FIELD DYNAMICS OF VISUAL PERCEPTION: POTENTIAL LANDSCAPES ARE DEPENDENT ON THE BORDER CONDITIONS

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Introduction

The subject of the research reported here is to be seen as a follow-up of an investigation published four years ago (STADLER et al., 1991), which revealed the hidden psychological field structure of a homogeneous area (standard rectangular sheet) and gave an explanation for the behaviour of the wandering point phenomenon (see BARTLETT, 1951).

The three dimensional representations of these psychological fields are called potential landscapes or gradient potentials. The potential landscapes we obtained as results from these first experiments reminded the authors of the field theory of perception developed by the gestalt psychologist Wolfgang KÖHLER. No matter whether KÖHLER's idea of the brain tissue as a homogeneous conductor in which electrotonic forces are built up at the cell membranes has proved to be a physiological fact relevant to perception, there are some general features of the field theoretical approach that may be worthwhile to be taken into account for further research (KRUSE et al., 1987). KÖHLER (1940) claimed that there are field forces caused by every contour in the visual field that are responsible for the displacement of other contours. The field strength follows a gradient being flat near the contour, becoming stronger at a certain distance and weaker again at a greater distance (cf. STADLER et al., 1996). Such a gradient has been proved to be existent in many experiments (e.g. SAGARA & OYAMA, 1957; CRABUS & STADLER, 1971).

When we take into account the enormous complexity of the central nervous system and the fact that every pattern of perception involves at least millions of nervous elements, there is no fundamental difference whether we explain the given contour gradient by a neural network approach or by a continuous field model (cf. UTTAL, 1988).

According to KÖHLER (1940), the profile of the gradient is dependent on the contour given, or, more generally spoken, it is dependent on the boundary conditions. The potential landscape therefore has to be modifiable correspondingly to variations of the boundary conditions.

The following experiments represent different modifications of the originally used stimulus material. First of all we varied the shape of the sheets used, to find out how strong the attractors within the potential landscape are dependent on the corners of the DIN A4 sheets. In the next step the influence of contours was tested. We used two different trapezoids drawn onto the stimulus sheets. The third experiment additionally investigated the effect of cognitive contours, which was expected to be less strong compared with real lines. Experiment 4 and 5 respresent the influence of psychological effects, dealing with stimuli suggesting a deviation in a certain direction on the one hand, respectively investigating the effect of a learning task on the other hand.

According to the original experiment described by STADLER et al. (1991), every follow-up experiment leads to an empirical vector field covering the whole investigated area. The experimental procedure was nearly the same in all investigations described here, therefore a detailed description will be given only for the first experiment. The mathematical treatment of the empirical vector fields has already been explained step by step (see STADLER et al., 1991). The first of the following experiments needed some modifications in the calculation of the potential landscape, as the points were arranged triangularly. This leads to different (mathematical) border conditions, which have to be taken into account in the calculation procedure.

In all experiments, the main mathematical steps are:

(1) Decomposition of the empirical vector field A(r) into circulation field *C = curl W(r)* and gradient field *G = -grad V(r)*

(2) calculation of the gradient potential *V(r)* out of the gradient field (and the ciculation potential *W(r)* out of the circulation field, which is not interpreted)

These two potentials provide a natural way of characterizing a given field (for more information see GROSSMANN, 1988). We prefer to interpret the gradient field *G* negative, although this is not common in mathematics. This interpretation leads to potentials, in which the vectors point „downhill", which corresponds with the psychological reality, which is empirically demonstrated in the wandering point experiments (cf. STADLER & WILDGEN, 1987; BARTLETT, 1951).

Experiment 1: The gradient potential of a circular field

As the four corners are considered to be the cause for strong attractors, it was close at hand to apply the systematic method described 1991 and below to a circular stimulus area (see PFAFF, 1991). A circular shape does not have any corners, so this influence on the potential landscape is eliminated. The only other clues in a homogeneous area are the border of the area itself and its psychological center.

Early experiments dealing with dot displacements, although not investigating the whole area systematically, suggest the field structure of a circle to be entirely different from the structure of a rectangular area (ATTNEAVE, 1955; MEHRING, 1970; SCHULZ, 1966, 1973). A similar experiment is described by HARVEY and SCHMIDT (1990), who used polar coordinates which only allow an interpretation of the empirical vector fields but are not suited to calculate a potential landscape, as they do not provide for a uniform ditribution of the vectors.

