TACTILE STIMULATION AND PERCEPTION OF THE VERTICAL

II. Effects of field dependency, arousal, and cue function

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In principle the experimental situation in the tilting-room/tilting-chair is the same as the Rod-and-Frame Test; not a rod, but the subject's body is to be adjusted to physical vertical in a tilted visual field, i.e. the tilted room. As reported by Witkin, field-dependent subjects erroneously perceived their own bodies as upright in the tilted chair, as long as they were under influence of the tilting room; however, if they closed their eyes they suddenly recognized that they were tilted, and keeping their eyes closed, they were now able to adjust themselves to correct or nearly correct physical vertical.

On this basis, Witkin stressed that the differences between field-dependent and field-independent subjects were not due to a specific difference in "body-sensitivity", but rather to the fact that the field-dependent subjects were unable to make sufficient use of the postural cues as long as they were also stimulated by the visual frame in which case, "There is a genuine suppression of the entire strong complex of sensations of body tilt" (Witkin, 1967, p. 122).

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However, despite Witkin's postulate that field-dependent and field-independent subject do not differ in "body-sensitivity" Culver et al. (1963) have shown that the field-dependent subjects generally have a higher threshold for two-point-discrimination; and they find it more difficult to identify letters "written on the skin"; similarly they take more time to discriminate between left and right body-parts in a series of portraits; finally they make many more errors when asked to localize a point on their hand that has been touched.

Obviously these observations are contradictory to Witkin's conception that there were no differences in "body-sensitivity" between field-dependent and field-independent subjects as long as they were not exposed to conflicting visual and postural cues.

For the present moment it is sufficient to note that the investigators seem to agree that field-dependent subjects are less able to integrate relevant cues to the same extent as field-independent might be. It might therefore be postulated that if groups of field-dependent and field-independent subjects were placed in a relatively unstructured perceptual situation, then the introduction of a specific stimulation, which previously had been shown to facilitate a given task, should be more profitable for the field-independent subjects than for the field-dependent in solving the task.

Thus if groups of field-dependent and field-independent subjects are tested in a modified Rod-and-Frame Test, a stimulus situation characterized by ambiguity and with input from most sensory modalities reduced to a minimum, and if input from the tactile modality is then made more specific it follows from the postulate that field-independent subjects should profit most from this change. That is, they set the rod nearer to physical vertical under specific tactile conditions than under reduced, diffuse conditions. The field-dependent subjects, on the other hand, should not be very different from that under diffuse stimulation condition.

From these assumptions three hypotheses were formulated:

1. Field-independent subjects are expected to adjust the rod nearer to physical vertical under specific than under diffuse tactile stimulation.

2. Field-dependent subjects are expected not to differ in the setting of the rod to physical vertical under specific or diffuse conditions.

3. Subjects with scores between the extremes are expected to adjust the rod nearer to physical vertical to a degree corresponding to their position on the scoring continuum in relation to the extremes.

According to the three hypotheses, a rectilinear function between increasing degree of field independency and optimal capacity to profit by improved tactile stimulation condition was to be expected.

To test these hypotheses an analysis was made of the data from the experiment reported in Nyborg (Nyborg 1971*a*).

ANALYSIS

According to his score under upright standing in the Rod-and-Frame Test each subject was marked out on the abscissa in a coordinate system (cf. Fig. 1). The projection on the abscissa illustrates in this way every subject's position on a field-dependency-independency scale according to his scorings under upright standing conditions. The male subjects were divided into three groups according to their scores: subjects with scores from 0–4.9° mean errors (the field-independent subjects); subjects with scores from 5–9.9° mean errors, and subjects with scores of 10° or higher mean errors (the field-dependent group).

Secondly the degree to which each subject profited from SBR compared to DBR under tilted standing was calculated by subtracting his average SBR score under tilted standing from his average DBR score under tilted standing. Differences between the two scores could be zero, positive (DBR increasing SBR), or negative (SBR increasing DBR). The position of each of the 24 male subjects on the ordinate in Fig. 1. represents the result of this calculation.

RESULTS

Male subjects

As can be seen from Fig. 1, very characteristic individual differences were observed with regard to the effect of the change in tactile stimulation on male subjects. For most subjects the mean error was several degrees lower or higher under SBR than under DBR. Relatively few subjects were found to be around the zero-line.

It was noticed that the changes were related to the subject's high, middle, or low mean error score in the upright standing series.

Ten male subjects scored under 5° average deviation from physical vertical when they stood upright. Under tilted standing, when the tactile conditions changed from DBR to SBR, seven of the ten subjects diminished their scores, while three subjects set the rod more deviating from physical vertical.

The group with scores from 5° to 9.9° mean error under upright standing consisted of eight subjects; all of them adjusted the rod nearer to physical vertical under tilted SBR relative to tilted DBR and seven of these diminished their mean errors more than 2° in average.

The highest scoring group consisted of six subjects with mean scores above 10°. The three lowest scoring adjusted the rod nearer to physical vertical under tilted SBR, while the three highest scoring subjects deviated more from vertical under SBR conditions.

The distribution in the coordinate system seems to indicate that an inverted U-shape curve might describe the relation between the male subjects' mean error scores under upright standing and the extent to which the subjects were able to profit by the improved tactile stim-

