMUNALITIES AND FACTOR PATTERN MATRIX

Table 5.5 summarizes the relationship among the factors and their observed indicators after dropping the items with low factor loading in the first round.

Table 5.5: Final Solution: Factor loading before rotation

Variable	Factor1	Factor2	Factor3	Communality
ET3	-0.021	-0.953	0.133	0.927
ET4	-0.154	-0.507	-0.117	0.295
CS1	0.269	-0.288	0.653	0.581
CS3	0.374	0.022	0.921	0.989
CS4	0.218	-0.056	0.527	0.328
GS1	1.0000	0.0000	-0.0000	1.0000
GS2	0.506	-0.220	0.032	0.305
Eigenvalue	1.8931	1.3006	1.2312	4.4249

We can immediately see that the variables are well defined with a factor (ET3 and ET4 with Factor 2; CS1, CS3 and CS4 with Factor 3; GS1 and GS2 with Factor 1). It is important to note that this initial factor matrix is unrotated.

The adequacy of the model can be determined by examining the scree plot in Fig 5.4. After three factors are retained, the eigenvalues of the additional factors attain a horizontal line (scree). Therefore, additional factors would add little to the model.

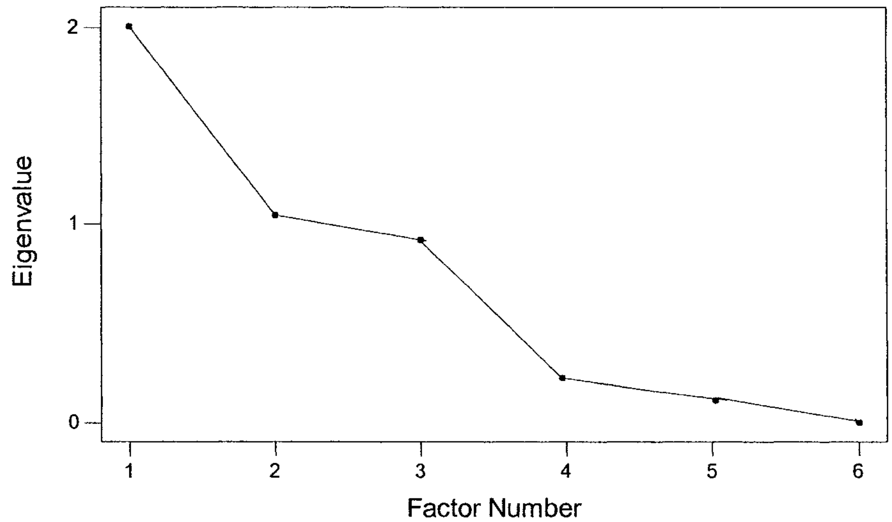


Fig 5.4: Final Solution: Scree Plot

- METHOD OF ROTATION

The score plot of unrotated factor loading is presented in Figure 5.5. After using the Varimax rotation scheme, the factor loading matrix is presented in table 5.6 and the graphical result is presented in Figure 5.6.

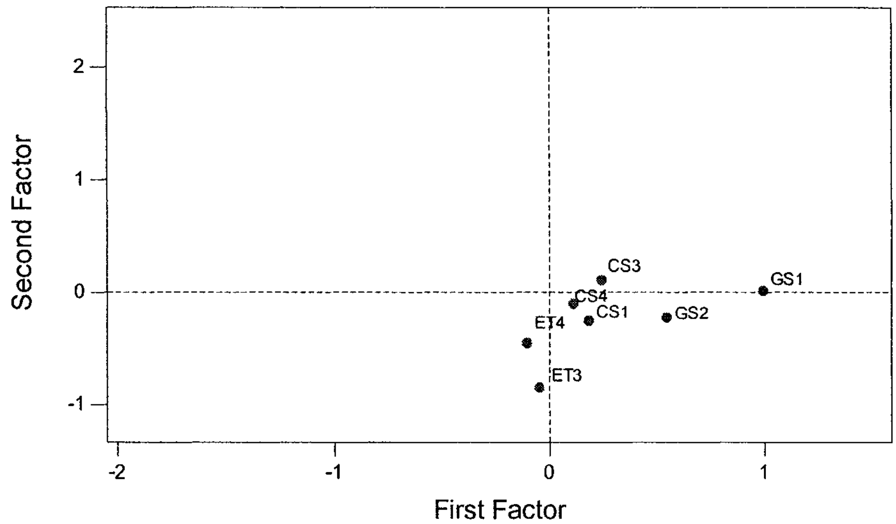


Fig 5.5: Final Solution: Score Plot before rotation

Table 5.6: Final solution: Factor loading after rotation

Variable	Factor1	Factor2	Factor3	Communality
ET3	0.150	0.156	-0.938	0.927
ET4	-0.031	-0.123	-0.528	0.295
CS1	0.367	0.651	-0.151	0.581
CS3	0.225	0.964	0.097	0.989
CS4	0.147	0.554	-0.011	0.328
GS1	0.969	0.141	0.202	1.0000
GS2	0.529	0.109	-0.113	0.305
Eigenvalue	1.7396	1.4415	1.2439	4.4249