We expected to find a circular attractor near the paper's edge, but still with some distance to it, caused by the repulsion effect of the edge itself. Near the center a repeller should be placed, in correspondence to the findings on the rectangular sheet: The potential landscape of a circular frame therefore should hypothetically look like a „mexican hat“.

Stimuli

163 DIN A 4 sheets were covered with a circular template (diameter 20 cm). An underlying triangular net, mesh size 1.5 cm, defined the positions of 163 black points (diameter 1.5 mm) providing for a uniform distribution in the area of the circle. Each sheet contained one point.

Procedure

The 163 stimuli were presented in random order on a pressure-sensitive board (EASYL) lying on a table in front of the subjects. The EASYL board was covered with a circular template and connected with a Commodore Amiga 2000 computer.

Each stimulus sheet was presented for about one second, covered with a black sheet of paper and then removed from the board. The subject was asked to reproduce the position of the black point immediately after the presentation, pressing a pencil onto the EASYL. The coordinates of the marked position were saved automatically. Then the next stimulus was presented. Ten subjects participated in this investigation. Each experiment took about 35 minutes.

Results

Figure 1 shows some characteristic experimental data: The empirical vector field and the gradient potential of one subject. The predicted „mexican hat“ shape of the gradient potential is not as distinct as we expected it to be, but by and large the potential resembles this specific form. Beyond this finding, the circular attractor has four slight depressions (dents) in those places, where they have been found in the originally used rectangular sheets: They are located where the corners of a square sheet would be. The somewhat rugged border of the potential is an artefact caused by the distribution of the stimulus dots. They are arranged not quite hexagonal, as one point is missing in each of the six corners. This was taken into account in the mathematical treatment, but it nevertheless does not completely level out the circle's edge.

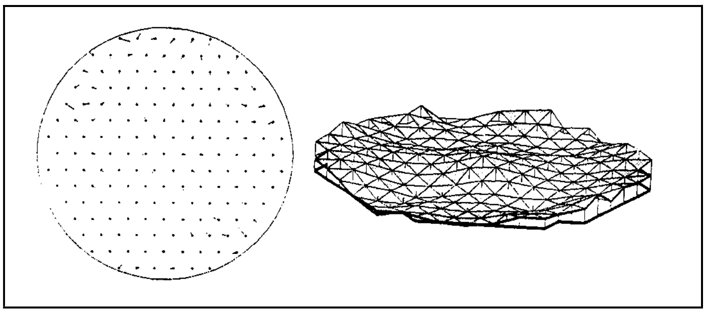

Figure 1: Empirical vector field and corresponding gradient potential of subject 10

Discussion

The fact that four slight attractors can be observed in a circular field leads to the assumption that the corners of a rectangular sheet are obviously not the only cause for the attractors which were discovered in the original experiment. The displacement of dots towards the center of a circle's quadrants has already been observed by ATTNEAVE (1955). He could not find a proper explanation for this phenomenon. Attneave suggests that this finding is caused by psychological and real landmarks, which either lead to a „sharpening“ or a „levelling out“ of the distance a given point has referring to this clue. This would mean that additionally to the center and the edge of the circle the dividing lines of the quadrants are used by the subjects. This could be regarded as a hint for the „rectangularity“ of the human visual field, as it was proposed by the so-called „carpentered world“-hypothesis (SEGALL et al., 1966).

However, these findings, as well as the results of the original experiment, support the considerations of HARTLEY (1978, 1979), that the major axes of a shape do not bear any attraction to singular dots (if it is possible to talk about „major axes“ in a circle). This could be concluded from the results of BEH, WENDEROTH and PURCELL (1971), BEH and WENDEROTH (1972) and WENDEROTH (1973). But HARTLEY (1979) speaks of an attraction of real lines whereas WENDEROTH (1980) interprets a repellent character of the major axes. This latter consideration would give an explanation for the four attractors of a circular field.

As the only real „lines“ we investigated so far are the borders of the shapes we used, some real landmarks, that is figures, are added to the investigation area in the next step.

Experiment 2: The influence of real contours on potential landscapes

The experiment described in the following was guided by two leading qustions. First of all, is the potential of an area altered by adding a specific clue, e.g. a shape or a figure? And, more important, how does the expected alteration depend on form and type of an object?

