Turkish Version of the Survey of Attitudes toward Statistics: Factorial Structure Invariance by Gender

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Abstract

This study examines factorial structure and the gender invariance of the Turkish version of the Survey of Attitudes toward Statistics (SATS-36). The SATS-36 has 36 items measuring six components: affect, cognitive competence, value, difficulty, effort, and interest. Data were collected from 347 university students. Results showed that the Turkish version of the SATS-36 had a six-factor structure and it was gender invariant. Internal consistency coefficients supported good score reliability for the subscales of the SATS-36.

Keywords: statistics education, statistics attitudes, survey of attitudes toward statistics, survey adaptation

1. Introduction

Higher education students from different disciplines are expected to possess statistical skills by the end of their education. Research shows that attitudes toward statistics are related to statistics achievement (i.e., Emmioglu & Capa-Aydin, 2012; Stanisavljevic et al., 2014). If we want our students to have positive attitudes toward statistics, we must first assess these attitudes (i.e., Garfield, Hogg, Schau, & Whittinghill, 2002; Schau, Millar, & Petocz, 2012).

The Survey of Attitudes toward Statistics (SATS) is the most commonly used survey developed to measure students' attitudes toward statistics (Combs & Onwuegbuzie, 2012; Lesser, Pearl, & Weber, 2016). Unlike the other statistics attitudes surveys, the SATS subscales are congruent with an established and widely used motivation theory (Schau, 2003). The early version of the SATS (SATS-28) contained 28 items assessing four motivation components: Cognitive Competence, Difficulty, Affect, and Value. Based on Eccles' expectancy-value model of achievement motivation (Eccles, 1983; Eccles & Wigfield, 1995; Eccles & Wigfield, 2002), the SATS was updated (SATS-36) by adding eight more items and two components: Effort and Interest (Schau, 2003). The SATS was developed in the US and the original version of the survey is in English. In order to study post-secondary students' attitudes toward statistics in different countries, the SATS has been translated into different languages; e.g., Serbian (Stanisavljevic et al., 2014), French (Carillo, Galy, Guthrie, & Vanhems, 2016), and Dutch (Vanhoof, Kuppens, Castro-Sotos, Verschaffel, & Onghena, 2011). Psychometric properties of the different translations of the SATS have been examined by confirmatory factor analysis techniques. In each case, component scores from these translations showed good psychometric properties (e.g., Barkatsas, Gialamas, & Bechrakis, 2009; Chiesi & Primi, 2009; Tempelaar, Schim Van der Loeff, & Gijselaers, 2007).

Results from the studies using the original English version, as well as the translated versions, of SATS are consistent in showing that positive attitudes were associated with higher achievement in statistics (i.e., Emmioglu & Capa-Aydin, 2012; Milic et al., 2016; Stanisavljevic et al., 2014; Zimprich, 2012). However, the relationships may differ in magnitude across geographical regions. For example, using a meta-analysis, Emmioglu and Capa-Aydin (2012) found that the effect sizes of the relationships from research conducted in the US were about double in size compared to those studies conducted in other countries.

In terms of gender, research has yielded mixed findings. For example, Tempelaar, Gijselaers, and Schim van der Loeff (2006), in their study with economics and business students in Netherlands, found that males had significantly higher mean scores on Affect, Cognitive Competence and Difficulty, and significantly lower mean scores on Interest and Effort than women students but statistically significant mean difference on Value. Likewise, Bechrakis, Gialamas, and Barkatsas (2011), in their study with Greek social and political sciences students, and Chiesi and Primi (2015), in their study with Italian psychology students, found that males had significantly higher mean scores on Affect, Cognitive Competence and Difficulty but no statistically significant mean difference on Value. Collecting data from Industrial and Organizational psychology university students in South Africa, Coetzee and van der Merwe (2010) found that males had significantly higher mean scores on Affect than females, but no mean differences in other attitudes component scores. However, in their study with Malaysian students from the Faculty of Information Science and Technology, Hairulliza, Noraidah, Hazura, and Tengku (2011) found no statistically significant mean difference in statistics attitudes in terms of gender. Likewise, Hannigan, Hegarty, and McGrath (2014), collecting data from medical students in Ireland, and Milic et al. (2016), collecting data from medical students in Balkans, found that gender was not significantly associated with attitudes toward statistics. These variations in results suggest that discipline and country are important factors to consider in examining mean gender differences in students' attitudes toward statistics.

