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We need to talk about statistical anxiety

A review of the evidence around statistical anxiety in the context of quantitative methods pedagogy

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## *Abstract*

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Recent reviews of the social research pedagogy literature conclude that there is a lack of pedagogical culture informing the teaching of research methods in social science. In this paper, we draw together main themes from the statistical anxiety (SA) literature, in order to prepare a more systematic and empirically grounded knowledge base from which to develop a research programme in quantitative methods teaching. It is regularly put forward that statistical anxiety has a negative influence on learning quantitative methods it is also suggested that women are more anxious in this context than men. Research examining the relationship between statistical anxiety and performance is summarized. A secondary analysis investigating the question of whether women are more likely to experience statistical anxiety than men is presented. The results show young women are more likely to experience anxiety than young men, but older women are less likely to experience anxiety than older men. Older men also have higher chance of experiencing anxiety than younger men. There were no significant differences evident between older women and younger women. In conclusion, the relationship between gender and SA is shown to be more complex than previous research has suggested. The review of previous findings indicates it is currently unclear that statistical anxiety has the negative influence it is often stated as having.

## 1. Introduction

Attempts to tackle innumeracy in UK social science go back to at least 1946 (Clapham 1946). There have been various initiatives undertaken to try to increase capacity and generate a supply of students who will use quantitative methods (QM) in postgraduate studies<sup>1</sup>. Platt (2012) argues that the strategy has had little impact on sociology where there is strong departmental and intellectual resistance to these methodologies. It may be expected that a fundamental aspect of a drive to increase capacity, or create a pipeline of practitioners, would be an emphasis on the quality of the teaching practice. To a large extent this is the case and QM teaching to undergraduates is receiving a focus in Q-step centres that it has not previously had (Scott Jones & Goldring 2015). Whilst there are ongoing initiatives to provide high quality training in methods through centres like the Cathie Marsh Centre ([www.cmist.manchester.ac.uk/](http://www.cmist.manchester.ac.uk/)), the National Centre for Research Methods (<http://www.ncrm.ac.uk/>) and the Essex Summer School (<http://www.essex.ac.uk/summerschool/index.html>).

It remains possible to argue that *how* we are teaching has less attention than the efforts aimed at ensuring a level of provision. For example, recent reviews of the social research pedagogy literature conclude that there is a lack of pedagogical culture informing the teaching of research methods in social science (Nind *et al.* 2015; Wagner *et al.* 2011). The same conclusion can be drawn from the QM pedagogy literature (Ralston 2015).

The concept of statistical anxiety is widely cited as a reason students do not engage in/enjoy/pursue statistics in their social science degrees (Paxton 2006; Bridges *et al.* 1998; Schacht & Stewart 1990). The literature on statistical anxiety also provides an example of how research into a pedagogical issue has largely been unsuccessful in generating clear recommendations for practice. Statistical anxiety is probably the most widely researched aspect of QM pedagogy and there have been two systematic reviews published summarising the anxiety literature (Chew & Dillon 2014; Onwuegbuzie & Wilson 2003). The review by Chew and Dillon (2014) concentrates particularly on psychology literature along with additional related works from relevant fields. An older paper, by Onwuegbuzie and Wilson (2003), draws upon a literature primarily published in education journals, particularly work by Onwuegbuzie himself. Despite this Chew and Dillon (2014) comment on the failure to successfully link work on the measurement of anxiety to the improvement of teaching practice.

The issue of a lack of pedagogical culture intersects with the policy focus on QM. It is at least possible that how we teach and deal with resulting issues, like statistical anxiety, is suboptimal and the focus on capacity building might be less effective because of the lack of a pedagogical culture. To alter this we need to build evidence-based social science QM pedagogy. This is, however, a daunting proposition and it requires the build-up of QM capacity while simultaneously critically reviewing how it is best taught. As a first step, we bring together literature which, though relevant to practice, is far from the mainstream

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<sup>1</sup> See the Q-Step programme (<http://www.nuffieldfoundation.org/q-step>); the evolution of the ESRC Doctoral Training Centres; the AQMeN initiative to build quantitative methods capacity (<https://www.aqmen.ac.uk/>); the British Academy's 'Count us in' report and suggested approach to a data skills strategy ([www.britishacademy.ac.uk/countusin](http://www.britishacademy.ac.uk/countusin)).

of social science research and teaching. We outline the main themes from the statistical anxiety literature, in order to prepare a more systematic and empirically grounded knowledge base from which to develop a research programme. An emphasis is placed on findings from empirical papers and the sociology literature. Many of the papers referred to below were not included in the reviews by Chew and Dillon (2014) or Onwuegbuzie and Wilson (2003). In addition an analysis investigating the question of whether women are more likely to experience statistical anxiety than men is presented.

The paper begins by defining statistical anxiety. Evidence of the relationship between SA and performance is then outlined in section 2. The next section outlines the measurement of SA, followed by a section considering how SA relates to performance in section 3 and 4. Section 5 summarises the recommendations for teaching practice and section 6 discusses facilitating anxiety. Section 7 introduces analysis of whether women are more likely to experience SA than men. Section 8 concludes the review.

## 2. *Statistical Anxiety*

Onwuegbuzie *et al.* (1997) define statistical anxiety as *'an anxiety that comes to the fore when a student encounters statistics in any form and at any level'*. It has been suggested that this definition is incomplete as it fails to encompass both prior attitudes and a need to separate the concept of statistical anxiety from maths anxiety, Chew and Dillon (2014) therefore propose a wider definition:

*'a negative state of emotional arousal experienced by individuals as a result of encountering statistics in any form and at any level; this emotional state is preceded by negative attitudes toward statistics and is related to but distinct from mathematics anxiety.'*

Macher *et al.* (2015) offer a definition which, again varies:

*'Statistics anxiety describes the apprehension that occurs when an individual is exposed to statistics content or problems and instructional situations, or evaluative contexts that deal with statistics. As statistics-anxious individuals always experience anxiety when doing statistics, statistics anxiety describes an enduring, habitual type of anxiety'*

That social science students react negatively to statistics, and that statistics units induce angst is widely accepted (Paxton 2006; Bridges *et al.* 1998; Schacht & Stewart 1990) and Chew and Dillon (2014) report that: *'A consistent negative relationship has been found between statistics anxiety and achievement in a variety of studies'*. Anxiety is also seen as a problem within more numerate subjects, including maths (Henrich & Lee 2011) and in other learning contexts such as the teaching of language (Liao & Wang 2015). In itself, being anxious about performing well in a new and difficult task is not necessarily a bad thing and there are circumstances where nerves, when controlled, can, improve performance (Savage & Torgler 2011).

In some contrast to the understanding that SA is a major problem in social science DeCesare (2007) suggests the concept is overstated. As evidence supporting this DeCesare (2007) presents research

based on a study in an institution in the USA where 40% of sociology students, who responded to a survey on a social statistics unit, reported no angst, 25% reported being very anxious and 33% reported being anxious. 57% of men in the sample reported being relaxed or indifferent to the thought of taking the course (n=196). Williams *et al.* (2008) similarly found only a slight majority to report being anxious of statistics in a sample of sociology and political science students in England and Wales (n=738). Some work has also been undertaken comparing anxiety between academic fields. In a limited study comparing social science, health science, arts and 'hard science' students, Hamza and Helal(2013) found no meaningful differences in the mean level of maths anxiety when comparing the USA and Egypt.

### 2.1. *The evidence that statistical anxiety influences performance*

One of the strongest reasons that anxiety amongst students taking statistics courses is considered a problem is that it may be negatively related to performance. The reviews by Chew and Dillon (2014) and Onwuegbuzie and Wilson (2003) cite several papers which find a negative relationship between anxiety and performance (see Appendix 1 for a tabulated summary of all the results cited in this section). Zeidner (1991), Bell (2001), Hanna and Dempster (2009), Onwuegbuzie (1995) and Elmore *et al.* (1993), present bi-variate analyses. They show either a correlation between a measure and exam/test results, or a regression, including sub-scales of a measure interpreted as capturing SA, with exam score as the outcome<sup>2</sup>. Macher *et al.* (2015) make a distinction between studies using measures of SA and studies purporting to measure SA but using measures which are not intended to directly capture SA. On this basis they exclude several of the studies included by Chew & Dillon (2014) and Onwuegbuzie & Wilson (2003) as evidence of a negative relationship between SA and performance. Macher *et al.* (2015) cite 11 works measuring a relationship between SA and performance suggesting the average correlation to be  $r=-.21$  (Macher *et al.* 2013; Macher *et al.* 2011; Chiesi & Primi 2010; Keeley *et al.* 2008; Lacasse & Chiochio 2005; Nasser 2004; Bell 2003; Bell 2001; Fitzgerald *et al.* 1996; Birenbaum & Eylath 1994; Lalonde & Gardner 1993). Of these 5 find no significant correlation and 6 show negative correlations. Papanastasiou and Zembylas (2008) report a positive significant correlation, but are not cited in the recent review papers.