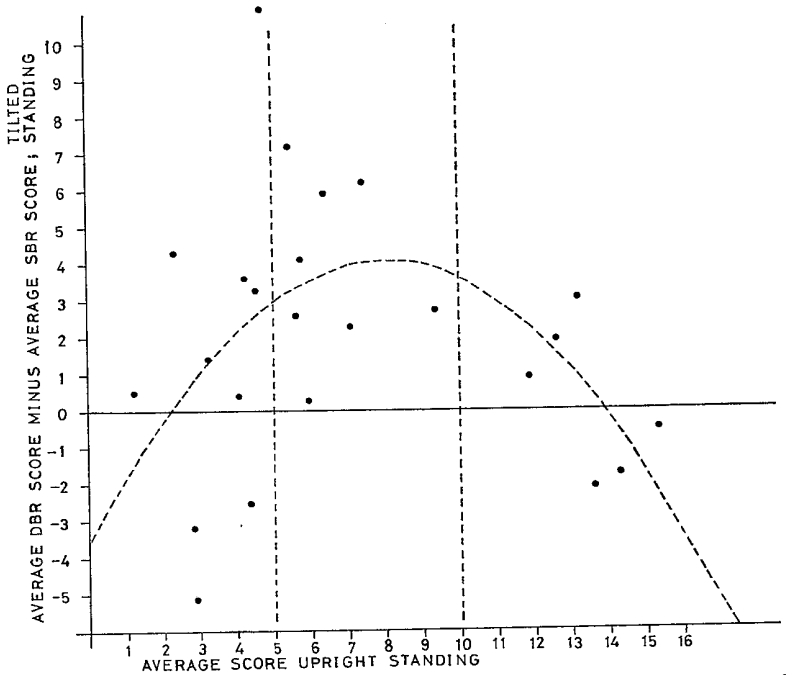

FIG. 1. Male subjects. Mean error scores in degrees under upright and tilted standing; tactile stimulation under tilted standing was either DBR or SBR. For explanation see text.

ulation under tilted SBR conditions. Alternative curves might be drawn and therefore not too much stress should be laid on the actual one; however, the observed intergroup differences seem interesting and will be discussed later.

Female subjects

Most of the female subjects were seen to distribute themselves in a manner similar to the male subjects.

For low-scoring subjects the tendency to increase their mean error score was even more pronounced in the female group; however, another group of women seemed to respond in the postulated way showing an inverse relationship between degree of field-dependency and capacity to profit by the change from DBR to SBR.

Considering that the female subjects as a group scored about 2° lower than did the male subjects, it seems reasonable to divide the females into groups according to low (0–2.9°), middle (3–7.9°) and high (above 8°) mean error scores.

DISCUSSION

If the mean scores for the highest scoring male subjects (10° or more) and for the middle scoring subjects (from 5° to 9.9°) are considered (cf. Fig. 1), the results might be in accord-

ance with the postulated rectilinear function: subjects from the highest scoring group reacted only slightly to the change from diffuse to specific tactile stimulation. The distribution of subjects in the middle scoring area followed also the postulated function. Accordingly, it was

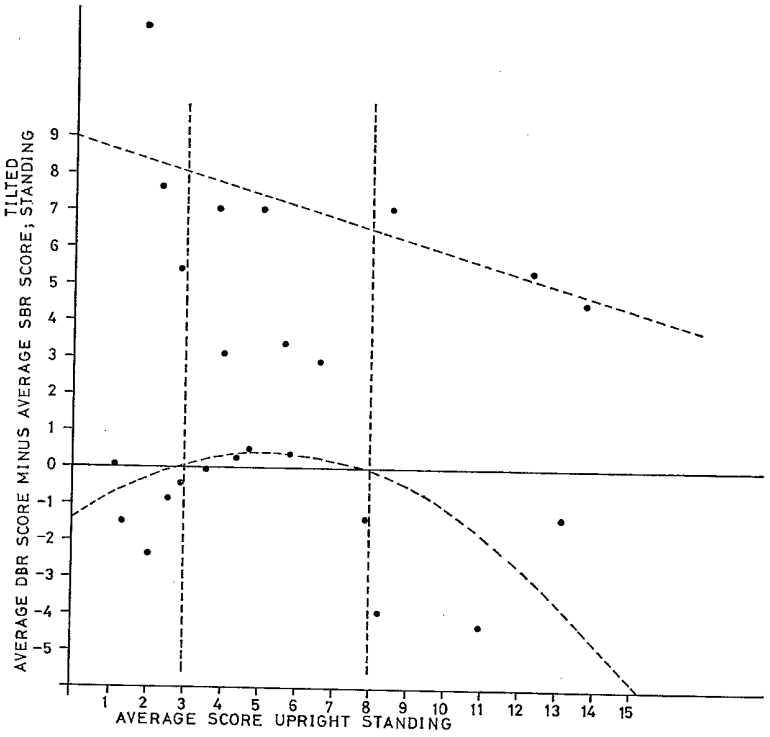

FIG. 2. Female subjects. For explanation see text.

expected that the lower the mean error these subjects obtained under upright standing, the more optimally would they profit by the change from DBR to SBR. One subject, situated near 5° diminished his mean error scores under tilted standing by more than 10°, while higher scoring subjects manifested a smaller capacity to profit from the change.

The lowest scoring subjects could not be incorporated in the hypothesis. A flattening tendency or even a weak slope of the line might be expected in the postulated function, because the reduction in mean error scores under change from DBR to SBR was restricted by the total of scorings for each subject under tilted standing. However, it was not expected that about one third of the subjects in this group increased their average error instead of decreasing it.

Female subjects in the middle scoring group (3° to 8° mean error during upright standing) had optimal capacity to "process" tactile cues, while the range of "optimal" capacity for male subjects was 5° to 13°. This sex difference might have occurred because the females as a group had lower mean error scores than the men, under upright as well as tilted standing.

Male subjects who scored 5° or more in mean deviation from vertical under upright standing conditions, and the female subjects who scored above 3° might then generally be charac-

erized by a smaller capacity to profit adequately from a given tactile stimulation the higher hey scored on the scoring continuum, i.e. the more field-dependent they scored. These observations fit easily into Witkin's and Culver's frame of reference.

Male subjects with less than 5° deviation from physical vertical and female subjects with ess than 3° mean error differed widely with regard to utilizing the change from diffuse to pecific stimulation; some subjects profited very much, others slightly diminished their mean rror. Thus part of the subjects enlarged their deviation from physical vertical and thereby howed that they had not only been unable to profit from the additional information in a way hat facilitated their adjustment of the rod to physical vertical but even seemed to have been n a condition that facilitated irrelevant responses. This observation fits with neither Witkin's nor Culver's frame of reference. However, in the following Witkin's and Culver's ideas will be reformulated in order to incorporate also the above mentioned results.

