Historisk-filosofiske Meddelelser
udgivet af
Det Kongelige Danske Videnskabernes Selskab
Bind **39**, nr. 7

Hist. Filos. Medd. Dan. Vid. Selsk. **39**, no. 7 (1962)

OSCILLATION EXPERIENCED IN THE PERCEPTION OF FIGURES

BY

KRISTIAN HOLT-HANSEN

København 1962
i kommission hos Ejnar Munksgaard

DET KONGELIGE DANSKE VIDENSKABERNES SELSKAB udgiver følgende publikationsrækker:

THE ROYAL DANISH ACADEMY OF SCIENCES AND LETTERS *issues the following series of publications:*

	Bibliographical Abbreviation
Oversigt over Selskabets Virksomhed (8°) *(Annual in Danish)*	Overs. Dan. Vid. Selsk.
Historisk-filosofiske Meddelelser (8°)	Hist. Filos. Medd. Dan. Vid. Selsk.
Historisk-filosofiske Skrifter (4°) *(History, Philology, Philosophy, Archeology, Art History)*	Hist. Filos. Skr. Dan. Vid. Selsk.
Matematisk-fysiske Meddelelser (8°)	Mat. Fys. Medd. Dan. Vid. Selsk.
Matematisk-fysiske Skrifter (4°) *(Mathematics, Physics, Chemistry, Astronomy, Geology)*	Mat. Fys. Skr. Dan. Vid. Selsk.
Biologiske Meddelelser (8°)	Biol. Medd. Dan. Vid. Selsk.
Biologiske Skrifter (4°) *(Botany, Zoology, General Biology)*	Biol. Skr. Dan. Vid. Selsk.

Selskabets sekretariat og postadresse: Dantes Plads 5, København V.

The address of the secretariate of the Academy is:

Det Kongelige Danske Videnskabernes Selskab,
Dantes Plads 5, Köbenhavn V, Denmark.

Selskabets kommissionær: EJNAR MUNKSGAARD's Forlag, Nørregade 6, København K.

The publications are sold by the agent of the Academy:

EJNAR MUNKSGAARD, *Publishers,*
6 Nörregade, Köbenhavn K, Denmark.

Historisk-filosofiske Meddelelser
udgivet af
Det Kongelige Danske Videnskabernes Selskab
Bind **39,** nr. 7

Hist. Filos. Medd. Dan. Vid. Selsk. **39,** no. 7 (1962)

OSCILLATION EXPERIENCED IN THE PERCEPTION OF FIGURES

BY

KRISTIAN HOLT-HANSEN

København 1962
i kommission hos Ejnar Munksgaard

CONTENTS

Printed in Denmark
Bianco Lunos Bogtrykkeri A-S

I. Introduction

A. The historical background

The following is a brief account of the historical background of the present investigations. These experiments concern experienced movements to which there are no corresponding movements of the physical objects. Such movements were first observed in stars.

In his well-known work "Kosmos" (1850), p. 73, Alexander von Humboldt gives the following account of star movements observed during a climbing expedition on Teneriffe in the year 1799: "Leuchtende Punkte stiegen aufwärts, bewegten sich *seitwärts* und fielen an die vorige Stelle zurück. Das Phänomen dauerte nur 7 bis 8 Minuten und hörte auf lange vor dem Erscheinen der Sonnenscheibe am Meerhorizont. Dieselbe Bewegung war in einem Fernrohr sichtbar; und es blieb kein Zweifel, dass es die Sterne selbst waren, die sich bewegten." (By this Humboldt presumably meant, not that the stars "in situ" moved, but that it looked as though they did). It may be noted in passing that von Humboldt mentions these observations of 1799 in his less well-known treatises, "Nachrichten aus Süd-Amerika" (1800), and "Voyage aux régions équinoxiales" (1814).

Von Humboldt calls these movements "Sternschwanken", and the reader can test their existence any starry night. If several people try the experiment together they may find that they are quite unable to agree as to the nature of the movements even though they have been watching the same star at the same time.

Taking von Humboldt's observation of 1799 as his starting-point, G. Schweizer made a further study of the problem of "Sternschwanken", first in his book "Über das Sternschwanken I" (1857). At that time G. Schweizer, who was born in 1816 in the canton of Zürich, Switzerland, was Professor of Astronomy

1*

and Mathematics at Moscow, where he died in 1873 after having achieved great eminence, especially as an astronomical observer. Thus he discovered several new comets. On p. 443 SCHWEIZER states that he has observed "Sternschwanken", e. g. in Canis Minor, Jupiter, and Sirius, ". . . ja sogar die drei Sterne des Orionsgürtels schienen *mit einander*, dieselben Abstände bewahrend, bald da bald dorthin ihre Schwankungen auszuführen."