Several pieces of research undertake multivariate analyses. Fitzgerald (1996) presents a logit model suggesting the anxious are more likely to fail their statistics course ( $b=0.13^*$ )<sup>3</sup>. Lalonde and Gardner (1993) undertake a structural equation based modelling approach (SEM) applied to an adapted model of language acquisition, which included 12 manifest variables such as math background and prior achievement, along with statistical anxiety. These were considered to represent the latent constructs of maths aptitude, situational anxiety, attitude-motivation and effort. They conclude that the path between anxiety and achievement was non-significant. Onwuegbuzie (2003) undertake a similar analysis to Lalonde and Gardner (1993), adapting a language achievement model and applying a SEM based path analysis. Onwuegbuzie (2003) concluded that statistical anxiety does have a significant relationship to

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<sup>2</sup> Tremblay *et al.* (2000) is also cited in Chew and Dillon (2014) but the paper is obscurely reported and results do not appear to be presented in the paper.

<sup>3</sup> \* $p<=0.05$  \*\*  $p<=0.01$  \*\*\*  $p<=0.001$

performance (-.18, p-value not reported). Zanakis and Valenzi (1997) present a general linear model, controlling for maths anxiety, together with grade-point-average and experience working with computers. Net of these factors they show a significant relationship between anxiety and result ( $b=-0.247^*$ ). Onwuegbuzie and Seaman (1995) include the test and class anxiety sub-scales of STARS, together with mid-term exam result and a number of co-variates in the model. They show that the model including anxiety is significant and report the correlation between anxiety and test result. The  $n=26$  in this analysis and the effect size is not reported, only the bivariate correlation. Papanastasiou and Zembylas (2008) undertook a study of education students at the University of Cyprus. The aim of the study was to research the nature and implications of anxiousness in students taking research methods courses. They found self-perception to be correlated significantly with anxiety but that expected grade was not. Students who thought statistics would be important for their future, in work, were more anxious, those who reported being anxious were significantly more likely to score lower in the exam. A subscale of a 32 item *Attitudes Towards Research* scale measure was applied to capture anxiety and the anxiety sub-scale is constructed from 8 items. From the reported results it is difficult to gauge the effect size. The research finds that a one unit increase in anxiety is associated with a reduction in score of  $-0.177^*$ , but neither the outcome nor the sub-scale is described in the paper.

Macher *et al.* (2011) report a SEM analysis controlling a number of SA antecedents finding a significant negative relationship between SA and performance ( $b=-.30^\Psi$ ). Nasser (2004) presents a SEM that includes 19 manifest and 7 latent variables, the model hypothesised to include SA was a 'very poor fit' so they drop SA from the model and keep MA. They propose MA influences performance via an indirect path through attitudes towards statistics ( $b=-.65^\Psi$ ) and has a direct positive influence ( $b=.15^\Psi$ ). They find maths ability to be the strongest predictor of performance. Bell (2003) compares traditional and 'non-traditional' students using 6 dimensions of the statistics anxiety ratings scale (STARS), suggesting the only significant difference between the groups is fear of statistics teachers. Macher *et al.* (2013) present a SEM controlling state and trait anxiety, gender and maths self-concept. Like Nasser (2004) they find a positive relationship between SA and performance ( $b=.25^\Psi$ ) but a negative indirect relationship between SA and performance via state anxiety ( $b=-.15^\Psi$ ). They suggest this is a result of a suppressor effect. Chiesi and Primi (2010) also present a SEM including 6 latent variables and 16 manifest variables in which the SA path was non-significant. Birenbaum and Eylath (1994) present a table of correlations, the relationship between SA and performance was non-significant. Hamid and Sulaiman (2014) find no significant associations between anxiety and course score in a sample of psychology students. This included controlling for previous test scores and statistical anxiety. Sesé Abad *et al.* (2015) examine maths background, trait anxiety, test anxiety, statistics anxiety and attitudes to statistics as predictors of performance. The direct relationship between SA and performance is non-significant ( $b=-.19$ ). Their model suggests SA predicts attitudes ( $b=-.49^{**}$ ), which has a positive influence

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<sup>Ψ</sup> No p-value reported with the effect size, only the SEM model fit is assessed

on performance ( $b=.54^{**}$ ). Zare *et al.* (2011) studied the relationship between SA, self-efficacy, achievement goals and performance amongst students in Iran. They report a significant direct relationship between anxiety and performance ( $b=-0.25^*$ ).

The evidence that statistical anxiety has a negative impact on outcomes is less compelling than sometimes suggested. There are a number of papers which highlight a negative association between a measure of statistical anxiety and test results, or exam score, and then there are a number which find no significant association. Figure 1 summarized the correlations reported in the papers. Figure 1 indicates that a larger sample correlates with a lower estimate. There is also a broad range of effect sizes reported from  $r=-.62$  to  $.29$  this lack of consistency in the magnitude of the effect and its significance level underscores that a substantively meaningful, negative relationship between SA and performance remains to be established (see Appendix 1 for a more comprehensive summary of effect sizes and correlations). Macher *et al.* (2011, 2015) offer a plausible explanation for the variation in findings that have been reported. They argue that SA has a dual effect, suggesting statistics anxiety has a negative effect, via state anxiety, during an exam, but has a positive effect, possibly through learning behaviours across a course (Figure 2). The model Macher *et al.* (2015) propose also remains to be confirmed.

### 3. *Measuring statistical anxiety, the dimensions and the antecedents of statistical anxiety:*

A list of the main instruments referred to in the research literature:

#### **Statistical Anxiety**

- Statistics Anxiety Rating Scale - STARS (Cruise *et al.* 1985)
- Statistics Anxiety Inventory - STAI (Zeidner 1991)
- 10 item, Statistics Anxiety Scale - SAS (Pretorius & Norman 1992)
- An unnamed instrument measuring statistics anxiety and attitudes developed by (Zanakis & Valenzi 1997)
- Statistics Anxiety Measure (Earp 2007)
- 24 item, Statistics Anxiety Scale by (Vigil-Colet *et al.* 2008)

#### **Attitudes**

- Attitudes Towards Statistics scale - ATS (Wise, S. L 1985)
- Multifactorial Scale of Attitudes Toward Statistics - MSATS (Auzmendi 1991)
- Survey of Attitudes Toward Statistics - SATS-36 (Schau *et al.* 1995)
- Attitudes Towards Research - ATR (Papanastasiou 2005)

#### **Maths Anxiety**

- Maths anxiety Ratings Scale - MARS (Richardson & Suinn 1972)

Chew and Dillon (2014) highlight confusion over attitudes and anxiety in the psychology literature. They suggest there is a lack of clarity, with anxiety defined as 'affective' but attitudes considered by many to be formed from affective, cognitive and behavioural elements, with anxiety being one part of wider attitudes. Another potential challenge is that researchers have used measures of maths anxiety,

measures of attitudes and measures of statistical anxiety interchangeably when researching the subject area (Macher *et al.* 2015).

In addition to the measures listed above there are further measures of maths anxiety available and there may be more instruments to measure various types of related attitudes. Chew and Dillon (2014) put forward that researchers examining statistical anxiety should be encouraged to focus on the instruments designed to measure statistical anxiety, rather than conflating statistical anxiety/maths anxiety and attitudes. They recommend the use of the first 3 sub-scales of STARS as the most validated measure available.

Differing measures purport to capture differing dimensions of anxiety. Cruise *et al.* (Cruise *et al.* 1985) identify six components of statistics anxiety used in the Statistical Anxiety Rating Scale measure, namely: worth of statistics, interpretation anxiety, test and class anxiety, computational self-concept, fear of asking for help and fear of statistics teachers. Zeidner's (1991) Statistics Anxiety Inventory is designed to measure test and content anxiety. Onwuegbuzie and Wilson (2003), cite four general components of statistics anxiety, namely, instrument anxiety, content anxiety, interpersonal anxiety, and failure anxiety. Chew and Dillon (2014) do not expand on the discussion over the dimensions of statistical anxiety. Rather they focus on issues of measurement and what aspects of anxiety different instruments claim to be measuring. Overall they highlight that researchers have failed to link measurement of statistical anxiety to practical interventions shown to influence anxiety.

