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The structure of the Statistics Anxiety Rating Scale: A confirmatory factor analysis using UK psychology students

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The structure of the statistics anxiety rating scale: A confirmatory factor analysis using UK psychology students

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Abstract

This study aimed to examine the structure of the statistics anxiety rating scale. Responses from 650 undergraduate psychology students throughout the UK were collected through an on-line study. Based on previous research three different models were specified and estimated using confirmatory factor analysis. Fit indices were used to determine if the model fitted the data and a likelihood ratio difference test was used to determine the best fitting model. The original six factor model was the best explanation of the data. All six subscales were intercorrelated and internally consistent. It was concluded that the statistics anxiety rating scale was found to measure the six subscales it was designed to assess in a UK population.

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Keywords: Statistics anxiety; Statistical attitudes; Confirmatory factor analysis; STARS

1. Introduction

The importance of statistics and research methods in the undergraduate Psychology degree programme has been acknowledged by both the Quality Assurance Agency for Higher Education (2002) and the British Psychological Society (2006) within the UK. Students undertaking these subjects learn both subject specific skills and generic, transferable skills. For example, it has been demonstrated that the statistics element of the psychology undergraduate programme enhances critical reasoning (Lawson, 1999; Lehman and Nisbett, 1990; VanderStoep and Shaughnessy, 1997). However, empirical evidence and commonly held subjective opinion suggest statistics is one of the students' most disliked subjects (Sciutto, 1995). In fact, if the majority of psychology students could choose to drop one required course from their curriculum it would be statistics (Connors, McCown, and Roskos-Ewoldsen, 1998). This is supported by literature which suggests that up to 80% of

students experience 'statistic anxiety' (Onwuegbuzie and Wilson, 2003).

Statistics anxiety has been defined as the specific feelings of anxiety students experience when they encounter statistics, for example, gathering, processing and interpreting data (Cruise, Cash, and Bolton, 1985; Onwuegbuzie, Da Ros, and Ryan, 1997). It could be argued that students experience anxiety with regards to many different aspects of their course (which will differ between students depending on their individual abilities and preferences) and indeed some anxiety is unavoidable as part of the assessment processes in higher education. However, studies have consistently demonstrated a negative relationship between statistics anxiety and performance (Benson, 1989; Feinberg and Halperin, 1978; Lalonde and Gardner, 1993; Onwuegbuzie and Daly, 1996; Onwuegbuzie and Seaman, 1995; Pretorius and Norman, 1992; Tremblay, Gardner, and Heipel, 2000; Zeidner, 1991). It has even been postulated that this anxiety is the best predictor of achievement in statistic courses (Fitzgerald, Jurs, and Hudson, 1996) and research methods courses (Onwuegbuzie, 2004). Furthermore, statistical anxiety has been shown to be

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related to increased levels of academic procrastination (Onwuegbuzie, 2004). This body of research has demonstrated the importance of statistical anxiety; therefore, it is imperative to have a valid assessment tool to assess this concept to ascertain if students are experiencing statistical anxiety, if it is impacting on their performance and to evaluate potential interventions to reduce such anxiety.

The statistical anxiety rating scale or STARS developed by Cruise et al. (1985) is currently the most widely used

measure for assessing statistics anxiety (Onwuegbuzie and Wilson, 2003). Cruise et al. (1985) utilized principal components analysis to identify six components of statistics anxiety which the STARS purports to measure; these are: worth of statistics, interpretation anxiety, test and class anxiety, computational self-concept, fear of asking for help and fear of statistics teachers. However, some of the items within the STARS may not be suitable for a UK population and the factor structure has not been confirmed.