However, SCHWEIZER reached the conclusion that it was not the stars themselves that moved, but the spectator who experienced the movements. In order to confirm this conclusion he took an assistant, BREDICHIN, with him one evening to make a simultaneous observation of Sirius. Of this experiment SCHWEIZER relates, p. 443: "Da stellte sich denn in kurzer Zeit das neue Factum heraus, dass *in ein und demselben Momente* die Erscheinung für einen Jeden von uns eine andere war. Bisweilen sah ich den Stern steigen, wenn Herr BREDICHIN ihn fallen sah; bisweilen schien derselbe mir still zu stehen, wenn der andere Beobachter ihn in rasch fortschreitender Bewegung erblickte; bisweilen beschrieb der Stern für mich einen Kreis, wenn er für Herr BREDICHIN in schiefer Richtung fiel oder stieg."

SCHWEIZER's next achievement was to carry out a series of experiments using a black figure on a light background, a white figure on a black background, and also a luminous point on both a light and a dark background. SCHWEIZER varied the experimental conditions in many different ways, and says on p. 454: "Die Schwingungen in horizontaler Richtung waren sehr bedeutend, in verticaler etwas geringer, aber das Phänomen hatte die grösste Aehnlichkeit mit den Sternschwankungen in dunkler Nacht, die beobachtet werden an Sternen, die nicht sehr hoch über dem Horizonte sich befinden."

In his work "Über das Sternschwanken II" (1858), SCHWEIZER proceeds to give a detailed account of the observations made as to "Sternschwanken" since von HUMBOLDT's observations in 1799, and the conclusion reached in this paper includes the statement, p. 500: "Es gibt zwei Arten des Sternschwankens, von denen das eine subjectiven, das andere objectiven Ursachen zuzuschreiben ist." By subjective "Sternschwanken" SCHWEIZER means what we should now describe as immediately experienced, while "das objective Sternschwanken" is to SCHWEIZER "ein Zittern der Bilder" – p. 500. As a condition of the latter, SCHWEIZER mentions air-currents of different temperatures. Lastly, it may be added that Schweizer himself realizes that there is much research to be done into the motion phenomena thus established.

A work entitled "Sur une illusion visuelle" – based solely upon laboratory observations – was published in 1886 by AUG. CHARPENTIER, who does not appear to know the publications mentioned above. CHARPENTIER gives the following description of the experimental situation and the experiences of movement (p. 1155): ". . . lorsque l'oeil regarde pendant quelque temps dans une *complète* obscurité un objet immobile de petit diamètre et faiblement éclairé, il arrive très souvent que cet objet paraît nettement se mouvoir avec une certaine vitesse dans une direction déterminée du champ visuel." Movements up and down and in a curved line may also be experienced. The experienced direction of the figure may deviate 30° or more from the direction of the physical objects. Unfortunately, CHARPENTIER does not give the distances; a specific term for these motion phenomena, instead of the expression "illusion visuelle", would also have been more to the point.

Such a step forward in terminology is however to be found in the work "Die Bewegungsempfindung" (1887 a), by HERMANN AUBERT. Like CHARPENTIER, AUBERT appears to be unaware of the works mentioned above; Charpentier's treatise is, however, referred to in "Nachtrag" (1887 b). AUBERT's treatise, "Die Bewegungsempfindung", is a large-scale investigation of the threshold of experienced movement. He found great uncertainty in the subjects. For instance, they sometimes experienced movement without movement on the part of the physical objects. AUBERT therefore introduces the term *Autokinesis* – "autokinetische Empfindungen" p. 477 – to designate experienced movement when the physical objects are motionless. Further details are given in the following passage, p. 477: "Diese autokinetischen Empfindungen treten im Finstern, wenn man nur einen glühenden Draht sieht, mit so grosser Energie auf, dass man die Bewegung zu sehen glaubt, selbst wenn man weiss, dass keine objektive Bewegung statthat, und mit derselben ändert sich zugleich die Lokalisation: so habe ich sehr oft gesehen, dass der Draht weit nach links hin ging oder gegangen war, ohne dass er in Wirklichkeit seinen Ort verändert hätte". By autokinesis AUBERT (cf. p. 479) therefore means the opposite of "wirkliche Bewegung". The particular significance of AUBERT's work was this formation of a word and a concept which from that time provided psychological literature with a fixed term.

SIGM. EXNER's work "Über autokinetische Empfindungen" (1896) includes an account of experiments with a small luminous point, and on p. 327 the author uses the term "Punktschwanken ... als den allgemeineren Fall des Sternschwankens". Experiments with a small luminous point in darkness have been used in autokinetic research right up to the present day. But autokinesis has also been established in experiments with large figures, and is described inter alia in works by KARWOSKI, REDNER and WOOD (1948) and WARD EDWARDS (1954). Historical surveys of autokinesis are to be found in German in the above-mentioned work by EXNER, in English by GUILFORD and DALLENBACK (1928), and in French by GERMAINE DE MONTMOLLIN (1956).