In addition to discussion of the dimensions of statistical anxiety a variety of antecedents of statistical anxiety is also outlined in the literature. The antecedents of statistical anxiety have been summarised as comprising, *situational*, *dispositional* and *environmental* factors (Onwuegbuzie and Wilson 2003). *Situational antecedents* comprise of prior knowledge of maths and statistics, statistics course grade, the status of the course (i.e. required or selected), major (whether the main degree subject has a more statistical emphasis), attitudes towards calculators, course and instructor evaluation, and satisfaction with the statistics course. Variables measuring aspects of maths experience which have been found to relate to statistical anxiety include basic mathematics skills, number of prior mathematics courses completed and poor prior achievement in mathematics. Wilensky (1997) also puts forward the concept of epistemological anxiety underlying statistical anxiety. This is the idea that the learner does not engage with the legitimacy of mathematics as a method for measuring the social world.

Dispositional antecedents of statistics anxiety comprise of self-concept and level of self-esteem (Onwuegbuzie and Wilson 2003). This also includes levels of self-perception such as levels of perceived academic competence, perceived intellectual ability and perceived creativeness. Perfectionism (other oriented and socially prescribed, discussed below) is also given as an antecedent of stats anxiety (Onwuegbuzie & Daley 1999). Other dispositional factors include academic procrastination, levels of hope (a positive outlook) and differences in preferred ways of learning. For instance, as discussed below, learners who are less oriented towards linguistic and logical-mathematical intelligence compared to those more oriented towards spatial and interpersonal intelligence may tend to have higher levels of statistics anxiety.

The list of factors put forward as comprising *environmental antecedents* is somewhat less substantial than the other antecedent categories. The label given is also misleading as it primarily contains demographic characteristics rather than environmental ones. These include gender, with women reported as more likely to experience higher anxiety (Papanastasiou & Zembylas 2008; Zeidner 1991). Age may also be a factor as older students have been found to report higher anxiety and also to prefer differing approaches to learning statistics (Maltby 2001). Research from the USA highlights that “race” could relate to differentially reported anxiety (Onwuegbuzie 1999). A study has also found international students to report higher levels of angst (in Onwuegbuzie and Wilson 2003). Although Onwuegbuzie and Wilson (2003) highlight that the sample in this was small including only 10 international students This small sample is not much smaller than groups that have been used elsewhere e.g. Onwuegbuzie and Seaman (1995) where n=26, with an experimental group and control group each of 13.

Egloff and Schmukle (2002) argue that the most important issue for a measure is that it show predictive validity. An assessment of which of the measures are ‘best’ in capturing anxiety that influences course performance would therefore help. It would also be useful if an evaluation of measures could take into account a distinction between facilitating and debilitating anxiety (Scovel, 1978). If there is a level at which SA becomes a problem this would be important to know.

#### 4. *Work examining mechanisms whereby anxiety impacts upon outcomes*

Chew and Dillon’s (2014) comment on a failure of research to make a link between the measurement of anxiety and how this relates to course outcomes. The pedagogical relevance of work up until this point is limited by this shortcoming. The model espoused by (Macher *et al.* 2015), that anxiety influences learning behaviour positively and exam performance negatively is outlined above (Figure 2). There is other research which also suggest how anxiety may influence performance (e.g. Onwuegbuzie & Seaman 1995).

Malik (2015) provides a working paper which uses MARS in assessing anxiety. The sample was small with only 6 students from the USA. The aim of the paper is to explore the factors that learners themselves believe to contribute to anxiety and which they believe may help to reduce their statistics anxiety. The findings report that those with a mathematics background were less anxious and also, those who did not understand the statistical jargon were more likely to give up or second-guess answers during tests. Feelings of statistical anxiety could therefore lead to poorer results because a failure to make a connection leads the anxious to give up more easily than the non-anxious.

Onwuegbuzie and Daley (1999) examine the relationship between perfectionism, statistical anxiety and performance. The sample was 107 social and behavioural science students. The Multidimensional Perfectionism Scale (MPS) was used to measure perfectionism and the STARS was applied to quantify anxiety. They report graduate students with relatively high levels of ‘other-oriented perfectionism’ (OOP) and ‘socially prescribed perfectionism’ (SPP) tend to have higher levels of statistics anxiety associated with interpretation anxiety, computational self-concept and fear of asking for help. The article highlights several ways in which perfectionism may relate to poorer performance, one whereby students do not

seek help for fear of seeming unintelligent (SPP) and a second where the set expectations are perceived as unrealistic (OOP) and elicit an anxious and inhibited engagement. A specific mechanism mentioned is that students in these circumstances may attempt to learn course material by rote rather than understand the underlying concept. They also found anxiety to relate to depression and procrastination, which may also adversely impact outcomes.

Despite making the link between mechanisms affecting performance and anxiety, neither of the two articles mentioned above establish how student results may be improved. One piece of research which does assess a practical intervention is provided by Onwuegbuzie and Seamen (1995). They test whether altering exam conditions differentially affect results of the anxious and non-anxious. The sample is 26 students on a statistical course, 13 of whom are identified as anxious and 13 as non-anxious. They were randomly assigned to timed and untimed exams. The untimed exam was associated with improved overall results and the anxious showed a larger improvement.

## 5. Recommendations for teaching and 'some' research evidence

This section outlines recommendations given in the literature for teaching practices which may help to reduce statistical anxiety and summarises related empirical evidence. The first section considers recommendations applicable to classroom level, the second, curriculum level.

### 5.1. Classroom level

Onwuegbuzie *et al.* (1997) provide a list of what they advise teachers can do to reduce student anxiety:

*'Encouraging and reassuring students that they can do the work, displaying positive attitudes, addressing the anxiety, improving students' perceived worth of statistics, using humour, incorporating humorous cartoon examples, teaching gimmicks, helping students to understand the course objectives, administering open book/open note examination, administering untimed examinations, using performance assessments (e.g., assigning projects, tasks, assignments, or investigations), exhibiting empathy for students, being flexible, being patient and understanding, having fair and consistent grading practices, being knowledgeable about the topic, having an effective teaching style, asking students to write journals, allowing students to share their levels of apprehension and anxiety about statistics, providing a lecture concerning ways of coping with their anxieties, clearly explaining the subject material, providing sufficient examples and sample problems, providing extensive feedback (especially via one-on-one, face-to-face discussions), using current news stories and similar sources to introduce and to explain basic statistical concepts and methodological issues in research, applying statistics to real-world situations, and promoting cooperative learning in and outside the classroom.'*

It is questionable how useful the list is. Many of the items put forward by Onwuegbuzie *et al.* (1997) are generic and would be considered good practice in many educational settings. For example the suggestions that the teacher be knowledgeable about the topic and be patient and understanding is good advice. Nonetheless, there are unlikely to be circumstances where it would be recommended that a teacher should not be knowledgeable about the subject being taught or, that they should be impatient

and show a lack of understanding to students. There is little evidence base to support the argument that strategies like these significantly impact anxiety specifically.

Paxton (2006) discusses anxiety in sociology students learning statistics in the context of attempting to motivate an interest in the practice of QM. She outlines an approach to teaching intended to alleviate these issues. Paxton (2006) suggests problems can be overcome if teachers employ three tactics: 1. Stress that statistics are worth calculating. 2. Demonstrate that the students have the ability to 'do statistics'. 3. Use a consistent example or examples that can be returned to time and again. Student feedback was used to assess how successful this approach was and students reported the style of teaching was successful and enjoyable. Several studies in the field employ student feedback as the mechanism to assess practice (e.g. Auster 2000; Schacht & Stewart 1990). Understanding whether students enjoy what and how they are being taught is useful (Richardson 2005), however it does not allow us to assess whether the approaches suggested were 'better' than another method in terms of whether it led to knowledge gain. This can be convincingly demonstrated using experimental design or a pre-test post-test. Although student feedback will often be readily available it is not sufficient in itself to show whether one method of teaching is more successful at imparting information than another (Ottoboni *et al.* 2016).

Schacht and Stewart (1990) highlight an example of using humour to attempt to reduce anxiety amongst learners of social statistics. In doing this they suggest a technique of using cartoons. Cartoons can be used in lectures, assignments and homework. This, they suggest, can help to make connections across the course. Humour inherently relieves stress and tension and tension and humour also helps shift focus from difficulty to 'fun'. In evaluation students identified cartoons as reducing anxiety, but feedback suggested the students did not regard the cartoons as effective in helping to understanding the course. This study employed the Math Anxiety Ratings Scale (MARS) and a reduction in angst was measured. The authors note limitations in their approach in that humour is volatile and can be difficult to manage and has a potential to undermine teaching. Also, the study did not employ experimental design therefore it cannot be shown that the humour directly impacted anxiety.

