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ANALYSIS OF ORIENTATION ABILITY AND ITS SIGNIFICANCE FOR THE REHABILITATION OF THE BLIND

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ABSTRACT. The author reviews his work on the mobility of the blind and the seeing and discusses its significance for the rehabilitation of the blind. In the differential-psychological studies of orientation performances the main concern was to isolate separate components of the orientation ability and to study differences between the blind and the seeing. The obstacle sense of the blind, i.e., the ability to perceive obstacles with the aid of auditory cues, was treated in the same context. These investigations also gave rise to the question of how the development of the obstacle sense can be speeded up by systematic training. A review of the results of this investigation is also included.

The mental abilities of the blind and the seeing are differentiated to the same degree, and the level of various abilities for both groups is the same (4). Therefore, training in the use of technical aids, for instance tape recorders and various writing devices, on one hand, and a search for suitable occupations and vocational training, on the other, are the most important aspects of the rehabilitation of the blind. The problems connected with these aspects are similar, in principle, to those met in the case of the seeing.

The essential problems of the blind, however, are associated with mobility and with mastery of environment. Research in this area has generally focused on the following two types of question: 1. What psycho-physiological processes form a necessary and/or sufficient basis for a given function (for example, the obstacle sense)? 2. How can a given function be improved technically (with the help of a cane, various ultrasonic aids, etc.)?

The studies providing the material for this article, which have been carried out at the Institute of Occupational Health, Helsinki, Finland, represent a slightly different approach. Their problems can be classified as follows:

1. Which components can be distinguished in the general orientation ability of the blind? How are these components interrelated? How are the various components related to the rest of the ability structure?

2. Can the development of the so-called obstacle sense in the blind be speeded up by systematic training? (The development of the obstacle sense itself and its relation to various ability traits were studied in connection with the problems listed under No. 1.)

Application of the results obtained in these studies to the rehabilitation of the blind has been considered in the discussion section of this article.

THE STUDY OF ORIENTATION

Principal hypotheses

It was first hypothesized that general orientation ability involves the following components, which are independent of one another at least to some extent: 1. the ability to estimate distances in terms of sequences of movements or in terms of time intervals; 2. the ability to gestalt movement patterns *per se;* 3. the sensitivity of the auditory area; 4. obstacle perception and avoidance; 5. the localization of objects on the basis of sound; 6. the mastery of positions of the parts of the body in the nearspace and memory of such positions.

According to the second main hypothesis, operations with spatial relationships based on various sense modalities correlate strongly with one another. It was supposed, in other words, that the interindividual differences in spatial performances are based on interindividual differences in the central nervous system and are independet of the sensory channel through which the relevant in-

Table I. *The rotated (Varimax) factor matrix of the blind*

Variables	Factors I	II	III	IV	V	h^2
1 Verbal intelligence	18	−69	07	08	24	58
2 Memory	−04	−79	−06	07	−01	63
3 Tactual spatial ability I	−10	−08	09	−79	−32	75
4 Tactual spatial ability II	−07	06	12	−81	01	68
5 Two-hand co-ordination	−09	24	28	−54	−14	46
6 Tactual discrimination	−50	20	37	−37	07	58
7 Kinesthetic discrimination	−09	09	−11	−21	−75	64
8 Obstacle perception	15	−25	−73	20	34	77
9 Walking straight	−44	−10	49	−41	−31	71
10 Walking-return	−41	17	58	−47	−23	80
11 Walking-locomotion patterns	−08	30	47	−59	00	67
12 Obstacle avoidance	18	−13	−88	19	−06	86
13 Sound localization	00	−08	50	−09	12	28
14 Pitch discrimination	−09	−50	−40	09	−12	45
15 Loudness discrimination	−43	−21	−18	−16	22	33
16 Audiometer, superior ear, 8000 cps	−72	−01	31	−24	−48	91
17 Audiometer, inferior ear, 8000 cps	−82	11	13	06	−14	72

formation is received. This hypothesis was suggested by certain previous research results.