Some investigators describe autokinesis in terms reminiscent of the experiences which are the subject of the present paper, and which we have given the name oscillation. B. BOURDON, for instance, in his book "La Perception Visuelle de L'espace" (1902), gives an account of his own observations of autokinesis, p. 335 f. BOURDON carried out experiments inter alia with two small luminous points, at a distance of some metres, placed one above the other with a 4 mm interval. He gives the following report of experiences in these conditions (p. 335): "... dès le début de la fixation, ils paraissent osciller l'un par rapport à l'autre ...". And of experiments with a vertical line 22 cm long placed at a distance of 1.5 m BOURDON says, p. 335: "..., elle me produit l'effet d'un fil qui flotterait en ondulant légèrement dans l'air ..., on dirait alors un serpent qui monterait verticalement avec de faibles ondulations du corps."

The nearly 75 years that have passed since the introduction of the concept autokinesis in 1887 have seen the publication of many works with a number of different aims, e. g.: a) to demonstrate new features and characteristics of experiences concerning autokinesis, b) to throw light on a number of external conditions affecting the occurrence of autokinetic experiences, e. g. the size of the figures, their shape, "frame", and time of exposure, and

c) to draw attention to the part possibly played by social factors (the presence of other people). Much of this leads on to a number of unsolved problems of research. We lack not only organizing classification of autokinetic phenomena, but also quantitative determinations, and detailed causal descriptions.

Finally, it may be noted that the concept autokinesis has acquired a wider sense since it was formed by AUBERT in 1887. The term is now used not only to describe the experience that figures change their position and/or direction in relation to the observer although the figures as physical objects remain motionless, but also as a description of the strange phenomenon that a figure is difficult to localize although as a physical object it is motionless.

Our investigations concern a new kind of autokinesis. Our figures remain in the same position, but the *parts* of the figures are experienced as moving. Since these movements are of an oscillating kind they might be called *oscillating autokinesis.*

B. The purpose of the investigation

The present paper gives an account of a series of experiments with oscillation experienced in the perception of figures, either projected onto a screen, or shown by stroboscopic light in a dark optical box. New devices and new methods have been used in the investigations.

II. Method

A. Projection experiments

A line-figure consisting of a white isosceles triangle on a dark ground (see Diag. 2) was projected onto a screen (see Diag. 1) in front of the subjects of the experiment, who sat in a dim light 2·6 m from the screen. The base of the triangle was 16 cm long, the thickness of the lines was approximately 1·5 mm, and the vertical angle was 135°.

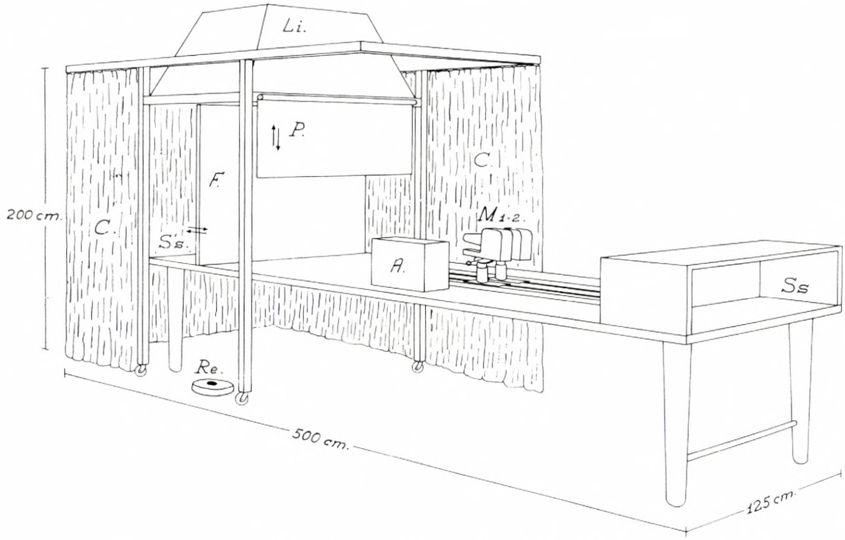

Diagram 1. The experimental equipment.

Diag. 1 shows an experiment table with room for the subjects, the optical box, the projection screen, and apparatus. The letters indicate:

Ss: Subject, placed at a desk at one end of the table in a position to see figures projected onto the screen P.

M_{1-2}: Two projectors, which run on rails, and can be raised, lowered, and turned as desired with the help of screw mechanisms.

S's: Subject placed at the other end of the table in the optical box in a position to see figures shown in the frame F.

C: Double curtain, black and green. This can be pulled round all four sides, forming walls for the optical box. The room has already been partially darkened with the help of black blinds.

Li: Light-box, providing daylight in the optical box. Possible variation of illumination level at eye level: 5–100 lux (measured with luxmeter type PLx 300/3000 F Metrawatt). The bottom (transparent frosted plastic sheet) of the light-box forms the ceiling of the optical box. When the lamps in the light-box are not lit it is practically dark in the optical box.

