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PREFACE

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A Validity Study: Attitudes towards Statistics among Japanese College Students

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ABSTRACT This cross-cultural study investigated the relationship between attitudes toward statistics (ATS) and course achievement (CA) among Japanese college students. The sample consisted of 135 male and 134 female students from the first two-year liberal arts program of a four-year college in Tokyo, Japan. Attitudes about statistics were measured using the Wise Attitudes Toward Statistics Scale (ATSS). A Japanese version of the ATSS was developed by a team of bilingual experts in Japanese studies and linguistics. The final course grade of the participants served as the measure of course achievement. Data analyses include factor analysis, reliability estimates for the ATSS, correlation analyses of CA, and the ATSS factor scores.

KEYWORDS *attitudes toward statistics scale (ATSS), factor analysis, factor score, statistics education research*

Introduction

Whereas the prevalence of statistics anxiety—i.e., attitudes toward statistics (ATS)—and their relationship to course achievement among American college students in the U.S. are well documented (Baloglu, 2003; Bell, 2001; Cashin & Elmore, 1997, 2005; DeVaney, 2010; Elmore & Vasu, 1980; Roberts & Bilderback, 1980; Roberts & Saxe, 1982; Scultz & Koshino, 1998; Waters, Martelli, Zakrajsek, & Popovich, 1988; Wise, 1985), little has been reported on such anxiety and attitudes among their Japanese counterparts in Japan. While statistics attitude has been linked to performance in undergraduate introductory statistics courses among American college students in the U.S. (Wise, 1985; Zimmer & Fuller, 1996), there is no evidence to suggest that such is the case with Japanese college students in Japan. The purpose of this study was to investigate the relationship between attitude toward statistics (ATS) and course achievement (CA) among Japanese undergraduate students who enrolled in an introductory statistics course at a two-year liberal arts program of a four-year college. The research questions of interest to be investigated were as follows:

What factors are underlying the construct of the Attitude toward Statistics Scale instrument (ATSS) among Japanese students? Are there any differences in factor loadings in ATS between the current study and Wise's (1985) study? Is there a significant relationship between the underlying main factors of the Attitude toward Statistics Scale instrument (ATSS) and Course Achievement (CA) among Japanese students?

Method

Subjects

The participants, 269 Japanese college students (135 males and 134 females), were randomly selected from the two-year liberal arts program of a four-year college, located in the metropolitan area of Tokyo. All of the students were from native-born and from middle to upper-middle socioeconomic households. All Japanese sample subjects were liberal arts majors who completed at least two years of high school mathematics at the time of their enrollment in introductory statistics.

Instruments

The original English version of the Attitude toward Statistics Scale instrument (ATSS), developed by Wise (1985), as shown in Table 1, served as the measure designed for the English-speaking American subjects in previous studies that targeted first and second-year non-mathematics majors at the undergraduate level. In this study, a Japanese version of the ATS instrument was developed and served as the attitude measure for Japanese subjects. The ATS instrument was designed to measure two domains of attitude toward statistics, namely *Attitude toward the Statistics Course* (ATSS–*Course*) and *Attitude toward the Field of Statistics* (ATSS–*Field*). Specifically, the former measures students' attitudes toward the statistics course in which they enrolled and the latter measures their attitudes toward the use of the subject matter within their disciplines. The ATSS instrument consists of 29 items (9 are labeled ATSS–*Course*: items 2, 4, 5, 7, 12, 15, 18, 20, 25; and 20 are labeled ATSS–*Field*: items 1, 3, 6, 8, 9, 10, 11, 13, 14, 16, 17, 19, 21, 22, 23, 24, 26, 27, 28, 29), on 5-point Likert-type scales. The instrument was designed to measure attitude changes in the introductory statistics student (Wise, 1985). The original data was converted into numerical values ranging from 1 (strongly disagree) to 5 (strongly agree). The final course grade of the participants, using a 10-point scale (A = 9, A– = 8, B+ = 7, B = 6, B– = 5, C+ = 4, C = 3, C– = 2, D = 1, and F = 0), served as the measure of course achievement (CA). To investigate the Japanese students' and instructors' views about the relationship between ATS and CA, a post-experiment open-ended discussion was held at the end of the study.

