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A Study of the Technology Acceptance of Object-Oriented Computing*

- The Case of Technology Acceptance Model -

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객체지향 컴퓨팅의 기술수용에 관한 연구

- 기술수용 모델의 경우 -

김 인 재

This paper presents an exploratory research on the application of the Technology Acceptance Model (TAM) to the domain of object orientation to investigate the validity of TAM in the perspective of its causal relationships. In the Management Information Systems (MIS) area, TAM has been applied to computer usage behavior as a specific technology adoption model. This paper also suggests the factors that affect the technology acceptance of object orientation in U.S. organizations through a modified TAM.

Two major research questions are addressed. First, this research investigates the effect of these external variables on the dependent variable, the actual usage of object orientation in the viewpoint of knowledge interaction between structured methods and object orientation. Second, is TAM valid for the technology acceptance of object orientation in terms of its causal relationships? This study empirically explores the impact of the external variables on the level of actual usage of object orientation via the mediating variables in TAM. A structured questionnaire is administered to Data Processing Management Association (DPMA) professionals in US.

The result of this study reveals one important contradictory finding that is not consistent with expectations based on related theory. TAM does not accommodate the technology acceptance of object orientation perhaps because object orientation is a complex and organization-level adoptive technology or the measures for the mediating constructs in TAM may not be appropriate in industry settings.

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I. Introduction

The object-orientation paradigm, in contrast to the conventional structured methods, requires different ways of thinking about building applications. The object-orientation paradigm, emerging in the mid-1980s, focuses not on processes but rather on objects that encompass processes and data. The basic difference between the structured methods and the object-orientation paradigm is how a target system is viewed. While an analyst/designer using the structured methods considers a system to be a collection of processes that convert well-defined inputs to predictable outputs, a person using the object-orientation paradigm regards a system as a collection of objects that interact with each other.

Adoption of new information technology is critical for organizations to survive in a competitive environment. While the life cycle of a new information technology gets shorter, the technology itself becomes more complex and harder to understand. The need to better understand the acceptance of a particular information technology by organizations provides the motivation for this paper.

In the basic TAM [Davis et al., 1989], three groups of mediating variables exist. The first group is related to two innovative aspects of technology consisting of the perceived ease of use and usefulness. The second group includes attitudes toward using the technology. The third group includes behavioral intention to use a new technology. According to TAM, these three groups of intermediate variables should mediate the path from the external independent variables to one dependent variable. These mediating effects are empirically tested in this research. Therefore, one central research question is addressed: Is TAM valid for the technology acceptance of object orientation in terms of its causal relationships?

Empirical studies of programmers in organizations have been highlighted because programmers are valuable human resource for building software applications. Even though they are working under organizational controls, their opinions about a certain technology influence management decisions. Coleman [1986] maintains that organizational decisions are not solely due to the intentions of management but are the results of interactions among employees in organizations. Therefore, programmers' perceptions in using object orientation provide valuable information about the adoption of object orientation in organizations.

In this paper, a modified research model based upon TAM is suggested and the causal relationships in TAM are empirically tested.

Ⅱ. Literature Review

The object-orientation paradigm has been a hot issue academically, but adoption of this technology remains questionable to many information officers. Lots of studies on technical issues have been done, but technology assessment of object orientation has rarely been reported. The analysis of cognitive process of the object-oriented analysis and design has recently been reported [Davies et al., 1995; Detienne, 1995; Pennington et al., 1995]. However, this approach focuses on the cognitive process rather than on managerial aspects, and the number of subjects in those experiments is

very limited. Industrial perceptions about object orientation should be carefully evaluated so that an accurate picture of object orientation can be available to IS professionals in organizations.

The related literaturethe theoretical models, affecting factors of technology adoption and previous empirical studies of object orientationwill be fully reviewed.

2.1 Theoretical Models of Technology Adoption

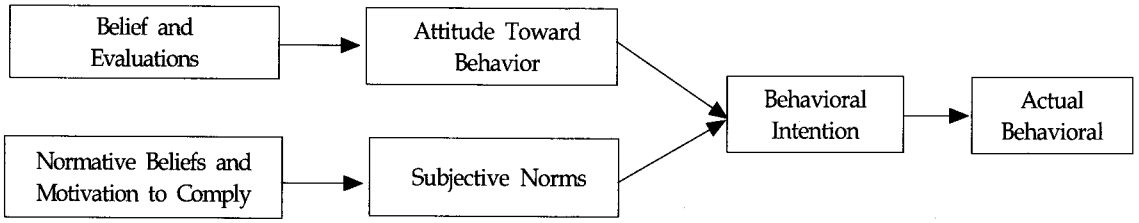
Previous researchers have studied a variety of models for technology adoption. The typical theoretical models can be enumerated: (1) a push-pull model [Zmud, 1984], (2) a model for micro-macro relationships [Coleman, 1986], (3) a unified model for technology adoption [Kwon & Zmud, 1987], (4) a technology acceptance model [Davis, 1989; Davis et al., 1989], (5) a theory of reasoned action [Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980; Davis et al., 1989], (6) a technology adoption grid [Fichman & Kemerer, 1993], and (7) a diffusion mapping for information technology [Fichman, 1992].

Push-pull model [Zmud, 1984]: Zmud [1984] tries to validate a push-pull theory [Fischer, 1980], in which innovation seems to occur when a need and means are simultaneously recognized. "Need-Pull" innovation is generally more related to commercial success than Technology-Push innovation. Zmud [1984] suggests that when a need and means for innovation are recognized simultaneously, innovation can be accelerated. Project complexity (length, cost, and effort) and six branches of software practices (top down development, structured design, structured review, chief programmer team, configuration management, and unit development folder) are respectively regarded as a need and means.