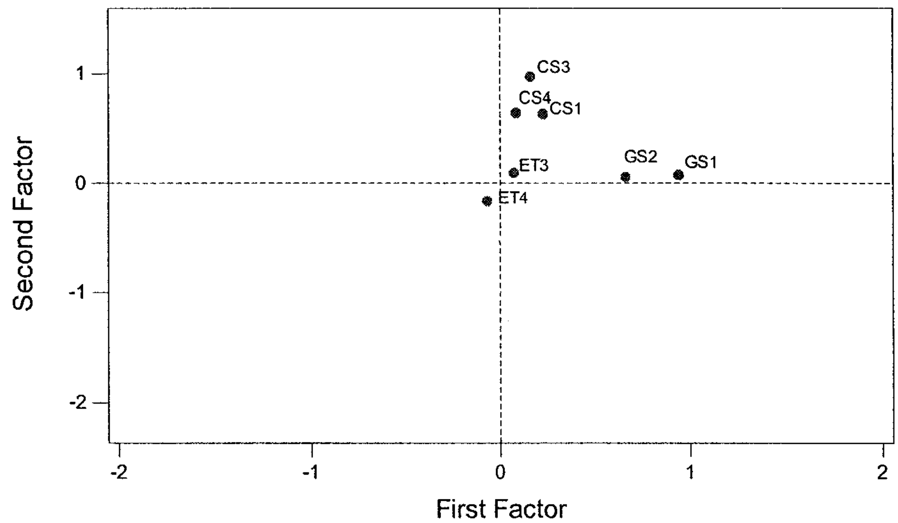


Fig 5.6: Final Solution: Score Plot after rotation

As one can see, after rotation, the two indicators of computer graphic skills still load very strongly on Factor 1. Notice that trough rotation, CS1, CS3 and CS4 now have higher loadings on Factor 2 and have move λ closer to the axis.

5.2 Confirmatory Factor Analysis

In this research, we test PEU and PU by using confirmatory factor analysis. We first use correlation matrix for confirmatory FA to test the correlation between items used in PEU and PU. Table 5.7 is the correlation matrix.

Table 5.7: Correlation matrix

	PU1	PU2	PU3	PU4	PEU1	PEU2	PEU3
PU2	**0.437**						
PU3	**0.25**	**0.329**					
PU4	**0.256**	**0.36**	**0.649**				
PEU1	0.059	0.222	0.032	0.093			
PEU2	0.004	0.225	0.087	0.098	**0.705**		
PEU3	0.139	-0.024	-0.007	0.046	**0.419**	**0.22**	
PEU4	-0.046	0.143	0.141	0.137	**0.523**	**0.418**	**0.522**

We can observe from the matrix that the items b elong to the same factor have higher correlation than the others.

Table 5.8 presents the results of the confirmatory factor analysis and reliability analysis performed on perceived usefulness and perceived ease of use. As shown in the figure, the scales used exhibited overall desirable psychometric properties. Reliability results using Cronbach's Alpha indicated that each scale was within an acceptable range (PU = 0.70, PEU = 0.88) (Nunnally, 1967). Items with low measure of sampling accuracy give a loading less than 0.5 (Hair et al., 1995) and are not presented in table 5.5. Factor loadings for PUE1, PUE2, PUE3, PEU4, PU3 and PU4 exceeded 0.7. The other factor loadings were above the cutoff of 0.5.

Table 5.8: Factor loading and cronbach alpha

Items	Factor Loading	Eigenvalue	% of Variance	Cronbach Alpha
PU		2.161	27.000	0.700
PU1	-0.611			
PU2	-0.699			
PU3	-0.795			
PU4	-0.802			
PEU		2.432	30.400	0.880
PEU1	0.869			
PEU2	0.765			
PEU3	0.665			
PEU4	0.787			

Based on these results, the scales used in this study validate the constructs and their corresponding reliabilities.

