A New Testing Procedure for Recruitment of Photogrammetrists

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ABSTRACT: The H-test, which has been used at the Survey Department of Rijkswaterstaat for training and testing photogrammetrists since its introduction in 1979, proved to be a reliable test for personal stereoscopic measuring precision. On the other hand, it became clear that recruitment tests, testing for stereoscopic acuity only, are inadequate. However, because candidates require intensive training before being able to pass this test, the H-test cannot be used for the recruitment of photogrammetrists. Therefore, investigations were made to find a more adequate testing procedure for the selection of photogrammetrists. This article presents a new testing procedure, based on the combination of two tests: one for stereoscopic acuity and one for the ability to include peripheral information (i.e., from outside the fovea) in adjusting a measuring mark.

INTRODUCTION

As a test for personal stereoscopic measuring precision, the so-called H-test has been used at the Survey Department of Rijkswaterstaat for training and testing photogrammetrists since 1979 (Schwarz, 1982, 1984). This internally developed test comes as close to matching a photogrammetrists's daily work as is possible. During the test, a candidate is asked to do exactly that which is, or will be, his main task: he is asked to measure some hundred points of varying difficulty. The resulting standard deviation and number of outliers indicate his personal skill. However, to be able to meet the H-test standard, candidates require 2 to 3 months of training, some a year or even longer. Consequently, the H-test cannot be used as part of a recruitment procedure. On the other hand, the H-test clearly showed that the tests for stereoscopic acuity, which were in use at the Survey Department for the recruitment of photogrammetrists, were inadequate. Having successfully passed these acuity tests, some 20 percent of over 60 candidate photogrammetrists, who have been trained since 1976 could in the end not meet the H-test standard. It will be obvious that the consequences in these cases are rather unpleasant, both for the employees and for the company. Thus, there were good reasons to pursue a more adequate recruitment procedure. The Survey Department was glad to get the help of specialists in the field of binocular vision: since 1983 the research has been carried out by the Department of Biological and Medical Physics of Erasmus University, Rotterdam.

SOME BASIC THOUGHTS

Tests for stereoscopic acuity indicate the minimum disparity (parallax) a candidate needs to obtain depth perception. Of course, a photogrammetrist should have an adequate sensitivity for disparities. This, however, clearly proved not to be sufficient. Based on former research (Duwaer, 1981, 1982; Duwaer and Van den Brink, 1981), Van den Brink postulated that a candidate's capability for using peripheral information in depth perception would also be of interest. It was assumed that information at the center of the visual field, the fovea, has the most influence in the process of stereoscopic vision and depth perception. On the other hand, according to a kind a weight function, decreasing with increasing distance from the fovea, peripheral information also has its impact. Different persons can have different weight functions and, therefore, a different sensitivity to peripheral information. This postulate underlies all psychophysical experiments that were done to find a more adequate recruitment procedure.

FIRST EXPERIMENT

In order to test if there exists a difference in capability of observers to make use of disparities that are not presented in the center of the visual field, i.e., in the fovea, the following pilot experiment was performed.

By means of dichoptic stimulation of the eyes (i.e., each eye is stimulated by a separate stimulus), disparities are presented in the periphery of the visual field. In our case the stimulus pattern in both eyes is identical except for the (horizontal, vertical) position, which can be varied independently in each eye, in order to vary the disparity. At the same time, a small circle is binocularly presented in the fovea, so that both eyes are fixating the same stimulus (Figure 1).

In case the peripheral disparity is horizontal (in other words, when the position of the stimulus in one eye is shifted horizontally relative to the position in the other eye), then the difference in disparity in the periphery and the fovea is interpreted by the visual system as a difference in depth. If, on the other hand, the peripheral disparity is presented vertically, by shifting the peripheral patterns vertically with respect to each other, the difference between the peripheral and the foveal disparity, when exceeding a certain magnitude, cannot be interpreted as a difference in depth. Hence, a conflicting situation is created. The eyes may fuse the peripherally presented stimuli. In that case, the fusion of the foveal stimulus is broken, and the small circle, on which the eyes are fixated, is seen as two separate rings, like a part of the Olympic symbol. When, on the other hand, the foveal stimulus is stronger, the eyes keep on fusing the foveal stimulus and the surrounding pattern is seen doubled. In this way, by using vertical disparities, a competitive situation is created between foveal and peripheral disparity information. Thus, the power of peripheral disparity information

[†]Sadly, Prof. Dr. G. van den Brink was suddenly taken from us at the end of May 1988. He was closely engaged in this project and its instigation. We regard this publication as a posthumous tribute to him and his work. We look back with fond memories of the time we were able to work closely with him.