Principal problems

The first main hypothesis involved the following problems: 1. How are the above-mentioned components interrelated? 2. How do these components relate to the rest of the ability structure? 3. How do the performances representing the various components depend on the degree, the age of onset and the duration of blindness?

The second main hypothesis gave rise to the problem of how spatial performances based on the sense of touch and the kinesthetico-proprioceptive senses are intercorrelated in the blind. In the case of the seeing, vision and visual performances were also investigated.

METHODS

Two or three tests were constructed for each of the abilities to be investigated. The reliabilities of the tests were 0.75 or higher. Space does not permit the description of all methods; detailed information can be found in former publications (2, 3). It should only be mentioned that spatial locomotion ability was measured by tests in which the subject was first guided along a path which formed a closed figure, in a hall measuring 6×12 m, and had thereafter to walk the same path unaided, or he was guided from one point to another in the same hall along a zig-zag path and had to return unaided directly to the starting point. The series also included tests for the estimation of distance and tests in which the task was to maintain a specific direction while in locomotion. There were two tests of obstacle sense. In the first the subject had to state whether an obstacle of a given side was at a given distance. The object was to discover how much the frequency of correct perceptions exceeded the frequency expected to result by chance. In the second test the subject had to approach various obstacles and to report when he first perceived them.

Statistical treatment

The study was almost exclusively carried out by factor analysis. The principal axis method was used to factor the correlation matrices, and the factors were rotated orthogonally by the Varimax method. In addition, the t-test was employed in the comparison of homogeneous subgroups.

The subjects

The subjects consisted of 52 totally blind males, aged between 17 and 50, the criterion of blindness being an inability to perceive variation in light.

RESULTS

The tests grouped into factors as shown in Table I. Only a few of the main results have been described here.

Obstacle sense

1. Of the blind, 87 per cent were capable of obstacle perception to a statistically significant extent ($p < 0.001$). Six of them never made a mistake when they were requested to state, on 60 occasions, whether there was an obstacle at a distance of 2.5 m.

2. Obstacle perception correlated positively with an early onset of blindness (about 0.60), with the duration of blindness (0.38) and with age, that is, how yong the subject was (0.28). Considered as a group, the congenitally blind were definitely superior to the adventitiously blind and to the seeing.

3. Factor III as shown in Table I represents the obstacle sense. The next largest loadings were those on the subject's mastery of directions, thus providing justification for calling this an obstacle

and direction sense factor. The common variance was obviously due in large measure to the auditory functions. Pitch discrimination was found to be of greater significance to the obstacle sense than loudness discrimination. The obstacle sense was wholly independent of intelligence.

Spatial locomotion performances

1. The spatial locomotion tests also correlated positively with an early onset, with duration and with age (by 0.35, 0.14 and 0.30, respectively), although not as strongly as the obstacle sense tests did.

2. As shown in Table I the locomotion tests obtained loadings mainly on Factor IV. It should be pointed out that the spatial performances based on the sense of touch and the kinesthetic sense obtained loadings on the same factor, suggesting that the hypothesis of an intermodal spatial ability was correct in the case of the blind.

3. Inspection of the distribution of the variances by rows reveals that the locomotion tests are rather multidimensional: in each case at least three factors (the auditory, the obstacle sense and the spatial factor) were necessary to account for the variance. A particularly surprising result was that the locomotion tests correlated with the audiometric variables better throughout the entire range of frequencies than they did with the obstacle sense tests. On the other hand, they did not correlate as well with loudness discrimination as the obstacle sense tests did. Thus the blind seem to utilize auditory cues in orientation, but not in the same way as they do when approaching an obstacle.