Re: Variable resistance for control of light intensity in the optical box.

A: Example of apparatus and aids for the experiments placed on the experiment table: 2 impulse shapers, stroboscope, timer, impulse generator, A. F. oscillator, tape recorder, note box, etc.

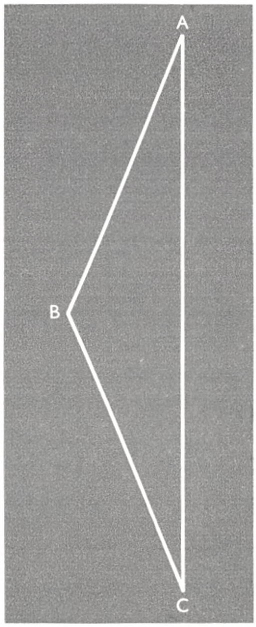

Diagram 2. Figure used for the basic experiments.

As the figure for these experiments we chose an isosceles triangle with the angle ABC = 135°, among other reasons because in favourable conditions the base of such a triangle is experienced as curving in a direction contrary to that of the obtuse angle.

We have termed the experiment with the light figure on the dark ground the basic experiment. But secondary experiments were made with a dark figure on a light ground. These experiments did not differ significantly from the basic experiments either in quality or in quantity. A number of subjects stated however that the figure used in the basic experiment was easier to work with.

The task of the subjects was to give an account of their experiences of the parts of the triangle: the base, the two sides, and the obtuse angle, including any movements of these. They were instructed accordingly. The subjects observed that the parts of the triangle oscillated, e. g. that they experienced that the base moved like a string swinging from side to side. I had observed these oscillation phenomena myself during a long period, and they were now confirmed by the subjects. The first aim now was to get as good a qualitative description of these movements as possible. We tried to achieve this by letting the subjects not only recount their experiences but also sketch them in on diagrams of the figure shown on the screen. Secondly, our aim was to determine the experienced oscillations quantitatively. For this we used two methods, the tap method and the sound method, for mutual checking.

The tap method: We asked the subjects to tap on the table with a pencil keeping time with the experienced oscillations. The experimenter counted the number of taps within a specific period, and the quantitative results – frequency and oscillation time – were worked out on this basis. As the subjects were quickly tired by this exacting task, and the oscillations tended to cease after a fairly short time, we aimed at determining the oscillations within 20 sec. Preliminary (exploratory) experiments have shown that determination over a longer period gave results on much the same scale as over 20 seconds.

The sound method: An audio frequency oscillator (A. F. oscillator) emitted a sound with a specific frequency. On the basis of experiments we chose a sound frequency of approximately 1000 c/s, since we found that this kind of sound was suitable, and agreeable to the subjects, being neither too "blurred" as with deep notes, nor too "sharp" as with higher notes, which can be unpleasant. In order to produce a particular sound-rhythm – a particular interval of time between the beginning of two consecutive sounds – we used an A. F. oscillator in connection with an impulse shaper. This was equipped with units which enabled the speed of the sound-rhythm to be varied until it corresponded to the oscillation experienced by the subject. The duration of the sound, which was generally 100–350 ms could also be changed as the subject directed. We found that some subjects preferred the duration of the sound to be c. 300 ms because a protracted sound of this kind corresponded to a protraction in the movement experienced. Other subjects, on the other hand, liked each oscillation to be briefly marked, and therefore preferred the short sound of 100 ms. In Section VI C we shall return to the methods and discuss their advantages and disadvantages.

Both the A. F. oscillator and the impulse shaper were constructed and put together by the engineering firm of M. P. Pedersen, Copenhagen.

Control measures were taken, e. g. by letting different experimenters do the actual measuring (counting, etc.) simultaneously and independently. Whether we used the tap method or the sound method or both, every subject generally showed the same measurement result in each experiment with the above-mentioned oscillation measurings. The few cases in which a subject's results were in several different stages will be discussed in section III A.

Here, as in the other experiments, there were a few subjects who were for one reason or another unable to carry out quantitative measurings. Two examples may be given: 1) One subject had as a child had an operation for a squint, and as a result looked with his right and left eye alternately, which interfered with the quantitative measurings. He had however no difficulty in drawing the qualitative experiences. It may be remarked that subjects with normal vision could see the oscillations with one eye and provide a basis for quantitative results; this applies to the stroboscope experiments also. 2) A few subjects began to tap, and we recognized the usual rhythm; but the experiences of oscillation quickly ceased. Tape-recordings were made of the subjects' statements, for study later.

B. Experiments with polarized light

For these experiments we used polarization filters in front of the tube of the projection apparatus, and spectacles with polarization glass for the subjects, so that one eye of the subject perceived the sides of the triangle while the other perceived the base. In these experiments the screen was of a special material (thin lamellas of tin-aluminium) suited to polarized light.