As mentioned earlier, Culver found—in contrast to Witkin—that field-independent subjects are more "body-sensitive" than field-dependent subjects. This observation led to the hypothesis that field-independent subjects should be more sensitive to a change in tactile stimulation. As indicated by results of the present study they in fact were so, but some in a way that apparently facilitated irrelevant responses when they adjusted the rod to physical vertical. This may indicate that another factor, so far neglected by Witkin and Culver who studied these phenomena, was responsible for this effect. This factor might be individual differences in cue function in relation to high level of arousal function in the experimental situation. The following investigations might clarify such a point of view.

Based on Culver's observations, Silverman et al. (1967) hypothesized, that field-dependent subjects have more difficulty in "estimating their internal and external world precisely and adequately" than have field-independent subjects. On the basis of this hypothesis Silverman et al. tentatively suggested that field-dependent persons were in a chronically high hypothalamic excitatory state. In order to test this hypothesis they investigated if a medical stimulation of the autonomic system would lead to different autonomic reaction pattern in field-dependent and field-independent subjects; they supposed that field-dependent subjects would not show radical reaction because of their postulated chronically high level of arousal; in field-independent subjects, on the other hand, the same stimulation was supposed to lead to a vigorous heightening of the arousal level.

By injecting insulin in field-dependent and field-independent subjects they found the following significant differences: the field-dependent subjects showed higher preexperimental GSR activity, but no increase in the functions of the autonomic system as response to insulin; the field-independent subjects reacted by a significant increase in pulse frequency, increased systolic blood pressure and decreased diastolic blood pressure. These results support the hypothesis that the autonomic centre functions on a different level in the two groups, although it might not be concluded from this experiment, that the differences are due to differences in coding of input.

Another study (Cohen et al. 1962) showed that field-dependent and field-independent subjects responded differently to sensory isolation; the field-dependent subjects maintained a

Other experiments have confirmed, that field-dependent subjects often maintain a high level of autonomic activity throughout the session (Hustmyer & Karnes, 1964; Block, 1957; Courter et al., 1965), while the field-independent subjects in most cases adapt more adequately to the experimental situations and show a progressive diminishing in autonomic activity.

But in some situations the field-independent person shows higher level of arousal than the field-dependent. In a study by Hein et al. (1964) field-independent subjects responded with higher arousal in situations adequate for such a reaction. This tendency has also been observed by Razran (1961) and Roessler et al. (1963).

In review of studies in this topic Witkin (1967) concluded that "Relatively field-independent subjects are likely to show a high level of arousal in situations where alert attentiveness or a vigorous orienting response is required and a clearly lower level of arousal where such responses are not called for. More field-dependent persons do not show this definite, situation-appropriate differentiation in arousal level. They respond indiscriminately to many stimuli and at the same time do not seem to respond vigorously enough when a high level of arousal would in fact be adaptive."

In short: the above mentioned observations suggest that the field-independent subject is more "arousable" than the field-dependent. But this does not help to explain the observation in the present study, that some field-independent subjects increased their mean error under specific body-reference condition, unless a notion about the relation between level of arousal function and cue function is added. When the level of arousal function is raised the effectiveness of cue function may, following Hebb, raise correspondingly up to a level where optimal adequate response is found; but if arousal is further heightened it "may interfere with the delicate adjustment involved in cue function, perhaps by facilitating irrelevant responses" (Hebb, 1955, p. 186).

When it is born in mind, that the level of cue function depends on level of arousal function, and that the field-independent subjects are more "arousible" than field-dependent, it becomes understandable that the field-independent differed more widely than the field-dependent subjects in making profit of the additional cues as they did when the tactile stimulation changed from diffuse to specific condition.

Thus large individual differences in this field-independent group are possible manifestations of different levels of arousal function which lead to differences in cue function, i.e. differences in capacity to "process" e.g. specific tactile stimulation adequately. And it is also conceivable that some of the field-independent subjects might have surpassed a degree of arousal that corresponds to optimal cue function and responded in an irrelevant way.

The possibility that "overarousal" has played a role is further supported when the stimulus situation in the modified Rod-and-Frame Test used in the present study is considered: the subject is led blindfolded into a room with no knowledge about what is required of him; he is placed in an apparatus the construction of which he has no idea about, but which tilts him standing to an unknown degree with no perceptible accelerations and decelerations. The earphones prevent possible directional auditory cues in the darkened room. His task is now to adjust the rod to physical vertical within the frame which from time to time seems to appear unstable, sometimes partly to disappear, sometimes appearing to move in autokinesis-like ways. The entire situation is ambiguous and produces uncertainty as is seen from the subjects' remarks.

Thus it might be argued that some of the factors that commonly are suggested to raise arousal were operating in the present modified Rod-and-Frame Test situation. Of these factors special attention should be focused on the so-called *Collative variable*, a term covering "the relation between physicochemical and statistical properties of stimulus patterns on the one hand and conditions of the organism on the other" (Berlyne, 1967, p. 19). Among collative variable that have been shown to influence arousal are Novelty (Berlyne, 1963), Complexity and Incongruity (Berlyne & McDonnell, 1965). Possibly other variables are to be found but they seem all to have in common that they involve conflict between incompatible response tendencies; to a degree they are found in the Rod-and-Frame test situation as well as the ambiguity mentioned previously.

When subjects are tested in this "arousal-inducing" situation and a radical change in the tactile stimulus condition is made then it might be reasonable to infer, that if one group of subjects—the most arousible—show itself to differ widely in capacity to make profit of the change, then these differences might reflect differences in level of arousal function; also is it conceivable that some of these arousible persons, due to the stressing conditions under which they were tested, might have been aroused to a degree that resulted in impaired cue function which led to the irrelevant responses observed.

Furthermore, the field-dependent persons were relatively unaffected by the change in stimulation as measured in their setting of the rod under the two conditions. These subjects have been observed in other experimental situations to remain on a relative high level of arousal function, but they do not seem to be able to respond with vigorously situation-appropriate hightening of arousal function when it in fact would be adaptive. Therefore, it is not very surprising that most subjects in the field-dependent group did not react by appreciable increase or decrease in mean error score when the change in tactile stimulation became actual.