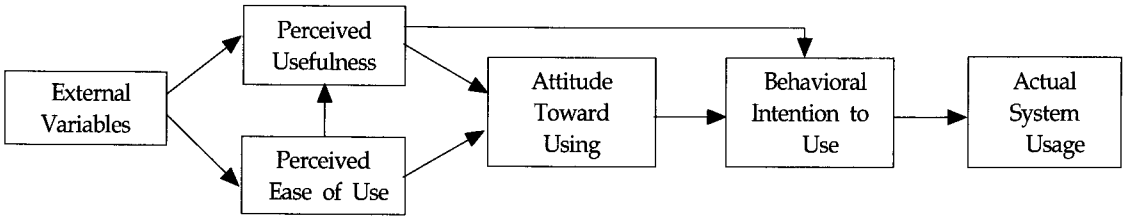
Model for micro-macro relationships [Coleman, 1986)]: Coleman [1986] specifies the relationships between organizational and individual variables. Organizational environment can change individuals' perceptions, and then individual actions contribute to organizational outcomes. Macro-level change in organizations is caused not only by intentional actions of management but also interactive actions among members.

Unified model [Kwon & Zmud, 1987]: Kwon and Zmud [1987] review empirical and non-empirical innovation studies in order to suggest a unified model that shows contributing factors at each stage of the innovation process. Five influential factors (individual, structure, technology, task, and environment) and six innovation-process stages (initiation, adoption, adaptation, acceptance, satisfaction, and incorporation) are used to show the relationship between the influential factors and the innovation process stages. Key contributing factors to organizational innovation and implementation are also identified in this model.

Theory of reasoned action [Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980; Davis et al., 1989]: Fishbein and Ajzen [1975] suggest a general model to predict and explain human behavior across many domains. Theory of reasoned action, originating from social psychology, regards attitude and subjective norms as two typical determinants of behavioral intention to perform behaviors. A person's attitude and subjective norms are affected by beliefs and other external factors. The special mea-



<Figure 1> Theory of Reasoned Action



<Figure 2> Technology Acceptance Model (TAM)

ning of this theory is that the other factors, expect for salient beliefs, regarding the behavior under investigation can be considered as external variables influencing indirectly attitude and subjective norm (See Figure 1).

Technology acceptance model [Davis, 1986; Davis, 1989; Davis et al., 1989]: Davis [1986] suggests a specific technology adoption model based on theory of reasoned action, and applied to computer usage behavior. Usefulness and ease of use are only used as two pre-defined beliefs influencing attitudes, and external variables are determined according to research areas under investigation. External variables are considered to influence attitudes and intention only via internal beliefs (See Figure 2).

Technology adoption grid [Fichman & Kemerer, 1993]: Fichman and Kemerer [1993] suggest a two-dimensional framework based upon innovation attributes and economic factors. The innovation attributes include: (1) relative advantage, (2) compatibility, (3) complexity, (4) triability, and (5) observability. The economic factors consist of: (1) prior technology drag, (2) irreversibility of investment, (3) sponsorship, and (4) expectations. While the innovation attributes are important to the perceptions of users, the economic factors are critical to adoption of software process technologies because new technologies require investment in equipment and training. Most previous studies fail to consider these economic factors. Fichman and Kemerer [1993] classify several information engineering technologies into the four quadrants, generated by two axes of the innovation perspective and economic perspective.

Diffusion mapping [Fichman, 1992]: Fichman [1992] classifies eighteen empirical studies of technology diffusion using a framework mapping classes of technology (level of knowledge burdens and user interdependencies) against locus of adoption (individual and organizational adoption). The class of technology can be characterized by knowledge burdens placed on potential adopters and user interdepen dencies. Word processors, spreadsheet, and desktop com-

puters are the examples of lowlevel knowledge burdens, and the structured methods and object orientation are the examples of high-level knowledge burdens. The higher the knowledge burdens, the more time and effort potential users require to use new technologies. An example of user interdependencies is an email system. The greater the user inter dependencies, the greater are benefits for potential users. Even though technology is adopted by small groups or industries, the locus of adoption is confined to individuals and organizations. This dichotomy will make this model simple and understandable. Fichman [1992] also insists that classical technology diffusion is characterized as low-class technology and individuallevel adoption, and argues that managerial influences, organizational adoption, network externalities, and knowledge barriers are the other influential factors that extend beyond the classical diffusion theory.

2.2 Affecting Factors of Technology Adoption

Based on previous studies[Rogers, 1983; Rogers et al., 1971], affecting factors can be classified into seven groups as follows. (1) Individual characteristics-personal experience, education, age, innovativeness, etc. (2) Innovational characteristics-observability, triability, compatibility, usefulness, ease of use of the technology, etc. (3) Managerial characteris-ticsmanagement support, management enforcement, training, etc. (4) Organizational characteristics-size, specialization, centralization, formalization, etc. (5) Environmental characteristicsexistence of technical champions, technical consultants, hardware/software environment, information channels, etc. (6) Economic aspectsprior technology drag, irreversibility of investments, sponsorship, expectations, etc. (7) Social systemexternality of the technology, uncertainty, competition, etc.

2.3 Previous Empirical Studies of Object Orientation

Empirical studies of object orientation trace back to the early 1990s. Most research can be classified as either cognitive-level or explorative studies. The studies cover a wide variety of topics: the relationship between the level of experience using object-oriented programming and problem type [Detienne, 1995]; a comparison of solutions produced by different systems development methodologies [Boehm-Davis & Ross, 1992]; different cognitive processes of novice and expert programmers [Davies et al., 1995; Weiser & Shertz, 1983]; the effectiveness of communication among team members using object orientation [Herbsleb et al, 1995]; the role of domain knowledge in the objectoriented design [Pennington et al., 1995]. A few researchers have learned valuable lessons from participating in projects using object orientation [Burkle, Gryczan, & Zullighoven, 1995; Capper, Colgate, Hunter, & James, 1994].