C. Stroboscopic experiments

The experiments were made in a darkened optical box (see Diag. 1), the figures, ordinary line-drawings 10×18 cm, being placed in the frame in the optical box at a distance of approximately 20–30 cm from the stroboscope lamp. The distance between the figure and the eyes of the subject was approximately 40–50 cm. The stroboscope flashed e. g. 10–11 times per second, that is 10·5 c/s.

A Disa Stroboscope was used. Frequency range 480–14400 flashes per minute. Accuracy 1 $^0/_0$. Unit allowing connection to an impulse shaper, and control of c/s. Made by Disa Elektronik, Electronic Division of Dansk Industri Syndikat, Copenhagen.

In order to be able to go below the internal frequency limit of a stroboscope, e. g. 8 c/s as for the Disa Stroboscope, we had a special impulse shaper made by the engineering firm M. P. Pedersen. This impulse shaper can externally initiate the flash of the stroboscope in the frequency range 20–0·3 c/s.

The tap and sound methods were also used in this experiment for determining the experienced oscillations quantitatively.

The experiments often resulted in headaches, particularly in the back of the head and neck. Some subjects felt unwell, and suffered from fatigue or nausea. Since this was often the case with subjects who gave valuable phenomenological descriptions it was important to keep a careful balance in these experiments: on the one hand to ascertain the necessary results, and on the other to subject the subjects to as little discomfort as possible.

The basic projection experiments also gave some of the subjects a headache. Altogether, these experiments were extremely tiring. On one subject the experiments made so strong an impression on the first occasion that he could not sleep the whole of the following night, but constantly saw triangles. On the following days of the experiment he had no particular inconvenience from these or the stroboscopic experiments.

D. Terminology

We use the following terminology (see Diag. 3):

R denotes the apical direction of an angle. R_1 and R_2 denote the anti-apical directions of an angle. If the angle ABC in the given situation distorts a straight line, we call it the *deformator*. The base AC of the triangle ABC is termed the *deformandum*, i. e. the line that is distorted by the deformator. The curved line AC is termed the *deformatum*.

As it appears that the deformatum can be experienced both as curving away from the apical direction of the angle (shown

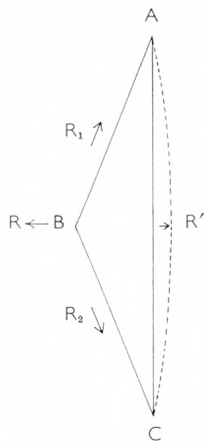

Diagram 3. A straight line AC distorted to a curved line AC. This also shows that the subject experiences the base as distorted into a curve.

in Diag. 3), and as curving in the same direction as the angle's apical direction, we use the term deformatum^{+} where the distortion is away from the apical direction and deformatum$^{\div}$ where it follows the apical direction. We note that the experienced directions – the apical direction of the angle ABC, and deformatum^{+} – are contrary to each other.

III. Oscillations in the Perception of Figures on the Projection Screen

A. Experiments with a triangle: basic experiments

The basic experiments showed that with a small percentage of exceptions all the subjects saw oscillation in the parts of the triangle. The subjects' way of working revealed considerable individual differences. This matter, which is perhaps of importance for differential psychology, will not be discussed further here.

TABLE 1. The number of subjects who experienced oscillation or distortion of the parts of the triangle.

	Any oscillation of the parts of the triangle	The base oscillating or curved	Oscillation of the vertical angle 135°	"Breathing"– simultaneously experienced oscillation of the vertical angle and base
% of all 40 subjects	39 = 97·5 %	37 = 92·5 %	36 = 90·0 %	17 = 42·5 %
% of the 32 subjects referred to in Fig. 1	32 = 100 %	31 = 96·9 %	30 = 93·8 %	15 = 46·9 %

Table 1 shows the appearance of the oscillations. Not only does the large majority of the subjects see oscillation of the parts of the triangle, but a majority also experiences oscillation of the obtuse angle, and oscillation or distortion of the base, approximately 4/5 seeing oscillation and 1/5 distortion (the base curving away from the apical direction of the obtuse angle).

In the beginning some subjects see the base of the triangle as curving away from the apical direction of the obtuse angle, but after a short time they experience it as curving first to one side, then to the other, i. e. it oscillates like a quivering string. The following rule therefore seems to apply, that in given circumstances an angle causes a straight line to oscillate.

In section II, Method, examples were given of reasons why some subjects were unable to carry out quantitative measurings. It is however possible that in some of these cases quantitative data may be obtained by close investigation.

It is also possible that those subjects who in a single experiment did not experience oscillation or distortion of the base may do so after repeated experiments.

The one subject who saw no oscillation took part in only one experiment. Further and more intensive investigations must be made before it can be said whether such a subject is incapable of seeing oscillation.