Subjects who scored intermediate in the field dependency-independency continuum also fit fairly well into the tentative explanation of the results of this study in terms of arousal function: most subjects in this group manifested adequate cue function by making considerable use of the change in stimulation in adjusting the rod nearer to physical vertical; the fact that none of the subjects in this group increased their mean error when going from diffuse to specific stimulation suggests that these subjects in this group were not aroused to a degree that impaired the cue function.

As might be seen from the foregoing discussion, an attempt was made to explain individual differences in capacity to profit from a change in tactile stimulation in terms of arousal function and the related cue function. However speculative this interpretation might be, it deserves further attention. It seems possible to test the theory experimentally: if individual differences in arousal function determine the degree of adequacy in cue function in a way that is measurable by the present experimental design when observing decrease and increase in mean error score under specific tactile stimulation relative to diffuse tactile stimulation, then experimental changes in arousal function (for example by medical stimulation) might also be reflected in cue function and in a way that is predictable on basis of a priori knowledge of a given person's degree of field-dependency-independency and his arousability.

REFERENCES

BERLYNE, D. E. (1963). Motivation problems raised by exploratory and epistemic behavior. In S. Koch (ed.), *Psychology: A. study of a science.* New York: McGraw-Hill.

BERLYNE, D. E. & MCDONNELL, P. (1965). Effects of stimulus complexity and incongruity on duration of EEG desynchronization. *Electroenceph. clin. Neurophysiol., 18,* 156–161.

BERLYNE, D. E. (1967). Arousal and reinforcement. In *Nebraska Symposium on Motivation.*

BLOCK, J. (1957). A study of affective responsiveness in a liedetector situation. *J. abnorm. soc. Psychol., 55,* 11–15.

COHEN, S. I., SILVERMAN, A. J. & SHMAVONIAN, B. M. (1962). Psychophysiological studies in altered sensory environments. *J. psychosom. Res., 6,* 259–281.

COURTER, R. J., WATTENMAKER, R. A. & AX, A. F. (1965). Physiological concomitants of psychological differentiation. *Psychophysiol., 1,* 282–290.

CULVER, C. M., COHEN, S. I., SILVERMAN, A. J. & SHMAVONIAN, B. M. (1963). Cognitive structuring, Field dependence-independence, and the psychophysiological response to perceptual isolation. In J. A. WORTIS (ed.), *Recent advances in biological psychiatry,* 6. New York: Plenum Press. Pp. 119–128.

HEBB, D. O. (1955). Drives and the C.N.S. (Conceptual Nervous System). In Fowler, H. (ed.), *Curiosity and exploratory behavior.* New York: Macmillan, 1965.

HEIN, P., COHEN, S. I. & SHMAVONIAN, B. M. (1964). Perceptual mode and pavlovian typology, In J. WORTIS (ed.), *Recent advances in biological psychiatry,* 7. New York: Plenum Press. Pp. 71–78.

HUSTMYER, F. E. & KARNES, E. (1964). Background autonomic activity and "analytic perception". *J. abnorm. soc. Psychol., 68,* 467–468.

NYBORG, H. (1971 *a*). Tactile stimulation and perception of the vertical. I. Effects of diffuse vs. specific tactile stimulation. *Scand. J. Psychol., 12,* 135–143.

RAZRAN, G. (1961). The observable unconscious and the inferable conscious in current Soviet psychophysiology. *Psychol. Rev., 68,* 81–145.

ROESSLER, R., ALEXANDER, A. A. & GREENFIELD, N. S. (1963). Ego strength and physiological responsivity: I. *Arch. gen. Psychiat., 8,* 142–154.

SILVERMAN, A. J., MCGOUGH, W. E. & BOGDONOFF, M. D. (1967). Perceptual correlates of the physiological response to insulin. *Psychosom. Med., 29,* 252–263.

WITKIN, H. A. (1948). The effect of training and of structural aids on performance in three tests of space orientation. *Rep. No. 80. Civil Aeronautics Administration,* Washington, D.C.

WITKIN, H. A. & ASCH, S. E. (1948 *b*). Studies in space orientation. IV. Further experiments on perception of the upright with displaced visual fields. *J. exp. Psychol., 38,* 762–782.

WITKIN, H. A., LEWIS, H. B., HERTZMAN, M., MACHOVER, K., MEISSNER, P. B. & WAPNER, S. (1954). *Personality through perception.* New York: Harper.

WITKIN, H. A. & OLTMAN, P. K., (1967). Cognitive style. *Int. J. Neurol., 6,* 119–137.

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From these assumptions three hypotheses were formulated:

In principle the experimental situation in the tilting-room/tilting-chair is the same as the Rod-and-Frame Test; not a rod, but the subject's body is to be adjusted to physical vertical in a tilted visual field, i.e. the tilted room. As reported by Witkin, field-dependent subjects erroneously perceived their own bodies as upright in the tilted chair, as long as they were under influence of the tilting room; however, if they closed their eyes they suddenly recognized that they were tilted, and keeping their eyes closed, they were now able to adjust themselves to correct or nearly correct physical vertical.

On this basis, Witkin stressed that the differences between field-dependent and field-independent subjects were not due to a specific difference in "body-sensitivity", but rather to the fact that the field-dependent subjects were unable to make sufficient use of the postural cues as long as they were also stimulated by the visual frame in which case, "There is a genuine suppression of the entire strong complex of sensations of body tilt" (Witkin, 1967, p. 122).

To explain this, Witkin claimed that field-dependent and field-independent subjects do not differ with regard to the perifere tactile sensory apparatus. Moreover, if a field-dependent subject closes his eyes and therefore is not exposed to conflicting cues (visual vs. postural) during the adjustment of his body to physical vertical, no differences can be found between his performance and that of a field-independent subject in the tilting-room/tilting-chair test. When the field-dependent subject opens his eyes and perceives the tilting visual field, central factors bring about a blocking of the postural cues in favour of the visual cues.

