AC 2008-1242: THE HAPTIC ABILITIES OF A SAMPLE OF MINORITY ENGINEERING AND TECHNOLOGY STUDENTS

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The Haptic Abilities of a Sample of Minority Engineering & Technology Students

Abstract

Minority engineering and technology students at an HBCU who had low visualization abilities as indicated by their test scores on the Purdue Spatial Visualization Test were found to have, as a group, average haptic abilities as measured by the Haptic Visual Discrimination Test. However, in an initial study, approximately 17 percent of the subjects were below average, with some individual scores indicating moderate to severe problems with sensory integration. Because the primary methods of improving these students' visualization abilities have involved sketching and other hands-on or haptic activities, the low scores of several individuals were cause for concern. Additional testing was done on a larger group of students and the mean score for the group was again found to be within the normal range. There were still several students who tested below the mean. This paper discusses the significance of those results and their possible affect on instruction, particularly the impact on attempts to improve the visualization abilities of these students

Introduction

Historically, incoming engineering and technology students at this university have tested significantly below average in their visualization abilities as measured by the Purdue Spatial Visualization Test (PSVT). The low visualization abilities of these students were improved by adding a variety of activities including sketching and manipulation of physical objects in introductory CAD courses[1]. The incorporation of hands on experiences can increase opportunities for the students to create mental models, which they may then relate to different academic areas[2]. Tactile interaction with physical objects can enhance visualization of scientific data[3] and the use of three-dimensional handheld models has been recommended to aid in the development of spatial visualization abilities[4].

A previous study of haptic abilities of freshman engineering students at a predominantly non-minority institution found that visualization abilities and haptic abilities are not mutually exclusive although some research attempts to categorize students as either haptic or visual or neither. Subjects who have average visualization abilities may also have haptic abilities that are above the mean[5]. In an initial study, the Haptic Visual Discrimination Test (HVDT) was administered to a small sample of minority engineering and technology students whose visualization abilities based on test scores on the PSVT were significantly below the mean[6]. In the initial study, students' scores on the HVDT centered around the normed mean for their age group with a few outliers both significantly above and below the mean. The study was repeated on a larger group of students with similar results.

Student Demographics

The subjects in the current study were all engineering or technology majors enrolled in a variety of drafting and design courses at an HBCU. Of the 31 students in this study, the average age was

20.1 and their mean pretest score on the PSVT was 15.8 indicating below average visualization abilities. There were 26 males and 5 females, all self identified as Black, and their class rank at the University ranged from freshman to senior. The mean combined SAT score for incoming freshmen at the University is 812 and minimum high school GPA for admission is 2.2. There are no additional requirements beyond admission to the University to declare a major in any of the engineering or technology concentrations. Three units of mathematics including algebra I, and either geometry or algebra II; and two or three units of science, one of which must be a laboratory science are suggested[7].

The Haptic Visual Discrimination Test

The Haptic Visual Discrimination Test (HVDT) is a standardized and quantitative test that measures a subject's skills in tactile sensitivity, spatial synthesis and the ability to integrate partial information about an object into a whole. The test is administered in a standardized fashion and the same scoring procedure is used for all age groups which allows for interpretation of results based on normed data[8].

The HVDT is individually administered and the subject sits across from the examiner at a testing table. The identification chart, a book with black and white images of the objects to be identified, is placed in front of the subject along with a visual screen. The screen is a wooden frame with a piece of felt suspended from the top section.

The case containing the test objects must be placed in a position where the subject cannot view the objects. The subject places their right hand through the opening in the visual screen and the examiner places an object in their hand. The subject is allowed to manipulate the object in their right hand without seeing it, and then is asked to point to the corresponding object on the identification chart with their left hand[8]. A picture showing the typical setup of the testing environment from the test examiner's perspective is shown in Figure1. There is no set time limit to administer the HVDT and the average time required by subjects in this study was 10 to 15 minutes. Scores were recorded on a standard score sheet by the examiner.

Figure 1. HVDT setup from examiner's perspective

For analysis, raw scores can be converted to scaled scores for each age group. A scaled score of 10 represents the mean of the raw scores. Scaled score deviations of 3 equal one standard deviation. A score within the range of 7 to 13 indicates normal performance and a difference of three or more scaled scores below the norm, a range of 4 to 7, indicates a moderate disability. A scaled score of 0 to 4 indicates severe problems in sensory integration[8].

Performance on the HVDT is significantly correlated, r = .66, with general intelligence. The scaled scores in most cases tend to approximate obtained IQ scores. For instance, a normal individual with a scaled score of 10 on the HVDT can be expected to have an IQ score of approximately 100. However, the correspondence between HVDT scaled scores and IQ scores may deviate quite considerably for subjects with specific neurological conditions[8]. Scaled scores for the age range of subjects in this study are shown in Table 1.

Scaled Score	**Age 17-Adult**
20	
19	47-48
18	46
17	45
16	43-44
15	42
14	41
13	39-40
12	38
11	37
10	35-36
9	34
8	33
7	31-32
6	30
5	29
4	27-28
3	26
2	25
1	23-24

Table 1. HVDT Table of Norms for Ages 17-Adult[8]

HVDT Test Results

The mean score on the HVDT for the 31 subjects in this study was 34.9, which falls within the normal range for their age, and the standard deviation was 3.75 (see Table 2). The scores ranged from 23 to 41. Six of the scores, approximately 19.4 percent of the subjects in this sample, fell below the range of normal performance and indicated moderate to severe problems in sensory integration. It is not known if any of the subjects who scored below the mean had any specific neurological conditions which may have affected their test scores. The mean score for the five female subjects was 36.0 and the mean for male subjects was 34.78. Due to the small number of subjects though, no conclusions can be made regarding gender differences.