In order to explore mean gender and country differences, the same attitudes survey must be translated into the languages of these countries (Ramirez, Schau, & Emmioglu, 2012). The factorial structure and gender invariance of the translations then must be confirmed since mean score differences cannot be compared without them. In the current study, the SATS-36 was translated into Turkish and the resulting psychometric characteristics were examined to make cross-cultural comparisons with the international literature.

2. Method

2.1 Measure and Translation

The SATS-36 was designed to assess attitudes as a multidimensional construct. It includes 36 items assessing six components: Affect, Value, Cognitive Competence, Difficulty, Effort and Interest. It has a Likert-type seven-point response scale. Scores higher than the neutral value of "4 = neither disagree nor agree" correspond to positive attitudes in each component. The SATS-36 is available in pre-and-post versions; these versions are identical except for grammatical tense.

The translation of the survey to Turkish was done by using a back-translation method. Five experts, who are fluent in both languages, translated the survey from English to Turkish; three different people, without knowledge of the original SATS-36, then translated the Turkish form of the SATS-36 back to English. The original SATS-36 and the back translated SATS-36 were compared and strong consistency (around 90%) was found between the back translated SATS-36 and original SATS-36.

2.2 Participant Characteristics

The data were collected from 347 students (59% female; $M_{age} = 23$, $SD_{age} = 2.29$) studying at a prestigious university in Turkey. The students were majoring in a variety of fields: economics (n=108), engineering (n=70), education (n=69), psychology (n=44), business administration (n=31), and applied mathematics (n=23).

2.3 Data Collection Procedure

Prior to the data collection, research approval was obtained from the Human Subjects Ethics Committee of the university. The SATS-36 was administered during regular classroom hours by the first author to the volunteer students. Students generally spent 15 to 20 minutes responding to the survey.

2.4 Data Analysis

Confirmatory factor analysis (CFA) was used to test the hypothesized six-factor structure. Prior to the main analyses, negatively worded items were reversed so that higher scores indicated more positive attitudes. This point is especially important for the interpretation of the "difficulty" component since higher scores on this component represent "lack of difficulty". For the other five components, higher scores represent positive attitudes toward statistics.

The data were examined for potential outliers using z-scores. Sixteen cases exceeded 3 standard deviations from the mean of that component. In order to investigate the influence of the outliers, analyses were done with and without these sixteen cases. Since there was no change in the results of the analyses, the complete data set, without eliminating the outliers, was used throughout the study.

Missing data were missing completely at random, Little's MCAR $\chi^2 = 14.93$, $df = 13$, $p = .31$. As the software used in the study, Mplus, required all missing values to be filled (Muthen & Muthen, 2007), missing data were imputed using maximum likelihood of estimation (Kline, 2005).

As is common in psychometric analyses of SATS-36 data, an item parceling approach was used (e.g., Bandalos, 2008; Chien, 2015). The items were assigned to the specific items parcels based on an earlier study (Tempelaar et al., 2007). This item parceling procedure, when possible, was based on balancing positively and negatively worded items and skewness and kurtosis values within the parcels. Items in each subscale were divided into three item parcels. Item parceling is defined as "averaging item scores from two or more items from the same scale to use in place of the item scores in a Structural Equation Modeling (SEM) analysis" (Bandalos, 2008, p.212).

The univariate and multivariate distributions of the parcels were examined. Quantile by quantile plots indicated that the small departures from univariate normality were acceptable. All bivariate scatter plots showed that parcels were linearly related and normally distributed. Skewness and kurtosis values were between -.03 to 3.87 indicating that the item parcel distributions were univariately normal (Kline, 2011). Mardia's test, which is based on the functions of skewness and kurtosis, revealed a significant *p* value and indicated multivariate non-normality. Since the multivariate normality assumption was not met, maximum likelihood estimation with robust standard errors (MLR) was used as the estimation method in Mplus software.