## 5.2. Curriculum level discussion

Bridges *et al.* (1998) took a quasi-experimental approach to assess whether teaching QM on a substantive course might be effective. The aim was to understand whether an alternative curriculum might work to reduce anxiety by potentially replacing the stand-alone QM methods unit by spreading QM teaching across the degree. The total sample was 455, with an analytic sample of 261. A pre-test and post-test design was used, the attrition was caused by a large number failing to complete both a pre-test and post-test. The results show that QM understanding improved on the substantive course. The improvement was not significantly associated with previously measured ability, therefore the improvement in quantitative reasoning was considered to be the result of the intervention. Onwuegbuzie *et al.* (2010) likewise argue that anxiety can be tackled by altering the curriculum. They also argue that QM should not be taught on an anxiety inducing stand-alone unit and that all methods should be taught together, as methods. This argument is also put forward by Gorard (2015) who points out that the identification, and separation of methods as quantitative, is divisive and politically contentious in the

UK, one consequence of which, in his view, is the perpetuation of questionable researcher practices. Payne and Williams (2011) also suggest that teaching QM on a stand-alone methods unit is a contributing factor to a lack of interest amongst many social scientists in QM.

Slootmaeckers *et al.* (2012, 2014) similarly support the call that QM should be distributed across the curriculum, rather than taught as stand-alone. They present articles intended to explore the relationship between statistical anxiety, its antecedents and prior experience. The analysis was undertaken with two samples of political science students, one at undergraduate level  $n=41$  (response 77%) and one at master level  $n=116$  (response 64%). They identify 3 categories of antecedents causing anxiousness: Disposition (attitude, perception, self-concept); Course/situational (nature of course, prior knowledge, grade, teacher, prior courses taken) and; Personal (socio-demographic characteristics). They control for pre-existing attitudes to statistics using the instrument, the Survey of Attitudes Toward Statistics (SATS-36) (Schau *et al.* 1995) to measure attitudes at the start of a course. To capture the other information necessary learners were later asked a series of questions. For example, to understand dispositional antecedents students were asked to rate the importance of statistics to their perceived future role and self-rate their own skill level in a 7 point Likert scale. For situational antecedents students were asked how experienced they were in working with statistics. The results show the antecedents significantly relate to anxiety. The number of statistics courses taken by an individual was not significantly related to knowledge retention but having quantitative material in non-methodological courses is shown to improve QM knowledge retention. Although the authors suggest that, if the inclusion of material is poorly implemented, then including quantitative materials in non-methods courses could negatively affect the attitudes of those who already have a difficult relationship with statistics.

Another potential problem of introducing QM on a substantive unit is highlighted by Williams *et al.* (2015). They undertook research in the UK which suggests teaching QM on a substantive unit is not a simple solution to the problem of angst inducing lessons in statistical understanding. They employed a quasi-experimental design to assess teaching QM embedded in a sociology unit. The control groups were small with only 18 students responding at a second time point, although 45 responded at the first. They found that those who were exposed to statistics had a wider trust and appreciation of statistical methods. However, this group was also less confident about using statistics. The results indicate that including QM on a substantive course can potentially have negative outcomes. A positive interpretation of the finding is that students may gain an awareness of their own limits which they did not previously possess and that exposure generates a more realistic appraisal of current ability.

#### 6. *Facilitating anxiety and areas where there may be scope to increase understanding*

A comprehensive comparison of the level of anxiousness, both within social science disciplines, and between social science and more numerate subjects, has yet to be undertaken. Although, intuitively it might be hypothesised that students in more mathematically based subjects would be more comfortable with statistics and that, if anxious, it may be a qualitatively different type of angst and there is not yet good empirical evidence about this. In the absence of studies of this nature, it is not known whether

social science students are significantly more 'frightened' of statistics than their more numerate counterparts or whether some social sciences are faring better than others in this respect.

There are also parallel literatures examining anxiety from which it is possible to collect insight that might be applied in a QM context. For example, Scovel (1978) draws a distinction between facilitating and debilitating anxiety. This is an older paper synthesising the language studies literature, with >700 citations. It considerably pre-dates either of the social science stats anxiety reviews, highlighting the long term engagement of this field with the concept of anxiety in learning. The first paper to refer to the concept of facilitating and debilitating anxiety is Alpert and Haber (1960) where they outline an instrument called the *Achievement Anxiety Test*. The fields where facilitating and debilitating anxiety seems to have been studied most are language, anxiety around tests/exams and also sports. Mellalieu and Hanton (2008) suggest the paradigm of the measurement of 'intensity,' rather than direction of anxiety (i.e. facilitating or debilitating), has been open to question within the sports anxiety literature for 30 years. Moyer (2008) makes the point that anxiety related to academic tasks can be seen by individuals as either inhibiting or enhancing performance. Whether anxiety has a positive or negative effect is understood to potentially be mediated by personality traits, such as, whether an individual is a 'worrier', or is confident, or not. When given a test it is suggested worriers identify increased anxiety as debilitating, non-worriers as facilitating.

There is potential for insights to be taken from the overlap between these literatures, especially as it is often suggested that maths should be considered as a form of language (Ellerton & Clarkson 1996). Despite the potential crossover, the facilitating/debilitating dichotomy is largely absent from the stats anxiety literature. A reason to apply the distinction may be to help focus effort towards practical interventions. If we focus research on whether interventions have a facilitating or debilitating effect on anxiety, in the context of outcomes, such as knowledge retention or statistical understanding, this would make a large contribution to pedagogy in the field.

## *7. More evidence is needed – an analysis of whether women are more likely to report anxiety*

Studies suggest that women report higher anxiety than men (Papanastasiou & Zembylas 2008; Onwuegbuzie 1998; Zeidner 1991). This section reports an analysis examining whether women are more likely than men to identify as anxious.

### *7.1. Data and methods*

Sources of secondary social science pedagogy data are limited. One resource are data collected by Williams *et al.* (2009)<sup>4</sup>. These data were gathered on a sample of (32) sociology and social policy departments in universities in England and Wales, this resulted in 738 cases. They provide an example of information collected on social science pedagogy, systematically, at a level beyond a single institution. Although gathered to describe attitudes to quantitative methods in general (Williams *et al.*

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<sup>4</sup> UK data archive study - SN 6173

2008) there is some scope to use these data to explore the relationship between statistical anxiety and its antecedents.

An item included in the survey asked individuals to respond to the statement: *the idea of learning statistics makes me feel anxious*. Categories of possible response were *Agree*, *Disagree*, *Not sure*. This is a simple measure of self-reported anxiety in the context of QM and is not a typical anxiety scale. It is the log of the odds that an individual agrees that they feel anxiety in relation to learning statistics that is measured as the outcome. This outcome was modelled as a multi-nominal outcome and a dichotomous outcome. Only the dichotomous results are reported<sup>5</sup>. This merges the *Disagree* and *Not sure* categories, contrasting those who agree they are anxious (a definitely anxious category) with those who are not 'definitely anxious'.

The analyses use logistic regression. The category in which people report being definitely anxious is coded 1, which means that the independent variable indicators express a coefficient which is the logged odds of agreeing that they are anxious. There are a number of variables in the dataset which are considered antecedents of statistical anxiety (see Table 1 for descriptive statistics). The review above identifies 3 types of antecedent, situational, dispositional and environmental (socio-demographic). The socio-demographic antecedents, sex and age are included in this analysis. Whether a respondent has recently obtained a maths qualification is included in these analyses and prior math experience has been characterised as a situational antecedent. Self-perception of maths ability is also incorporated and this is considered a dispositional antecedent.

Sex is recorded as dichotomous and initially included in a model with men as the reference category. Age was tested as linear and quadratic and on the basis of sensitivity analysis is reported as a simple dichotomy with those 24 years and below set as a reference category, contrasted with those 25 and over. Age and sex are interacted together, to check the consistency of this results are also stratified by age and sex and a linear probability model was estimated (but is not reported). The conditional marginal probabilities (Williams 2012) of the interaction are reported. The design of the survey required an individual to confirm the level of their most recent qualification. Individuals' were then asked whether this includes maths. The maths qualification variable is therefore sub-optimal, only controlling for whether the most recent qualification obtained included maths, or not. Nevertheless it might be expected that a recent math qualification would be associated with lower anxiety. Finally, self-assessed maths ability is set with those who agree that they are 'good' at maths as the reference category, contrasted with those who 'disagree', and those who are 'not sure'. There are 6 item missing cases excluded from the analysis.

