

INFLUENCE OF OUTCOME EXPECTANCY AND UNCERTAINTY ON STATISTICS ANXIETY AND ACHIEVEMENT AMONG PSYCHOLOGY UNDERGRADUATES

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Previous research has shown a consistent, albeit weak, negative correlation ($r \approx -0.20$) between statistics anxiety and statistics achievement. Additionally, self-efficacy has been shown to be a consistent predictor of both anxiety and achievement. This study showed that if self-efficacy is assumed to reflect a distribution of confidence, then the relationship between statistics anxiety and statistics achievement can be explained by the differential impact of two features of the self-efficacy distribution. Although only outcome expectancies predict statistics achievement, statistics anxiety is predicted by the interaction between outcome expectancies and outcome uncertainty. It is suggested that these results are indicative of at least two sources (or cognitive interpretations) of statistics anxiety, namely lack of confidence about one's ability and uncertainty in one's performance. The results are discussed in terms of cognitive appraisals of threat and challenge.

INTRODUCTION

Among all of the components of a psychology undergraduate course, the statistics and research design or methodology components appear to be the most feared and unfavourably received by students. Researchers have identified the following relevant aspects, which are often referred to as *statistics anxiety*: fear, trepidation, worry, emotionality, (fear of) failure, and negative attitude. In a more general vein, Zeidner (1991) refers to the unpleasant cognitive and emotional reactions associated with statistics anxiety. The perceived importance of statistics anxiety to statistics educators is reflected in the emphasis on (the negative impact of) statistics anxiety in various introductory statistics textbooks (e.g., *The statistical exorcist: Dispelling statistics anxiety*, Hollander & Proschan, 1984; *Statistics without Tears*, Rowtree, 1981). Furthermore, in a review of statistical texts, Schacht (1990) defined a key evaluative criterion as whether or not the issue of statistics anxiety was addressed.

Although success in introductory statistics courses has been shown to be a function of an array of affective and cognitive variables (e.g., Birenbaum & Eylath, 1994; Feinberg & Halperin, 1978; Zeidner, 1991), a consistent predictor of statistics achievement has been statistics anxiety. These studies have shown that the correlation between statistics achievement and statistics anxiety, although varying across studies, is typically negative and of a magnitude in the range between 0.20 and 0.30. These studies have all been correlational, although all studies have implicitly assumed a causal link, with most (but not all) assuming that anxiety affects achievement.

Although the direction of the observed relationships are consistent with the hypothesized negative impact of statistics anxiety on achievement, the modest size of the correlations casts some doubt on the importance of statistics anxiety in relation to statistics achievement. There are two possible approaches to explaining the modest size of the observed statistics anxiety-achievement correlations. The first is to consider moderator variables that may identify under what conditions, or for which groups of students, the statistics anxiety-achievement correlation is larger. Here, the goal is to identify those students for whom statistics anxiety is related to achievement from those for whom anxiety is unrelated to achievement. Such an approach is consistent with Feinberg and Halperin (1978) who concluded that "[s]ince the ultimate goal in this research is to increase the likelihood of students successfully completing a statistics course, treatments specifically designed to improve functioning on these [identified] factors should be developed and applied differentially as determined by a student's individual diagnostic profile" (p. 18).

The second approach is to consider that the relationship between statistics anxiety and achievement is spurious rather than causal. Within this theoretical framework, it is assumed that both statistics anxiety and achievement are outcomes which share some common causes which

lead to the spurious observed correlations. The modest size of the correlations is a result of differential causes. Hence, this approach suggests that we will learn most about statistics anxiety and achievement by studying their antecedents and identifying those causes in common, and those that differentially impact. The focus in this study was on this latter approach.

Variables pertaining to the measurement of self-efficacy have commonly been identified as predictors of both statistics (and math) anxiety and achievement. Self-efficacy reflects a judgement, not just about the skill one possesses, but about what one can do with these skills (Sexton & Tuckman, 1991); it is akin to a judgement about the confidence one has in one's own ability to perform a task. Previous research has shown self-efficacy to be positively related to statistics achievement and negatively related to statistics anxiety.