Table 1

Wise's Attitudes toward Statistics Questionnaire (1985)

1.	I feel that statistics will be useful to me in my profession.
2.	The thought of being enrolled in a statistics course makes me nervous.
3.	A good researcher must have training in statistics.
4.	Statistics seems very mysterious to me.
5.	Most people would benefit from taking a statistics course.
6.	I have difficulty seeing how statistics relates to my field of study.
7.	I see being enrolled in a statistics course as a very unpleasant experience.
8.	I would like to continue my statistical training in an advanced course.
9.	Statistics will be useful to me in comparing the relative merits of different objects, methods, etc.
10.	Statistics is not really very useful because it tells us what we already know anyway.
11.	Statistical training is relevant to my performance in my field of study.
12.	I wish that I could have avoided taking my statistics course.
13.	Statistics is a worthwhile part of my professional training.
14.	Statistics is too math oriented to be of much use to me in the future.
15.	I get upset at the thought of enrolling in another statistics course.
16.	Statistical analysis is best left to the "experts" and should not be part of a lay professional's job.
17.	Statistics is an inseparable aspect of scientific research.
18.	I feel intimidated when I have to deal with mathematical formulas.
19.	I am excited at the prospect of actually using statistics in my job.
20.	Studying statistics is a waste of time.
21.	My statistical training will help me better understand the research being done in my field of study.
22.	One becomes a more effective "consumer" of research findings if one has some training in statistics.
23.	Training in statistics makes for a more well-rounded professional experience.
24.	Statistical thinking can play a useful role in everyday life.
25.	Dealing with numbers makes me uneasy.
26.	I feel that statistics should be required early in one's professional training.
27.	Statistics is too complicated for me to use effectively.
28.	Statistical training is not really useful for most professionals.
29.	Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write.

Translation Procedure of ATSS Japanese Version

The Japanese version of the ATSS was developed by the author of the current study through a series of steps to ensure equivalency of meaning and freedom from cultural bias. First, the English version was translated into Japanese by two bilingual college professors of Japanese studies and two professional translators, independent of each other. Second, the two translations were compared thoroughly and corrected for discrepancies in vocabulary, phrasing, and syntax and finally cast into a single, modified version. The modified Japanese version then was translated back into English by other bilingual professors of linguistics and professional translators, who had no knowledge of the original English version. Third, the original English version and the second English version were compared and corrected for discrepancies. Last, in order to further measure the accuracy of translation from English to Japanese, a rating form was prepared by placing the original English and the Japanese version side-by-side. Another two language experts, who were proficient in both English and Japanese and held doctoral degrees in linguistics, were asked to rate the accuracy of the translation of each item independent of each other, ranging from 0 (totally inaccurate) to 10 (totally accurate).

Translation Validity

The two language experts' ratings of the accuracy of translation of each item ranged from 8 to 10 ($\bar{x} = 9.76$ and SD = 0.33). To determine the concurrent validity of the two versions of the ATSS, Pearson product-moment correlation coefficients between the two experts' ratings were used. The result revealed that the two ratings were highly positively correlated to each other ($r = 0.957$, $p < 0.05$). Out of the total of 29 items, 27 items received 9 or higher ratings, indicating high accuracy. Additionally, the internal consistency coefficient (ICC) was computed to determine the rate of agreement amongst the experts. The mean ICC was 0.930 ($p < 0.05$), which also indicated that there was a significant agreement among the two language experts across their ratings.

Test Administration

To ensure uniformity of administration, an instructor was provided with detailed instructions on procedures to follow and directions to be read aloud, and the instrument was administered on the last day of the course.

Data Analysis

Reliability

The overall reliability estimates for the attitude measure for all 29 items using Cronbach's alpha were 0.9150 for the Japanese subjects who participated in the current study. Cronbach's alpha is a measure of internal consistency, and is used for test items that are scored with multiple answers (e.g., multiple-choice items, like the author's ATSS Japanese-version that includes 5-point rating scales). It provides indications of the homogeneity of test items relative to overall performance on a measure as an index of reliability (Schiavetti, Metz, & Orlikoff, 2011; Maxwell & Satake, 1997).

Therefore, this alpha value indicates excellent internal consistency (Gorsuch, 1983). Additionally, using Wise's factor loadings of the ATS instrument, the test-retest reliabilities were found to be 0.9077 for the ATSS–Course and 0.9133 for the ATSS–Field, which also indicates that the instrument appears reliable in terms of internal consistency at the two testing points.