For the answering of these questions we used two different shapes which are wellknown in gestalt psychology: Two different trapezoids, one of them bearing the tendency to be regarded as a triangle, the other one is similar to a rectangle (cf. METZGER, 1975). These two figures were drawn on standard rectangular sheets.

Of course we expected the gradient potential to be changed by the influence of the figure. As it was mentioned before, the gradient should be flat near the contour and stronger at a certain distance (KÖHLER, 1940). The expression „stronger“ does not tell if a vector in this region is pointing up or down, or, in other words, if the potential is to be interpreted mathematically or psychologically. Therefore we had two contrary hypotheses about the influence of a contour on the potential landscape: Either the lines are attractors, which would lead to a concave impression of the figures in the potentials, or they are repellers like the edges of the sheets in the original experiment (cf. IGEL & HARVEY, 1991). In this case a convex form of the landscape in the area close to the lines is to be expected and the figures should protrude from the gradient potential.

Stimuli

Two sets of 609 black points (21 x 29, diameter 2 mm) on a rectangular net, meshsize 1 cm were used on rectangular sheets, onto which two different trapezoids were drawn. In one stimulus set the sheets contained the trapezoid resembling a triangle (plus one black point), in the other stimulus set the the more quadrilateral trapezoid (and one black point, of course) was drawn onto the sheets. The base line of the two trapezoids measured 10 cm, the upper line of the more triangular figure was 1 cm, of the more quadrilateral figure 6 cm.

Procedure

The experiment was carried out as described before, with the difference that according to the original rectangular-sheets-experiments the stimuli were not exposed on the EASYL, but on the left side of it. The two figures were to be seen on the stimulus sheets only, the reproduction sheets were empty. 20 subjects participated in this experiment, 10 for each set. Each experiment took about two hours and was interrupted by a 15 minutes break after the first hour.

Results

As a most surprising result, the influence of the both trapezoids on the potential is so strong, that the whole landscape is turned upside down, reversing hills and valleys. The contours of the figures used are literally carved into the landscape (see fig. 2 and 3). The experimental vector fields show that the lines of the figure have an unexpected strong attraction for the stimulus points. All vectors, even those in the far away corners, are pointing to the center of the sheet, leading to the reversion of the gradient potential.

The corners of the figures seem to be impressed even deeper into the landscape. This observation corresponds with the fact that corners bear a greater amount of information than straight lines (see Attneave, 1954), which obviously even increases their attraction.

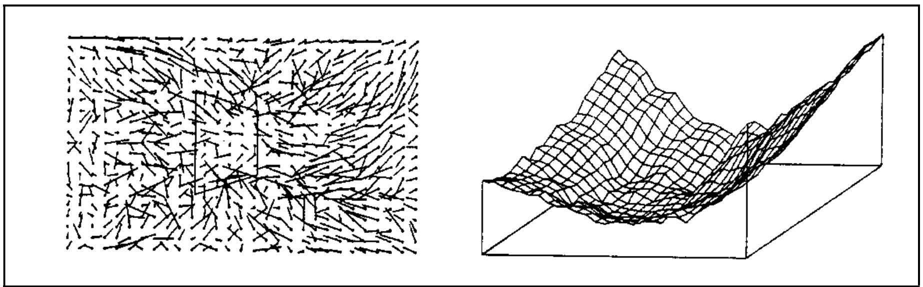

Figure 2: Empirical vector field and corresponding gradient potential of subject 5 (rectangular area, „quadrilateral“ trapezoid)

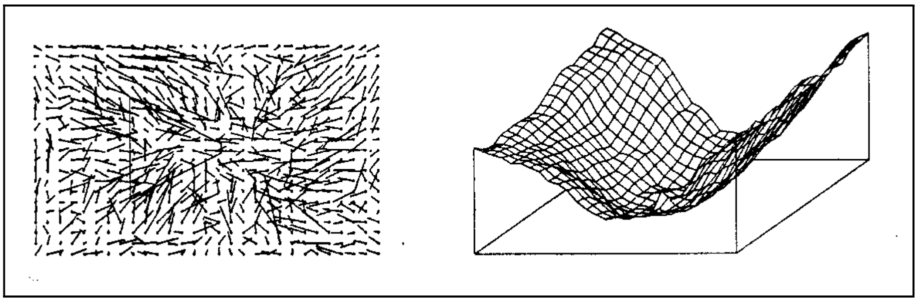

Figure 3: Empirical vector field and corresponding gradient potential of the same subject (rectangular area, „triangular“ trapezoid)

Discussion

As we have expected, the potential landscape is altered if real landmarks are added. Figures respectively lines are strong attractors. The fact that the original gradient potential is completely reversed shows that the influence of a contour does not end at a certain distance, but can be strong enough to affect the whole field. The strength of the field forces proceeding from the contour, is probably dependent on several factors: The size of the investigated area and of the contour might as well be influencing factors as the type of the additional landmark.

