Gender bias in mental rotation tests

Problem
In some psychology tests such as a mental rotation task, boys appear to do better than girls. But is this due to actual ability or task bias?

Question
Using the data set provided, how would you score individuals using standardised scores across all students in order to minimise gender bias for all courses for a cohort of 1000 college students, but with minimal impact on the precision of the test?

Possible changes include (but may not be limited to) deleting some items, change the order of items, introduce items weightings, using error analysis, incorporating time taken on an item or whole test basis.

Data Characteristics
- Cohort size - 1000 students
- Score by question (32 questions)
- Time taken per question
- Order of item
- Student characteristics:
  - Age of student
  - Gender of student
  - Course being taken

In the event of a tie, comments on the following aspects may positively influence judges
- To what extent can you predict gender from the data provided?
- Did the slowed down of the internet have an impact?
- Is there an apparent learning component or change of strategy during the test?
- Can the group scores for a given course help improve prediction?
- To what extent can each item be classified as more solvable by one of the two main strategies - mental rotation and feature analysis?

Metric of competition
Full details of the metric to be used will be released at the same time as the data set. It will involve a single measure which will reflect the reduction of gender differences across courses, and thereby improve gender equality.

Information provided
- Brief background article (See this document)
- Research reading list: (See this document)
- Video of background 10 minutes (Available 8 July 2016)
- Document that shows test items (Available 8 July 2016)
- Access to the test online (Available 8 July 2016)
- Data set: Available as a csv with no NA’s – to be made available on 8 July
Competition 1
Brief background article

Visual Spatial Mental Rotation - Stereotypes or Gender Bias

The visual spatial mental rotation task has been widely researched since the early studies of Shepard and Metzler (1971). One re-occurring theme has been the way that men are consistently better at this task than women. However, a critical review of the research (see Recommended Reading for a list of the most relevant research papers, all available free on the internet) suggest that as little as a few hours can provide enough practice to significantly reduce the difference between the two genders.

This, combined with the other research, suggests that the difference may simply be a function of the early learning environment. Or to put it another way, if you played a lot with Lego and did a lot of jigsaws, you would probably be better at this task than if you did not. So if there is a bias in the use of visual spatial tasks, particularly at pre-school ages, then one would expect this to impact upon scores.

Jigsaws are a mental rotation exercise, and have been used to measure mental rotation skills. The more you do jigsaws, the better you will be at jigsaws and to a lesser extent, mental rotation tasks.

Mental rotation by question and gender
N.B. Girls were better than the boys in 9 of the 32 items.

N = 1620
Visual Spatial Mental Rotation - Stereotypes or Gender Bias

As can be seen in the graph on the previous page, it would be presumptuous to suggest that boys are better than girls in this task. At best one can say that in 72% of the items, the boys did score higher.

However, given that different items can invoke different strategies, and in turn there is a gender preference for those strategies, an alternative interpretation is that the test, by its very construction, is biased towards the boys. Interestingly, the strategy that research suggests is preferred by girls usually takes longer than the other, which again could suppress scores for girls if there is a time limit.

**Implications for Course Selection**

Wai et al (2010) reported the importance of mental rotation tasks in science, technology, engineering, and mathematics (STEM), suggesting that success in these subject may, in part, be due to mental rotation skills. Similarly, students selection of courses may be influenced by their perception of their own mental rotation skills. (N.B. In future we hope to have exam results to see the impact of this task on academic outcomes. But not for now.) So the question is are there differences between courses in this test. And if yes, to what extent is there a gender bias, and it is consistent across all courses.

A quick look at the data will show that there are difference between courses, though not necessarily statistically significant in all cases.

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**The real question**

It is easy to show that there are gender differences on this task in a given course. So if we wanted to establish norms for a course, arguably for the current test you would have to have two norms, one for boys and one for girls. Alternatively, you adjust the items (e.g. remove some or change the order) to ensure the norms based on gender were the same (or as close as possible). However, it is not possible to have a different test for each course. Therefore, there must be a compromise and the difference between genders must be minimised for all courses.

What is needed is a standardised score which reduces the gender gap, and offering equal opportunities for all.

- Deleting some items
- Change the order of items
- Items weightings
- Using error analysis, incorporating time taken on an item or whole test basis.

The winning metric will be one that provides a way to score all individuals in a way that minimise gender inequality.
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Research Papers
Below is a series of papers whose titles are indicative of the diversity of research in this area. They may provide valuable information with respect to the competition, and all are available free on the web.