3. Results

3.1 Confirmatory Factor Analysis

Item parcels were allowed to load only on their hypothesized factor. Factors were allowed to intercorrelate. Parcel errors were not allowed to covary. The CFA yielded a statistically significant chi square value, $\chi^2(120) = 286.95$, $p<.05$. Because χ^2values are sensitive to the size of the correlations and to sample size, the values of multiple model fit indices were examined (Tabachnick & Fidell, 2013). The CFI value was .95, RMSEA was .06 (90% CI = .05-.07), and SRMS was .07, indicating good fit of the model to the data (Kline, 2011; Tabachnick & Fidell, 2013).

The standardized estimates of the factor loadings indicated that the item parcels loaded on their hypothesized factors. They were large (.43 to .90) and statistically significant. The pattern found among the estimated factor correlations showed the same pattern commonly found in previous research (e.g., Stanisavljevic et al., 2014; Vanhoof et al., 2011 and references therein). All factor pairs, with the exception of difficulty and effort (r = -.09), were statistically significantly and positively related, ranging from .26 to .92 (Figure 1).

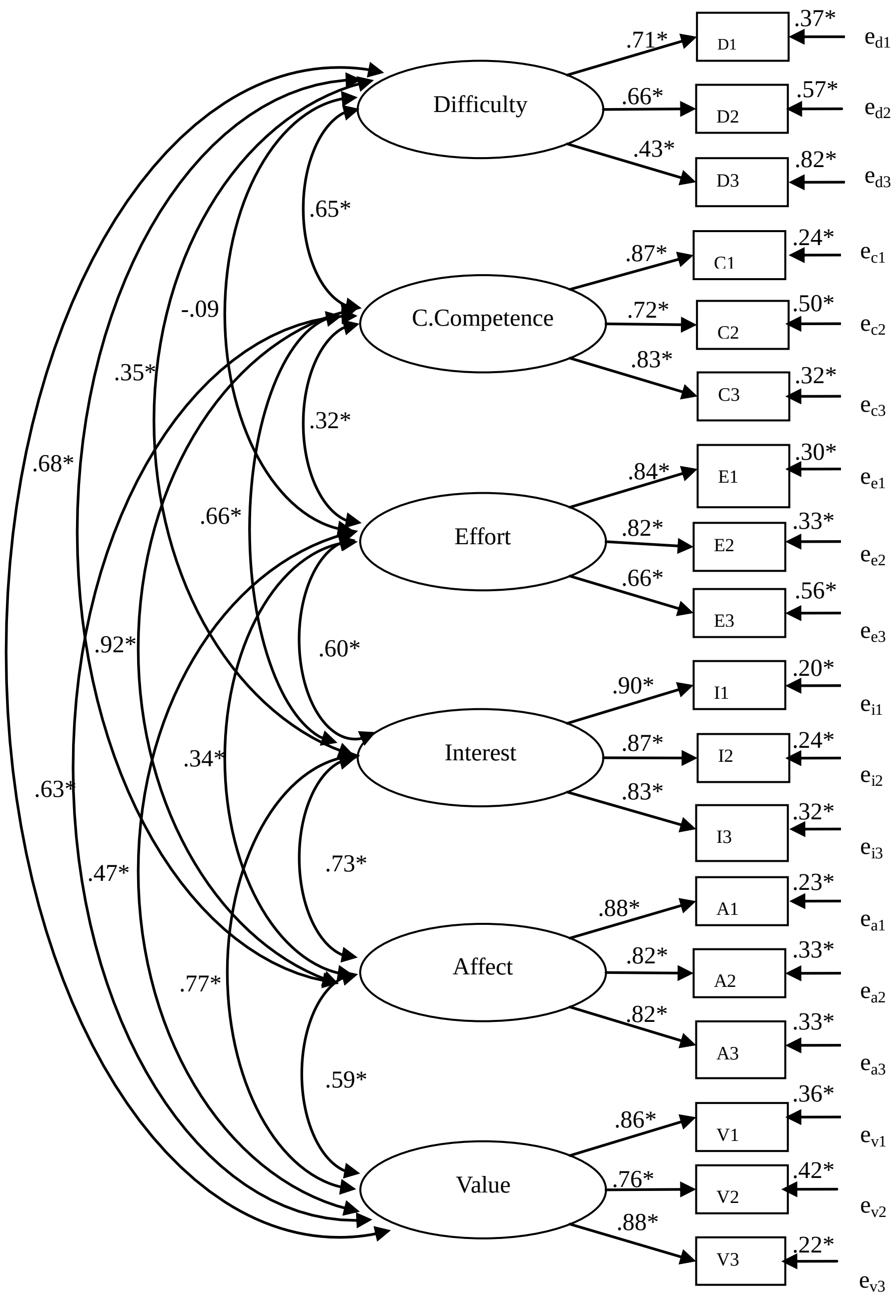

Figure 1. The standardized estimates of the factor loadings and correlations

Description: **p*<.05, D1-D3: Difficulty item parcels; C1-C3: Cognitive Competence item parcels; E1-E3: Effort item parcels; I1-I3: Interest item parcels; A1-A3: Affect item parcels; V1-V3: Value item parcels

3.2 Model Invariance across Gender

A multi-group CFA was performed to investigate the measurement and structural invariance properties of the Turkish SATS-36 across gender. First, configural invariance was tested by examining the fit of the baseline model. The baseline model is the least restrictive model with all parameters freely estimated. Second, metric invariance was tested by