PHOTOGRAMMETRIC ENGINEERING AND REMOTE SENSING,
Vol. 56, No. 4, April 1990, pp. 501–504.

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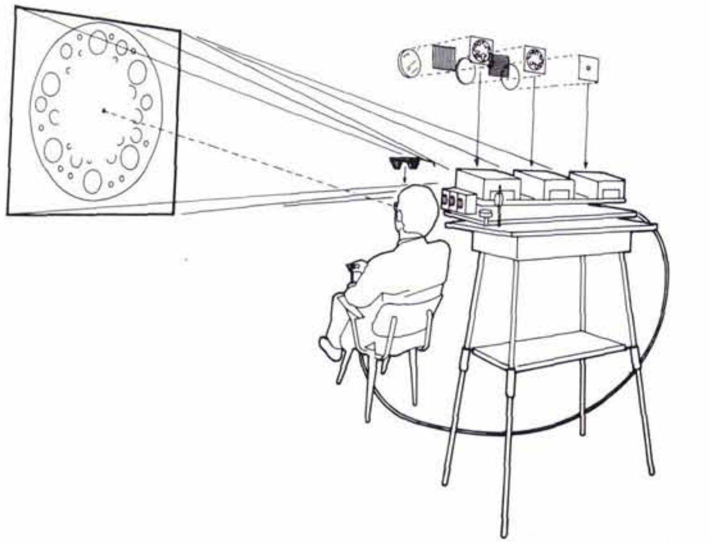

FIG. 1. Pilot experiment: creating competition between foveal and peripheral disparity information, introducing purely vertical disparities.

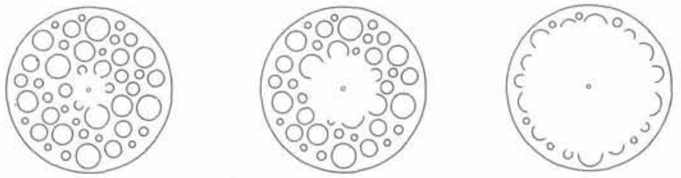

FIG. 2. Example of slides for peripheral stimulation. A growing central part of the stimulus is covered up.

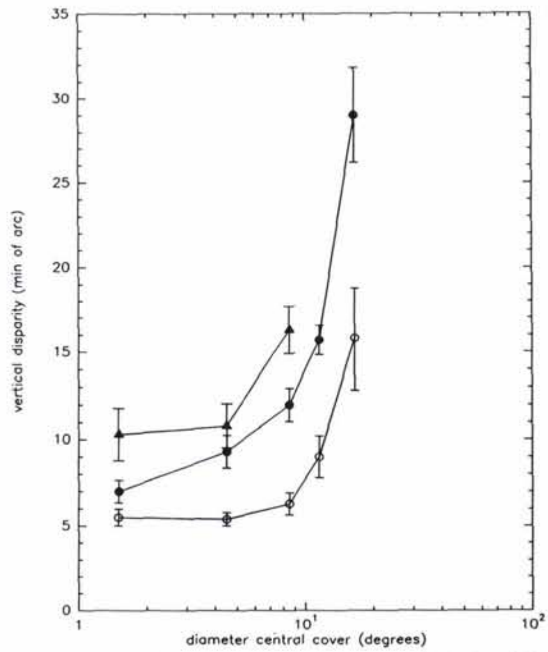

FIG. 3. The critical peripheral disparity as a function of the diameter of the central covered part. Open circles: successful photogrammetrists; filled circles: inexperienced subjects; and filled triangles: trainees that failed to meet the required measuring precision.

can be determined relative to that of foveal disparity information.

The eccentricity of the peripheral information can be varied by covering up a growing central part of the peripheral stimulus using a disk of increasing diameter. Figure 2 shows three situations in which a growing part of the stimulus is covered up. The small ring in the center is unaffected in all cases.