In this experiment the difference between the gradient potentials of the two trapezoids is very small. The triangular trapezoid seems to be leading to a more triangular impression in the landscape. An extending, more systematic investigation of the influence of the triangular respectivly the quadrilateral tendency of the two trapezoids , for example the comparison with a real triangle or rectangle would be of additional interest.

Experiment 3: A comparison between the effect of cognitive and real contours on the potential landscape

As the influence of a figure is strong enough to alter the whole potential landscape, we decided to try the effect of cognitive contours in the next step, which were discovered and investigated by KANISZA (1955). As it does not seem convenient only to investigate cognitive contours separately, similar stimulus material had to be found to allow some propositions about the differences between cognitive and real contours. The use of three different variations of the KANISZA-Triangle seemed to be suited to provide for a direct comparison between real, cognitive and no contours.

This comparison is particularly interesting for biological considerations: Neurophysiological investigations show that almost no neuronal response to cognitive contours is to be found in area 17 (except by REDIES, CROOK and CREUTZFELD (1986), who used only one stimulus configuration), wheras reactions can indeed be measured in area 18 (cf. GREGORY, 1987; PETERHANS & von der HEYDT, 1989; VON DER HEYDT, PETERHANS & BAUMGARTNER, 1984). According to these findings, any differences between the cognitive and the real contours condition could be interpreted as differences between the areas 17 and 18.

For this experiment the reproduction sheets had to contain the figures as well as the stimulus sheets, so that the cognitive contours investigated in condition 2 could be preserved. We expect the cognitive contours to produce a similar distortion of the potential landscape as the real contours, that is a more or less deep impression of a triangle in the gradient potential. The third condition is to be understood as a control experiment, where no impression of a triangle but only of the three „corners“ should occur.

Stimuli

Three sets of stimuli were used, each consisting of 441 points (21 x 21). Refining the mesh size (0.5 cm) the investigated field was 12 x 12 cm. The three sets represented different variations of the KANISZA-Triangle (4.5 cm length of side). To confirm the preceding hypothesis the KANISZA-Triangle was slightly altered, first of all it was reduced to the cut-out circles. Thus the effect of the cognitive contours is certainly somewhat weakened, but it will not vanish until the distance between the circles is not chosen too long.

For the first experimental condition (cognitive contours) only the cut-out circles were used. In the second condition (real contours) the connecting triangle lines were actually drawn into the picture.The control condition with no contours was achieved by cutting out more parts of the KANISZA circles, which thus looked like radioactivity signs (KANISZA, 1955; METZGER, 1966). Figure 4 shows the stimulus material for the three experimental conditions.

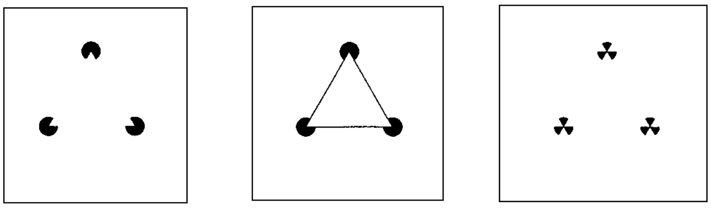

Figure 4: The stimuli for three experimental conditions: cognitive contours, real contours, no contours (square sheet)

Procedure

According to experiment 1, presentation and reproduction were performed in the same place, namely on the EASYL-board. In this investigation the reproduction sheets were not blank but contained the corresponding stimulus shapes, in order to preserve the difference between the three experimental conditions. 30 subjects participated in this experiment, that is 10 for each set.