Validity

The author used factor analysis for assessing and measuring construct validity. The main purpose of such an analysis is to determine the extent to which the items appear to be measuring a common theme (Satake, 2014). A common factor analysis was performed on the item data for post-measure of the study. A varimax rotation was performed on the final factor structures because, in varimax rotation, it is assumed that the generated factors are independent of each other (i.e., uncorrelated). Not knowing the level of independence among ATSS-Japanese-version items, the author strongly believes that the varimax rotation is most suitable for the data analysis in the current study. The following literatures also support the use of the varimax rotation over the other types of the rotations when an investigator is uncertain about the independence of all items in a questionnaire. For instance,

According to Garrett-Mayer (2011),

> ....Although the choice of rotations is generally not critical, interpretation with varimax is simple because factors are independent and loadings are correlations. (Slide 52)

Additionally, Pett, Lackey, and Sullivan (2003) stated:

> A varimax solution is easily interpreted and provides relatively clear information about which items correlates most strongly with a given factor. Varimax provides us, therefore, with a good picture of our ability to reach a simple structure. (p. 142-143)

Additionally, as a prerequisite for factor analysis, the authors used the Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy as the index of the proportion of variance among the 29 variables on the ATS instrument that might be common variance. Several articles suggest that a KMO near 1.0 supports a factor analysis and that any KMO value falling below 0.5 is not appropriate for useful factor analysis (Kim & Mueller, 1978b; Nie, Hull, & Jenkins, 1975; Satake, 2014; Steinbrenner & Bent, 1975). For the current study, the KMO measure was 0.880, indicating that the degree of common variance among the twenty-nine variables is "meritorious" to "marvelous" (Dziuban & Shirkey, 1974). This also means that the two factors accounted for a fair amount of variance, and the sample sizes were adequate for factor analysis of the ATSS–Japanese (Gorsuch, 1983; Kim & Mueller, 1978a, 1978b).

Statistical Procedures

The following statistical procedures were used in the analysis of data.

1. A Japanese version of the ATS instrument was subjected to factor analysis using varimax rotation with an eigenvalue of 1 and item correlation equal to or greater than the 0.6 criteria (Kim & Mueller, 1978a, 1978b; Nie at al., 1975; Satake, 2014). Subscale items were computed into *factor scores.*
2. Pearson Product-Moment correlation coefficients *(r)* were computed for measures of relationship between ATS factor scores and CA.

The level of significance set for all tests was 0.05.

Results and Findings

The number of factors and items meeting eigenvalue 1 and item-total correlation 0.6 criteria varied widely (Kim & Mueller, 1978b; Satake & Amato, 1995). The results of the factor analysis for the Japanese versions of the ATSS revealed a two-factor solution, with Factor 1 consisting of items related to *Course* and Factor 2 items related to *Field.* However, as can be seen in Table 2, the number of items loading on these factors obtained from Japanese subjects was different from Wise's result.

Additionally, Wise (1985) stated that the results of pre-measure analysis were found to be unreliable for further data analysis, mainly due to the students' unfamiliarity with the subject matter at the beginning of the course. He commented that: "[ATSS instrument] items are inappropriate for students who are just beginning their statistics course because beginning students cannot meaningfully answer these types of items, as they typically have little or no experience with statistical problems or concepts" (Wise, 1985).

All items loaded at .60-or-above selection criteria were retained for final analyses and only those selected items were presented in Table 2. Note that neither the specific criteria for selection of the factors nor item-total correlations for each factor were available on Wise's study.

The two factors retained in the final analysis of Japanese data consisted of five items related to *Course* and seven items related to *Field,* as shown in Table 2. The eigenvalues for the two factors were 14.938 and 13.166, respectively, accounting for 96.91 percent of the total variances, namely 51.51 percent for *Course* and 45.40 percent for *Field.* The items of the retained factors were combined to form two factor scores or subscales labeled "ATSS–*Course*" and "ATSS–*Field*" for the Japanese ver-

Table 2

Final Factor Loadings on the ATS Japanese translation: List of All Retained Items for ATS-Course and ATS-Field among Japanese sample