The magnitude of the peripheral disparity that breaks up the fusion of the foveal stimulus is determined as a function of the eccentricity of the peripheral stimulus. In the test this is done by increasing the disparity of the peripheral stimulus until the subject reports that the fusion of the foveal circle is broken. This critical disparity is shown in Figure 3 as a function of the diameter of the covered part.

The curves given in Figure 3 present the average results obtained by three different groups. A group of eight successful photogrammetrists, a group of six trainees that failed meeting the measuring precision standard (H-test), and a group of six persons not trained in photogrammetry at all.

The results given in Figure 3 indicate significant differences between the three groups. Good photogrammetrists (upper curve) are more sensitive to peripheral information than the unsuccessful photogrammetrists (lower curve). Inexperienced subjects have scores in between. So a person's sensitivity to peripheral information might be a discriminating factor. However, there are some practical problems in using this test for recruitment. It appeared to be difficult, especially for untrained subjects, to respond adequately to the conflicting situation caused by a vertical disparity. Therefore, we returned in a second experiment using horizontal disparities, which are easily interpreted as depth information in a natural way.

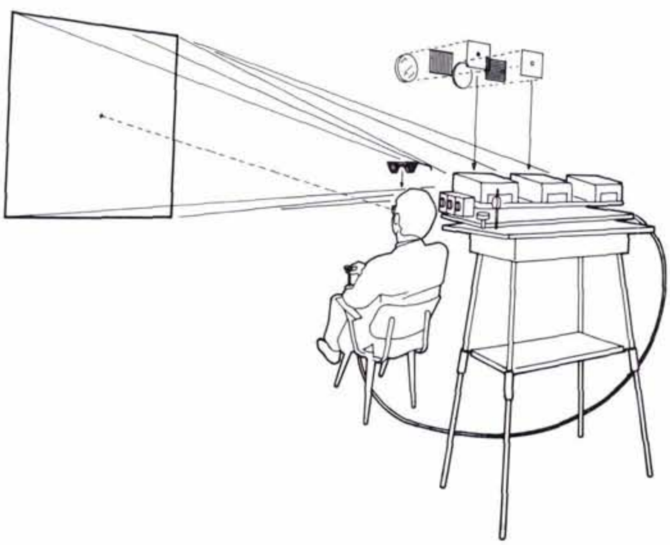

FIG. 4. Second experiment: depth adjustment of a "measuring mark" to a plane defined only by the edge of a screen.

SECOND EXPERIMENT

Now a peripheral stimulus of constant eccentricity is presented binocularly, whereas foveally a small circle (0.4 degrees diameter) is presented dichoptically. The horizontal disparity of the foveal stimulus can be varied, which is seen as depth variation (see Figure 4).

The peripheral stimulus is the black edge of a projection screen in a dusky room. The subject is asked to fit the ring into the screen's plane. In fact, this is a task very similar to that of an operator in normal photogrammetry. The depth variation in adjusting the "measuring mark" repeatedly is taken as the measure for the subjects capacity to make use of peripheral infor-