Results

The potential landscapes of all three conditions show three deep valleys, where the (altered) KANISZA circles were positioned. At first sight they look very similar, nearly identical. This is no surprise, as the stimulus material exhibits only small alterations as well. Looking closer it can be seen that in the no-contours-condition the landscape shows only three valleys, whereas in the two other conditions the connecting lines are slightly imprinted into the saddles between the valleys. This effect even seems to be stronger in the cognitive contours condition (see fig. 5a-c).

Figure 5a: Averaged gradient potentials (5 subjects each) of the „cognitive“ conditi-
on

Figure 5b: Averaged gradient potentials (5 subjects each) of the „real“ condition

Figure 5c: Averaged gradient potentials (5 subjects each) of the „no contours“ condition

For a mathematical comparison between the potentials of the three experimental conditions, the landscapes where subtracted from each other (that is the height in each investigation point). Figure 6a-c shows the resulting landscapes of these subtractions, expressed in the absolute amounts. The differences between the control condition (no contours) and the other two conditions is considerably bigger than between the cognitive and the real contours conditions, as expected.

Figure 6a: Subtractions of the gradient potentials of figure 5: averaged no contours minus averaged cognitive contours

Figure 6b: Subtractions of the gradient potentials of figure 5: averaged no contours minus averaged real contours

Figure 6c: Subtractions of the gradient potentials of figure 5: averaged cognitive contours minus averaged real contours

Discussion

In these experiments the extremely deep imprinting of the triangle corners is certainly caused by the large circles used and not by the information load we mentioned before, although the amount of information definitely is even bigger using a cut-out circle as a corner than only two lines meeting. The different degree of imprinting into the landscape comparing the KANISZA circles with the radioactivity signs could be explained with the „weight" of the two figures: The obviously „light", fragile radioactivity sign seem to be of less weight than the „heavy" black KANISZA circles.

The mathematical comparison between the potentials of the three stimuli shows a high similarity between cognitive and real contours. This result is especially interesting, as the mere optical impression seems to propose a higher relationship between the no contours and the cognitive contours condition. Obviously there are no real lines in both stimuli, only the shape of the corner-figures is different. Although the alteration of the original Kanisza triangle leads to a considerable weakening of the cognitive contours, they have lost nothing of their presence.

Experiment 4: Psychological influence, Part 1: Using stimuli suggesting a certain direction

Following the investigation of visual stimuli, we focussed on different kinds of psychological influence. In the following experiment the character of the points we used so far was altered to find out if the shape of the stimuli can be seen as a cause for the structure of the potential landscapes. In this case it should be possible to influence the gradient potential by changing the stimulus points into small arrows, which suggest a deviation in the direction they are pointing at.

Stimuli

The usually used black points were replaced with

(1) equilateral black triangles (0.5 cm length of side) with a white point (diameter 1.5 mm) in the centre (fig. 7a)

(2) the same triangles with a shaft attached to them, so that they resembled an arrow (fig. 7b)

(3) elongated isosceles triangles, length of the long sides 1 cm, short side 0.5 cm (fig. 7c)

Each sort of stimulus was arranged in two different ways: One stimulus set contained the stimuli pointing in the same direction as the vectors of the gradient field of the original rectangular-sheet-experiment (into the corners), the other set contained the direction vice versa, with the stimuli pointing at the geometrical center of the sheets. Of course the triangles, being equilateral, actually pointed into three equivalent directions.

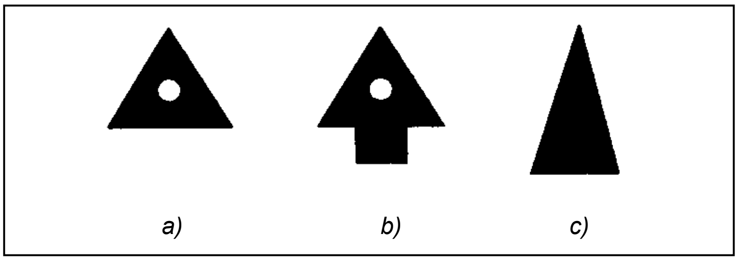

*Figure 7:*a) Stimulus for condition (1), b) Stimulus for condition (2), c) Stimulus for condition (3).

117 stimuli on 117 rectangular (DIN A4) sheets. (meshsize 2 cm) were used for the experimental conditions (1) and (2), 40 stimuli on 40 rectangular (DIN A4) sheets (meshsize 4 cm) were used for condition (3).