Self-efficacy for specific tasks (in contrast to global measures of self-efficacy) has been measured in many different ways. Lee and Bobko (1994) concluded that there are five distinct ways in which self-efficacy has been measured that correspond to Bandura's (1986) recommendation that measures of self-efficacy must consider its strength and magnitude. Most researchers operationally measure self-efficacy by asking "individuals whether they can perform at specific levels on a specific task (responses are either yes or no) and ask for the degree of confidence in that endorsement (rated on a near-continuous scale from *total uncertainty* to *total certainty*) at each specific performance level" (Lee & Bobko, 1994, p. 364). From these responses, a single self-efficacy score can be derived. This score represents the degree of confidence a person has about task performance in terms of how well they expect to perform. Higher scores represent a belief that, on average, the person expects to gain a higher score. Specifically, we can define such measures as representing the outcome expectancy.

However, we (Peay & Williamson, 2000; Williamson, Peay, & Mattiske, 2001) propose that self-efficacy can be better conceptualised as a distribution of confidence rather than as a point estimate of confidence (represented by the outcome expectancy measures defined previously). If one considers all of the ratings of degree of confidence associated with each specific level across the continuum of possible performance on the task as representing the cumulative distribution of confidence, then self-efficacy is conceptualised as a distribution of confidence rather than a point estimate on a uni-dimensional continuum. Separate aspects of self-efficacy can then be defined by the features of the distribution. A measure of central tendency (e.g., the mean) reflects the *outcome expectancy*. A measure of dispersion (e.g., the standard deviation) reflects the *uncertainty* in expected performance.

In the current study, these two aspects of self-efficacy were investigated in relation to statistics anxiety and achievement. It was hypothesized that both outcome expectancy and outcome uncertainty would be related to statistics anxiety but only outcome expectancy would be related to statistics achievement. Hence, the anxiety-achievement relationship is assumed to be spurious arising from their sharing of a common cause, namely, outcome expectancy.

METHOD

Participants

First year undergraduate psychology students ($N = 128$) were recruited from a topic designed to teach skills in research methodology and statistics. The topic was aimed at students enrolled in a psychology-focussed degree (i.e., a degree where students completed a minimum of three years of psychology as a major). Of the 116 students who provided data on gender, 89 were female and 27 were male. Age of students ranged between 17 and 47 ($M = 22.79$, $SD = 7.82$).

Procedures

Data were obtained from a questionnaire administered to students during their class. The main variables assessed were three measures of statistics anxiety, and outcome expectancies and outcome uncertainty in relation to the topic. Participation was voluntary, and statistics achievement data were obtained from the topic coordinator and matched to student questionnaire data using personal identification codes.

Materials

Three measures of statistics anxiety were obtained. Two measures were derived from an adaptation of the Revised Mathematics Anxiety Rating Scale (R-MARS; Plake & Parker, 1982).

The R-MARS uses a Likert type scale and contains two factors: A 16-item Learning Mathematics Anxiety factor and an 8-item Mathematics Evaluation Anxiety factor. These scales were modified to create a Learning Statistics Anxiety scale and a Statistics Evaluation Anxiety scale by replacing the word “mathematics” with “statistics” where appropriate. Scores for both scales were calculated by taking the mean score on all items, and could potentially range from 1 (not at all anxious) to 5 (very anxious). Both scales had high internal consistency in this study (Learning Statistics Anxiety, $\alpha = 0.95$; Statistics Evaluation Anxiety, $\alpha = 0.86$). In addition, a global rating of statistics anxiety was assessed using a single item question asking *How anxious are you about statistics*, which was rated on an 11-point scale from 0 (no anxiety at all) to 10 (a very high level of anxiety).