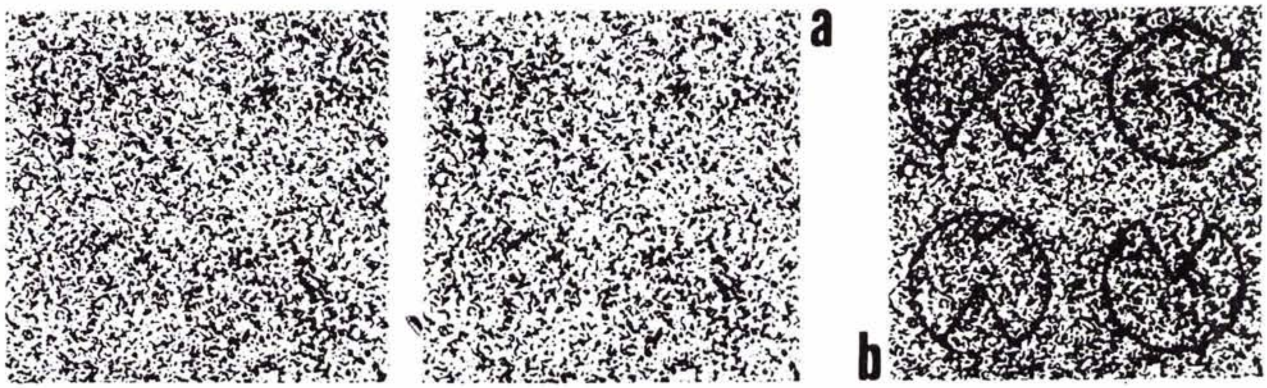

FIG. 5. Example of a stereogram (a) of the TNO-random dot test for testing stereoscopic acuity. Stereoscopic observation shows four discs (b).

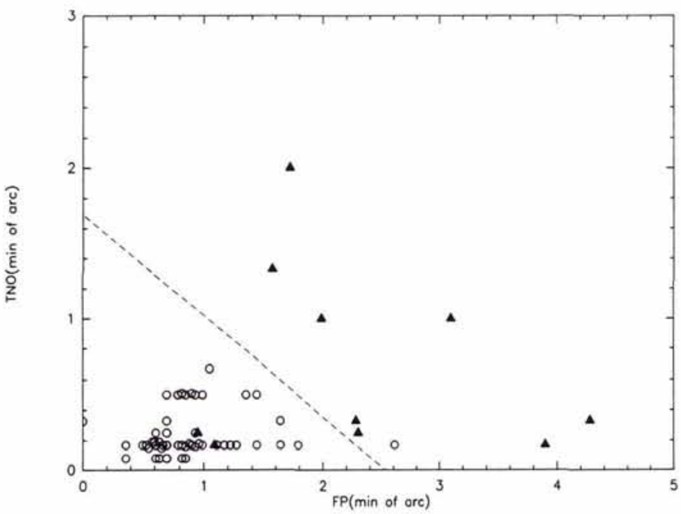

FIG. 6. The scores of experienced subjects with the TNO random-dot test (vertical axis) and the FP-test (horizontal axis). Each data point represents a subject. Open circles: successful photogrammetrists; and filled triangles: unsuccessful trainees. The dashed line represents the best dividing line between the two groups of subjects.

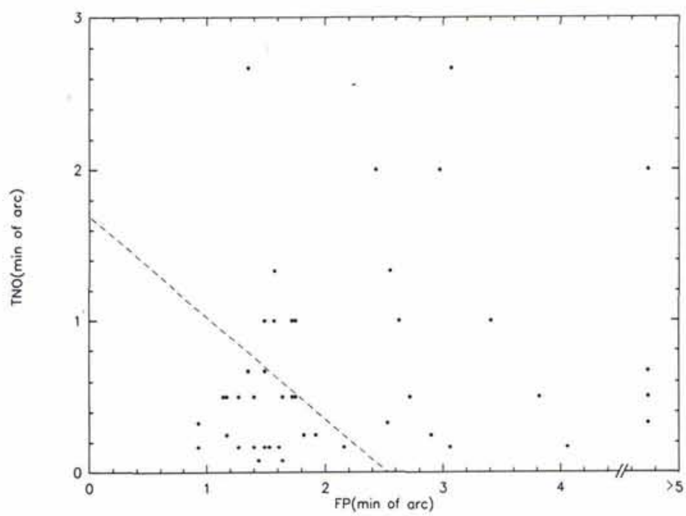

FIG. 7. The scores of fully untrained subjects (dots). The dashed line is replotted from Figure 6.

mation (the edge of the screen), its eccentricity being about 20 degrees. A standard deviation is calculated from a set of ten depth adjustments. We termed this test the FP-test (Foveal versus Peripheral).

In addition to the sensitivity to peripheral depth information, foveal depth acuity is also of importance for the task of a photogrammetrist. This parameter can be determined by existing tests for stereoscopic acuity. Therefore, a testing procedure was developed consisting of a commonly used test for stereoscopic acuity (the random-dot test developed by the Institute for Perception TNO, the Netherlands) in combination with the FP-test described above. Figure 5 shows an example of this TNO-test.