5.3 Regression

Table 5.9 represents the regression analysis results used to test the hypotheses. In this table, the dependent and independent variables are shown in the column "hypothesized relationship" of table 5. 9, the estimated regression coefficient describes the amount of change in the dependent variable for 1 unit change in the independent variable. And their SE which represents the estimated population's standard deviation of error in estimating the dependent variable from in independent variable, "T" is the statistic for determining whether the independent-dependent relationship is statistically significant. P-value, is the statistical significance of the test and R^2 is the percentage of variance explained by the variable tested in the sample.

1. Hypothesis 1 is supported in MDI with a high level of significance (P-value = 0.04), but is not supported in IBI with a low level of significance. (P-value = 0.625)

2. Hypothesis 2 is supported in MDI with a high level of significance (P-value = 0.007), but is not supported in IBI with a low level of significance. (P-value = 0.303)

3. Hypothesis 3 is supported in MDI with a high level of significance (P-value = 0.024), but is not supported in IBI with a low level of significance. (P-value = 0.112)

4. Hypothesis 4 is supported in MDI with a high level of significance (P-value = 0.073), but is not supported in IBI with a low level of significance. (P-value = 0.549)

5. Hypothesis 5 is not supported in MDI with a low level of significance (P-value = 0.103), and is also not supported in IBI with a low level of significance. (P-value = 0.503)

6. Hypothesis 6 is supported in MDI with a high level of significance (P-value = 0.002), and is also supported in IBI with a high level of significance. (P-value = 0.036)

7. Hypothesis 7 is supported in MDI with a high level of significance (P-value = 0.003), but is not supported in IBI with a low level of significance. (P-value = 0.530)

8. Hypothesis 8 is supported in MDI with a high level of significance (P-value = 0.040), and is also supported in IBI with a high level of significance. (P-value = 0.012)

9. Hypothesis 9 is not supported in MDI with a low level of significance (P-value = 0.211), and is also not supported in IBI with a low level of significance. (P-value = 0.220)

10. Hypothesis 10 is supported in MDI with a high level of significance (P-value = 0.001), but is not supported in IBI with a low level of significance. (P-value = 0.259)

11. Hypothesis 11 is supported in MDI with a high level of significance (P-value = 0.004), but is not supported in IBI with a low level of significance. (P-value = 0.787)

Table 5.9: Hypotheses test

Hypothesis	**Relationship**		**b**		**Standard error of b**		**T**		**P-value**		**R^2 (%)**	
	IBI	MDI	IBI	MDI	IBI	MDI	IBI	MDI	IBI	MDI	IBI	MDI
1	CS→PEU	CS→PEU	0.138	0.209	0.280	0.102	0.490	2.050	0.625	0.040	0.8	10.0
2	CS→P	CS →P	-8.607	-8.130	8.222	2.817	-1.050	-2.890	0.303	0.007	3.4	18.8
3	CS3 → P	CS3 → P	-7.655	-4.724	4.678	2.013	-1.64	-2.35	0.112	0.024	8.0	12.7
4	CS4 → P	CS4 → P	-5.441	-5.192	8.990	2.814	-0.61	-1.85	0.549	0.073	1.2	8.2
5	GS→PEU	GS→PEU	-0.099	0.111	0.147	0.066	-0.680	1.670	0.505	0.103	1.4	6.8
6	GS→P	GS→P	-10.86	-5.810	4.965	1.712	-2.190	-3.390	0.036	0.002	13.4	23.3
7	GS2→P	GS2→P	-2.341	-4.757	3.689	1.509	-0.63	-3.15	0.530	0.003	1.3	20.7
8	PEU→PU	PEU→PU	0.336	0.274	0.125	0.135	2.680	2.040	0.012	0.040	18.8	10.3
9	ET → PU	ET → PU	-0.169	0.126	0.135	0.099	-1.250	1.270	0.220	0.211	4.8	4.3
10	ET → PEU	ET →PEU	-0.043	0.357	0.104	0.103	1.140	3.480	0.259	0.001	1.8	25.2
11	ET → P	ET → P	1.28	-7.811	4.704	2.564	0.27	-3.05	0.787	0.004	0.2	17.5

5.4 ANOVA

5.4.1 (2 x 2) (gender x interface)

For the data, a 2 (gender) x 2 (interface) two-way repeated measures analysis of variance (ANOVA) was conducted, with dependent variables consisting of the task completion time (P) of the participants.

The two-way repeated measures ANOVA showed no interaction effect between gender and the interface, $F=0.00$, $p= 0.956$. However, the main effect for interface was significant, $F= 36.62$, $p<0.001$, with IBI ($M=101.050$, $SD=37.950$) reporting significant higher over-all task completion time than MDI ($M=37.930$, $SD=21.680$). The main effect for the gender was also significant, $F=6.46$, $p=0.016$, with female ($M=79.00$, $SD = 31.5$) reporting higher over-all task completion time than male ($M=57.4$, $SD=23.3$).