## 7.2. Results

The cross-tabulation in Table 1 suggests no significant association between anxiety and sex. There is a weak association between anxiety and age. Those aged 25+ are significantly more likely to agree that

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<sup>5</sup> On checking the outcome as a multinomial the direction of the effect for responses on the *Disagree* and *Not Sure* categories were identical whilst the magnitudes were similar. On this basis it was decided to collapse these categories together as it leads to a simpler interpretation of a dichotomous outcome.

they are anxious than those who are 24 years and less. The indicators capturing whether an individual recently passed a maths qualification and self-reported maths ability also show significant bivariate associations.

The models in Table 2 estimate the relationship between the independent variables and the outcome. Model 2.1 (see also Figure 3) suggests that sex is not significantly associated with different odds of reporting anxiety between men and women, net of the other variables included in the model. The older age group have a significantly higher chance of reporting anxiety and the level is quite large at an logged-odds (lo) of 1.1 (confidence interval (ci) .56 - 1.7). This is different from the impression given in the age cross tabulation where it would be concluded that there is, at best, a weak association between age and anxiety.

Model 2.2 controls for the same variables as 2.1, but specifies an interaction between sex and age. In this instance the interaction is specified as a 4 level variable of all possible combinations of age and sex. The reference category is men, 24 years old and under. It can be seen that all other categories on the variable exhibit significantly higher logged-odds of reporting anxiety. Model 2.3 (see also Figure 4) provides an alternative specification of the interaction. The model is statistically identical, although the output differs. Specified in this manner the male female output expresses the relationship between young women and young men. The age coefficient describes the relationship between older men and younger men. The multiplicative interaction term indicates how much the influence of sex changes when the younger group are considered instead of the older group. The other variables controlled may be considered to measure confidence (whether an individual considers themselves to be good at maths) and recent experience (whether their most recent qualification included maths). Those who do not identify as being 'good' at maths have a higher logged-odds of reporting anxiety than those who report being good. Those whose most recent previous qualification included maths have lower odds of reporting anxiety. The direction of these associations are consistent across models, the magnitude and levels of significance vary somewhat.

The substantive consistency of the results introduced above have been checked using a linear probability model (unreported), examining the effects stratified by age and sex (Tables 3 and 4, and Figure 5) and marginal effects, conditional probabilities - Table 2. Model 3.1 contains only those aged 24 years or less, model 3.2 includes only those aged 25 or more. Model 3.1 shows that women aged under 24 are more likely to report anxiety than men 24 and under. Model 3.2 shows women 25 and older have lower odds of reporting anxiety than men over 25. Model 4.1 contains only men and model 4.2 only women. In these models it can be seen that age is only significant for men, with older men having a higher odd of reporting anxiety. In sum, these models suggest the same direction of effect and similar magnitudes to the models discussed in Table 2.

Marginal conditional probabilities for the interaction categories are estimated and reported in Table 2. This shows the probability that an individual in a category reports that they are anxious, with the other variables set as having a maths qualification and reporting good maths ability. Young men have a low additional probability of disclosing anxiety and older men have a higher probability of identifying as anxious, whilst older women and young women have similar probabilities.

From these analyses it seems reasonable to put forward that a lower odds of 'young' men reporting anxiety drives the age effect seen in model 2.1. Specifying the model with an interaction is a better expression of the relationship between sex and anxiety in that it highlights a gender difference in the odds of being anxious that is absent from a bivariate cross tabulation and the model simply controlling for sex as a dummy category. Here, it is possible to see younger women and older women appear far more likely to report anxiety than young men. Stratifying by sex it is possible to see clearly that there are no significant differences between older women and younger women.

### *7.3. Discussion*

This is a simple analysis primarily intended to examine the relationship between sex and self-reported anxiety of statistics. Studies suggest that women report higher anxiety than men (Papanastasiou & Zembylas 2008; Onwuegbuzie 1998; Zeidner 1991). The results reported above suggest an association where young women are more likely to experience anxiety than young men, but older women are less likely to experience anxiety than older men. Older men also have higher chance of experiencing anxiety than younger men. There were no significant age differences evident between older women and younger women (model 4.2). This indicates a more complicated relationship between gender, age and anxiety than reported in other studies and indicates a somewhat different relationship to statistical anxiety for men and women. These results suggest a need to consider the relationship between anxiety and its antecedents in a multivariate context where sensitivity analyses can be undertaken.

There are limits to these analyses, they are intended only to give an indication of the current need for more research. More comprehensive analysis can be undertaken where appropriate data are gathered. The outcome variable is a simple measure of self-reported anxiety, rather than a statistical anxiety scale. Anxiety scales have been specifically designed to measure an intensity of anxiety and benefit from published validity testing. Given this, the analyses here do not necessarily contradict the previous findings. It is possible that women could consistently report a higher intensity of anxiety than men even although an older age group reports a lower chance of feeling anxious in the first instance. This sample is clustered in universities, but we cannot correct for possible biasing generated by this because the necessary information is not in the dataset. Another potential issue is that the number of women in the sample is more than four times larger than the number of men. This represents the numbers of women undertaking social science degrees (Williams *et al.* 2008). The 6 item missing cases are all women.

### *8. Conclusion – A level of anxiety can be expected*

In their review of statistical anxiety literature Chew and Dillon (2014) argue persuasively that a new research agenda needs to be adopted, one which assesses practical interventions rather than simply continues to suggest a relationship between anxiety, its antecedents and performance. This needs to be looked at in tandem with the question of what level(s) of anxiety is problematic. There is also a more fundamental aspect of statistical anxiety that still need to be talked about. The QM pedagogy literature often assumes anxiety to be a problem but our view is that the current evidence is not yet strong enough to draw the conclusion that statistical anxiety necessarily has a systematic and substantive impact on

performance. Work still needs to be undertaken to establish whether statistical anxiety has the negative affect it is often stated as having. Our analysis shows that even the most fundamental questions, such as the nature of the associations between gender and anxiety are still unresolved. Furthermore, it may be considered acceptable for assessment and competitive tested environments to induce a level of anxiety.

If the goal is to train social scientists who can understand and apply QM then an academically rigorous level of instruction and assessment in this area is required. If the statistical aspect of a social science degree is the most difficult, as is often suggested (Macher *et al.* 2015; Murtonen & Lehtinen 2003), it is likely to follow that it is the most angst laden. In this context anxiety in itself does not matter, unless it leads to wider health problems (Onwuegbuzie & Daley 1999) or prevents an individual from achieving a higher level of understanding. This is what we should look to understand. We need to disentangle whether there is a level of anxiety that is problematic for learning and knowledge retention and, if there is, what evidence there is for practical interventions at class and at institutional level that could improve the situation. Some evidence of practice in teaching, assessment and programming that influences anxiety is highlighted above. For instance Sloomaeckers *et al.* (2014) present evidence that spreading QM across the curriculum can improve knowledge retention. Whilst, Onwuegbuzie and Seaman (1995) indicate that altering assessment can affect the anxious disproportionately. This type of work needs to be built upon, replicated and the results validated in different circumstances. If it is the case that students gain the most from repeated contact with methods across a degree, rather than in anxiety creating, stand-alone units, this needs to be firmly established empirically. If our aim is to focus on methods training as opposed to substantive interests then this type of research could be used as evidence to break down opposition to a shift towards methods.

The direction teaching practice goes is contingent. Referring back to a point made at the outset, there is some opposition to the use of QM in the social sciences (Williams *et al.* 2016; Mills 2013; Platt 2012). This implies there may be underlying resistance to increasing the curriculum presence of QM. It may be that many social-scientists are content to keep QM as a specialism and something they do not have to engage with (Wilder 2010), by it being taught once on a degree programme, in a stand-alone unit. Furthermore, it is a real possibility that a policy focus on capacity will not in itself trigger the creation of a full scale QM pedagogy culture. In a competitive academic environment it is far from clear that researchers will be persuaded by current developments to invest research time in a historically unfashionable field. The research synthesised in this paper highlights that the groundwork exists on which a pedagogical culture could be built. A new pedagogical culture could be created and renewed if social scientists are prepared to generate a hitherto unreached level of pedagogical engagement, by talking about issues like statistical anxiety and committing to the role and place of methods pedagogy.