These two tests for stereoscopic vision were carried out with a large group of people (103), again consisting of good photogrammetrists (50), unsuccessful trainees (10), and fully inexperienced people (43). The results are shown in Figures 6 and 7.

Each data point in Figure 6 represents a subject, its position depending on the subject's score in the TNO random-dot test (vertical axis) and in the FP-test, which is plotted along the horizontal axis. The filled triangles represent the unsuccessful trainees, the open circles the good operators.

Considering the results, especially those of the unsuccessful trainees, it is obvious that the combination of the two tests leads to better and more reliable decisions on the aptness of a person as photogrammetric operator than in case only one of the tests is used.

The dashed line in Figure 6 has been computed by discriminant analysis. It represents the best dividing line between the two groups of subjects as calculated by discriminant analysis. The calculated discriminant function is

$$D2 = 1.36 \times FP + 2.04 \times TNO - 2.14$$

where D2 = the discriminant score,
FP = the score of the peripheral sensitivity test in min. of arc, and
TNO = the score of the TNO-test in min. of arc.

Best results for selection are obtained by choosing $D2 < 1.3$ as a critical value.

Classifying the experienced operators according to this criterion ($D2 < 1.3$), 49 of the 50 subjects (98 percent) are accepted and one operator is wrongly rejected. From the group of ten trainees who could not meet the H-test standard, eight subjects were correctly rejected and two were wrongly accepted.

In Figure 7 the scores are shown for the untrained people (dots). Applying the same classification criterion to this group of fully inexperienced subjects, some 50 percent scored within the acceptance region. This makes clear that the testing procedure is suitable for testing untrained people, although 20 to 30 percent wrongly rejected candidates seems to be unavoidable.

Comparing the data given in Figures 6 and 7, it is remarkable that the scores in the FP-test of the successful photogrammetrists (open circles in Figure 6) were systematically better than those of the unexperienced subjects (dots in Figure 7). None of the FP-scores in Figure 7 are below 1 min. of arc, whereas nearly 70 percent of the successfully trained photogrammetrists scored below 1 min. of arc. This means that training has significant effect in respect to the capacity to make use of peripheral depth information in a stereometric task.

A NEW TESTING PROCEDURE

For the recruitment of photogrammetrists, the Survey Department now has a new testing procedure consisting of two fast and simple tests:

- the TNO random dot test for stereoscopic acuity, and
- the new FP test for sensitivity to peripheral information.

The TNO test gives a candidate's threshold disparity. The FP-test gives his accuracy when fitting a mark into a plane, which is defined only by sparse peripheral reference. A simple formula transforms both outcomes into a parameter that should not exceed a critical value.

RECENT RECRUITMENT RESULTS

Since August 1986, 35 candidates have been tested using the new procedure. Thirteen candidates could not meet the standard, while 22 had a score within the acceptance region. The group of rejected candidates consisted of eight people having a bad score on both the TNO-test and the FP-test, three people having a good FP- and a bad TNO-test and two people having a good TNO- and a bad FP-test. Using the old testing procedure, these last two people would have been wrongly accepted.

Finally, in total 12 candidates were selected. A first group of five trainees all proved to be able to meet the H-test's standard after half a year of training. A second group of seven candidates started training in November 1988, of which six met the H-test's standard already, whereas the seventh is still making progress. He just seems to need more time.

CONCLUSIONS

A new testing procedure has been developed in order to reduce considerably the number of wrongly accepted candidate photogrammetrists in the recruitment procedure. The experiments described above indicate that the number of wrong decisions will decrease from about 20 percent when using tests on stereoscopic acuity only, to about 5 percent when using the new procedure. The experiments also made clear that, by using this procedure, 20 to 30 percent of the candidates will be rejected wrongly. This is unavoidable as both tests are not invariant in respect to training effects. Luckily, from a practical point of view, it is much better to wrongly reject then to wrongly accept a candidate.

ACKNOWLEDGMENT

The authors would like to mention the intensive cooperation of E. Tenkink, P.G.M. Knol, and G.S.A.M. van de Ven. Thanks also to the Governmental Medical Department for its help and practical assistance. And, last but not least, a special thanks to all the people who participated in the experiments.

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(Received 22 March 1989; accepted 24 May 1989; revised 1 August 1989)