A sample of 218 predominantly non-minority freshman engineering students at another university had a mean HVDT score of 39.54, one standard deviation above the mean. Of the 218 subjects, only three scores were below the mean. The mean score for the 41 female subjects in this predominantly non-minority sample was 39.78 and the mean score for male subjects was 39.49. These subjects also had average visualization abilities as measured by a mean score of 24.17 on the PSVT[5].

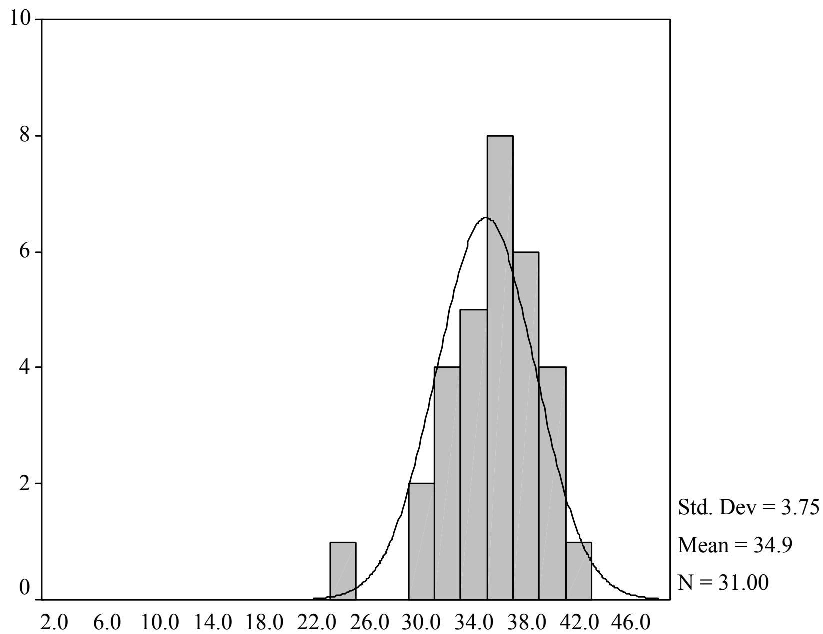

Table 2. HVDT Results

Discussion

The minority subjects in this study and its preceding study tended to have significantly lower than average spatial visualization abilities as measured by the Purdue Spatial Visualization Test (PSVT). These abilities however can be developed through instruction[9, 10, 11, 12, 1] and it is important to consider the differences in learning style when planning instruction, remediation and testing of spatial abilities.

Because the use of a variety of remediation activities that specifically included sketching and manipulation of physical objects led to improved PSVT scores for similar minority engineering and technology students[1], the haptic abilities of the subjects were of interest. Previous data comparing the visualization and haptic abilities of a group of predominantly non-minority freshman engineering students found that their average visualization abilities as measured by the PSVT had no significant correlation with their HVDT scores which were one standard deviation above the mean[5].

However, the two groups of engineering and technology students whose HVDT scores are being discussed in this paper should not be considered equivalent. The subjects vary not only in their minority status but in their average SAT scores and pre-college preparation all of which may have an affect on their test scores.

The mean HVDT score for students in this study was equal to the expected score for their population. Their accompanying low visualization abilities may be attributed to lack of previous exposure to visualization enhancing activities in school and extracurricular activities because of limited experience to hands on activities in math, science and technology. The low haptic abilities of some of the subjects are not as easily attributable to a particular cause without further research into their backgrounds and performance on other standardized tests.

Although visualization and haptic abilities are not necessarily correlated, the use of haptic activities has been shown to improve visualization abilities. The below average haptic abilities, along with the below average visualization abilities call in to question the best way to address students with these tendencies. The current body of research involving haptics and instruction has yielded little practical evidence as to the overall impact of using haptic activities[13] not just in the field of engineering graphics, but overall in educational settings.

When around 20 percent of the population in an engineering graphics course not only has low visualization abilities but also the potential for difficulty in integrating sensory input, what is the best method for approaching instruction? A semester of instruction with traditional methods of sketching and using manipulatives has had success in improving below average subjects to mean scores approaching average for other engineering and technology students, but not all students had significant improvement. Also, retention has been an issue in this department, with six year graduation rates averaging around 30 percent, freshman to sophomore one year progression rate at 25 percent, and overall retention rate approximately 47 percent.

Enrolling in and passing a course that specifically emphasized improvement of visualization skills and incorporated haptic techniques had some improvement on retention in the short term with approximately 69 percent of those subjects remaining in their engineering and technology majors two years later. However, 66 percent of students who enrolled in engineering graphics courses that did not emphasize improvement of visualization skills were also retained in their majors two years later. Further data must be collected to note if there is any actual long term improvement. For those students who have low HVDT scores and who did not improve as significantly on their PSVT scores after taking a course that emphasized improvement of visualization, there is currently not sufficient long term data to analyze their retention in their majors and retention at the University.

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