Therefore, Hypothesis 12 was rejected (no interaction effect). Hypothesis 13 was accepted: there was a significant main effect for Gender ($P<0.016$). Hypothesis 14 was also accepted: there was a significant main effect for interface ($P<0.001$)

Table 5.10: Over-all and gender by interface means and standard deviation

	P			
	MDI		**IBI**	
	M	**SD**	**M**	**SD**
Overall	37.93	21.68	101.05	37.95
Male	31.40	14.68	83.30	31.90
Female	53.48	23.87	104.50	39.00

6. Conclusions

This research was motivated by a strong interest in understanding the application of TAM constructs to performance and post-beliefs of users after they use software with either a MDI or an IBI. Previous work mostly focused on command based interfaces and direct manipulation interfaces, however, in the last decade interfaces have changed significantly. Today the most relevant interface types are the Menu driven Interfaces and Icon Based Interfaces. Therefore, this research examines these two interface types.

Table 5.9 summarizes the most important findings from this experiment: most hypotheses relating to IBI were not supported (only 2 out of 11 supported), most of those related to MDI were supported (9 out of 11 supported). For example, subjects with higher level of computer skills (CS) had significantly better performance and higher PEU of the MDI version. CS had no significant influence on subjects' performance and PEU of the IBI. The only exception was that graphics skills (GS) positively influenced performance for both types of interfaces, though in a more significant way (P=0.002) in the MDI treatment than in the IBI treatment (P=0.036)

Another important finding is that task completion times were significantly lower (better performance) for subjects in the MDI treatment.

It can be argued that either the IBI version of Adobe Photo Deluxe was not a good implementation of that class of interfaces, or that MDI is mostly a superior type of interface. The later possibility requires repeated support from similar future experiments.

Another unexpected finding was that Gender played an important role in subjects' performance levels for both treatment groups. Males had considerably lower task completion times. In the past, males used to be more computer skilled than females, but in this sample of commerce university students, it was expected that females would be equally skilled. One possibility is that females fare worse in ease of learning new software. Again, future research could investigate this possibility further.

Experimentation trait had a very significant effect on Performance and PEU for MDI (P=0.004 and P=0.001). It had no effect on the same variables for the IBI group. This indicates that experimentation traits is an important personality factor that requires more attention in future research.

There are several potentially important implications for IS researchers and practitioners. The findings of the study demonstrate the value of the TAM perceived usefulness and perceived ease of use in the interface-performance context. This study is a theory-based empirical test of the belief constructs of the TAM model as they related to interface consistency issues. In developing and testing this research model, future research concerning interface consistency/inconsistency, interface design, and acceptance of commercial software issues will benefit and present findings will be used by interested IS investigators.

For practitioners and in a corporate environment this study h as important implications and may provide guidance on the following:

- Development of interface design
- Development of training scenarios for a new software

- Selection of most appropriate software to purchase and use in the organization

- Selection of most appropriate individuals to use a specific software purchased

The results of the survey received support from the theoretical foundation upon which this research is built on. But for the experimentation traits, the results of the survey received are not well supported. Future research can explore this personal trait and how it affects other elements in the TAM model. Certainly, it is hoped that firms will be able to enhance their understanding of what makes different individuals use different software for better performance in their activities.

7. Discussion, limitations and Suggestions for Future Research

- Experimentation traits (ET) was a variable that we attempted to measure through a 5-item scale. After running factor analysis, only two items were used to operationalize this variable. Future research could attempt to reword some of the other three items in an attempt to improve the reliability of this measure of ET. Nevertheless, subject with higher ET had significantly better PEU in the MDI treatment group. Perception of Usefulness (PU) was not influenced by ET for either type of interface. Again, future research could investigate under different conditions the potentially powerful effect of ET on learning and efficiency, and effectiveness.

- Students sample had not enough age or educational background variation. The significant effect of gender on many output variables calls for further testing of these other personal variables.

- The application (photo Editing) was not relevant to most participants. Developing a Perception of usefulness of the software in photo editing is not easy for users, most of whom who had no previous reference in that area.

- Computer skills, and graphics skills were mostly measured through subjects' self appraisal. More detailed questions designed to test subjects' actual relative knowledge of those variables could yield a better operationalization.