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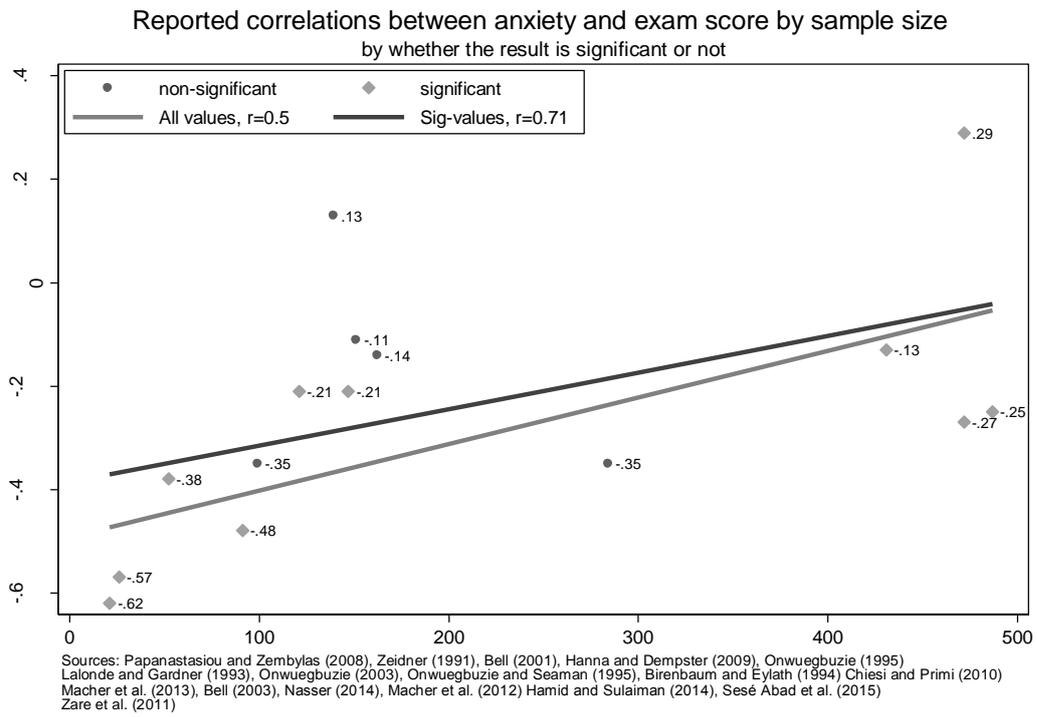
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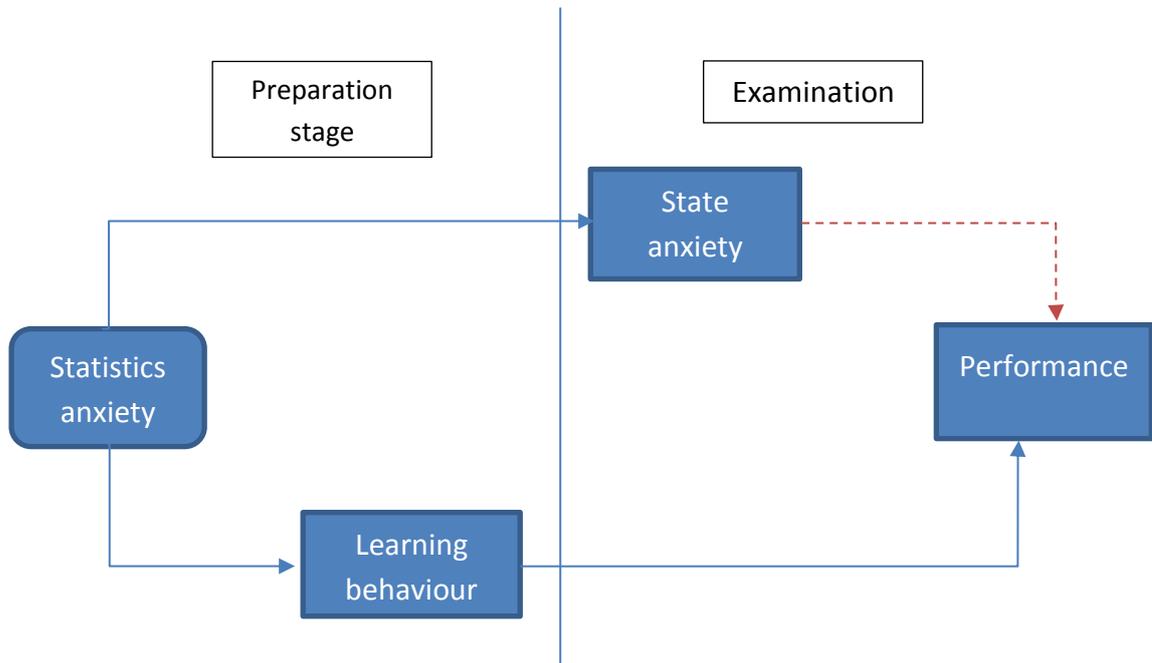
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Figure 1



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**Figure 2,** The twofold effect of statistics anxiety on performance proposed by Macher *et al.* 2015



**Table 1**, Descriptive statistics: bivariate crosstabs of the independent and dependent variables

	<b>% Do not agree</b> (n)	<b>% Agree</b> (n)		
<i>Learning statistics makes me feel anxious?</i>	<b>54</b> (339)	<b>46</b> (393)	Chi square	Phi $\Phi$
Sex				
Male	<b>52</b> (65)	<b>48</b> (60)	0.16	$\Phi$ 0.05
Female	<b>45</b> (274)	<b>56</b> (333)		
Age				
<=24	<b>48</b> (312)	<b>52</b> (338)	0.01	$\Phi$ 0.10
>=25	<b>33</b> (27)	<b>62</b> (55)		
<i>On the whole I am good at maths.</i>				
Agree	<b>66</b> (213)	<b>34</b> (108)	0.00	$\Phi$ 0.38
Disagree	<b>26</b> (78)	<b>74</b> (226)		
Not Sure	<b>45</b> (48)	<b>55</b> (59)		
<i>Last qualification obtained included maths.</i>				
Yes	<b>66</b> (72)	<b>34</b> (37)	0.00	$\Phi$ 0.17
No	<b>43</b> (267)	<b>57</b> (356)		

