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Sex Differences in Mechanical Aptitude: An Investigation of Sex Differences in Mechanical Aptitude and Its Relation to Nonverbal Abilities

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Faculty Sponsor: Dr. Susana Urbina, Professor of Psychology

Abstract

This study investigates sex differences in mechanical abilities. Numerous research findings support the existence of sex differences in mechanical aptitude as well as in other abilities. Recent research suggests that there is a relationship between mechanical aptitude and certain nonverbal reasoning (e.g., visual-spatial) abilities. Due to the possible links between these constructs, sex differences in a nonverbal measure of general intellectual functioning, made up of five subtests, were also evaluated. Thus, the purpose of this study is twofold: to investigate sex differences in mechanical aptitude and nonverbal abilities, and to explore the construct validity of all the measures employed.

Females and males were compared in terms of their performance on two mechanical aptitude tests and one test of nonverbal abilities. It was expected that, on average, men would do better on both of the mechanical aptitude tests. The construct validity of all the measures was investigated by correlating the scores on the various instruments and by comparing the results obtained with the expectations suggested by the empirical literature on sex differences. Thus far, all the major hypotheses have been confirmed. However, these results are based on a smaller sample than originally planned.

Little research has been conducted examining the basis for the reported sex differences in mechanical aptitude. Mechanical aptitude tests are used extensively in selection procedures for mechanical jobs. A study investigating the validity of two of these measures and the differential performance of each sex group on them is quite timely because more women are seeking employment in areas that require mechanical abilities.

Introduction

The empirical literature suggests that the construct of general intelligence, or the "g factor," encompasses a wide spectrum of learned and innate human behavior and functioning made up of factors such as cognitive abilities, personal variables, and experience, as well as musical and mechanical aptitudes (Anastasi and Urbina, 1997). The g, or general, factor originally identified by Spearman, is placed by Vernon at the top of the hierarchy of cognitive abilities followed by specific abilities such as mechanical knowledge, spatial ability, verbal ability and quantitative ability (Vernon, 1950). The g factor has proved to be useful in predicting criteria of job performance as well as performance in academic settings.

Although the g factor is very useful, there are a number of situations in which it is desirable to learn about an individual's profile of strengths and weaknesses in intellectual abilities, for example, in vocational counseling. Therefore, we must also look at performance levels in abilities that are narrower than g, such as mechanical aptitude. According to Bennett (1994), mechanical aptitude "may be regarded as one aspect of intelligence, if intelligence is broadly defined" (p. 8). However, tests developed to assess general intelligence typically do not provide information on a person's standing in mechanical aptitude.
There is a need for specialized instruments, such as mechanical aptitude tests, that measure specific clusters of abilities pertaining to certain tasks or occupations. Although mechanical aptitude is related to general intelligence, it also comprises a complex yet relatively independent set of abilities. Wiesen (1999) suggests that mechanical aptitude is “a function of general intelligence, spatial ability, interest, and mechanical knowledge” (p.3). Mechanical aptitude tests measure a set of complex cognitive abilities whose central components are spatial abilities, mechanical reasoning and information, as well as perceptual discrimination (Anastasi and Urbina, 1997).

Related to individual performance levels in cognitive abilities, and of equal importance, is the issue of individual and group differences in cognitive functioning. Sex differences in cognitive abilities are one such difference of interest. Whereas there is no evidence of a sex difference in general intelligence, sex differences have been observed in broad cognitive abilities. For example, Halpern (1992) identifies verbal, quantitative, and visual-spatial ability as the “main loci of sex differences” (p.64). Males excel in certain quantitative tasks and on most visual-spatial tasks. Females tend to have better verbal skills and outscore males on certain tests of quantitative abilities with verbal components. In addition to the documented sex differences in these broad cognitive abilities, research shows that females and males also differ in specific abilities, including some that have been implicated in performance on mechanical tasks, such as spatial abilities and perceptual speed (Hedges and Nowell, 1995; Hegarty and Sims, 1994).

Studies of sex differences in mechanical aptitude have consistently favored males. For example, research comparing females and males on the Bennett Mechanical Comprehension Test (BMCT), one of the oldest and most widely used instruments in its field, typically indicates that males outperform females by a wide and significant margin (e.g., Fortson, 1991). The BMCT assesses the constructs of mechanical information, spatial visualization, and mechanical reasoning (Tippins, 1991).

Recently, a new test of mechanical aptitude, the Wiesen Test of Mechanical Aptitude (WTMA), was developed with the intention of creating a fairer measure for women than the traditional measures used in this area, such as the BMCT. Although males still outperform females on the WTMA, the male advantage is not as great as on the BMCT (Chapman, 1998; Wiesen, 1999).

In spite of these well-documented sex differences on mechanical aptitude tests, little research has been conducted examining the basis for sex differences on these measures. Since more and more women are seeking employment within fields that involve mechanical ability and since mechanical aptitude tests are used extensively in selection for such jobs, it is important to investigate and to better understand the reasons for sex differences in various available measures of mechanical aptitude. The increasing number of women seeking employment in mechanical occupations also underscores the need for valid and fair predictors of job performance in this field.

The purpose of this study is twofold: to investigate the construct validity of all the measures employed by means of correlational analyses, and to investigate sex differences in abilities by comparing the performance of males and females on mechanical aptitude and on a nonverbal test of general intelligence. An exploration of the interrelationships among some of these abilities by means of the newly revised Beta III (Kellogg & Morton, 1999) should clarify the basis for the sex differences in mechanical ability. The following hypotheses are postulated:

(1) Men will perform significantly better than women on the BMCT and WTMA.
(2) Differences between the mean scores of females and males will be greater on the BMCT than on the WTMA.

