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ABSTRACT

The relationship between several individual difference variables and test performance using computerized adaptive testing (CAT) was studied with 208 South Korean college students. The general individual difference variable selected was test anxiety, and the math-related individual difference variables were mathematics aptitude, math test anxiety, and math self-concept. Computer-related individual difference variables were computer literacy, computer anxiety, and computer experience. The CAT was an algebra test. Test anxiety and other individual difference variables were measured with instruments translated into Korean for the study. The seven difference variables and their squares were submitted to an analysis using the RSQUARE Procedure from Statistical Analysis System software. Math aptitude, math self-concept, math test anxiety, and computer literacy, in that order, were significantly related to test performance using CAT, but test anxiety, computer experience, and computer anxiety were not. Results suggest that the relationship between individual difference variables and test performance using CAT may be curvilinear. Two tables present analysis results. (Contains 27 references.) (SLD)

THE RELATIONSHIPS BETWEEN INDIVIDUAL DIFFERENCE VARIABLES AND TEST PERFORMANCE IN COMPUTERIZED ADAPTIVE TESTING

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THE RELATIONSHIPS BETWEEN INDIVIDUAL DIFFERENCE VARIABLES AND TEST PERFORMANCE IN COMPUTERIZED ADAPTIVE TESTING

Research on computerized adaptive testing (CAT) has paid much attention to the efficiency and precision of the examinees' ability estimation. However, research on the relationships between examinees' demographic and psychological characteristics and CAT has been largely neglected (Legg & Buhr, 1992; Kim, 1993, November). The purpose of this study is to examine the relationships between several individual difference variables and test performance using CAT.

The literature review indicated that there are several examinee demographic and psychological characteristics that may be related to specific tasks and to computers as a test delivery medium (Kim, 1993, November). It is essential to consider not only general individual difference variables but also specific task-related variables when doing CAT research. In this study, the selected individual difference variables include a general individual difference variable (test anxiety) and six specific task-related variables (math aptitude, math test anxiety, math self-concept, computer literacy, computer anxiety, and computer experience).

The general individual difference variable selected for this study was test anxiety. Only a few studies have investigated the relationships between test anxiety and CAT (Powell, 1991; Rocklin & O'Donnell, 1991; Vispoel & Rocklin, 1993). In most previous studies except the Powell's study (1991), test anxiety was negatively correlated with test performance using CAT (Rocklin & O'Donnell, 1991; Vispoel & Coffman, 1994; Vispoel & Rocklin, 1993; Vispoel, Rocklin, & Wang, 1994).

The selected math-related individual difference variables were math aptitude, math test anxiety, and math self-concept. Although a large volume of literature was available concerning the math-related individual difference variables, previously reported research did not examine the relationships between math-related variables and CAT scores.

The selected computer-related individual difference variables were computer literacy, computer anxiety, and computer experience. Although computer literacy is an important predictor of computer-

related achievement, no previous studies were reported on the relationship between computer literacy and CAT. Previous research on computerized tests suggests that computer anxiety and computer experience may affect test performance. Only a few studies (Legg & Buhr, 1992; Vispoel & Rocklin, 1993) have examined the relationships between either computer anxiety or computer experience and CAT performance. Some aspects of these variables have been investigated as potentially related to CAT, but clear-cut results have not been obtained.

Considering the lack of investigation into this area, it seems that the literature strongly supports application of CAT to a college classroom testing situation and the expansion of the field of CAT research with non-English speaking subjects. If it can be demonstrated that the best variables predict the CAT test performance, more educators might make use of CAT in the classroom. In addition, if relationships between CAT performance and the selected individual difference variables can be demonstrated, more research might explore more specific individual difference variables.

Method

Subjects

The subjects in this study were 208 Korean college students enrolled in educational statistics and test and measurement courses for the spring semester of 1994 at the Kyungpook National University, Taegu, Korea. There were 149 females and 59 males ranging in age from 19 to 24.

Instrumentations

Computer Adaptive Algebra Test Item Bank

The CAT used a pool of 70 items. These items came from a pool developed to be used for identifying introductory statistics students whose basic mathematics skills were in need of remediation (Wise, Plake, Johnson, & Roos, 1992). Each item used a four-choice, multiple-choice format. The original validation procedure resulted in a final pool of 93 items. Three items were deleted by the original developers of the item pool (Wise, Plake, Johnson, & Roos, 1992). After reviewing the 90 algebra test

items, the authors of the current study selected 70 items that could be applied to Korean students without translation. The adaptive test began with an item of medium difficulty and employed a maximum information item selection method thereafter, using the MicroCAT Testing System (Assessment Systems Corporation, 1989). The adaptive test terminated when 20 items were administered or when the variance of .10 was reached (Legg & Buhr, 1992).

Math Aptitude Test

The Math Aptitude Test consisted of 20 retired Graduate Record Examination items. Two Korean mathematics professors and the first author chose five items in each of four subscales. Each item used a five-option, multiple-choice format. The test were translated into Korean by the first author and reviewed by two Korean mathematic professors. They were asked to check the test items and compare the Korean version to the English version. The alpha coefficient for the Math Aptitude Test was .74.