Items	Factor 1 (Course)
7	.794
2	.748
12	.731
25	.685
15	.618
Total Variance Accounted For	51.51%
Eigenvalue	14.938
Items	**Factor 2 (Field)**
6	.745
16	.714
22	– .705
19	– .668
1	– .639
21	– .625
9	– .609
Total Variance Accounted For	45.40%
Eigenvalue	13.166

Table 3

Summary for Pearson Product-Moment Correlation between post-measure Factors (Course and Field) and Course Achievement (CA) and Factor Correlation Matrices among Japanese students

		CA	Factor 1 vs. 2
Combined (n = 269)	Factor 1 (Course)	$r = -0.305$ ($p < 0.05$)	$r = -0.1890$ ($p < 0.05$)
	Factor 2 (Field)	$r = 0.099$ ($p \geq 0.05$)	

sion of the ATSS instrument. As seen in Table 3, the Pearson product moment correlation *(r)* on the *Course* subscale revealed significant negative correlations between ATS and CA ($r = -0.305$, $p < 0.05$). On the other hand, slightly positive yet non-significant correlations were detected on the Field subscale ($r = 0.099$, $p \geq 0.05$). Additionally, the correlations between Factor Score 1 *(Course)* and Factor Score 2 *(Field)* were found to be negative and statistically significant ($r = -0.1890$, $p < 0.05$).

Discussion

The results of the current study reveal that there is a significant negative relationship between ATSS–*Course* and CA among Japanese college students. Meanwhile no significant relationship was detected between ATSS–*Field* and CA among them. However, the inference must be tempered for several reasons, the least of which concerns the inconsistencies observed in the results of English and Japanese versions of the ATSS instruments. The KMO indicated the size of the sample was quite adequate for the factor analysis, the translation validity was appropriate enough to ensure similarity and accuracy of the two versions, and the total amount of the variances accounted for is 96.91%. However, the variance in item loadings and number of the items contained in Factor 1 and Factor 2 suggests that "something" other than statistical significance, possibly related to cultural difference, was detected in the Japanese version's ATS instrument and Wise's original ATSS instrument for English speaking subjects.

Another perplexing aspect of the results of this study concerns the observed contrasting relationships between ATSS–*Course*/*Field* and CA among Japanese subjects and their American counterparts reported by Wise (1985). Wise reported a significant, positive correlation between ATSS–*Course* and CA ($r = 0.27$, $p < 0.05$) and a non-significant, slightly negative correlation between CA and ATSS–*Field* ($r = -0.04$, $p \geq 0.05$) among American students, as can be seen in Table 4.

Although the level of statistical significance and the p values were unavailable on the Wise report (1985), it is considered to be statistically significant ($p < 0.05$) by conventional criteria.

In the post-measure study reported here for Japanese subjects, the results were different from Wise's results for American subjects. While the correlation between ATSS–*Field* and CA for Japanese students was non-significant positive, the correlation between ATSS–*Course* and CA was negatively significant. Perhaps the negative correlation observed between ATSS–*Course* and CA was due to students who earned higher grades but found the course less challenging and stimulating. Alternatively, perhaps the negative correlations emerged because of a lack of adequate orientation to the role and importance of statistics in professional training and practice by the course instructor, text, or both. It could also have been a combination of these and the fact that the two countries have different educational systems, which could have accounted for these findings on both ATSS-*Course* and ATSS-*Field*. One of the reasons high achievers in Japan reported greater negative attitudes toward the

Table 4

Summary of Pearson Product Moment Correlation between Factors and Course Achievement (CA) and Factor Correlation Matrix among American Students by Wise (1985)

		CA	Factor 1 vs. 2
Combined (n = 92)	Factor 1 (Course)	$r = 0.27$ ($p < 0.05$)	$r = -0.33$ ($p < 0.05$)
	Factor 2 (Field)	$r = -0.04$ ($p \geq 0.05$)	

course might be attributable to cultural factors. In Japan, high achievers, especially those who usually earn an A or B in the course, are under much greater social and educational pressure to perform well in school than low achievers because of the stringent entrance requirements of the prestigious schools and careers. In other words, teaching is geared toward the system of the rigorous exams that the Japanese students must take in order to get into an elite school. Entry into an elite high school puts them on track for entry into an elite college, which leads to the prestigious jobs at blue-chip companies. Students who don't qualify for the better schools end up in technical and vocational schools, as reported by the instructor of the present study. That being said, the high achievers are quite aware of the fact that their performance on these exams and classroom performance have a very significant impact on their future career goals and lives (Judson, 1999; Satake & Amato, 1995; Sudo, 1989a; Sudo, 1989b; Takikita, 2005).