Table 1
The STARS questionnaire

No.	Item
1	Studying for an examination in a statistics course
2	Interpreting the meaning of a table in a journal article
3	Going to ask my statistics teacher for individual help with material I am having difficulty understanding
4	Doing the coursework for a statistics course
5	Making an objective decision based on empirical data
6	Reading a journal article that includes some statistical analyses
7	Trying to decide which analysis is appropriate for my research project
8	Doing an examination in a statistics course
9	Reading an advertisement for a car which includes figures on miles per gallon, depreciation, etc
10	Walking into the room to take a statistics test
11	Interpreting the meaning of a probability value once I have found it
12	Arranging to have a body of data put into the computer
13	Finding that another student in class got a different answer than I did to a statistical problem
14	Determining whether to reject or retain the null hypothesis
15	Waking up in the morning on the day of a statistics test
16	Asking one of your lecturers for help in understanding a printout
17	Trying to understand the odds in a lottery
18	Watching a student search through a load of computer printouts from his/her research
19	Asking someone in the computer lab for help in understanding a printout
20	Trying to understand the statistical analyses described in the abstract of a journal article
21	Enrolling in a statistics course
22	Going over a final examination in statistics after it has been marked
23	Asking a fellow student for help in understanding a printout
24	I am a subjective person, so the objectivity of statistics is inappropriate for me
25	I have not done maths for a long time. I know I will have problems getting through statistics
26	I wonder why I have to do all these things in statistics when in actual life I will never use them
27	Statistics is worthless to me since it is empirical and my area of specialization is abstract
28	Statistics takes more time than it is worth
29	I feel statistics is a waste
30	Statistics teachers are so abstract they seem inhuman
31	I cannot even understand secondary school maths; how can I possibly do statistics?
32	Most statistics teachers are not human
33	I lived this long without knowing statistics, why should I learn it now?
34	Since I have never enjoyed maths I do not see how I can enjoy statistics
35	I do not want to learn to like statistics
36	Statistics is for people who have a natural leaning toward maths
37	Statistics is a pain I could do without
38	I do not have enough brains to get through statistics
39	I could enjoy statistics if it were not so mathematical
40	I wish the statistics requirement would be removed from my academic program
41	I do not understand why someone in my field needs statistics
42	I do not see why I have to fill my head with statistics. It will have no use in my career
43	Statistics teachers speak a different language
44	Statisticians are more number oriented than they are people oriented
45	I cannot tell you why, but I just do not like statistics
46	Statistics teachers talk so fast you cannot logically follow them
47	Statistical figures are not fit for human consumption
48	Statistics is not really bad. It is just too mathematical
49	Affective skills are so important in my (future) profession that I do not want to clutter my thinking with something as cognitive as statistics
50	I am never going to use statistics so why should I have to take it?
51	I am too slow in my thinking to get through statistics

Baloglu (2002) conducted the only attempt to confirm the six factor structure of the STARS in American college students however this analysis appears to have been conducted on scale scores rather than item scores; effectively demonstrating the six factors did not form a high order structure (on the assumption that the six factors are structurally valid). For completeness, this study assessed not only the six factor model but one and four factor models also. The high internal consistency of the total 51 item scale reported by Onwuegbuzie (1993) and Baloglu (2002), both reported $\alpha = 0.96$, may suggest the STARS is a uni-dimensional scale. Additionally, Onwuegbuzie et al. (1997) conducted focus groups which suggested there were four main elements to statistics anxiety.

The aim of this article was to test the factor structure of the STARS questionnaire for a UK population. In addition to the unconfirmed six-factor model, one- and four- factor models will also be assessed. If either of the multi-factorial models is found to be acceptable an additional second order model will be tested to determine if

the first order factors can be explained by a higher order general factor representing statistics anxiety.

2. Methods

2.1. Participants

The STARS questionnaire was made available on-line and universities throughout the UK that offered undergraduate psychology courses were invited to inform their students about the study. A total of 849 participants completed the questionnaire during the 3 weeks it was available on-line during May 2007. As 199 of the participants did not complete all 51 items in the STARS questionnaire the sample size used for analysis in this study was reduced to 650. These students constituted approximately 12.7% of the total UK psychology undergraduate population and represented 31 different universities. The mean age was 22 years ($SD = 5.44$) and ranged from 18 to 56. The majority of the participants were female ($n = 533$; 82%); this is reflective of gender split in the total UK population where approximately 79% of the students are female. The students were relatively evenly distributed with regards to the progression through their course; 31.1% were in first year, 31.7% were in second year, 26% were in third year and 6.3% were in their fourth year. Additionally three students indicated they were part-time and 29 (4.5%) did not answer this question.