Math Test Anxiety Scale

The Math Test Anxiety Scale consisted of 10 items from the Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972) which were identified by Rounds and Hendel (1980) as loading heavily on mathematics test anxiety. The items were rated on a 5-point Likert-type scale. The alpha coefficient for this scale was .88.

Math Self-Concept Scale

The modified 10-item math self-concept scale was used to measure math self-concept in this study. Six items from the Self Description Questionnaire (SDQ) III math subscale (Marsh & O'Neill, 1984) and four items from Math Self-concept Scale (Benson, 1989) were selected based on face validity. The items were rated on a 5-point Likert-type scale. The alpha coefficient for this scale was .93.

Computer Competence Instrument

The Computer Competence Instrument, developed by Martinez and Mead (1988), was used to test subjects' computer vocabulary and to measure their knowledge about computers. The instrument consisted

of 33 4-choice items. Massoud (1991) reported a rank order correlation between the results from his own study and that of Martinez and Mead (1988) as .79 using the Computer Competency Instrument. The alpha coefficient for this instrument in the present study was .80.

Computer Anxiety Scale

The computer anxiety subscale from the Computer Attitude Scale (Loyd & Gressard, 1984) was used to measure computer anxiety. The subscale has 10 4-point agree-disagree items. The alpha reliability coefficients for the computer anxiety subscale in previous studies were .89 (Gressard & Loyd, 1986), .86 (Loyd & Gressard, 1984), and .78 (Massoud, 1990). The alpha coefficient in the present study was .87.

Computer Experience Questionnaire

The Computer Experience Questionnaire developed by Lee (1986) and modified by Mazzeo, Druesne, Raffeld, Checketts, and Muhlstein (1991) was used to measure test-takers' computer experience and familiarity. Response options "a" through "e" were recoded as 1 through 5, and scores on the first seven items were summed to produce a total score for each individual. Item 8 was not included in the total score, since the correct ordering of the options (face validity) was not readily apparent. The alpha coefficient for this questionnaire was .70.

Test Anxiety Inventory

The Test Anxiety Inventory (TAI; Spielberger, 1980) was used to measure test anxiety. The TAI scale consists of 20 4-point Likert-type items (1=almost never, 4=almost always). The alpha coefficient for this scale was .90.

The Translation of the Instruments into Korean

All of the instruments except the Math Aptitude Test were translated into Korean using the same procedures. The process began with the first author translating the instruments from English into Korean. Every attempt was made to provide a Korean version that was a faithful representation of the English

version. The Korean versions of the instruments were be translated back to English by a Korean linguist. The back-translated versions were compared with the original English to ensure that the translations were accurate. Two Korean educational psychologists and the first author checked the Korean and the back-translated English versions of the instruments and compared them to the original English versions.

Data Collection

The students completed the seven instruments (Math Aptitude Test, Math Test Anxiety Scale, Math Self-Concept Scale, Computer Competence Instrument, Computer Anxiety Scale, Computer Experience Questionnaire, and Test Anxiety Inventory) during the first week of class. Instruments were assembled into packets and distributed to the students as they arrived for class. Each packet contained the seven instruments arranged in random order.

The computerized adaptive algebra test was then given to each student during the second or third week of the semester. When each student arrived for testing at the computer laboratory, he or she was administered the CAT on an IBM compatible 486 personal computer.

Data Analysis

Means, standard deviations, and alpha coefficients were calculated for each individual difference variable. Intercorrelations among the individual difference variables were also computed. The basic analysis procedure was the use statistical regression to identify the best combination of the seven difference variables for predicting achievement on the CAT. Square of the difference variables were also used in the analysis. A correlation matrix was computed for the variables and scattergrams were produced to depict the relationship between each difference variable and computer adaptive test performance.

The seven difference variables and their squares were submitted to an analysis using the "RSQUARE PROCEDURE" from the SAS computer software library. The squares of the difference variables were included to consider the possibility of curvilinear relationships. The SAS RSQUARE procedure runs a regression model with every possible combination of predictor variables (McLean,

Lindly, & El-Sayed, 1991, November). The results from this procedure provided multiple correlation coefficients (R^2s) and several diagnostic statistics to assist in choosing the best model.

Results

Descriptive data from the seven individual difference variables and computer adaptive test performance are presented in Table 1.

Table 1

Descriptive Data

Variables	Mean	Std Dev	Label
MATO	14.59	3.01	Math Aptitude
MSCTO	24.84	6.81	Math Self-Concept
MTATO	35.17	7.14	Math Test Anxiety
CLTO	23.41	4.98	Computer Literacy
CETO	12.54	4.34	Computer Experience
CATO	23.68	5.66	Computer Anxiety
TATO	38.46	8.35	Test Anxiety
SCORE	1.79	0.77	Score using CAT

The correlation matrix is shown in Table 2. As can be seen in Table 2, the highest bivariate correlations between the individual difference variables and computer adaptive test performance using CAT are .63 (math aptitude score), .37 (computer literacy), and .36 (math self-concept). The relationships between the anxiety-related variables (test anxiety, math test anxiety, and computer anxiety) and computer adaptive test performance were related negatively.