Detienne [1995] investigates the design strategies of object orientation for both procedural and declarative problems and demonstrates the difficulties that procedural programmers have in switching to the objectorientation paradigm. Boehm-Davis and Ross [1992] examine three approaches to decomposition (data-structure based, function based, and object based methods) that can lead to differences in the final solutions of

three different types of problems. They find that the datastructure and object based methods have advantages in consistency, completeness, complexity, and design time.

Davies et al. [1995] find that while novice programmers think of programs in terms of objects and their relations, experienced programmers think of programs in terms of components and their functional relations. Pennington [1987] shows that programmers represent their programs in different ways depending on the task they are performing. Weiser and Shertz [1983] insist that novice programmers organize their thinking in terms of application domains, whereas expert programmers build up their logical thinking in terms of algorithmic structures.

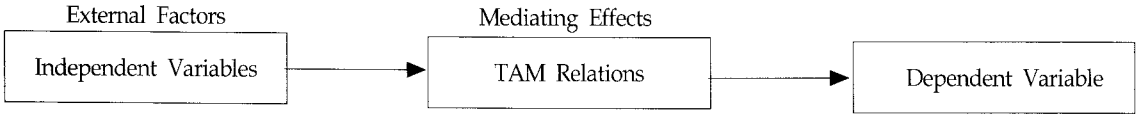
Herbsleb et al. [1995] find that teams using object orientation use their communication skills more effectively than teams using traditional methods. Their findings, including more walk-throughs and integration, are matched with seamless development [Henderson-Sellers, 1992] in object orientation. Pennington et al. [1995] insist that domain knowledge can play a critical role in the object-oriented design phase. They also discuss two difficulties in learning the object-oriented design: (1) providing principles for training; and (2) answering several questions of knowledge transfer and interference in skill acquisition. Burkle et al. [1995] apply object orientation successfully to an ongoing project which has failed using traditional procedural design methods. They consider the system development as a learning and communication process, and show how their methods facilitate both mapping between the application domain and software solution, and communication among team members. Capper et al. [1994] demonstrate the increase of software quality in terms of low defect rates, low level of design changes through early user interface, and close users' involvement.

Ⅲ. Research Model and Hypotheses

A path model is suggested for testing the mediating variables that are defined at the Technology Acceptance Model (TAM). The path model is analyzed according to external and internal variables. Three hypotheses are suggested.

3.1 TAM Description

In this section, the related research variables in TAM will be explained. Two different groups of variables can be identified in TAM: external, and internal variables. The external variables, considered as independent variables, must be defined by specific research purposes. The internal variables are composed of four mediating variables and one dependent variable. The pre-defined mediating variables are called the perceived usefulness, perceived ease of us, attitude toward using, and behavioral intention to use [Davis, et al., 1989; Davis, 1989]. The one dependent variable is the actual usage of end-user computing technologies [Davis, et al., 1989; Davis, 1989]. The mediating variables should mediate the relationship between the external variables and the dependent variable. The dependent variable, the actual usage of object orientation, is a final measure through the mediating and external variables. The relationships among the external, mediating, and dependent variables are shown in Figure 3.



<Figure 3> The Relationships among External, Mediating, and Dependent Variables

Affecting factors of technology adoption can be classified into seven groups: (1) individual characteristics, (2) innovational characteristics, (3) managerial characteristics, (4) organizational characteristics, (5) environmental characteristics, (6) economic aspects, and (7) social system.

The scope of this study is defined to be an individual-level adoption of object orientation in organizations which is related to the five affecting groups such as the individual, innovational, managerial, organizational, and environmental factors. In particular, the innovational factor is included in the TAM relations in Figure 3. Economic and social factors are not included in this study because these variables are too global to be included in TAM.

One or two independent variables, important to adoption of object orientation, are selected from the other four affecting groups-individual, managerial, organizational, and environmental group. Even though the organization-level adoption of object orientation has more practical implication than the individual-level adoption, macro-level adoption of object orientation is also influenced by perceptions of members [Coleman, 1986].

3.2 Research Variables

3.2.1 External/Independent Variables

Many researchers suggest a variety of variables in the context of adoption of software process technologies, but the following independent variables are considered to be most important to the adoption of object orientation. This explorative study of factors affecting the adoption of object orientation should include the concept of a paradigm shift [Barker, 1992] from the structured methods to object orientation. The factors affecting the adoption of object orientation are composed of individual, managerial, organizational, and environmental group. These external variables, also independent variables, are assumed to strongly influence the mediating variables that are pre-defined in TAM.

Individual factors include two variables: (1) the amount of experience in using the structured methods and (2) the level of openness toward new technologies. These two variables are respectively assumed to be negatively and positively related to the actual usage of object orientation through the mediating variables. For example, the more a person is accustomed to using the structured methods, the less he or she is comfortable in using object orientation because object orientation requires different ways of thinking in building applications. The another aspect is the personal innovativeness toward technology [Leonard-Barton & Deschamps, 1988], which will also affect the adoption of object orientation. The more open a person is toward new technology, the more he or she is apt to adopt the technology.

Managerial factors include two variables: (1) management support [Leonard-Barton & Deschamps, 1988; Wynekoop, Senn, & Conger,

1992] and (2) training [Alexander, 1989; Dolan & Tziner, 1988; Leonard-Barton, 1987]. Perceived management support [Leonard-Barton & Deschamps, 1988] and cumulative number of formal training [Alexander, 1989] are assumed to increase the actual usage of object orientation in organizations.