Additionally, several mathematics and statistics instructors reported that mathematics education in Japan is heavily dependent on, first and foremost, rote memorization without a firm grasp of quantitative reasoning. Interestingly, during the post-experiment open-ended discussion, several instructors and participants, along with the previous literatures (e.g., Mastrull, 2002; Sudo, 1989a), noted that the Japanese, in general, are not good at interpreting the test results in words, at thinking creatively, or expressing themselves orally in a clear manner because those skills are neither included in the mathematics curriculum nor required for the college entrance exams. Both instructors and participants in this study are fully aware that in understanding and deepening their knowledge of the subject matter of statistics, one must demonstrate such essential skills as putting ideas into their own words, taking material apart to understand its components, or putting parts together to make or remake the whole. The lack of such skills may create unnecessary tension, apprehension, and anxiety toward the subject matter, especially among those high achievers, who are constantly evaluated by their classroom teachers. Therefore, high achievers may exhibit feelings of "fear and dislike" toward the course more so than low achievers, as reported by the instructor of the course. Also, the instructor in the current study noted that high achievers are more likely to be called on than low achievers in the classroom. This tendency may have caused the higher degree of classroom performance anxiety and less positive attitude toward the course among high achievers. The instructor's opinion was also consistent with the previous findings of several research literatures, as reported by Mastrull (2002), Satake & Amato (1995), Sudo (1989a, 1989b), and Takikita (2005).

The author also conducted open-ended discussion with the instructors and students who participated in this study. The primary purpose of such discussion was to promote mathematics educators' knowledge about statistics education in Japanese classrooms further. All instructors and the vast majority of the students were present to participate in the discussion. Based on the report from the discussion , the author learned the fact that Japanese college students do not always see or identify the career relevance of the subject matter of statistics most of the time, because the course is often treated purely as a prerequisite for other courses and/or preparation for exams. Therefore, many mathematics and statistics instructors in Japan tend to emphasize the practical applications of the subject matter significantly less than their American counterparts (Mastrull 2002; Satake & Amato, 1995; Sudo 1989a; Sudo, 1989b; Takikita, 2005). This is mainly due to Japan's more centralized educational system, that includes these two factors: (1) the curriculum and the textbooks, which are nationally standardized by the Ministry of Education, so that every student learns the same material, and (2) the instructors, who are strongly encouraged to heavily emphasize more on the theory of the subject matter. These guidelines prevent the students from enjoying the study of statistics, as reported by the instructor. Therefore, the non-significant correlation between ATSS–*Field* and CA among the Japanese subjects may be a reflection of how the course instructor taught the subject and how strongly the instructor emphasized the practical application of statistics to the various fields.

A supplementary finding was that the correlation coefficient between the two factors revealed that there exists a negative statistically significant relationship ($r = -0.1890$) for Japanese subjects, whereas Wise's study showed a positive statistically significant correlation ($r = 0.33$) for American subjects. Although the correlation for the Japanese subjects is statistically significant, it is hardly of practical significance (the coefficient of determination r-squared is equal to only 0.036). Regardless, it appears that these two subscales were measuring slightly different attitudes between the two cultures.

Finally, at a very basic level, the results of this study suggest that it is necessary and important to revisit and reevaluate the validity of Wise's original English version as well as the authors' Japanese version of the ATS instrument to ensure the accuracy of both versions of the instrument to the fullest extent. Additionally, if the constructs from the factor analysis are placed within a multiple regression model, then more information will be obtained, that is to say more specifically, it would be possible to determine if the constructs were actually predictive of performance in CA.

The discrepancies of the results between the Wise report and the current study may be a function of a mixture of two cultures at one level and different educational system at another, they also may suggest a need for replication to determine the staying power of the original results. Also, pedagogically, it is necessary to emphasize on the practical applications of statistics more to increase the Japanese students' interest in the subject matter, as reported by the instructor and participants in this study. In doing so, the author believes that the Japanese students' overall attitude toward the course and its relevance to their future careers will certainly improve in a more positive way.

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