2.2. Measures

The data was collected using a set of demographic questions and the STARS questionnaire. These were made available on-line. The STARS is a 51 item questionnaire with responses gathered on a 5 point Likert scale (see Table 1). The rubric asked participants to indicate how much anxiety they would experience (from no anxiety to strong anxiety) in each of the situations for the first 23 items and then the participants were asked their level of agreement (from strongly agree to strongly disagree) on the remaining 28 items. Higher scores on an item or subscale indicate higher levels of that attitude or anxiety except for the 'fear of statistics teachers' subscale where higher scores indicate lower levels of anxiety or more

Table 2
The original and revised items in the STARS questionnaire

No.	Version	Item
4	Original	Doing the homework for a statistics course
	Revised	Doing the coursework for a statistics course
9	Original	Reading an advertisement for an automobile which includes figures on gas mileage, compliance with population regulations, etc
	Revised	Reading an advertisement for a car which includes figures on miles per gallon, depreciation, etc.
10	Original	Walking into the classroom to take a statistics test
	Revised	Walking into the room to take a statistics test
16	Original	Asking one of your professors for help in understanding a printout
	Revised	Asking one of your lecturers for help in understanding a printout
25	Original	I have not had math for a long time. I know I will have problems getting through statistics
	Revised	I have not done maths for a long time. I know I will have problems getting through statistics
31	Original	I cannot even understand seventh- and eighth-grade math; how can I possibly do statistics
	Revised	I cannot even understand secondary school maths; how can I possibly do statistics

Table 3
Fit indices for the alternative models of the STARS questionnaire

Item	Model 1 1-factor	Model 2 4-factor	Model 3 6-factor	Model 4 6-factor with second order factor
S-B χ^2	13,448.90	5939.86	4218.67	4391.75
df (p)	1224 (.00)	1218 (.00)	1209 (.00)	1218 (.00)
RMSEA 90% CI	.12 (.12–.13)	.077 (.075–.079)	.062 (.060–.064)	.063 0.061–.065)
ECVI 90% CI	23.96 (20.47–21.62)	10.72 (9.12–9.86)	7.74 (6.56–7.17)	7.10 (6.79–7.42)
IFI	.87	.95	.97	.97
CFI	.87	.95	.97	.97
SRMR	.091	.072	.068	.110

Note: S-B χ^2 , Satorra–Bentler scaled χ^2 ; RMSEA, root mean square error of approximation; CI, confidence intervals; ECVI, expected cross validation index; IFI, incremental fit index; CFI, comparative fit index; SRMR, standardised root mean residual.

positive attitudes. Each of the six subscales purports to measure a different aspect of statistical anxiety. These scales demonstrated 5-week test–retest reliabilities between .67 and .83 and concurrent validity was claimed as strong positive correlations were evident with the mathematics anxiety scale (Cruise et al., 1985). The ‘worth of statistics’ subscale attempts to measure the perceived usefulness of statistics. The ‘interpretation anxiety’ subscale attempts to measure anxiety when interpreting statistical results. ‘Test and class anxiety’ is designed to assess the anxiety experienced when taking a statistics test or attending a statistics class. The ‘computation self-concept’ subscale is related to a person’s self-belief in their ability to cope with the calculations and mathematics related to statistics. The ‘ask for help’ subscale attempts to assess the anxiety experienced when an individual intends to ask for help on a statistical problem. The final subscale, ‘fear of statistics teachers’, claims to measure students’ perceptions of their statistic teachers. However, during piloting of the STARS with staff and postgraduate students to ensure the items could be easily read and understood at Queens University Belfast it became apparent that the language used in six of items was not appropriate for UK students (see Table 2). These six items were revised slightly so they could be more readily understood by UK students; for example the word ‘automobile’ was changed to ‘car’.

2.3. Analysis

Three confirmatory factor models were specified and estimated using LISREL 8.72 (Jöreskog and Sörbom, 2005a). A covariance matrix and an asymptotic weight matrix were computed using PRELIS 2.72 (Jöreskog and Sörbom, 2005b) based on the 51 items of the STARS questionnaire and the model parameters estimated using maximum likelihood. All factors were allowed to correlate and no correlated errors were included in any of the models. The use of an asymptotic weight matrix allows for weaker assumptions regarding the distribution of the observed variables and results in improved fit and test statistics (Satorra, 1992; Curran, West, and Finch, 1996).