However, despite Witkin's postulate that field-dependent and field-independent subject do not differ in "body-sensitivity" Culver et al. (1963) have shown that the field-dependent subjects generally have a higher threshold for two-point-discrimination; and they find it more difficult to identify letters "written on the skin"; similarly they take more time to discriminate between left and right body-parts in a series of portraits; finally they make many more errors when asked to localize a point on their hand that has been touched.

Obviously these observations are contradictory to Witkin's conception that there were no differences in "body-sensitivity" between field-dependent and field-independent subjects as long as they were not exposed to conflicting visual and postural cues.

For the present moment it is sufficient to note that the investigators seem to agree that field-dependent subjects are less able to integrate relevant cues to the same extent as field-independent might be. It might therefore be postulated that if groups of field-dependent and field-independent subjects were placed in a relatively unstructured perceptual situation, then the introduction of a specific stimulation, which previously had been shown to facilitate a given task, should be more profitable for the field-independent subjects than for the field-dependent in solving the task.

Thus if groups of field-dependent and field-independent subjects are tested in a modified Rod-and-Frame Test, a stimulus situation characterized by ambiguity and with input from most sensory modalities reduced to a minimum, and if input from the tactile modality is then made more specific it follows from the postulate that field-independent subjects should profit most from this change. That is, they set the rod nearer to physical vertical under specific tactile conditions than under reduced, diffuse conditions. The field-dependent subjects, on the other hand, should not be very different from that under diffuse stimulation condition.

From these assumptions three hypotheses were formulated:

1. Field-independent subjects are expected to adjust the rod nearer to physical vertical under specific than under diffuse tactile stimulation.

2. Field-dependent subjects are expected not to differ in the setting of the rod to physical vertical under specific or diffuse conditions.

3. Subjects with scores between the extremes are expected to adjust the rod nearer to physical vertical to a degree corresponding to their position on the scoring continuum in relation to the extremes.

According to the three hypotheses, a rectilinear function between increasing degree of field independency and optimal capacity to profit by improved tactile stimulation condition was to be expected.

To test these hypotheses an analysis was made of the data from the experiment reported in Nyborg (Nyborg 1971 *a*).

ANALYSIS

According to his score under upright standing in the Rod-and-Frame Test each subject was marked out on the abscissa in a coordinate system (cf. Fig. 1). The projection on the abscissa illustrates in this way every subject's position on a field-dependency-independency scale according to his scorings under upright standing conditions. The male subjects were divided into three groups according to their scores: subjects with scores from 0–4.9° mean errors (the field-independent subjects); subjects with scores from 5–9.9° mean errors, and subjects with scores of 10° or higher mean errors (the field-dependent group).

Secondly the degree to which each subject profited from SBR compared to DBR under tilted standing was calculated by subtracting his average SBR score under tilted standing from his average DBR score under tilted standing. Differences between the two scores could be zero, positive (DBR increasing SBR), or negative (SBR increasing DBR). The position of each of the 24 male subjects on the ordinate in Fig. 1. represents the result of this calculation.

RESULTS

Male subjects

As can be seen from Fig. 1, very characteristic individual differences were observed with regard to the effect of the change in tactile stimulation on male subjects. For most subjects the mean error was several degrees lower or higher under SBR than under DBR. Relatively few subjects were found to be around the zero-line.

It was noticed that the changes were related to the subject's high, middle, or low mean error score in the upright standing series.

Ten male subjects scored under 5° average deviation from physical vertical when they stood upright. Under tilted standing, when the tactile conditions changed from DBR to SBR, seven of the ten subjects diminished their scores, while three subjects set the rod more deviating from physical vertical.

The group with scores from 5° to 9.9° mean error under upright standing consisted of eight subjects; all of them adjusted the rod nearer to physical vertical under tilted SBR relative to tilted DBR and seven of these diminished their mean errors more than 2° in average.

The highest scoring group consisted of six subjects with mean scores above 10°. The three lowest scoring adjusted the rod nearer to physical vertical under tilted SBR, while the three highest scoring subjects deviated more from vertical under SBR conditions.

The distribution in the coordinate system seems to indicate that an inverted U-shape curve might describe the relation between the male subjects' mean error scores under upright standing and the extent to which the subjects were able to profit by the improved tactile stim-