Organizational factors include one variable: the number of IS professionals. Many researchers [Ettlie, 1983; Inkson, Pugh, & Hickson, 1970; Jones, 1987; Zmud, 1984] empirically tested the effects of organizational size in their study areas. The IS professionals in a working group or an organization may affect other persons' perceptions of using object orientation because object orientation is at the initial stage of adoption in many organizations.

Environmental factors include two variables: (1) technology champions and (2) software and hardware environment. Rothwell and Zegveld [1985] mention a product champion as a person who can contribute to an organization as a business innovator, technological gatekeeper, and problem solver. Technology champions in information systems must be an information gatekeeper about new information technologies, problem solver, and helper. They will eventually promote the usage of object orientation. The hardware and software environments for using object orientation are also critical to the adoption at an initial stage because the available environments may provide visible and trial effects of object orientation.

3.2.2 Mediating Variables

The group of mediating variables includes the perceived usefulness, ease of use, attitude toward using, and behavioral intention to use [Davis, 1986; Davis, 1989; Davis et al., 1989]. The usefulness and ease of use present innovation-related factors. The usefulness and ease of use are two pre-determined beliefs influencing the attitude, and this attitude also affects the behavioral intention to use information technologies. In addition to these four mediating variables, one more variable is added. Tornatzky and Klein [1982] suggests that compatibility, relative advantage, and complexity have the most significant relationships to innovation adoption according to their meta-analysis of previous studies. The relative advantage and complexity are the same concepts as, respectively, the usefulness and ease of use in TAM. The compatibility is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of the receivers. [Roger & Shoemaker, 1971] Therefore, the compatibility [Tornatzky & Klein, 1982] is added as a mediating variable into the modified TAM.

3.2.3 Dependent Variable

The actual usage of object orientation is defined as one dependent variable. TAM's strength comes from the mediating variables used to explain user acceptance of information systems. The dependent variable can be thus explained through the external and mediating variables.

3.3 Research Model

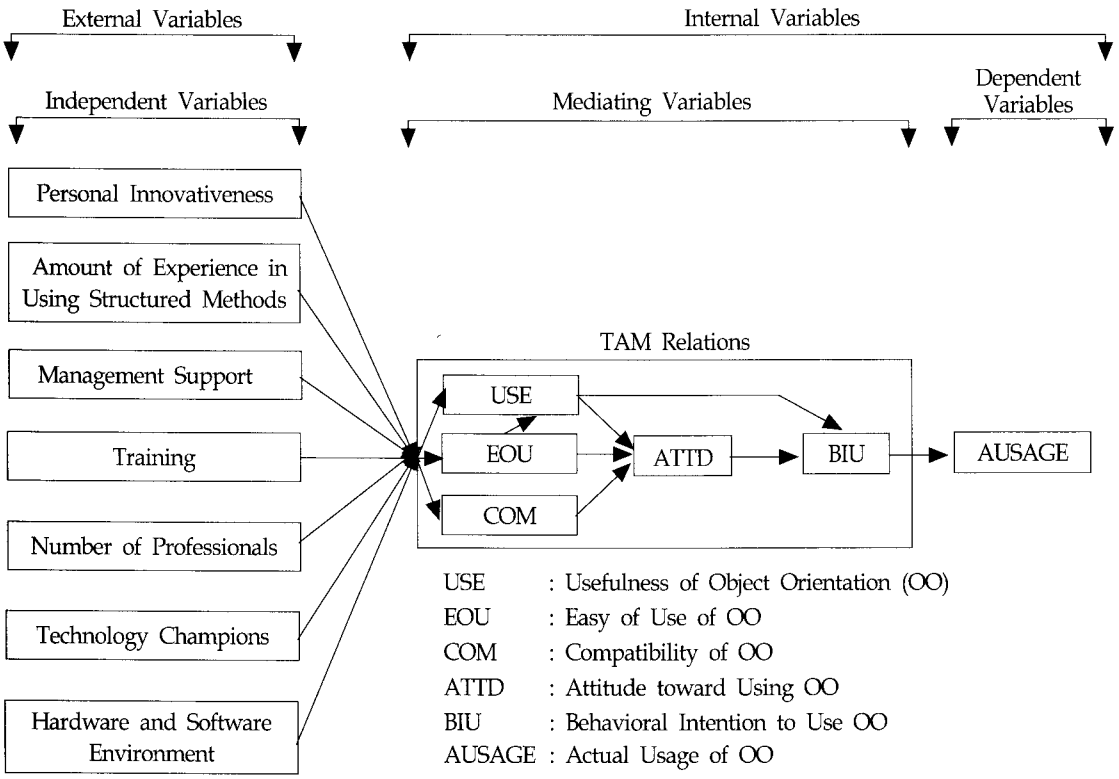
Based on these independent, mediating, and dependent variables, a final research model is

suggested in Figure 4. The research model is based on a path model that is utilized for empirically testing the effects of the independent variables on the dependent variable. In TAM, the external/independent variables should affect the dependent variables through only the mediating variables. The mediating variables form a path to explain the variations of the dependent variable caused by the external variables.

In Figure 4, the actual usage of object orientation is used as one dependent variable, and the seven independent variables are selected from four groups that will affect the dependent variable. The TAM relations, composed of five mediating variables, step in the effects of the independent variables on the dependent variable.

Research Questions: Two research questions are related to the research model: the knowledge interaction between structured methods and object orientation, and the validity of TAM.

Q1: Is the previous experience of the usage of structured methods reversely related to the technology acceptance of object orientation? The ease of use, that is one of several mediating variables and is reversely affected by the length of the usage of structured methods, may influence the actual usage of object orientation. A path model examines the relationships among research variables in TAM.