Following the guidelines suggested by Hoyle and Panter (1995) the goodness of fit for each model was assessed using a range of fit indices including the Satorra–Bentler scaled chi-square ($S-B\chi^2$), the incremental fit index (IFI: Bollen, 1989), and the comparative fit index (CFI: Bentler, 1990). A non-significant χ^2 , and values greater than .95 for the IFI and CFI are considered to reflect acceptable model fit. In addition, the root mean square error of approximation (RMSEA: Steiger, 1990) with 90% confidence intervals (90% CI) were reported, where a value less than .05 indicates close fit and values up to .08 indicating reasonable errors of approximation in the population (Jöreskog and Sörbom, 1993). The standardized root-mean-square residual (SRMR: Jöreskog and Sörbom, 1981) has been shown to be sensitive to model mis-specification and its use recommended by Hu and Bentler (1999). Values less than .08 are

considered to be indicative of acceptable model fit (Hu and Bentler, 1999). The comparative fit of the models was assessed using the expected cross validation index (ECVI; Browne and Cudeck, 1989), an index used for the purposes of model comparison, with the smallest value being indicative of the best fitting model.

Table 4

Standardised factor loadings for the 6-factor model of the STARS questionnaire

	Test	Interpretation	Ask for help	Worth	Teacher	Self-concept
Q1	.81					
Q4	.64					
Q8	.81					
Q10	.74					
Q13	.55					
Q15	.74					
Q21	.64					
Q22	.57					
Q2		.66				
Q5		.72				
Q6		.72				
Q7		.60				
Q9		.46				
Q11		.71				
Q12		.55				
Q14		.67				
Q17		.42				
Q18		.54				
Q20		.75				
Q3			.85			
Q16			.94			
Q19			.68			
Q23			.48			
Q24				.52		
Q26				.73		
Q27				.71		
Q28				.76		
Q29				.81		
Q33				.78		
Q35				.63		
Q36				.51		
Q37				.74		
Q40				.80		
Q41				.68		
Q42				.81		
Q45				.60		
Q47				.67		
Q49				.74		
Q50				.85		
Q30					.77	
Q32					.66	
Q43					.80	
Q44					.60	
Q46					.71	
Q25						.58
Q31						.73
Q34						.75
Q38						.80
Q39						.67
Q48						.51
Q51						.80

Note: All factor loadings significant ($p < .05$).

Table 5
Inter-factor correlations and descriptive statistics

	Test	Interpretation	Ask for help	Worth	Teacher	Self-concept
Interpretation	0.68					
Ask for help	0.44	0.46				
Worth	−0.54	−0.54	−0.34			
Teacher	−0.50	−0.42	−0.47	0.66		
Self-concept	−0.67	−0.60	−0.41	0.76	0.66	
Cronbach's alpha	.87	.87	.83	.94	.83	.87
Mean score	27.07	30.26	10.39	56.98	18.2	23.91
Standard deviation	6.69	8.42	3.87	14.13	4.72	6.60
Range	8–40	11–53	4–20	17–80	5–25	9–35
Potential range	8–40	11–55	4–20	16–80	5–25	7–35

3. Results

3.1. Confirmatory factor analysis and reliability analysis

The fit indices for the three models are reported in Table 3.