In most cases this oscillation is experienced with great regularity. As preliminary datum giving the level or extent of the oscillation time, we have arrived at approximately 1.45^{S}, corresponding to a frequency of approximately 0.7 c/s, see Fig. 1.

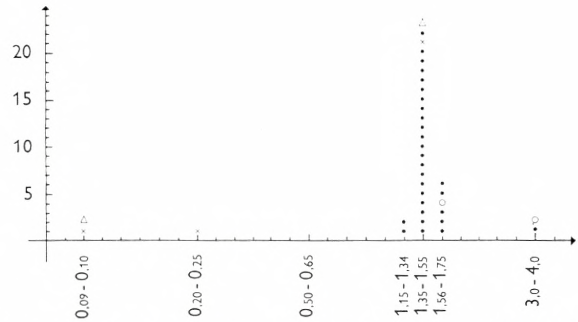

Figure 1. Distribution of the subjects over oscillation times in the basic experiment.
Abscissa: Oscillation time in seconds.
Ordinate: Number of subjects.

The subjects are distributed more or less symmetrically around the oscillation time 1·45 seconds (see Fig. 1). A number of subjects had the oscillation time 1·43 seconds. We have therefore indicated an interval of 1·35–1·55 seconds on this and the following Figures. The maximum deviation of the adjoining intervals from 1·45 seconds is approximately 20 %. A few subjects have oscillations in two or three stages, so that one measurement value comes within the above-mentioned common group, and one is either a very much higher or a very much lower value. The results given by these subjects are denoted by special signs: ×, ○ and Δ. The transition from one oscillation time to another does not take place continuously, but very suddenly. The above-mentioned much higher or lower values, which are here isolated cases, will be discussed further in another paper. It may be noted that 10 subjects who had up to 6–8 repeat experiments provided very similar results.

Each of the subjects was given a drawing of the triangle and asked to indicate on it the extreme positions of the oscillations they experienced. Characteristic types of these are shown on Diagram 4.

Diagram 4 shows seven types of oscillation experienced when the isosceles triangle is viewed on the screen. Of the seven, the large majority of the subjects experience type a, then follow c, d, e, and f, which are almost as common, while experience of type b is relatively rare, and g is in a class of its own. a: The subjects experience the base and obtuse angle as moving outwards simul-