(3) The correlation between the BMCT and the WTMA will be statistically significant for females and males as well as for the total group.

(4) The correlation between the Beta III and the two mechanical aptitude tests will be smaller than the correlation between the WTMA and the BMCT.

Methods

Participants

The sample was composed primarily of white college students enrolled in various undergraduate psychology courses. The 57 subjects tested (36 females and 21 males) were recruited from the UNF Psychology Department Participant Pool. Participation was strictly voluntary. The mean age for females was 24.69, ranging from 18 to 52. The mean age for males was 23.48, ranging from 17 to 50.

Materials and Apparatus

The study involved the administration of three paper-and-pencil tests and a demographic information sheet designed to gather basic background data. The BMCT and the WTMA are group instruments comprised, respectively, of 68 and 60 items measuring mechanical aptitude. The BMCT uses pictures to present mechanical problems and asks the examinee to choose from three possible options. The WTMA is in the same format as the BMCT; the examinee is asked a question and given three options from which to choose the correct answer. The intention of the WTMA is to minimize sex differences by using test content that is based on common everyday objects and events. The Beta III is also a group test and it measures nonverbal intellectual abilities by means of five distinct subtests.

Procedure

The subjects were tested in groups of no fewer than two and no more than eight people. Testing sessions lasted for approximately two hours, with variations in length depending on the number of subjects. The three tests were administered to each group of subjects in one session, with a 15-minute break in the middle. In the first half of the session, subjects were asked to read and sign the informed consent and had an opportunity to ask questions. After this informal question and answer session, subjects were asked to fill out the demographic information sheet. Finally, the Beta III was administered. The two mechanical aptitude tests were administered in counterbalanced order, during the second half of the testing session, after a 15-minute break. Eighteen females and seven males took the BMCT first followed by the WTMA and 15 females and 13 males took the WTMA first followed by the BMCT.

Results

One-way ANOVAs of total scores on the BMCT, WTMA, and Beta III were conducted. The results, seen in Table 1, show (1) a significant sex difference (p<.001) favoring males, on the BMCT; (2) a significant sex difference (p=.039) favoring males, on the WTMA; and (3) a negligible sex difference (p=.605), favoring females, on the Beta III.

The correlation between the BMCT and the WTMA for the total group was significant (p<.01), as were the separate correlations between these measures for both sex groups. These correlations are shown both jointly and separately in Figures 1, 2, and 3.

The correlation between the BMCT and the Beta III for the total group was .462, which is significant at the .01 level. The corresponding correlation between the WTMA and the Beta III was lower (.363) but still significant at the .01 level.
Table 1. Sex Differences on Mechanical Aptitude Measures and Beta III

<table>
<thead>
<tr>
<th>Test</th>
<th>Female Mean</th>
<th>Female SD</th>
<th>Male Mean</th>
<th>Male SD</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMCT</td>
<td>40.22</td>
<td>7.05</td>
<td>49.05</td>
<td>7.28</td>
<td>20.298</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>WTMA</td>
<td>44.14</td>
<td>4.31</td>
<td>46.86</td>
<td>5.26</td>
<td>4.481</td>
<td>0.039</td>
</tr>
<tr>
<td>Beta III</td>
<td>104.61</td>
<td>9.61</td>
<td>103.24</td>
<td>9.63</td>
<td>0.270</td>
<td>0.605</td>
</tr>
</tbody>
</table>

Discussion

The small sample size is obviously a serious limitation of the study. Another limitation related to the small sample size was the small number of males compared to the number of females, which likewise influenced the results. Also, though statistical analysis does not show any order effects, the number of females and males in the two order conditions (BMCT first vs. WTMA first) is uneven.

So far, all the major hypotheses have been confirmed. In addition, there are some interesting trends that will be explored in future research, as the sample size increases and analyses concerning differences between the sexes are expanded into subtest and item data. The results confirmed the expected relationships among the constructs assessed by the BMCT, the WTMA, and the Beta III. As expected, the results show greater convergence between the BMCT and the WTMA than between the Beta III and the two mechanical aptitude tests.

Also as expected, males scored higher than females on both of the mechanical aptitude tests. Males scored significantly higher than females on the BMCT. Even though males outperformed females on the WTMA, the sex difference was smaller, a finding that suggests the WTMA may indeed be a fairer measure of mechanical aptitude for women, provided that the predictive power of both measures is found to be comparable. The fact that the gender gap was smaller on the WTMA compared to the BMCT does support the claim that the WTMA reduces sex differences and is less biased towards women. No significant sex difference was expected on the Beta III and none was obtained, although females did score higher than males on that test.

The finding that women performed better (compared to men) on the WTMA than on the BMCT is promising. However, future research on the predictive validity of the WTMA is needed.
Lessons Learned

I have become very familiar with the library as a result of countless hours spent researching my subject. I have learned the different stages of the research process from research design to administering group tests to statistical analysis. I have learned the formalities, procedures, and practicalities that are involved in the research process, including ordering materials and writing to the IRB just to name a few. However, my knowledge expands beyond the time consuming processes of recruiting subjects, collecting data, entering data, and writing informed consent forms. I have gained an insight into how much time, effort, dedication, and patience is needed in my future profession. I believe that this experience will benefit me tremendously for continuing onto graduate school and eventually becoming an I/O Psychologist.

References