<Figure 4> Research Model

Q2: Is TAM valid for the technology acceptance of object orientation in terms of its causal relationships? A path model will test the mediating function defined in TAM. A Path model is a useful tool to verify the rela-tionships among many variables. The indirect relationships between the external and dependent variables will be presented on the basis of the modified TAM.

3.4 Research Hypotheses

Two basic research questions are proposed and three hypotheses are also generated.

Q1: Is the previous experience of the usage of structured methods reversely related to technology acceptance of object orientation?

Is there any interaction between knowledge of structured methods and that of object orientation? The length of experience in using structured methods is selected for analyzing the knowledge interaction. The basic idea supporting the interaction is that the more a person gets used to using the structured methods, the more he or she feels uncomfortable in using object orientation. The empirically tested construct of perceived ease of use is used as the dependent variable to analyze the effects of individual experience on the perceptions of using object orientation. Two hypotheses are proposed.

Hypothesis 1:

A period of experience in using the structured methods is negatively related to the perceived ease of use in using object orientation.

Hypothesis 2:

The perceived ease of use in using object orientation is positively related to the actual usage of object orientation.

Q2: Is TAM valid for the technology acceptance of object orientation in terms of its causal relationships?

The mediating variables in the modified TAM are the usefulness, ease of use, compatibility, attitude, and intention. The relationships among these five mediating variables are presented in Figure 4. One hypothesis can be suggested.

Hypothesis 3:

TAM accommodates its causal relationships in case of technology acceptance of object orientation.

Ⅳ. Data Analysis

This section presents data analysis on the basis of the research models described in the research model. The implications of the results will be discussed in detail in discussion section. Data analysis includes three major parts: basic analysis of data, operationalization, and analyses of measures.

4.1 Basic Data Analysis

Data were gathered from active members of the Data Processing Management Association (DPMA) in February, 1996. Before the final questionnaires were distributed, phone calls were made to local presidents of DPMA asking for the support of member participation in the

survey. Subsequently, lists of DPMA directories were obtained with their permission. Eight hundred fifty-four structured questionnaires were sent to nine DPMA chapters across four midland states. Six of these questionnaires were returned because of incorrect addresses. One hundred twenty-seven subjects responded to the questionnaires (response rate=14.9 percent). The response rate was relatively low because using object orientation was not popular to the DPMA members. Eighteen subjects did not answer the questionnaires completely because they were not familiar with using object orientation. Finally, one hundred nine subjects, having experiences in using both the structured methods and object orientation, gave almost complete information to the questionnaires.

The average age of the subjects is 43.4 years. That finding indirectly indicates that IS professionals have much experience in building applications. The percent of males is 78 and that of females is 22. The ratios of males and females are not balanced because there seems to be more male IS professionals. Most subjects have a job title of "supervisor" (42 percent), while remaining subjects are distributed among technical and managerial jobs. Most of the subjects have earned bachelor's degrees (76 percent). Major areas of study are classified into natural sciences (5.5 percent), applied science (25.7 percent), engineering (6 percent), business administration (40.4 percent), social sciences (12.8 percent), and no response (11 percent). The average of job experience is 18 years, which shows relatively high IS experience. The average percent of management-oriented tasks is 35.3, with most IS respondents being technically-oriented.

4.2 Operationalization

The research variables can be classified into: (1) one dependent variable (actual usage); (2) seven external variables (personal innovativeness, amount of experience in using structured methods, management support, training, technology champions, number of IS professionals, and hardware and software environment); and (3) five mediating variables (usefulness, ease of use, compatibility, attitude toward using new technologies, and behavioral intention to use). Table 1. summarizes the operationalization of the research variables.

4.3 Analyses of Measures

The data collected from the structured questionnaire were utilized to test the proposed hypotheses. Four kinds of validity [Cook & Campbell, 1979] were carefully considered: internal validity, external validity, statistical conclusion validity, and construct validity. Internal validity is related to the reduction of third variables causing changes in a dependent variable. Randomization can take care of most threats to internal validity [Cook & Campbell, 1979]. External validity can generalize findings across times, settings, and persons [Mitchell, 1985]. The goal of external validity can be achieved by utilizing the multiple measurements from previous studies, structured questionnaire, and thorough literature review. Statistical conclusion validity means correct conclusions about the existence of treatment effects. Even though α=0.05 is traditionally selected, the cutting point may not draw correct conclusions. Construct validity

<Table 1> The Operationalization List of the Research Variables

Classification	Variable	Previous Measure	Item Type
Dependent Variable	Actual Usage	Davis [1989], Davis et al.[1989], Hill et al. [1987]	Likert Scale (5 point)
Mediating Variables	Usefulness	Davis [1989], Moore & Benbasat [1991], Mathieson [1991]	Likert Scale (5 point)
	Ease of Use	Davis [1989], Moore & Benbasat [1991], Mathieson [1991]	
	Compatibility	Tornatzky & Klein [1982],	
	Attitude toward Using New Technologies	Davis [1989]	
	Behavioral Intention to Use	Mathieson [1991]	
Independent Variables	Personal Innovativeness	Leonard-Barton & Deschamps [1988]	Likert Scale (5 points)
	Experience in Using Structured Methods	Hill et al. [1987]	Number of Years: the experience length in using conventional structured method
	Management Support	Leonard-Barton & Deschamps[1988]	Likert Scale (5 points)
	Training	Alexander [1989], Dolan & Tziner [1988], Leonard-Barton [1987]	Days of Formal Training in a Year: the up-to-date days of formal training
	Technology Champions	Alexander [1989]	Likert Scale (5 points)
	Number of Professionals	Zmud [1984]	The mean value of IS professionals in a working group and an organization
	Hardware and Software Environment		Likert Scale (5 points)

is threatened when the measures can not represent the constructs or respondents are not properly selected.