n= 732

Source: Williams *et al.* 2009, SN: 6173

Figure 3, Model 2.1

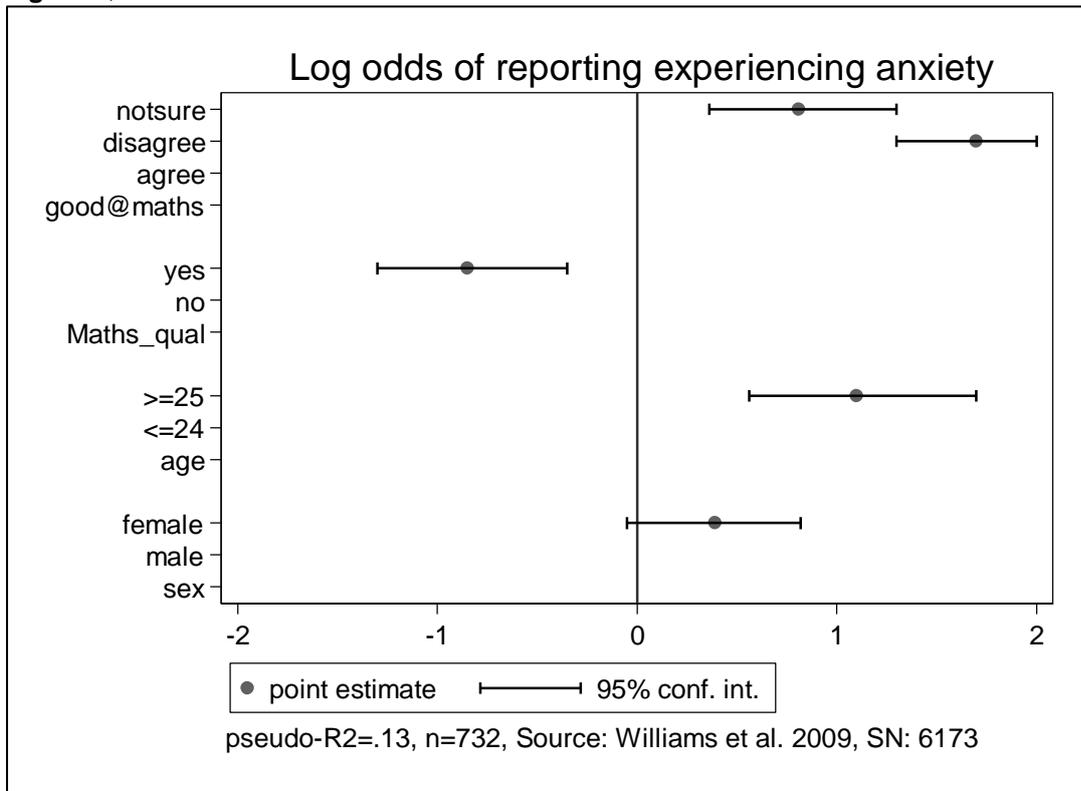
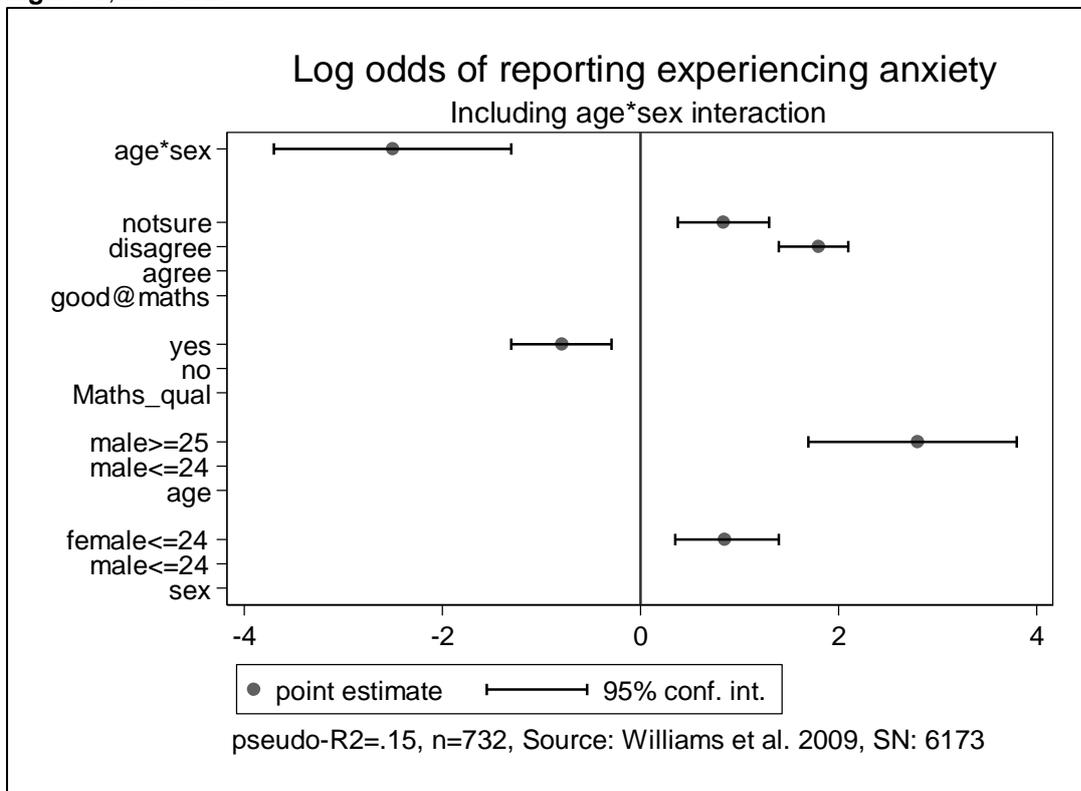


Figure 4, model 2.3



**Figure 5**, estimates for models from Table 3 and 4

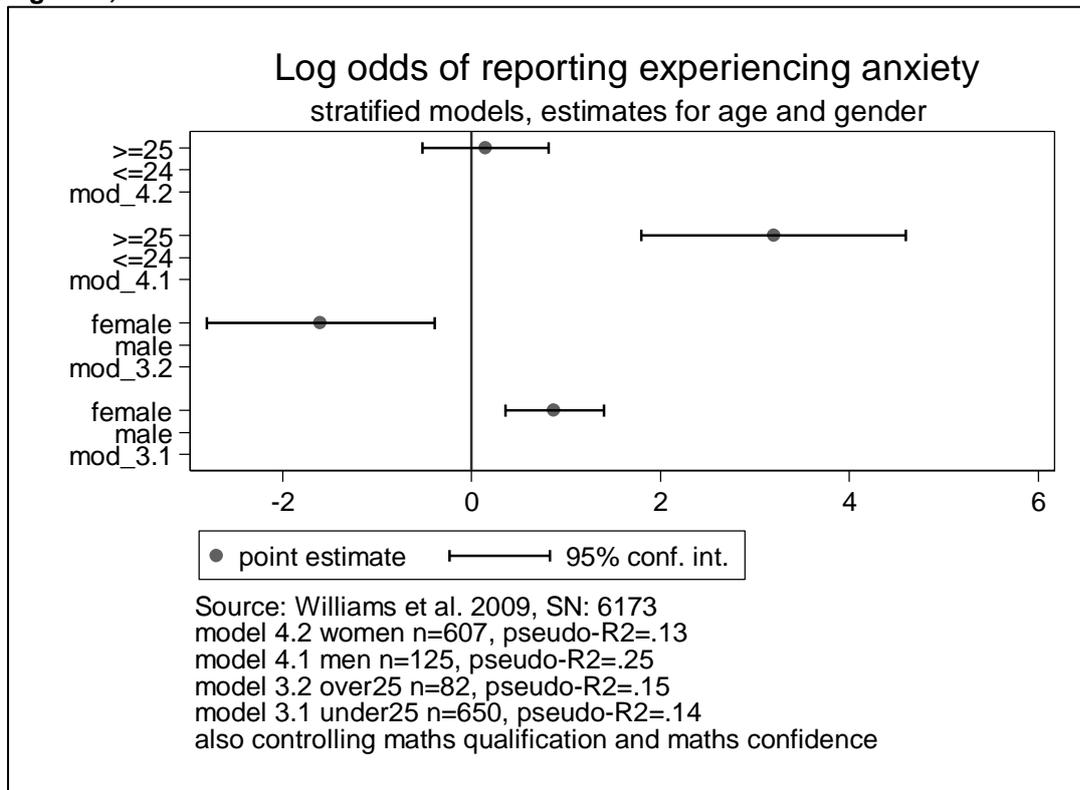


Table 2. Logistic models. The outcome is whether an individual agrees they feel anxious about statistics as contrasted with those who either disagree or do not know whether they feel anxious about statistics

		Model 2.1				Model 2.2				Model 2.3				Conditional probabilities		
		Log-odds	se	lci	uci	Log-odds	se	lci	uci	Log-odds	se	lci	uci	lci	uci	
Sex	Male	-	-	-	-	-	-	-	-	-	-	-	-			
	Females	.39	(.22)	-.051	.82					.85***	(.26)	.35	1.4			
Age Group	Age <=24	-	-	-	-					-	-	-	-			
	Age >=25	1.1***	(.29)	.56	1.7					2.8***	(.54)	1.7	3.8			
Maths qualification	No	-	-	-	-					-	-	-	-			
	Yes	-.85***	(.25)	-1.3	-.35	-.79**	(.26)	-1.3	-.29	-.79**	(.26)	-1.3	-.29			
I am good at maths	agree	-	-	-	-					-	-	-	-			
	disagree	1.7***	(.18)	1.3	2	1.8***	(.19)	1.4	2.1	1.8***	(.19)	1.4	2.1			
	not sure	.81***	(.23)	.36	1.3	.84***	(.24)	.38	1.3	.84***	(.24)	.38	1.3			
Age sex interaction	Male age<=24					-	-	-	-					.10***	.04	.16
	Male age>=25					2.8***	(.54)	1.7	3.8					.64***	.41	.86
	Female age<=24					.85***	(.26)	.35	1.4					.21***	.12	.29
	Female age>=25					1.1**	(.4)	.32	1.9					.25***	.12	.38
	Age*Sex									-2.5***	(.63)	-3.7	-1.3			
Constant		-.96***	(.23)	-1.4	-.51	-1.4***	(.27)	-1.9	-.89	-1.4***	(.27)	-1.9	-.89			
Log-likelihood		-440				-431				-431						
McFadden's pseudo-R2		.13				.15				.15						
BIC null-model	1020															
BIC		919				908				908						
n		732				732				732						

Source: Williams *et al.* 2009, Study Number: 6173, downloaded from the UK data archive