Procedure

All three conditions were performed as paper-and-pencil experiments. After presenting one sheet, the subject was asked to draw the position of the stimulus „point“ onto another sheet of paper. All sheets were collected. After the experiment was finished, the reproductions were transfered into the computer, using the EASYL-board once again.

48 subjects participated in the experimental conditions (1) and (2), that is 12 for each condition and stimulus direction. In condition (3) 20 subjects participated, that is 10 for each stimulus direction.

Results

The results of the three experimental conditions are evidently very different. As expected, the smallest alteration of the gradient potential happens in condition (1), where the equilateral triangles we used as stimuli seem to cause only a certain amount of confusion (see fig. 8a and 8b). The potentials we obtained in condition (2) look a little bit more structured. In some cases the landscapes are flattened, or even reversed in the „other direction“ version, where the arrows point to the center of the sheet. One fine example is depicted in figure 9b. The best results were obtained in condition (3). Figures 10a and 10b show the averaged potentials of 10 subjects each. In this investigation the semantic content of the stimuli is remarkably reflected by the resulting landscape: In the corner-direction condition the potential seems to be even more distinct, in the center-direction condition it is completely turned upside down.

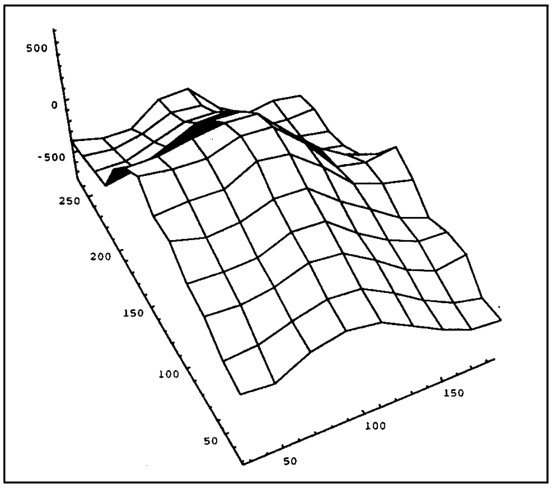

Figure 8a: Empirical vector field and gradient potential of subject 1 (rectangular sheet, isosceles triangles „pointing“ at the corners)

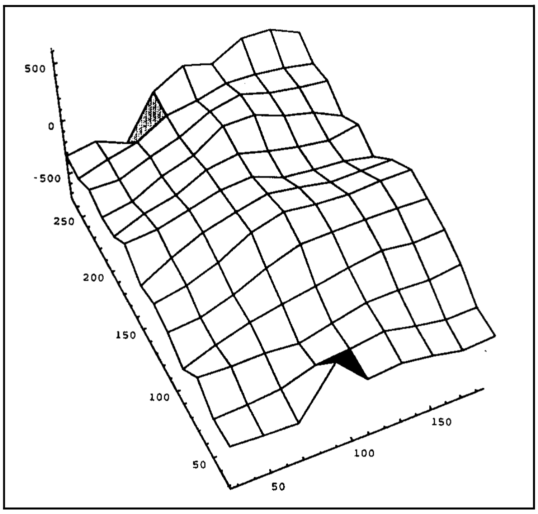

Figure 8b: Empirical vector field and gradient potential of subject 2 (rectangular sheet, isosceles triangles „pointing“ at the center)

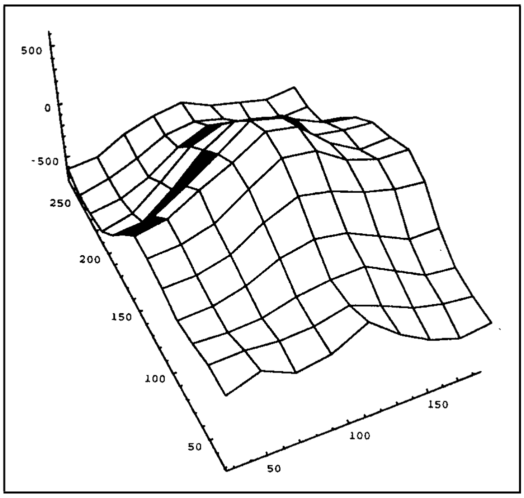

Figure 9a: Empirical vector field and gradient potential of subject 1 (rectangular sheet, arrows pointing at the corners)