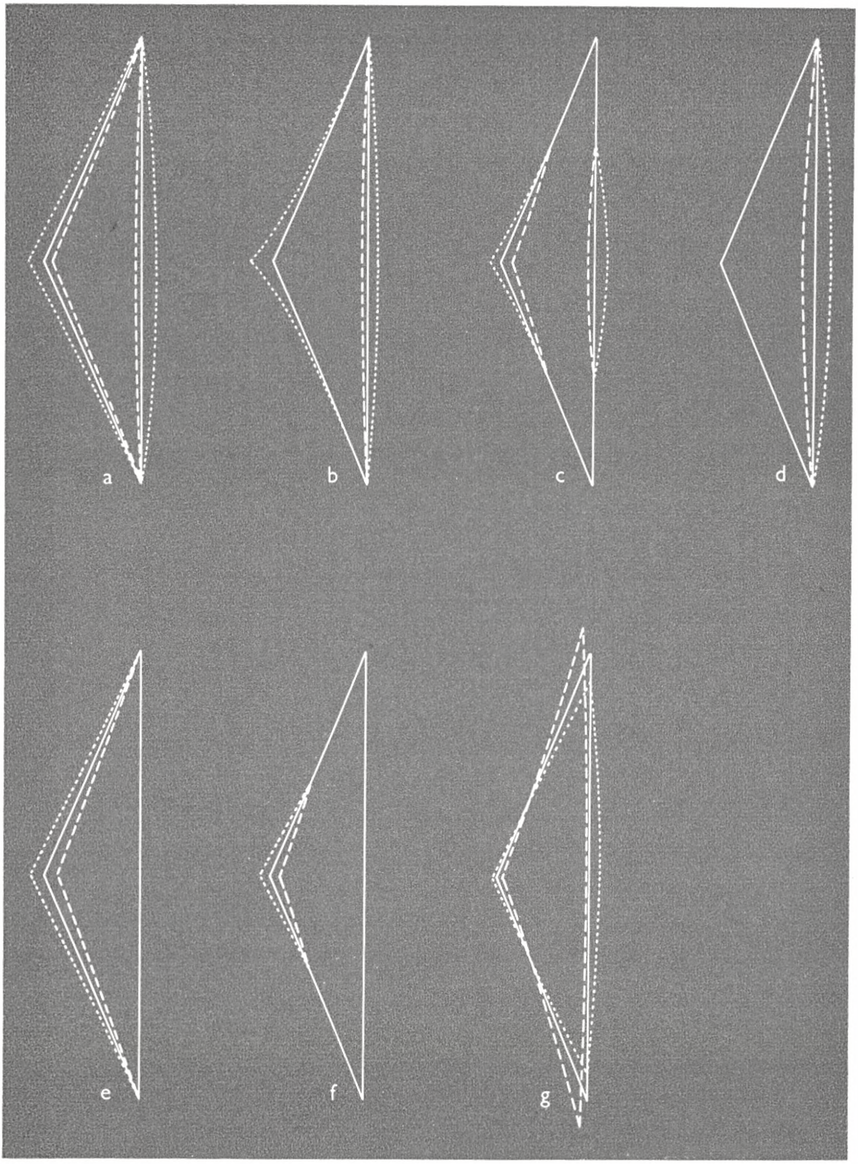

Diagram 4. Examples of oscillations of the parts of the triangle experienced by the subjects.

taneously and then inwards simultaneously. The figure oscillates as a whole – it "breathes", as the subjects put it. Some experience the obtuse angle as pointed, some as rounded. b: Again experience of a kind of breathing, but the movement occurs chiefly in the obtuse vertex, which becomes more pointed, i. e. diminishes in degrees. c: A movement of all parts of the triangle, without the breathing phenomenon. The movement occurs in a large or small part of the sides and the base. The whole of the base in particular may oscillate. d: Oscillation of the whole, or part, of the base. e: Oscillation of the vertex and sides only. f: Oscillation of the vertex only. g: One subject had the special experience that the length of the triangle increased when the width lessened, and vice versa – in his opinion a sort of area constancy.

A few subjects have said in their phenomenological description that slow frequencies (c. 0·7 c/s) show slight indications of being internal (which of course is also the case with the breathing rhythm), while a rapid rhythm of c. 4 c/s "seems more to be part of the actual figure on the screen". Another subject said: "The rhythm quickly acquired a very special character, as if it came from within, as if it originated in the brain or the pulse. The rhythm itself remained, sounding in my ears, long afterwards". A third subject said: "I feel as if I have the rhythm inside me (in my head)". Some subjects are able to feel the experienced rhythm in their heads, without looking at the triangle. One subject, who experienced oscillation with the frequency 0·7 c/s, gave the following account: "I can reproduce the same rhythm without looking at the triangle when I shut my eyes and concentrate. The rhythm occurs as a sensation in my head (between the temples). During the triangle oscillation I discovered that I "knew" or "recognized" the rhythm. I have a more intense, but similar feeling with certain kinds of headache." Experiments with this subject, with eyes closed, showed 25 oscillations in 35 seconds, i. e. about 0·7 c/s. The pulse frequency was considerably higher. Another subject stated: "The picture stays in my mind long afterwards. It is felt as a pressure in the head (like something moving from one temple to the other), as a kind of slight throbbing." On the other hand, other subjects state as their opinion that the experience has to do with something that takes place on the screen.

Thus one subject said: "It is as if the figure lives and breathes. The short sides arch themselves, the angle becomes rounder, and the base oscillates."

These results may seem disconcerting, and some subjects have in fact made remarks that indicate astonishment at their experiences. Thus one subject said: "At first I thought there was something "wrong" about the oscillation, so I hesitated a little before saying how much the figure vibrated. When the experimenter asked me to tap the rhythm I thought this would be quite impossible. To my surprise I found I was able to tap regularly in time with the oscillation."

A single subject had the experience that the triangle advanced and retreated, repeatedly. This experienced oscillation had the frequency 0·7 c/s. When experienced in the first-mentioned position the triangle was twice as large as in the second position. The subject used the expression "Comes towards me and moves away from me". By readjusting himself to the situation this subject had no difficulty in experiencing the usual oscillation of the parts of the triangle.

As regards the subjects' fixation in observing oscillations, the results in the main showed the following interconnections: 1) Fixation of the triangle as a whole occurs together with oscillation of the triangle as a whole, i. e. breathing. 2) Fixation of the vertical angle occurs together with oscillation of the vertex and/or the sides. 3) Fixation of the base occurs together with oscillation of the base. An exception was formed by one subject, who said: "I could only experience movement of the sides of the triangle, even though I looked at the whole triangle!" A number of subjects fixate the vertex and the base alternately, and may thus experience oscillation of both, but cannot synthetize these two movements Thus a subject said: "The part I look at oscillates, i. e. if I look at the vertex it oscillates, if I look at the base that oscillates while the angle remains still."

Finally, it must be remarked that most of the subjects experience a certain depth in the lines forming the figure. Our question to them was formulated as follows: "How thick would you find the lines to be if you were to grasp them with your fingers?" In the answers the following articles were some of those mentioned in comparison: thread, string, a 2 mm thick wire, and a match – altogether a range of thickness of about 0·5–2 mm.