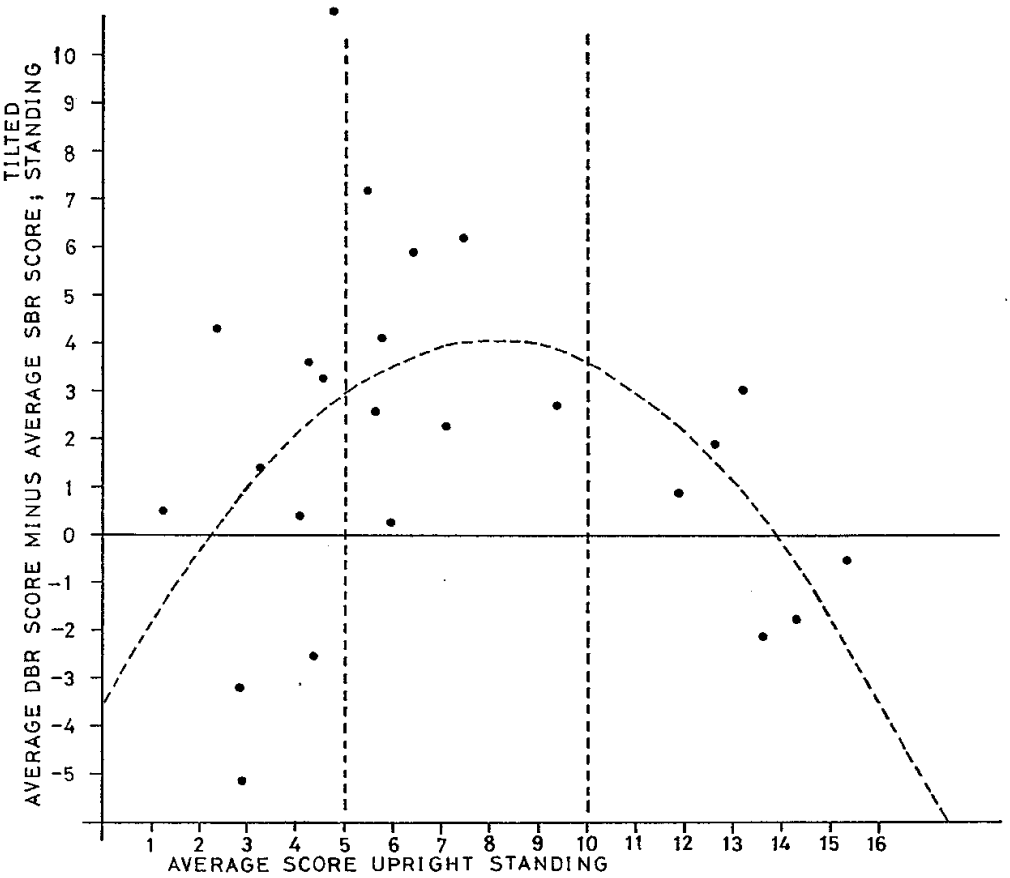

FIG. 1. Male subjects. Mean error scores in degrees under upright and tilted standing; tactile stimulation under tilted standing was either DBR or SBR. For explanation see text.

ulation under tilted SBR conditions. Alternative curves might be drawn and therefore not too much stress should be laid on the actual one; however, the observed intergroup differences seem interesting and will be discussed later.

Female subjects

Most of the female subjects were seen to distribute themselves in a manner similar to the male subjects.

For low-scoring subjects the tendency to increase their mean error score was even more pronounced in the female group; however, another group of women seemed to respond in the postulated way showing an inverse relationship between degree of field-dependency and capacity to profit by the change from DBR to SBR.

Considering that the female subjects as a group scored about 2° lower than did the male subjects, it seems reasonable to divide the females into groups according to low (0–2.9°), middle (3–7.9°) and high (above 8°) mean error scores.

DISCUSSION

If the mean scores for the highest scoring male subjects (10° or more) and for the middle scoring subjects (from 5° to 9.9°) are considered (cf. Fig. 1), the results might be in accord-

ance with the postulated rectilinear function: subjects from the highest scoring group reacted only slightly to the change from diffuse to specific tactile stimulation. The distribution of subjects in the middle scoring area followed also the postulated function. Accordingly, it was

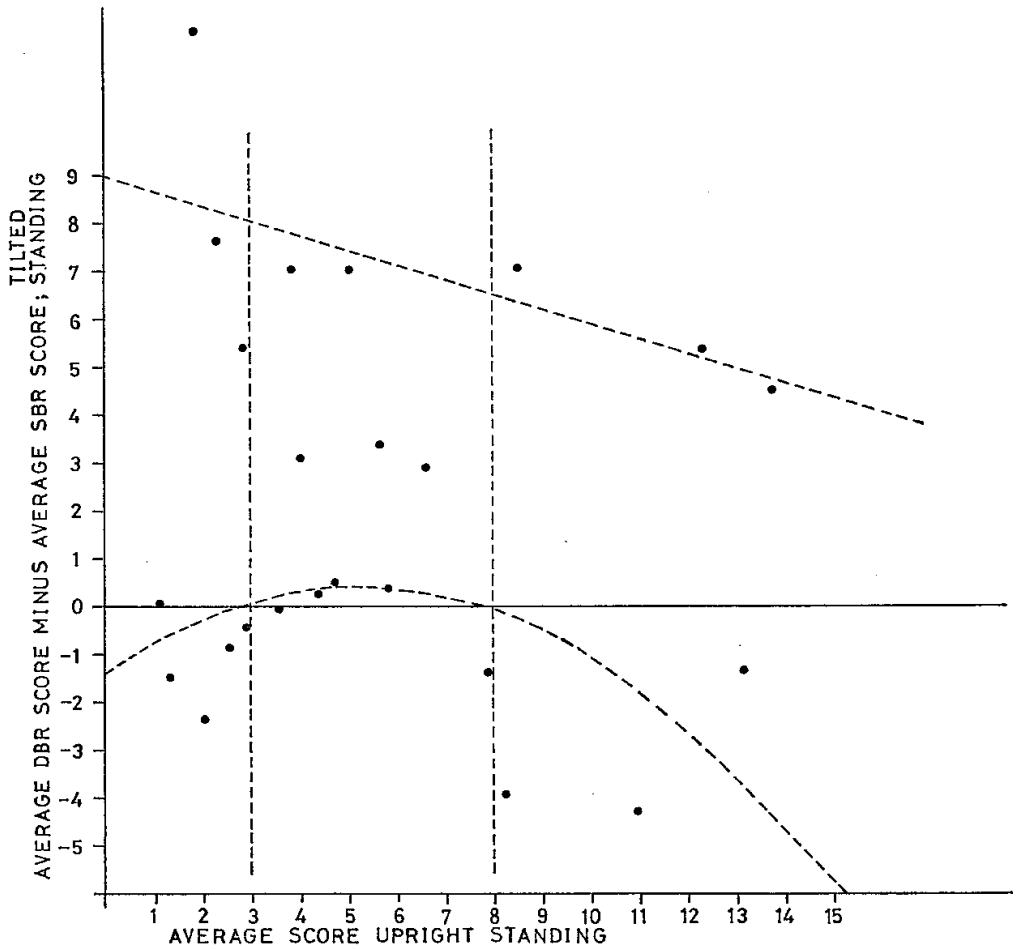

FIG. 2. Female subjects. For explanation see text.

expected that the lower the mean error these subjects obtained under upright standing, the more optimally would they profit by the change from DBR to SBR. One subject, situated near 5° diminished his mean error scores under tilted standing by more than 10°, while higher scoring subjects manifested a smaller capacity to profit from the change.

The lowest scoring subjects could not be incorporated in the hypothesis. A flattening tendency or even a weak slope of the line might be expected in the postulated function, because the reduction in mean error scores under change from DBR to SBR was restricted by the total of scorings for each subject under tilted standing. However, it was not expected that about one third of the subjects in this group increased their average error instead of decreasing it.