Outcome expectancy and outcome uncertainty were assessed using a scale where students rated their confidence (from 0% to 100%, in 10% increments) about attaining nine specified performance levels for the research methodology and statistics topic. The nine performance levels were selected to reflect the grading system used at Flinders University (e.g., high HD – 93% or better, low HD – 85% or better, high DN – 80% or better, etc.). The cumulative distribution of confidence ratings obtained can be converted to a probability distribution by subtracting confidence ratings from adjacent levels. By calculating the mean and standard deviation of the subsequent probability distribution, estimates of outcome expectancy and outcome uncertainty can be derived. Statistics achievement was measured by their final percentage mark obtained for the topic which was calculated as a weighted average of marks obtained from a multiple choice exam and several written assignments.

RESULTS

Data for most variables met parametric assumptions for regression analysis, although there was evidence of a positive skew for learning statistics anxiety and a negative skew in the achievement marks distribution.

To test the main hypotheses, hierarchical multiple regression analyses were carried out for all four criterion variables (the three statistics anxiety measures and statistics achievement), where outcome expectancy and outcome uncertainty were entered at the first step, and the product term was entered at step 2. For all four analyses, only performance expectancy explained significant unique variance in the criterion at the first step: learning statistics anxiety, $R^2 = .22$, statistics evaluation anxiety, $R^2 = .17$, global statistics anxiety, $R^2 = .23$, statistics achievement, $R^2 = .06$. However, for all three anxiety measures, the interaction between outcome expectancy and outcome uncertainty explained significant additional variance: learning statistics anxiety, $R^2_{change} = .032$, statistics evaluation anxiety, $R^2_{change} = .033$, global statistics anxiety, $R^2_{change} = .039$. On the other hand, the additional variance in statistics achievement explained by the interaction between outcome expectancy and outcome uncertainty was negligible and non-significant ($R^2_{change} = .001$). The pattern of relationships showed that the relationship between outcome expectancy and (all three measures of) statistics anxiety is not only negative, but more strongly negative when outcome uncertainty is *lower* (i.e., the outcome is seen as more certain). As uncertainty increases, the regression slope flattens to show almost no relationship, although at a moderate level of anxiety. The results are consistent with the interpretation that, when the outcome is perceived to be highly *certain*, anxiety is inversely related to outcome expectancy, whereas, when the outcome is perceived to be highly *uncertain*, anxiety is unrelated to outcome expectancy and, in an absolute sense, is moderate in intensity. For the relationship between outcome expectancy and statistics achievement, the relationship is positive and does not vary as a function of outcome uncertainty.

DISCUSSION

The pattern of results evident for the relationship between self-efficacy and statistics anxiety suggests that high anxiety arises from a combination of low outcome expectancy and outcome certainty and low anxiety from a combination of high outcome expectancy and outcome certainty. However if the outcome is perceived to be uncertain, this leads to moderate levels of statistics anxiety, irrespective of the level of outcome expectancy. In contrast better performance is linked to higher outcome expectancy but is unrelated to level of outcome uncertainty. Of

particular interest is the issue of why some students who are moderately anxious also perform well; specifically, these students are those with high outcome expectancy and high outcome uncertainty.

One possible suggestion is that different combinations of outcome expectancy and outcome uncertainty lead to differential cognitive appraisals of threat and challenge. Although anxiety is typically considered to be associated with appraisals of threat, psychological literature also points to the idea that anxiety can act to facilitate performance, possibly through challenge appraisals, and/or debilitate performance, possibly through threat appraisals (Allpert & ,1960). Hence, it is suggested that outcome uncertainty may be a precursor to challenge appraisals, particularly when outcome expectancy is high. An important consequence is that it suggests that students exhibiting statistics anxiety should not be considered alike, and may possess different cognitive-motivational characteristics.

At present, the direction of the causal link between cognitive appraisals and anxiety is not specified since a case may be argued for both directions. That is, threat and challenge appraisals may reflect appraisals of anxiety dictated by self-efficacy *or* anxiety may be a reflection of threat and challenge appraisals that are themselves dictated by one's own self-efficacy. Research is currently being conducted to explore the links between threat and challenge appraisals in relation to the current findings linking self-efficacy to statistics anxiety and achievement.

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