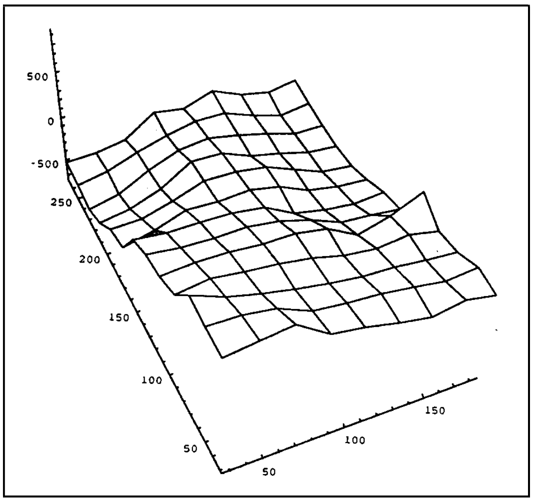

Figure 9b: Empirical vector field and gradient potential of subject 3 (rectangular sheet,
arrows pointing at the center)

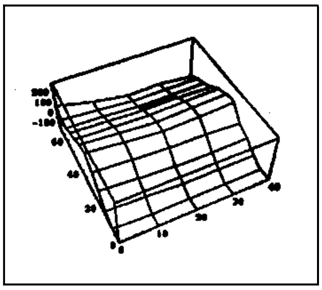

Figure 10a: Averaged empirical vector field and gradient potential (rectangular sheet, elongated triangles pointing at the corners)

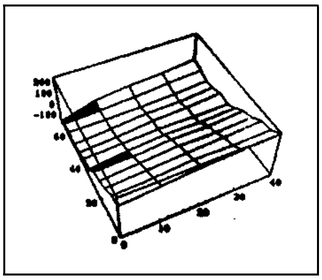

Figure 10b: Averaged vector field and gradient potential of (rectangular sheet, elongated triangles pointing at the center)

Discussion

It obviously is possible to obtain alterations in the gradient potentials through psychological influence, but the stimuli have to be chosen very carefully, as not all of them lead to satisfactory results. On the one hand it is necessary not to use too obvious items, in order to avoid reactant behavior of the subjects. On the other hand it would be very interesting to use extremely non-obvious stimuli, which would mean to try some kind of suggestible influence which the subjects are not even aware of. A first experimental trial of this kind is described by STADLER, KRUSE and STRÜBER (1995). In this investigation the subliminal, verbal suggestions „up“ and „down“ lead to an elongated respectively shortened vertical divergence of the subject's response.

The fact that semantic contents are able to affect the gradient of a homogeneous area leads to the conclusion, that this experiment can be seen as an argument for top-down processes in the cognitive system (cf. DAVIS, SCHIFFMAN & GREIST-BOUSQUET, 1990; STADLER, KRUSE & STRÜ-

BER, 1995): The usually assumed stimulus-reaction-process, according to the course of time of the stimulus assimilation, is reversed by the meaning of the stimulus, which already influences its perception.

Experiment 5: Psychological influence, Part 2: A learning task

As semantic influence of a gradient potential is easily obtained by using „semantic“ stimuli, which means a short-term effect on the subject, it is close at hand to investigate long-term influence in the next step. This is to be achieved by learning, which could prove if it is possible to obtain a persistent effect.

For this experiment the subjects were trained to find the geometrical center of a rectangular sheet, which is localized somewhat above the psychological center (KLIX, 1962), therefore it takes some practice to learn the correct position. We expect that the training leads to an attractor in the geometrical center of the sheets, as if it was depicted there.

Stimuli

For ten subjects 117 points (meshsize 2 cm) on on standard rectangular sheets were used. Two more subjects were tested with the same sheets, but a higher resolution (425 points, meshsize 1 cm).

Procedure

Starting with the learning task, every subject tried to find the geometrical center of a sheet, getting a feedback about the deviation every time. Depending on the subject's skill it took more ore less trials to „learn“ the center position within a satisfactory allowance, which was determined at 1cm. Afterwards the standard procedure was performed.

Results

Figure 11 shows one of the resulting landscapes: The mountain top in the center of the sheet is evidently flattened and even imprinted.A large part of the landscape is affected by this change, as we have seen before in the other experiments.