- Other IBI software could be tested. For example, later versions of Adobe Photo Deluxe (version 4) fixed for some of the shortcomings of version 1, in particular: the elimination of buttons that did not have enough differentiation

- Sample size was too small to study "effectiveness", measured here as number of correctly finished tasks. Very few subjects failed to finish some of the tasks. These cases were dropped from the study. Much larger original sample size is needed to have a significant number of less than perfect performance results, if "Effectiveness" is to be studied.

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Appendix1 (The questionnaire)

This questionnaire is part of an academic research conducted for Concordia University's Management Information Systems department, Masters of Science in Administration program. Your answers will be analyzed in combination with all other participants' answers. Results might be published in scientific MIS research journals. Thank you for your participation.

1 Questionaire

Please circle one choice (number) for each question.

---

1. Using ADOBE PHOTO DELUXE would improve my performance in photo editing.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

2. Using ADOBE PHOTO DELUXE would improve my efficiency in photo editing.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

3. Using ADOBE PHOTO DELUXE would improve my ability to edit photo flexibly.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

4. Using ADOBE PHOTO DELUXE would make photo editing interesting.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

5. Using ADOBE PHOTO DELUXE would let me feel that I really control the process of photo editing.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

6. Learning to operate ADOBE PHOTO DELUXE would be easy for me.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

7. I would find it easy for me to use ADOBE PHOTO DELUXE to finish my photo editing.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

8. It would be easy for me to become skillful at using ADOBE PHOTO DELUXE.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

9. I think that the process of using ADOBE PHOTO DELUXE to do photo editing is clear and understandable.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

10. I would find ADOBE PHOTO DELUXE easy to use.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

11. In general, when I travel, I like to always go back to the same places I tried and known before.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

12. I like to meet new people and make new friends, when I have the time.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

13. I would be motivated to try the latest version of my favorite software, or even a different company's version.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

14. I would feel uncomfortable if I wear the latest in fashion clothing.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

15. In general, I enjoy trying different types of international cuisine.

1	2	3	4	5	6	7
strongly disagree	disagree	slightly disagree	undecided	slightly agree	agree	strongly agree

16. The period for finishing the assigned tasks of photo editing.

_____ minutes_____ seconds.

17. I used at least one of the following software: Lotus 123 for DOS, word perfect for DOS, dBase III, DOS, WordStar for DOS.

Never 1 2 3 4 5 6 7 Everyday

18. The number of Internet sites I usually visit is

small 1 2 3 4 5 6 7 very large

19. I have ------ knowledge about at least one of the following software products: MS Word for windows, MS Excel, Word Perfect for windows, Visual Basic.

Little 1 2 3 4 5 6 7 Considerable

20. I am familiar with at least one of the following software: MS Encarta (or other encyclopedias), Kai's power tools, Fractal Design Painter, Fractal Design Dabbler, Softimage Digital Studio.

Little 1 2 3 4 5 6 7 Very

And finally, please tell a few general things about yourself:

21. Place of Birth : ________________________

22. Gender : Male ____________ Female ____________

23. Mother tongue : English ____________ French ____________ Other: ________

24. Proficiency in English

I manage 1 2 3 4 5 6 7 I'm very comfortable

25. Education

(1) Finished high School (2) Finished CEGEP (3) Finished University (4) Finished Graduate studies (masters, Ph.D.)

26. Age group

18-24 25-34 35-49 50-65

27. General Computer skills

Novice 1 2 3 4 5 6 7 Expert

28. Computer Graphics skills

Novice 1 2 3 4 5 6 7 Expert

MARGINS

On final submission, **thesis must have 1.5"(3.81 cm) left-hand margin** and 1" (2.54 cm) top, bottom and right-hand margins. If the size of a table or figure does not fit in the standard margins, margins may be reduced to 1 inch on the left and half-inch top, bottom and right. Page number header or footer can be set at .6 or .7 of an inch.

PRINT QUALITY

Must be clear, even and dark on the final submission

PAPER QUALITY and QUANTITY

Required 3 final submission copies (1 for Library, 1 for Microfilm/Library, 1 for Department) should be printed on good quality minimum 25% cotton or linen, min. 20 lb., bond paper with watermark and submitted in separate boxes available at the bookstore or copy centres. Extra copies cost $14 each for binding payable to Thesis Office at time of final submission (cash, cheque or money order only made out to Concordia University).

COMMENTS

Please check every page of each copy at the time of final submission

ABSTRACT

At final submission, email abstract (if not already, make comprehensible to an interested non-specialist, approx. 250 words) to   with name, ID and program in subject line. No supervisor signature required. For inclusion in thesis database: http://graduatestudies.concordia.ca/thesis/index.php

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