For reliability test, this study used factor analysis and Cronbach's alpha. Reliability is defined as the accuracy or precision of an instrument. By using factor analysis, an analyst can determine independent dimensions being measured by a research [Hair, Anderson, Tatham, & Grablowsky, 1979]. Grouped factors based on varimax rotation were tested to determine whether they reliably presented surrogated measures or not.

Finally, the correlation matrix was used to analyze whether the predictor variables were independent or not. Incorrect estimation of regression coefficients may be caused from strong correlation between predictor variables. This is called a multicollinearity problem.

4.3.1 Factor Analysis

Factor analysis is separately conducted according to the external and internal variables because the external and internal variables show totally different conceptual dimensions. The external or independent variables may be slightly correlated to each other, while the internal variables should have mutually exclusive dimensions.

Factor analyses are conducted for OOAD (Object-Oriented Analysis and Design) and OOP (Object-Oriented Programming). During the factor analysis, because the compatibility factor loads with the usefulness factor, the compatibility measure is excluded from this internal variable set. The attitude and intention factors are combined together to make a new factor named "attitude and intention." Therefore, the final dimensions for the internal variables are reduced to four, which are ease of use, usefulness, attitude & intention, and actual usage.

4.3.2 Reliability of Measures

Each variable's reliability is verified by conducting a reliability test based on the results of the factor analyses. Variables with more than two items are analyzed. Cronbach alpha values are listed in Table 2. Even though the variable of perceived management support was adapted from the previous study [Leonard-Barton & Deschamps, 1988], the alpha value was low (0.5631). An elimination of one item

<Table 2> Reliability Test of Each Variable with More than Two Items

Type	Variable	Number Items	Alpha Value
External Variables	Personal Innovativeness	3	0.7298
	Perceived Management Support	4	0.5631
	Number IS Professional	2	0.6513
	Environment for OO	2	0.7188
Internal Variables for OOAD	Perceived Usefulness	6	0.9511
	Perceived Ease of Use	4	0.8580
	Attitude and Behavioral Intention	5	0.9481
	Actual Usage	2	0.9269
Internal Variables for OOP	Perceived Usefulness	6	0.9441
	Perceived Ease of Use	4	0.8633
	Attitude and Behavioral Intention	5	0.9112
	Actual Usage	2	0.9161

<Table 3> Correlation Matrix of OOAD

	INV	SAD	SUPPORT	TRAIN	SIZE	ACCESS	ENV	USE1	EOU1	AI1	AUSAGE1
INV	1.000	-.057	.161	.184	.071	-.103	.252**	.107	.106	.053	.315**
SAD	-.057	1.000	-.148	.000	-.098	.173	-.043	-.180	-.202*	-.172	-.046
SUPPORT	.161	-.148	1.000	.150	.225*	.386**	.229*	.282**	.107	.189	.330**
TRAIN	.183	.000	.150	1.000	.153	.183	.262**	.076	.136	.022	.446**
SIZE	.071	-.097	.225*	.153	1.000	.120	-.008	-.266**	-.169	-.091	.003
ACCESS	-.102	.172	.386**	.183	.120	1.000	.042	.166	.110	.280**	.267**
ENV	.251**	-.043	.229*	.262**	-.008	.042	1.000	.275**	.372**	.276**	.388**
USE1	.107	-.179	.282**	.076	-.266**	.166	.275**	1.000	.675**	.809**	.411**
EOU1	.105	-.202*	.107	.136	-.169	.110	.372**	.675**	1.000	.621**	.398**
AI1	.052	-.172	.189	.022	-.091	.280**	.276**	.809**	.621**	1.000	.425**
AUSAGE1	.315**	-.045	.330**	.446**	.003	.267**	.388**	.411**	.398	.425**	1.000

<Table 4> Correlation Matrix of OOP

	INV	SAD	SUPPORT	TRAIN	SIZE	ACCESS	ENV	USE2	EOU2	AI2	AUSAGE2
INV	1.000	-.025	.161	.184	.071	-.103	.252**	.076	.069	.040	.272**
SP	-.025	1.000	-.177	-.035	-.145	.082	-.075	-319**	-269**	-.292**	-.143
SUPPORT	.161	-.177	1.000	.150	.225*	.386**	.229*	.203	.054	.129	.272**
TRAIN	.184	-.035	.150	1.000	.153	.183	.262**	.102	.173	.050	.458**
SIZE	.071	-.145	.225*	.153	1.000	.120	-.008	-264**	-.258*	-.123	-.036
ACCESS	-.103	.082	.386**	.183	.120	1.000	.042	.123	.078	.214*	.195
ENV	.252**	-.075	.229*	.262**	-.008	.042	1.000	.232*	.375**	.323**	.382**
USE2	.076	-319**	.203	.102	-264**	.123	.232*	1.000	.687**	.824**	.399**
EOU2	.069	-269**	.054	.173	-.258*	.078	.375**	.687**	1.000	.661**	.412**
AI2	.040	-292**	.129	.050	-.123	.214*	.323**	.824**	.661**	1.000	.406**
AUSAGE2	.272**	-.143	.272**	.458**	-.036	.195	.382**	.399**	.412**	.406**	1.000

INV : Personal Innovativeness toward New Technology
SAD : Amount of Experience in Using Structured Analysis and Design
SP : Amount of Experience in Using Structured Programming
SUPPORT : Perceived Management Support
TRAIN : Cumulative Day of Formal Training
SIZE : Mean Number of IS Professionals in a Working Group and an Orga- nization
ACCESS : Accessibility to Technology Cham- pions
ENV : Hardware and Software Environ- ment for OO
USE1 : Usefulness of OOAD
USE2 : Usefulness of OOP
EOU1 : Ease of Use of OOAD
EOU2 : Ease of Use of OOP
AI1 : Attitude and Behavioral Intention to- ward Using OOAD
AI2 : Attitude and Behavioral Intention to- ward Using OOP
AUSAGE1 : Actual Usage of OOAD
AUSAGE2 : Actual Usage of OOP