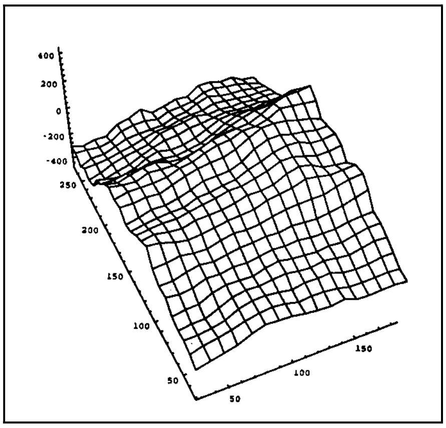

Figure 11: Empirical vector field and gradient potential of subject 11 (learning task, rectangular sheet)

Discussion

Like experiment 4, this investigation supports the assumption of top-down processes as well, because it leads to a similar influence of the stimulus on the cognitive system. As we expected, the learning and thus the confirmation of a special position on the paper does have an influence on its potential landscape, but the effect is somewhat weaker. This was the only experiment where not the whole field was affected by the stimulus (the trained center). It could be concluded that the effect of a learning task is weaker than optical stimuli, but perhaps this conclusion leads too far. It may as well depend on the extent the stimulus has.

General discussion

As we have shown, the potential landscapes can easily be influenced and altered by different visual stimuli. When homogeneous areas are investigated, the shape of the area determines the form of the gradient potential. When the area contains one ore more figures, they have a strong influence on the potential landscape, influencing the whole field and covering the influence of the areas shape, and what is even more interesting, the field seems to represent the „gestalt qualities" of the chosen figures.

It seems to be impossible to change only a part of the potential, in almost every case (Except the learning task in experiment 5) the whole landscape is influenced by even the smallest changes. It is likely that there is an influence on the whole area in the learning task condition as well, but it is not obvious enough to be seen in the representation of the potentials.

The determination of every local point by the whole and vice versa is a typical feature of physical fields, which leads to an interpretation of a psychological field as a physical field, or more carefully speaking, both types of fields have at least a very significant similarity.

The most interesting results were obtained in experiment 4 and 5. They show, that the gradient field is not only altered by physical („real“) stimuli, but by psychological, indirect influences as well. These results emphasize the assumption, that the perception of our environs is formed respectively changed through the physical *and* psychological effect of each single stimulus. The changes over time, especially the weakening influence of learning through forgetting could be measured by repetition of the last experiment after some time. A later generated, second landscape should correlate with wellknown forgetting rates.

All experiments, but especially the two last ones, demonstrate, that visual perception can not exclusively be organized in a bottom-up direction. The fact that the stimuli are perceived in a different locus than they actually are and the influence of meaning, require the assumption of top-down processes as well.

Summary

The investigation of field dynamics of a standard rectangular (DIN A4) sheet (see STADLER et al., 1991) is the starting point for several experiments reported here. Different variations of the original stimulus material were tested. Starting with a different shape of the sheet (experiment 1), we investigated the influence of figures (experiment 2) and a comparison between real versus virtual lines (experiment 3) in the next step. Experiment 4 and 5 use psychologically orientated concepts, dealing with suggestive stimulus points (4) and a learning task (5). The results show that the gradient potentials are strongly determined by the border conditions. They could be compared with physical fields, as even small influences (variations) are able to affect the whole field.

Zusammenfassung

Die Untersuchung der Felddynamik eines normalen DIN A4 Blattes (vgl. STADLER et al., 1991) bildete den Ausgangspunkt für die Experimente, die in diesem Artikel beschrieben werden. Verschiedene Variationen des ursprünglichen Reizmaterials wurden untersucht. Zunächst wurde eine andere Blattform gewählt (1. Experiment). Anschließend untersuchenten wir die Auswirkungen von Figuren auf das Feld (2. Experiment), sowie im 3. Experiment einen Ver-

gleich zwischen dem Einfluß von realen versus virtuellen Konturen. Die Experimente 4 und 5 gehen von rein psychologisch orientierten Konzepten aus, indem sie die Auswirkungen suggestiver Reizpunkte (4) bzw. eines Lernprozesses (5) untersuchen. Die Ergebnisse zeigen, daß die Gradientenpotentiale in großem Maße durch die gesetzten Randbedingungen bestimmt werden. Sie können mit physikalischen Feldern verglichen werden, da kleinste Einflüsse und Variationen Auswirkungen auf das gesamte Feld haben können.

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