holding factor loadings equal for male and female students. Third, scalar invariance was tested by investigating the invariance of factor loadings plus intercepts. Fourth, the equality of the factor loadings and intercepts plus factor variances and covariances for males and females were examined.

To determine the best fitting model, each model's results were sequentially compared to the increasingly more constrained one. As the parcels taken together did not meet the assumption of multivariate normality, the Satorra-Bentler scaled chi-square difference (TRd) test was used with the usual normal-theory chi-square statistic divided by a scaling correction to better approximate the chi-square distribution under non-normal conditions (Muthen and Muthen, 2005). As Table 2 shows, none of the TRd values was statistically significant. These findings demonstrate that the SATS-36 is invariant across gender in terms of factor loadings, intercepts, and factor variances and covariances.

Table 2. Goodness-of-fit statistics for tests of invariance across gender

Model[a]	χ^2	*df*	χ^2/df	*CFI*	*AIC*	*RMSEA*	*SRMR*	*TRd*	Δdf	*p*(TRd)
Baseline	614.80*	240	2.56	.89	16579.67	.10	.10	-	-	-
1	653.36*	252	2.59	.88	16594.23	.10	.11	10.76	12	.55
2	665.67*	264	2.52	.88	16654.54	.10	.11	9.71	12	.64
3	693.00*	285	2.43	.88	16639.87	.10	.12	24.34	21	.28

Description: [a] 1: metric invariance model, 2: scalar invariance model, 3: invariance model, *$p<.05$

3.3 Internal Consistency

Factor internal consistency estimates were assessed using Cronbach alpha coefficients calculated from responses to the individual items contained within each factor: Interest=.90, Value=.85, Affect=.85, Cognitive Competence=.82, Effort=.81, Difficulty=.69. Difficulty had adequately reliable scores. Except for the difficulty subscale, all subscales had very good to excellent score reliabilities (Kline, 2011).