<Table 5> Research Techniques for the Research Hypotheses

Research Question	Hypothesis	Research Technique
Knowledge Interaction (Question 1)	H1 and H2	Path Analysis
TAM (Question 2)	H3	Goodness of Fit of Model in a Path Model

H1 : A period of experience in using the structured methods is negatively related to the perceived ease of use in using object orientation.
H2 : The perceived ease of use in using object orientation is positively related to the actual usage of object orientation.
H3 : TAM accommodates its causal relationships in case of technology acceptance of object orientation.

did not increase the alpha value. The number of IS professional was the mean value of the numbers in a working group and an organization. The alpha value (0.6513) was relatively low because the number of IS professional in a working group did not always correspond with the number in an organization.

4.3.3 Correlation Analysis

The correlation matrices of OOAD and OOP are shown in Tables 3 and 4. For the independent variables, there were three highly-correlated groups: ENV and INV; ACCESS and SUPPORT; and ENV and TRAIN ($p < 0.01$). However, this high correlation may be expected in the social science studies

Three hypotheses based on two research questions were suggested, and two research techniques were presented to empirically test these hypotheses. Explicit research questions and hypotheses were shown in Table 5.

V. Results

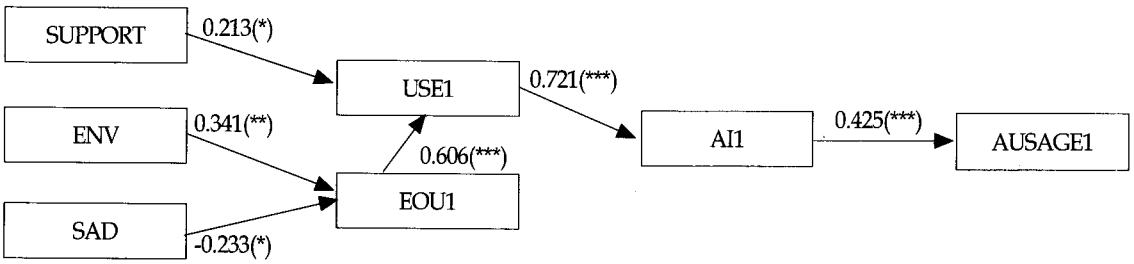
5.1 Path Analysis

A path model will be empirically tested to verify the relationships among variables in TAM. The seven independent variables are selected from four groups: individual, managerial, organizational, and environmental factors. Path analyses are conducted on the basis of TAM, and the final results for OOAD and OOP are depicted respectively in Figures 5 and 6.

The figures show the causal relationship between the amount of experience in using structured methods and ease of use in using object orientation, and causal paths between the ease of use and actual usage of object orientation. The numbers on the arrows are standardized coefficients and the arrows correspond to direct effects. In Figure 5, the amount of experience in using structured analysis and design (SAD) is negatively related to the perceived ease of use (EOU) in using OOAD with α=0.05, and EOU is positively related to the actual usage of OOAD with α=0.001. The causal paths in Figure 6 are very similar to those in Figure 5, but the amount of experience in using structured programming is negatively related to EOU in using OOP with α=0.01. These results show strong evidence to support the hypotheses 1 and 2.

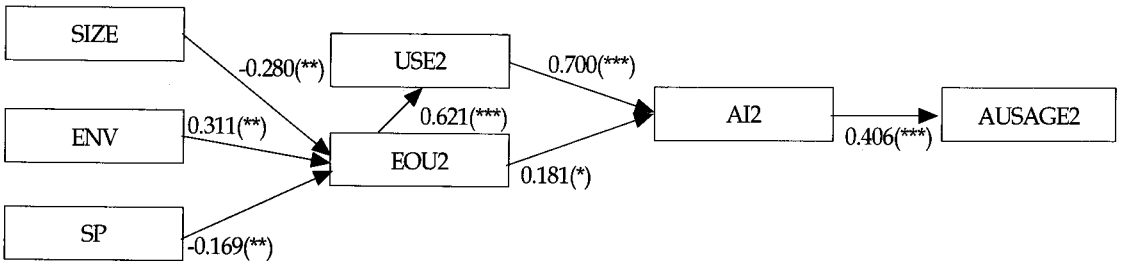
5.2 Goodness of fit of model

A covariance matrix is used as input to the LISREL 8 program [Joreskog & Sorbom, 1993] in order to analyze the structural model of this research. The estimation method used for the



SUPPORT : Perceived Management Support
ENV : Hardware and Software Environment for OO
SAD : Amount of Experience in Using Structured Analysis and Design
USE1 : Usefulness of OOAD
EOU1 : Ease of Use of OOAD
AI1 : Attitude and Behavioral Intention toward Using OOAD
AUSAGE1 : Actual Usage of OOAD
* (α=0.05); ** (α=0.01); *** (α=0.001)

<Figure 5> Path Analysis of OOAD



SIZE : Mean Number of IS Professionals in a Working Group and an Organization
ENV : Hardware and Software Environment for OO
SP : Amount of Experience in Using Structured Programming
USE2 : Usefulness of OOP
EOU2 : Ease of Use of OOP
AI2 : Attitude and Behavioral Intention toward Using OOP
AUSAGE2 : Actual Usage of OOP
* (α=0.05); ** (α=0.01); *** (α=0.001)

<Figure 6> Path Analysis of OOP

current research is maximum likelihood (ML). The management support, usefulness, ease of use, attitude and intention were re- presented by the total scores on these scales.