Table 2

Intercorrelations between Individual Difference Variables and Test Performance using CAT

Variables	MATO	MSCTO	MTATO	CLTO	CETO	CATO	TATO	SCORE
MATO	1.00	.38*	-.19*	.45*	.14*	-.05	-.12	.63*
MSCTO		1.00	-.53*	.20*	.20*	-.10	-.21*	.36*
MTATO			1.00	-.05	-.18*	.17*	.51*	-.15*
CLTO				1.00	.39*	-.26*	-.06	.37*
CETO					1.00	-.55*	-.10	.11
CATO						1.00	.27*	-.05
TATO							1.00	-.13
SCORE								1.00

* P < .05

The results showed that math aptitude (.400), computer competence (.137), math self-concept (.121), math test anxiety (.021), test anxiety (.017), computer experience (.013), and computer anxiety (.003) accounted for the largest proportions of computer adaptive test variance when considered individually (proportions of variance accounted for by each variable are shown in parentheses.

When the seven individual difference variables were combined into three categories; math-related variable (math aptitude and math self-concept), computer-related variable (computer literacy and computer experience), and anxiety-related variable (test anxiety, math test anxiety, and computer anxiety), the R^2s were .26, .09, and .02 for the math-related, computer-related, and anxiety-related variables, respectively.

The largest R^2s ranged from .4190 with one predictor variable to .4825 with all 14 predictor variables. Considering the maximum R^2 and the number of variables used, the best model appeared to be the one that included MATO (Math aptitude), MCSTO (Math self-concept), MATO2 (Math aptitude squared), and MSCTO2 (Math self-concept squared). The resulting prediction equation was: CAT Score = .5727 - .2326 (MATO) + .1159 (MSCTO) + .0140 (MATO squared) - .0021 (MSCTO squared). The

R^2 associated with these variables was .46, only .02 less than the maximum R^2s attained using all 14 predictor variables including the squares.

Discussion

In this study, we examined the relationships between individual difference variables and test performance using CAT. We found that math aptitude, math self-concept, math test anxiety, and computer competence (literacy) were significantly related to test performance using CAT, while test anxiety, computer experience, and computer anxiety were not significantly related. The results showed that, in order of magnitude, math aptitude, computer competence, math self-concept, math test anxiety, test anxiety, computer experience, and computer anxiety were most related to computer adaptive test performance.

We found that math aptitude had the largest relationship with computerized adaptive test performance. Computer competence was more strongly related to than computer experience and computer anxiety to test performance using CAT. These findings suggest that cognitive ability is the greatest single predictor of student achievement in school (Bloom, 1976). The present finding that math self-concept was significantly related to test performance using CAT is consistent with results from previous CAT research (Vispoel, Rocklin, & Wang, 1994). It is also consistent with results from previous PPT (paper-and-pencil test) research that found academic self-concept to be positively correlated with measures of academic achievement (Hansford & Hattie, 1982; Marsh, 1990, 1992; Marsh & O'Neill, 1984).

However, test anxiety and math test anxiety in this study were negatively correlated with test performance using CAT, but only math test anxiety was significant statistically. These results are not consistent with the results other CAT studies (Rocklin & O'Donnell, 1991; Vispoel, Rocklin, & Wang, 1994) that found test anxiety to be significantly correlated with test performance. Computer experience and computer anxiety were not significantly correlated with achievement on computer adaptive tests. These results are consistent with the findings from other CAT research (Vispoel, Rocklin, & Wang, 1994;

Wise et al., 1989). The absence of significance for computer experience and anxiety effects may have occurred because Korean students had experience with computers and were provided sufficient practice items before taking the CAT.

We found that math-related variable was more strongly related to test performance using CAT than computer-related and anxiety-related variables. Generally, measures of individual difference are strongly related to measures of academic achievement in the same content domain. For example, when self-concept and achievement measures relate to the same content domain, the causal linkages are strongest (Marsh, 1990, 1992). Vispoel, Rocklin, and Wang (1994) demonstrated that verbal self-concept was significantly correlated with verbal ability estimates in CAT research. Although test anxiety was strongly related to test performance for American students, the anxiety-related variable was the least related variable to achievement for Korean students. There is at least one possible explanation. Korean students come to college with a tremendous amount of test experience from having had to pass the competitive college entrance examination. It is possible that they are not only sophisticated in terms of testwiseness, but they are not afraid of taking tests of any kind. Perhaps this combination of experience is why they feel comfortable taking computerized adaptive tests even though most of them never had taken before.

The best model to estimate test performance using CAT is the four variable model described in the previous section. This result suggests that the relationship between individual difference variables and test performance using CAT may be curvilinear. This model should be cross-validated as additional data are collected.

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