Female subjects in the middle scoring group (3° to 8° mean error during upright standing) had optimal capacity to "process" tactile cues, while the range of "optimal" capacity for male subjects was 5° to 13°. This sex difference might have occurred because the females as a group had lower mean error scores than the men, under upright as well as tilted standing.

Male subjects who scored 5° or more in mean deviation from vertical under upright standing conditions, and the female subjects who scored above 3° might then generally be charac-

terized by a smaller capacity to profit adequately from a given tactile stimulation the higher they scored on the scoring continuum, i.e. the more field-dependent they scored. These observations fit easily into Witkin's and Culver's frame of reference.

Male subjects with less than 5° deviation from physical vertical and female subjects with less than 3° mean error differed widely with regard to utilizing the change from diffuse to specific stimulation; some subjects profited very much, others slightly diminished their mean error. Thus part of the subjects enlarged their deviation from physical vertical and thereby showed that they had not only been unable to profit from the additional information in a way that facilitated their adjustment of the rod to physical vertical but even seemed to have been in a condition that facilitated irrelevant responses. This observation fits with neither Witkin's nor Culver's frame of reference. However, in the following Witkin's and Culver's ideas will be reformulated in order to incorporate also the above mentioned results.

As mentioned earlier, Culver found—in contrast to Witkin—that field-independent subjects are more "body-sensitive" than field-dependent subjects. This observation led to the hypothesis that field-independent subjects should be more sensitive to a change in tactile stimulation. As indicated by results of the present study they in fact were so, but some in a way that apparently facilitated irrelevant responses when they adjusted the rod to physical vertical. This may indicate that another factor, so far neglected by Witkin and Culver who studied these phenomena, was responsible for this effect. This factor might be individual differences in cue function in relation to high level of arousal function in the experimental situation. The following investigations might clarify such a point of view.

Based on Culver's observations, Silverman et al. (1967) hypothesized, that field-dependent subjects have more difficulty in "estimating their internal and external world precisely and adequately" than have field-independent subjects. On the basis of this hypothesis Silverman et al. tentatively suggested that field-dependent persons were in a chronically high hypothalamic excitatory state. In order to test this hypothesis they investigated if a medical stimulation of the autonomic system would lead to different autonomic reaction pattern in field-dependent and field-independent subjects; they supposed that field-dependent subjects would not show radical reaction because of their postulated chronically high level of arousal; in field-independent subjects, on the other hand, the same stimulation was supposed to lead to a vigorous heightening of the arousal level.

By injecting insulin in field-dependent and field-independent subjects they found the following significant differences: the field-dependent subjects showed higher preexperimental GSR activity, but no increase in the functions of the autonomic system as response to insulin; the field-independent subjects reacted by a significant increase in pulse frequency, increased systolic blood pressure and decreased diastolic blood pressure. These results support the hypothesis that the autonomic centre functions on a different level in the two groups, although it might not be concluded from this experiment, that the differences are due to differences in coding of input.

Another study (Cohen et al. 1962) showed that field-dependent and field-independent subjects responded differently to sensory isolation; the field-dependent subjects maintained a high level of autonomic activity throughout the experiment; the field-independent persons started the experiment with the same high level of physiological arousal but ended the session on a lower level.

Other experiments have confirmed, that field-dependent subjects often maintain a high level of autonomic activity throughout the session (Hustmyer & Karnes, 1964; Block, 1957; Courter et al., 1965), while the field-independent subjects in most cases adapt more adequately to the experimental situations and show a progressive diminishing in autonomic activity.

But in some situations the field-independent person shows higher level of arousal than the field-dependent. In a study by Hein et al. (1964) field-independent subjects responded with higher arousal in situations adequate for such a reaction. This tendency has also been observed by Razran (1961) and Roessler et al. (1963).

In review of studies in this topic Witkin (1967) concluded that "Relatively field-independent subjects are likely to show a high level of arousal in situations where alert attentiveness or a vigorous orienting response is required and a clearly lower level of arousal where such responses are not called for. More field-dependent persons do not show this definite, situation-appropriate differentiation in arousal level. They respond indiscriminately to many stimuli and at the same time do not seem to respond vigorously enough when a high level of arousal would in fact be adaptive."

In short: the above mentioned observations suggest that the field-independent subject is more "arousable" than the field-dependent. But this does not help to explain the observation in the present study, that some field-independent subjects increased their mean error under specific body-reference condition, unless a notion about the relation between level of arousal function and cue function is added. When the level of arousal function is raised the effectiveness of cue function may, following Hebb, raise correspondingly up to a level where optimal adequate response is found; but if arousal is further heightened it "may interfere with the delicate adjustment involved in cue function, perhaps by facilitating irrelevant responses" (Hebb, 1955, p. 186).

When it is born in mind, that the level of cue function depends on level of arousal function, and that the field-independent subjects are more "arousible" than field-dependent, it becomes understandable that the field-independent differed more widely than the field-dependent subjects in making profit of the additional cues as they did when the tactile stimulation changed from diffuse to specific condition.

Thus large individual differences in this field-independent group are possible manifestations of different levels of arousal function which lead to differences in cue function, i.e. differences in capacity to "process" e.g. specific tactile stimulation adequately. And it is also conceivable that some of the field-independent subjects might have surpassed a degree of arousal that corresponds to optimal cue function and responded in an irrelevant way.

The possibility that "overarousal" has played a role is further supported when the stimulus situation in the modified Rod-and-Frame Test used in the present study is considered: the subject is led blindfolded into a room with no knowledge about what is required of him; he is placed in an apparatus the construction of which he has no idea about, but which tilts him standing to an unknown degree with no perceptible accelerations and decelerations. The earphones prevent possible directional auditory cues in the darkened room. His task is now to adjust the rod to physical vertical within the frame which from time to time seems to appear unstable, sometimes partly to disappear, sometimes appearing to move in autokinesis-like ways. The entire situation is ambiguous and produces uncertainty as is seen from the subjects' remarks.