Values of several goodness of fit indices for the original TAM model are shown in Table 6. NFI (Normed Fit Index) can be interpreted as the improvement in a model fit of a hypo- esized model over a baseline model. Because a better model-fit can always be obtained by adding parameters to the model, James, Mulaik, and Brett [1982] have proposed a PNFI (Parsi- nious Normed Fit Index) by adjusting the NFI that gains the improvement in a model fit at the expense of degrees of freedom. In addition to these, conventional chi-square statistics is

<Table 6> Goodness of fit indices for TAM

Model (TAM)	Chi-Square	DF	Prob.	NFI	PNFI
OOAD	48.48	22	< 0.01	0.87	0.35
OOP	49.90	22	<0.01	0.87	0.35

<Table 7> indicates the final results of three hypotheses

Hypotheses	Results
H1: A period of experience in using the structured methods is negatively related to the perceived ease of use in using object orientation.	Supported
H2: The perceived ease of use in using object orientation is positively related to the actual usage of object orientation.	Supported
H3: TAM accommodates its causal relationships in case of technology acceptance of object orientation.	Not Supported

reported for testing the goodness of fit of the models in this research. Except for chi-square value, larger values are desirable for NFI and PNFI. This result does not support the hypoesis 3.

Ⅵ. Discussion

Final answers to two research questions can be obtained from the results. The research questions are restated as follows: (1) the knowledge interaction of the structured methods with object orientation; (2) the validity of TAM in terms of its causal relationships.

The knowledge interaction exists both in object-oriented programming and object-oriented design and analysis. The more a person is accustomed to using structured programming, the less easy he or she feels in using object-oriented programming. The previous experience in using structured analysis and design also affects the perceived ease of use in using object-oriented analysis and design. Even though programming task is more concrete and is relatively well defined, the paradigm difference between the structured and object-oriented analysis and deign also exists.

The causal relationships between the ease of use in using object orientation and the actual usage of object orientation can explicitly be explain in Figures 5 and 6. The ease of use affects the actual usage in case of object orientation.

The overall causal relationships defined in TAM are not valid. This indicates that other paths which can not explained by TAM may exist. Why is TAM not applicable in the technology acceptance of object orientation? First, Fichman [1992] says TAM is appropriate for simple and individual-level adoptive technologies. But object orientation is a complex and organizationlevel adoptive technology, and this study mainly concentrates on the individual-level acceptance of object orientation. This may inhibit the validity of TAM. Second, well-defined mediating constructs in TAM may not be appropriate at industry settings. Even though those measures were empirically tested for MBA stu-

dents [Davis et al., 1989], the external validity may have problems.

Ⅶ. Conclusions

7.1 Concluding Summary

Two research questions, phrased as three testable hypotheses, are proposed as a means of investigating the knowledge interaction between structured methods and object orientation and of verifying TAM. The first research question tries to find whether there is any knowledge interaction of structured methods with object orientation, and the knowledge interaction is related to the technology acceptance of object orientation in industry settings. The tests of hypotheses 1 and 2 show that there is strong evidence for such knowledge interaction in the case of object-oriented programming and object-oriented analysis and design, and the interaction influences the acceptance of object orientation. The existence of the knowledge interaction and its effects on the acceptance of object orientation correspond to the results of previous studies.

The second research question seeks to find whether TAM is valid for the acceptance research of object orientation. This paper is the first to apply TAM to the area of object orientation. The test of hypothesis 3 suggests that TAM is not valid in the research area of object orientation. TAM may not be appropriate to a complex and organizational-level adoptive technology in industry settings.

7.2 Implications

The basic differences between structured methods and object orientation is not only programming methods, but also view points of a target system. While the structured methods regard the system as a collection of logical procedures defined by input and output formats, object orientation consider the system as a set of objects that are composed of data and procedures. This difference in thinking may be compared to a paradigm shift.

This research has implications for technology adoption, MIS researcher, and IS practitioners. First, even though TAM is first applied in this study to the area of object orientation, the validity of TAM is not presented in terms of its causal relationships. This unexpected result may enforce limited applications on TAM. Second, the measure of the perceived compatibility is not factorized in the factor analysis, and the measures of attitude and intention are combined together in the modified TAM. Further analysis of the mediating constructs will be required. Third, the existence of the knowledge interaction suggests some hints for cognitive-level MIS researchers. Previous studies are confined to a limited number of subjects under simulated problems through deep analyses. This study shows that the existence of the knowledge interaction can be empirically tested in industry settings.

7.3 Contributions of Research

This study makes several contributions to both information technology adoption and information systems research areas. A review of IS literature reveals this research may be the first to apply TAM to the area of object orientation.

Even though the validity of TAM is not supported, several informative results can be shown.

This study empirically investigates whether the structured methods interact with object orientation in industry settings. The existence of the knowledge interaction is shown both in OOP and OOAD. The existence of the interaction is important because it may suggest more effective training methods for object orientation.

TAM is empirically tested in terms of its causal relationships. The fact that TAM is not workable in the area of object orientation implies TAM might not be applied to every area of information technology.

7.4 Limitations and Suggestions for Future Study

Several limitations are imposed on this research. A research design depends on a cross-sectional survey of respondents through structured questionnaires [Cook & Campbell, 1979]. Longitudinal survey may be more informative in the area of this study.

While the subjects are chosen to ensure variety, the participating subjects are confined to the mid-west area of the US. Nationwide data may increase external validity of this study.

Even though the measure items show high internal consistency, further improvement of the measures is required.

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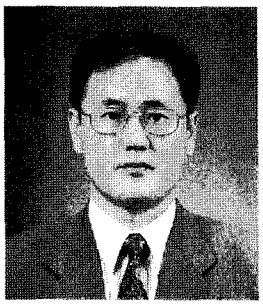
◆ 저자소개 ◆



김인재 (Kim, Injai)
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