3.4 Descriptive Statistics

Mean values of the SATS-36 components represented neutral or positive attitudes as the mean scores were higher than the neutral value of 4. Students reported that statistics is a difficult subject (*M*=3.55, *SD*= .92) but they somewhat like statistics (*M*=4.64, *SD*= 1.33), they feel competent in statistics (*M*=5.33, *SD*= 1.11), they value statistics (*M*=5.19, *SD*= 1.08), they are somewhat interested in statistics (*M*=4.52, *SD*= 1.53), and they put a great deal of effort into learning statistics (*M*=5.75, *SD*= 1.02). We did not find statistically significant difference between male (*n*=125) and female (*n*=206) students' mean scores of the SATS-36 components: Affect (males: *M*=4.74, *SD*= 1.25; females: *M*=4.55, *SD*=1.35), Cognititive Competence (males: *M*=5.43, *SD*= .99; females: *M*=5.25, *SD*=1.17), Value (males: *M*=5.15, *SD*= 1.07; females: *M*=5.20, *SD*=1.10), Difficulty (males: *M*=3.64, *SD*= .88; females: *M*=3.48, *SD*=.94), Interest (males: *M*=4.57, *SD*= 1.43; females: *M*=4.45, *SD*=1.58), Effort (males: *M*=5.73, *SD*= 1.00; females: *M*=5.72, *SD*=1.05).

4. Discussion

In this study, the six-factor structure of the Turkish version of the SATS-36 demonstrated a very good fit to the data. All of the item parcels loaded strongly and statistically significantly on each hypothesized factor. The Turkish version of the SATS-36 was gender invariant in terms of factor loadings, intercepts, and factor variances/covariances. Additionally, internal consistency coefficients supported the score reliability of each component score.

Cross-cultural studies are important for understanding students' attitudes toward statistics and the factors related to them. Cross country comparisons are only possible when the same data collection instruments are used. In our study of the Turkish SATS-36, we found consistent results with previous studies done in other countries examining the six-factor structure, factor loadings, factor correlations, and Cronbach alpha internal consistencies of the SATS (e.g., Hannigan, Hegarty, & McGrath 2014; Ratanaolarn, 2016; Stanisavljevic et al., 2014; Vanhoof et al., 2011; Tempelaar et al., 2007). Although the SATS is the most commonly used statistics attitudes instrument, gender invariance of the SATS (the stability of the SATS constructs across females and males) has been examined in only a limited number of studies. Consistent with our results, these studies supported factorial structure invariance by gender (i.e., Bechrakis et al. 2011, Carillo, Galy, Guthrie, & Vanhems, 2016). By confirming the factorial structure and gender invariance of the SATS, these studies allow researchers to compare their results with those from the international literature and to confidently use the SATS for comparing male and female students' attitudes toward statistics.

Our component mean findings also were consistent with previous findings from earlier studies. For example, as we found, students from the Netherlands (Tempelaar et al., 2007), the US (Gundlach, Richards, Nelson, & Levesque-Bristol, 2015), Ireland (Hannigan, Hegarty, & McGrath, 2014), and Serbia (Stanisavljevic et al., 2014), reported that students view statistics as a difficult subject but that they like statistics, they feel competent in statistics, they value and are interested in statistics, and they put effort into learning statistics. In the current study, we did not find statistically signifant difference between male and female students' attitudes toward statistics. This finding was not suprising as the current literature reported mixed findings on mean differences between male and female students' statistics attitudes. More studies are needed to understand why mean gender differences do and do not exist. However, when there are significant mean gender differences, overall females tend to have more negative attitudes toward statistics. Chiesi and Primi (2015) argued that gender differences in statistics attitudes may occur more frequently in the disciplines/classes where there are more male students; they suggested that an imbalance with males in the majority may create a potentially threatening environment for females that causes females to underestimate their own competence and to have other more negative attitudes toward statistics. They also argued that gender differences in attitudes toward statistics may result from students' differential high school experiences with quantitative subjects. Whatever the reasons, we recommend that instructors examine their students' attitudes toward statistics during their courses, be aware that female students could have more negative attitudes toward statistics, and create a learning environment that reinforces students' positive attitudes toward statistics.

The present study shows that the Turkish version of the SATS-36 is a consistent form of the original version of the SATS-36 and scores from it exhibit good psychometric properties. The six-component factor structure mirrors that of the original SATS-36. The factor structure also is stable across females and males, and component item data are internally consistent. These findings enable researchers to compare their Turkish results with those found in the literature and to ensure that the Turkish version of SATS-36 measures students' attitudes toward statistics.

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