4. The finding that the congenitally blind were able to master spatial locomotion patterns as well as, or better than, the other subjects was of particular theoretical interest and importance. After being guided from one point to another along a complicated zig-zag path, for example, the congenitally blind subjects were able to return directly to the starting point. All the experiments carried out at the Institute of Occupational Health speak against the theory, advanced by von Senden, that the blind can learn only various time and muscle-tension schemata and do not possess any kind of spatial sense. A congenitally blind person does possess a spatial sense, but an insurmountable linguistic barrier makes it logically impossible for a seeing individual to recognize its qualitative phenomenological character.

Auditory variables

1. As already mentioned, the auditory variables correlated strongly with both the locomotion tests and the obstacle sense.

2. As shown in Table I, two auditory factors (I and V) emerged. The first was associated, in addition, with the sensitivity of touch and the second with the sensitivity of kinesthesis. Both can be thought to indicate the existence of a kind of intermodal sensitivity, which may appear in various combinations.

Comparison of the blind and the seeing

1. The blind were definitely superior to the (blindfolded) seeing controls in spatial performances based on touch as well as in those based on the kinesthetic sense ($p < 0.001$).

THE TRAINING OF OBSTACLE PERCEPTION

Problem and method

The learning of obstacle perception often requires several years; Juurmaa (2), for instance, observed that an obstacle sense was scarcely ascertainable in persons who had been blind for less than 5 years. In order to evaluate the possibilities of training the obstacle sense, a systematic training series was developed (6). The subjects had to walk along a path in a large hall. The obstacles, numbering 0 to 2 each time, were situated at random along the path. The obstacles measured 2 m in height and 1 m in breadth, and they were equipped with a thin net to protect the subjects from colliding too strongly with them. Three visually handicapped, but not totally blind, male persons with no obstacle sense served as subjects. According to prior knowledge it was considered necessary that the subjects have normal hearing and a normal or better than normal ability to discriminate variations in pitch. The subjects traversed the path 15 times each day during about half-an-hour.

Results and conclusions

The results of the empirical study and the conclusions made from them can be summarized as follows:

1. The behavior of the recorded obstacle-perception variables (the number of collisions with obstacles and the distance at which they were

first perceived) show that rapid learning took place.

2. The average first-perception distances indicate that, by the end of the training series, the subjects had reached a level where they were able to perceive obstacles at a distance of 1.5 m. The check trials showed that none of them had learnt to perceive obstacles at a distance of 2.5 m.

3. The results thus suggest that a person can be trained comparatively rapidly to avoid colliding with obstacles.

4. On the other hand, the ability to estimate the size of obstacles obviously takes a much longer time to learn. The size of an obstacle was found to influence its perceptibility.

5. Comparison of the results obtained with large and small obstacles reveals that transfer effects clearly occur in the learning of obstacle perception. Moreover, the check trials showed that transfer was also in evidence when the circumstances were entirely different.

DISCUSSION

A few remarks regarding the relevance of the above results to the rehabilitation of the blind have been made below.

Obstacle sense

Two important facts concerning the development of an obstacle sense were suggested by the results. First, the obstacle sense was found to correlate strongly with an early onset of blindness; the congenitally blind were by far the most successful group. It was discovered, secondly, that none of the subjects who had been blind for less than 5 years possessed an obstacle sense to a statistically significant extent. When examined against this background, the results of the study concerning the training in obstacle perception seem almost incredible: a degree of obstacle sense can be created in a few weeks through systematic training. How can this phenomenon be accounted for?

First of all, there is the question of information relevant to the rehabilitation of the blind. There are blind persons who are not at all aware that they possess any degree of an obstacle sense. Moreover, very few blind individuals have a knowledge of the acuity of their own obstacle sense or have been informed about the highest level that this ability may attain. Finally, the blind do not know, as a rule, what forms the basis of the obstacle sense, and most of them have erroneous views of it.