The fit indices showed that a 1-factor model was a poor model and was rejected. On the basis of meeting the criteria associated with the RMSEA, IFIF, CFI and the SRMR both the 4-factor and 6-factor models were judged to exhibit reasonable model fit, but all the fit indices indicated that the 6-factor model was a better model. The ECVI for the 6-factor model was the lowest. The 4- and 6-factor models are nested so a likelihood ratio difference test¹ is possible to determine statistical difference between the fit of the models. The 6-factor model was a significantly better explanation of the data than Model 1 ($\Delta S-B\chi^2 = 1645.74$, $df = 9$, $p < .05$). Although the chi-square for these models were large relative to the degrees of freedom, and statistically significant, this should not lead to the rejection of the models as the large sample size increases the power of the test (Tanaka, 1987). The increased power of the chi-square test can result in models with no serious mis-specification being rejected as minor discrepancies between the sample and implied covariance matrix are detected. On the basis of this it is proposed that the 6-factor represents an adequate description of the data, and is judged the best of the alternative models. This model was re-specified to include a single second order factor (Model 4). All first order factors were specified to load on the second order factor. The fit indices are reported in Table 3. The fit of this model was acceptable on the basis of the RMSEA, IFI, and CFI and the ECVI was lower than for Model 3. However, the SRMR was relatively high and the likelihood ratio difference test indicated that Model 3 provided a significantly better explanation of the sample data ($\Delta S-B\chi^2 = 73.08$, $df = 9$, $p < .05$). The standardized factor loadings for Model 3 are presented in Table 4. All loadings were statistically significant ($p < 0.05$).

The factor correlations and estimates of reliability (Cronbach's alpha) are reported in Table 5.

All factor correlations were statistically significant ($p < .05$). The estimates of reliability were all high and ranged from $\alpha = .83$ (Ask for Help) to $\alpha = .94$ (Worth).

4. Discussion

This article tested a series of alternative factor structures of the STARS based on a sample of UK undergraduate psychology students. Three alternative methods were specified and tested. On the basis of the fit indices, a six-factor model was considered to be the best explanation of the data. This model was based of the original structure proposed by Cruise et al. (1985) although six of the items were revised to be more suitable for the UK population. The standardized factor loadings were all positive and statistically significant, ranging from 0.42 to 0.94. Each of the six subscales demonstrated high levels of internal consistency ranging from 0.83 to 0.94. These internal consistency figures compare favorably with previous research which found a range between 0.68 and 0.94 (Cruise et al., 1985), 0.83 and 0.92 (Onwuegbuzie, 1993), 0.80 and 0.84 (Onwuegbuzie, 1998) or 0.64 and 0.96 (Baloglu, 2003). The fact the intercorrelations indicated positive and negative directional relationships reflected the way in which the subscales were scored. Higher scores on interpretation anxiety, test and class anxiety and fear of asking for help indicated higher anxiety or more negative attitudes. Higher scores on worth of statistics, interpretation anxiety, and fear of statistics teachers indicated more positive attitudes or lower anxiety. Researchers using the scale should endeavor to administer the full questionnaire and report the scores of all six of these subscales. It should be noted that many of the items and subscales do not appear to measure statistical anxiety directly but related concepts, for example, views on the worth of statistics. This was substantiated by the correlated six first order factor model (Model 3) being found to be a significantly better model than the second order model (Model 4), where all first order factors loaded on a single second order factor. Therefore it is suggested that the term 'statistical attitudes and anxiety' is a more appropriate label for the concept currently referred to as statistical anxiety.

The findings of the research are consistent with exploratory factor analysis conducted on the STARS among a

¹ Satorra and Bentler (2001) have developed a scaled difference chi-square statistic to compare the $S-B\chi^2$ for nested models.

sample of students from the USA (the only previously conducted factor analysis of the STARS). Therefore, it appears that there are no differences in the structure of statistical attitudes and anxiety among students in the UK and USA. However, comparing the mean scores on each of the STARS scales found in the present study with scores obtained from samples in the USA (Baloglu, 2003; D'Andrea and Waters, 2002), the present sample had notably more negative scores on the worth of statistics and computation self-concept scales. This suggests that the sample in the present study were less likely to recognize the value of statistics and more likely to have low computational self-concept. It is possible that this may be a result of geographical/cultural differences or that the present study was restricted to psychology students. Further work with students from a broader range of disciplines in the UK is required to investigate these differences.

In conclusion, the STARS was found to measure the six internally consistent factors it had been designed to assess in a sample of UK undergraduate psychology students. Future research could establish the temporal stability of the six-factor model, and its invariance across groups (educational, cultural, or gender). In addition, the robustness of the reported solution could be examined by using alternative measures of association (e.g. polychoric correlations) and estimators (e.g. mean and variance adjusted weighted least squares estimation).

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