Thus it might be argued that some of the factors that commonly are suggested to raise arousal were operating in the present modified Rod-and-Frame Test situation. Of these factors special attention should be focused on the so-called *Collative variable*, a term covering "the relation between physicochemical and statistical properties of stimulus patterns on the one hand and conditions of the organism on the other" (Berlyne, 1967, p. 19). Among collative variable that have been shown to influence arousal are Novelty (Berlyne, 1963), Complexity and Incongruity (Berlyne & McDonnell, 1965). Possibly other variables are to be found but they seem all to have in common that they involve conflict between incompatible response tendencies; to a degree they are found in the Rod-and-Frame test situation as well as the ambiguity mentioned previously.

When subjects are tested in this "arousal-inducing" situation and a radical change in the tactile stimulus condition is made then it might be reasonable to infer, that if one group of subjects—the most arousible—show itself to differ widely in capacity to make profit of the change, then these differences might reflect differences in level of arousal function; also is it conceivable that some of these arousible persons, due to the stressing conditions under which they were tested, might have been aroused to a degree that resulted in impaired cue function which led to the irrelevant responses observed.

Furthermore, the field-dependent persons were relatively unaffected by the change in stimulation as measured in their setting of the rod under the two conditions. These subjects have been observed in other experimental situations to remain on a relative high level of arousal function, but they do not seem to be able to respond with vigorously situation-appropriate hightening of arousal function when it in fact would be adaptive. Therefore, it is not very surprising that most subjects in the field-dependent group did not react by appreciable increase or decrease in mean error score when the change in tactile stimulation became actual.

Subjects who scored intermediate in the field dependency-independency continuum also fit fairly well into the tentative explanation of the results of this study in terms of arousal function: most subjects in this group manifested adequate cue function by making considerable use of the change in stimulation in adjusting the rod nearer to physical vertical; the fact that none of the subjects in this group increased their mean error when going from diffuse to specific stimulation suggests that these subjects in this group were not aroused to a degree that impaired the cue function.

As might be seen from the foregoing discussion, an attempt was made to explain individual differences in capacity to profit from a change in tactile stimulation in terms of arousal function and the related cue function. However speculative this interpretation might be, it deserves further attention. It seems possible to test the theory experimentally: if individual differences in arousal function determine the degree of adequacy in cue function in a way that is measurable by the present experimental design when observing decrease and increase in mean error score under specific tactile stimulation relative to diffuse tactile stimulation, then experimental changes in arousal function (for example by medical stimulation) might also be reflected in cue function and in a way that is predictable on basis of a priori knowledge of a given person's degree of field-dependency-independency and his arousability.

REFERENCES

BERLYNE, D. E. (1963). Motivation problems raised by exploratory and epistemic behavior. In S. Koch (ed.), *Psychology: A. study of a science*. New York: McGraw-Hill.

BERLYNE, D. E. & MCDONNELL, P. (1965). Effects of stimulus complexity and incongruity on duration of EEG desynchronization. *Electroenceph. clin. Neurophysiol., 18*, 156–161.

BERLYNE, D. E. (1967). Arousal and reinforcement. In *Nebraska Symposium on Motivation.*

BLOCK, J. (1957). A study of affective responsiveness in a liedetector situation. *J. abnorm. soc. Psychol., 55*, 11–15.

COHEN, S. I., SILVERMAN, A. J. & SHMAVONIAN, B. M. (1962). Psychophysiological studies in altered sensory environments. *J. psychosom. Res., 6*, 259–281.

COURTER, R. J., WATTENMAKER, R. A. & AX, A. F. (1965). Physiological concomitants of psychological differentiation. *Psychophysiol., 1*, 282–290.

CULVER, C. M., COHEN, S. I., SILVERMAN, A. J. & SHMAVONIAN, B. M. (1963). Cognitive structuring, Field dependence-independence, and the psychophysiological response to perceptual isolation. In J. A. WORTIS (ed.), *Recent advances in biological psychiatry*, 6. New York: Plenum Press. Pp. 119–128.

HEBB, D. O. (1955). Drives and the C.N.S. (Conceptual Nervous System). In Fowler, H. (ed.), *Curiosity and exploratory behavior*. New York: Macmillan, 1965.

HEIN, P., COHEN, S. I. & SHMAVONIAN, B. M. (1964). Perceptual mode and pavlovian typology, In J. WORTIS (ed.), *Recent advances in biological psychiatry*, 7. New York: Plenum Press. Pp. 71–78.

HUSTMYER, F. E. & KARNES, E. (1964). Background autonomic activity and "analytic perception". *J. abnorm. soc. Psychol., 68*, 467–468.

NYBORG, H. (1971 *a*). Tactile stimulation and perception of the vertical. I. Effects of diffuse vs. specific tactile stimulation. *Scand. J. Psychol., 12*, 135–143.

RAZRAN, G. (1961). The observable unconscious and the inferable conscious in current Soviet psychophysiology. *Psychol. Rev., 68*, 81–145.

ROESSLER, R., ALEXANDER, A. A. & GREENFIELD, N. S. (1963). Ego strength and physiological responsivity: I. *Arch. gen. Psychiat., 8*, 142–154.

SILVERMAN, A. J., MCGOUGH, W. E. & BOGDONOFF, M. D. (1967). Perceptual correlates of the physiological response to insulin. *Psychosom. Med., 29*, 252–263.

WITKIN, H. A. (1948). The effect of training and of structural aids on performance in three tests of space orientation. *Rep. No. 80. Civil Aeronautics Administration*, Washington, D.C.

WITKIN, H. A. & ASCH, S. E. (1948 *b*). Studies in space orientation. IV. Further experiments on perception of the upright with displaced visual fields. *J. exp. Psychol., 38*, 762–782.

WITKIN, H. A., LEWIS, H. B., HERTZMAN, M., MACHOVER, K., MEISSNER, P. B. & WAPNER, S. (1954). *Personality through perception.* New York: Harper.

WITKIN, H. A. & OLTMAN, P. K., (1967). Cognitive style. *Int. J. Neurol., 6*, 119–137.