As regards the acuity of the obstacle sense, an investigation carried out at the Institute of Occupational Health (5) revealed, for example, that it was possible for a blind person to discriminate between two square aluminium plates whose sides measured 50 and 51 cm, respectively, at a distance of 2.5 m in 98 out of 100 cases. Comparable results, though at smaller distances, have been reported by Kellogg (7) and Rice (8). The blind subjects of our own investigations were very surprised to learn what they were able to do: none of them had previously had any awareness of their own capabilities in this respects.

The auditory area has shown to be both a necessary and a sufficient prerequisite of accurate obstacle perception. Nevertheless, most of our blind subjects considered their obstacle sense to be dependent on sensations in the face. This is due to phenomenological facts, which cannot be discussed here.

Before the systematic training given for obstacle perception was started, each subject was provided with detailed information on (*a*) the general occurrence of the obstacle sense, (*b*) the basis of this ability, and (*c*) the degree of acuity it may reach. A knowledge of these facts undoubtedly led the subjects to pay particular attention to auditory sensations and raised their level of motivation. Information of this kind forms a very important aspect of the courses arranged in Finland for the newly blind.

Another important factor that serves to explain the results of the training experiments is the following: Under ordinary circumstances the obstacle sense develop gradually through a random process of conditioning. A blind person learns mostly unconsciously to associate collisions with the preceding auditory sensations, and such a haphazard learning process is bound to proceed slowly. In the above experiments, by contrast, the process was condensed, in a sense, by employing the reward-punishment principle of the psychology of learning. Training series based on this principle have been included in the rehabilitation courses for the newly blind in Finland.

The above-mentioned facts undoubtedly open up important new vistas for the development of the obstacle sense. A knowledge of the highest possible level that this ability can reach will enable a blind person who already possesses a degree of it to develop it increasingly through training series in which the material, the size and the distance of obstacles are systematically varied. The blind participants at rehabilitation courses can be taught to plan such training series by themselves, so that they can continue later, under ordinary conditions, with the assistance of some suitable person. Similar techniques should also be included in the curricula of the shools of the blind, beginning from the lowest grades.

One further fact, significant for rehabilitation, should be mentioned at this point. The more insecure and fearful a person is, the slower, obviosly, his progress is in developing the ability to perceive and avoid obstacles. Yet if a blind person is trained to perceive and avoid obstacles safely, this may affect his characterological traits—for example, make him increasingly secure.

Orientation ability

The above results suggested that three components can be distinguished in the orientation ability of the blind: 1. a spatial ability in the narrow sense of the word, 2. an acuity of audition and 3. an obstacle sense and an associated ability of sound source localization.

If we know the acuity of a person's hearing and the length of time for which he has been blind, the degree to which he possesses an obstacle sense can be inferred with a degree of accuracy definitely sufficient for practical purposes. We also know that, if a person's hearing is even slightly poorer than normal, he cannot be trained to perceive and avoid obstacles to any noticeable extent. Hence, one of the first things to be done at rehabilitation courses is to examine the hearing of the participants quite thoroughly. It would be a bad mistake to try and train a hard-of-hearing blind person in obstacle perception. American investigators (e.g. 1) have asserted the highest frequency ranges to be the most important for obstacle perception. In our own studies the correlations were almost equally high throughout the range from 1500 to 8000 cps, the highest correlation being the one for 6000 cps. Secondly, from a knowledge of an individual's performances in tasks involving operations with spatial relationships based on the sense of touch and the acuity of hearing, it is possible to infer how he is likely to succeed in mastering a new environment.

A practical question associated with the ability to operate with spatial relationships and with orientation ability is concerned with the extent to which these abilities can be developed through training in such a way that the person is taught to pay attention to the relevant auditory stimuli and, in general, to differentiate his global auditory impressions. This question is suggested by the result, reported above, that the locomotion pattern tests correlated strongly with the acuity of hearing. This is because the spatial ability based on the central nervous system can scarcely be developed to the same extent as the ability for auditory perception. It should only be mentioned at this point that efforts are being made at the Institute of Occupational Health to devise training programs suitable for this purpose.

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