Model 3.1, logit model

Model 3.2, logit model with an interaction specified unconventionally as a combination of all possible categories and in comparison to a base category

Model 3.3, includes a multiplicative interaction and main effects

Conditional probabilities, estimated with the other predictors set as having a maths qualification and reporting good maths ability

\*p<0.05, \*\*p<=0.01, \*\*\*p<=0.001

se, standard error

lci, lower confidence interval, 95%

uci, upper confidence interval, 95%

Table 3. Logistic models. The outcome is whether an individual agrees they feel anxious about statistics as contrasted with those who either disagree or do not know whether they feel anxious about statistics. The first model includes only those 24 years old and younger, the second includes those 25 years old and older

		Model 3.1, Age <=24				Model 3.2, Age >=25			
		Log-odds	se	lci	uci	Log-odds	se	lci	uci
Sex	Male	-	-	-	-	-	-	-	-
	Females	.87***	(.26)	.36	1.4	-1.6**	(.6)	-2.8	-.39
Maths qualification	No	-	-	-	-	-	-	-	-
	Yes	-.75**	(.29)	-1.3	-.18	-.94	(.53)	-2	.1
I am good at maths	Agree	-	-	-	-	-	-	-	-
	Disagree	1.8***	(.2)	1.4	2.2	1.4*	(.59)	.22	2.5
	Not sure	.79**	(.25)	.3	1.3	1.6	(.93)	-.21	3.4
	Constant	-1.4***	(.27)	-2	-.9	-1.4**	(.54)	.35	2.5
McFadden's pseudo-R <sup>2</sup>		.14				.15			
BIC		804				110			
BIC Null model		909				108			
n		650				82			

Source: Williams *et al.* 2009, Study Number: 6173, downloaded from the UK data archive

\*p<=0.05, \*\*p<=0.01, \*\*\*p<=0.001

se, standard error

lci, lower confidence interval, 95%

uci, upper confidence interval, 95%

Table 4. Logistic models. The outcome is whether an individual agrees they feel anxious about statistics as contrasted with those who either disagree or do not know whether they feel anxious about statistics. The first model includes men only the second model women only.

		Model 4.1, Men				Model 4.2, Women			
		Log-odds	se	lci	uci	Log-odds	se	lci	uci
Age Group	Age <=24	-	-	-	-	-	-	-	-
	Age >=25	3.2***	(.7)	1.8	4.6	.15	(.34)	-.52	.82
I am good at maths	Agree	-	-	-	-	-	-	-	-
	Disagree	1.4**	(.47)	.49	2.4	1.9***	(.2)	1.5	2.3
	Not sure	.65	(.71)	-.74	2	.87***	(.25)	.38	1.4
Maths qualification	No	-	-	-	-	-	-	-	-
	Yes	-2.1**	(.71)	-3.5	-.74	-.48	(.28)	-1	.07
	Constant	-1.1**	(.38)	-1.8	-.33	-.64***	(.14)	-.92	-.36
McFadden's pseudo-R <sup>2</sup>		.25				.13			
BIC		155				756			
BIC Null model		178				854			
n		125				607			

Source: Williams *et al.* 2009, Study Number: 6173, downloaded from the UK data archive

\*p<=0.05, \*\*p<=0.01, \*\*\*p<=0.001

se, standard error

lci, lower confidence interval, 95%

uci, upper confidence interval, 95%

## Appendix 1

**Table A.1**, association between anxiety and test/exam performance reported in papers,  $r$ = correlation reported,  $b$ = coefficients reported in the paper.

Author	Sample	Sampling Design	n	Measure of anxiety	Analysis	Association between anxiety and test/exam	Note
Papanastasiou and Zembylas (2008)	Education undergraduates on research methods course, Cyprus	None reported	472	Attitudes Toward Research scale	Regression, all ARS sub-scales	$b=-0.177^*$ , $r=0.292^{**}$	Reports a positive correlation between anxiety and grade!
Keeley (2008)	Social science students in the USA	Convenience sample	83	STARS	Regression	Associations not reported	Worth of statistics and interpretation anxiety sub-scales produced significant models, curvilinear specification gave larger $r^2$ .
Zeidner (1991)	Behavioural sciences, Israel	None reported	431	Statistics Anxiety Inventory	Correlation (n=429)	$r=-0.128^*$ , $p<0.05$	
Bell, J. A. (2001)	Business Students, USA	None reported	99	STARS	Correlation (n=35)	$r=-0.35$	Non-sig
Hanna, D., & Dempster, M. (2009)	First year psychology students, UK	None reported	52	STARS	Correlation Regression	Computation self-concept $r=-0.355^*$ Interpretation Anxiety $r=-0.364^*$ Worth of Statistics $r=-0.383^*$ $r=-0.62$ $p<0.05$	Regression of all STARS subscales. 3 correlations reported significant.
Onwuegbuzie (1995)	Female, education students, USA	Random assignment	21	STARS, test and class anxiety sub-scales	Correlation	$r=-0.62$ $p<0.05$	
Elmore, P.B. et al (1993)	A range of students majoring in non-mathematical courses in the USA	None reported	289	STARS	Regression	Some models including STARS found to be significant	Effect sizes not reported. Low quality, unpublished paper.
Lalonde and Gardner (1993)	Canadian, Psychology Students	None reported	91	Bespoke measure	SEM approach	$r=-0.48^{**}$ ,	The 'anxiety' path was not significant, model did not fit
Zanekis and Valenzi (1997)	USA, business students	None reported	166	Bespoke measure of maths anxiety	GLM	$b=0.247^*$	Included grade Point Average and Computer Experience Significance of correlation not reported
Onwuegbuzie (2003)	USA, education and psychology students	None Reported	130	STARS, computational self-concept sub-scale only	SEM approach	$r=-0.24$ $p$ value not reported. $b=-0.18$	
Onwuegbuzie and Seaman (1995)	Education, nursing and health administration	Random assignment	26	Test and Class Anxiety subscale of the STARS	Regression, mid-term exam as covariate	$r=-0.57^*$	Only the correlation is reported. Although significance levels of models are reported
Tremblay, Gardner, & Heipel, (2000)	Psychology students	None	166	10 item scale, adapted from Lalonde and Gardner (1993)	SEM	Not apparent	Paper is obscurely reported, figures and tables are missing
Fitzgerald <i>et al.</i> , (1996)	Advanced level Graduate students	None	109	Bespoke statistics test anxiety scale	Logistic regression (pass/fail, n=104)	$b=0.13^*$ (log-odds)	Higher odds of failing associated with anxiety
Birenbaum and Eylath (1994)	Female education students	None reported	151	Bespoke 10 point scale	Correlations	$r=-.11$	Non-significant,
(Chiesi & Primi 2010)	Psychology Students	None reported	487	STARS	SEM	Interpretation anxiety: $r=-.25^{**}$ Test and class anxiety: $r=-.18^{**}$ Asking for help: $r=-.15^{**}$	
Lacasse and Ciochio (2005)	Psychometrics Students	-	-	-	-	-	This was a conference paper, untraced at present
Macher <i>et al.</i> , (2013)	Psychology students	None reported	284	STARS	SEM	$r=-.35$ non-sig	Model showed small sig +ve

Author	Sample	Sampling Design	n	Measure of anxiety	Analysis	Association between anxiety and test/exam	Note
Bell (2003)	Business students	None reported	121	STARS	Correlations	r=-.21*, test and class anxiety sub-scale, non-traditional	association between anxiety and performance Compares traditional (n=100) and non-traditional students (n=21)
Nasser (2004)	Arabic speaking education students in Isreal	None reported	162	STARS	SEM	r=-.14	SA non sig, e.g Worthlessness of statistics sub-scale as reported
Macher (2011)	Psychology students, Austria	None reported	147	STARS	SEM	r=-.21*	sub-scales, test and class anxiety, interpretation anxiety, fear of asking for help
Hamid and Sulaiman (2014)	Psychology Students	none	139	STARS	OLS regression	.13, self-concept sub-sale (largest relationship)	No sig correlations between anxiety and grade reported.
Sesé Abad (2015)	Health sciences	none	472	SAS	SEM	Examination anx -.27** Asking for help -.20** Interpretation anx -.23**	Attitude completely mediates anxiety
Zare (2011)	Iranian students	Multi-stage cluster sampling	323	STARS	Path/SEM	r=-.41*	This is a poorly reported confusing paper

Source: references primarily identified from Chew and Dillon (2014) and Onwuegbuzie and Wilson (2003) Macher et al (2015)

\*p<=0.05 \*\* p<=0.01 \*\*\* p<=0.001