B. The Hering Illusion

The experiments described in Section A showed regularities of oscillation in the perception of a triangle. Do these throw light upon open questions within the field of perception psychology? As regards the oscillation of a line opposite the angle of a triangle this may possibly tell us something about the Hering Illusion. The basis of this is as follows:

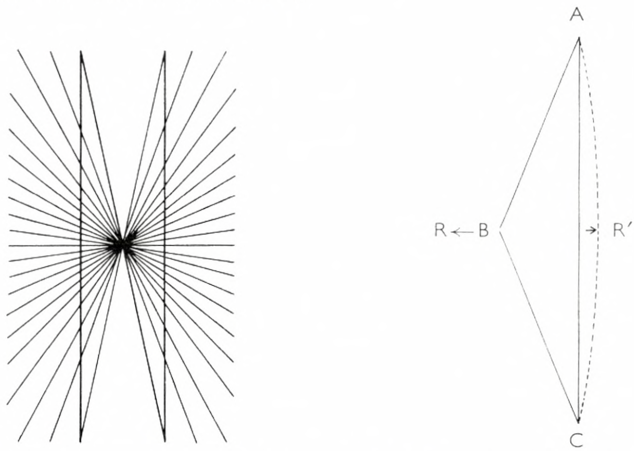

Diagram 5. a. The Hering Illusion. b. Illustration of the Hering Illusion.

In our work on Hering's Illusion (1960 and 1961) we have made a detailed analysis of the pattern of the illusion – the two ray pencils – and its effect upon the two parallel lines, cf. Diagram 5a. The nature of the effect, in brief periods of exposure of fractions of a second, is also investigated. In particular we have investigated the effect when there is a short interval of time between the exposures of the pattern and the parallel lines. These investigations lead to the conclusion that an aspect of the Hering Illusion can be ascribed to the following simple deformation or distortion phenomenon, illustrated in Diagram 5b: An angle ABC distorts a straight line AC into the curve AC, following a direction R′, contrary to the apical direction of the angle.

On a basis of the information gained in Section A, this distortion may perhaps be explained by saying that the curve AC, see Diagram 5b, is the furthest position of a line which oscillates like a vibrating string, but which has stopped at one of its two extreme positions. If this explanation is tenable, we have advanced a step in the understanding of the Hering Illusion, since we now view it in a wider context. In order to make a closer experimental examination of this context, we made experiments with a form of the Hering Illusion which we have termed the simple Hering Illusion, and which is shown in Diagram 6b (cf. also our work of 1960 and 1961). As can be seen, the simple Hering Illusion consists of a simplification of the Hering pattern into two lines only, intersecting at an angle of 135°.

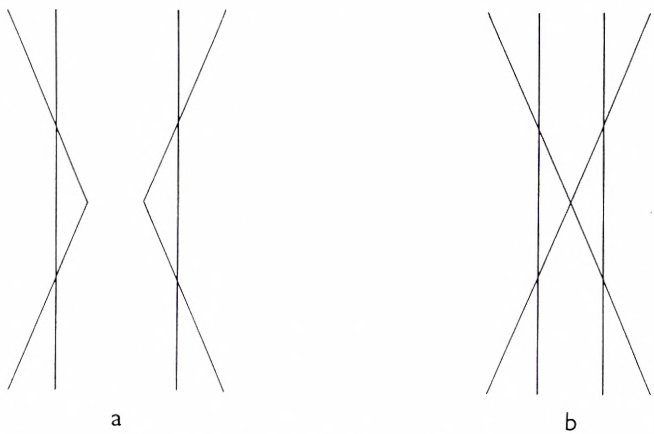

Diagram 6. a. Variation of the figure in the basic experiment. b. The simple Hering Illusion.

First a brief account will be given of how a simple Hering Illusion can be obtained on a basis of the triangle used in the experiments in Section A. The subjects of the experiment were shown on the screen a variation of the figure used in the basic experiment, see Section A, the variation being produced by extending the three sides of the triangle to give the appearance shown in both the two symmetrical figures, cf. Diagram 6a:

Figures of this kind were shown with the aid of the two projectors, the direction of the projection being adjustable by screw mechanisms. When these symmetrical figures are made to touch each other – the obtuse angles are brought together, as the vertices touch – the simple Hering Illusion is produced, cf. Diagram 6b.

In experiments with the two figures the subjects were required to describe their experience, firstly, of one figure or of both figures shown apart from each other as in Diagram 6a, and secondly, when the two figures were brought into contact with each other to form the simple Hering Illusion, cf. Diagram 6b. The subjects were furthermore asked to describe their experiences when the distance between the two figures was made progressively smaller. The figures were shown either as white figures on a black ground, or as black figures on a white ground.

The frequency figures for the oscillations of the parts of the figures in their different variations, cf. Diagram 6a, were on the same level as in the basic experiments. The subjects experienced oscillation both of the bases and of the vertical angles of the triangles.

When the obtuse angles of the figures were about 2 mm apart, some of the subjects experienced the two angles as sometimes touching one another and sometimes separating. When the figures as physical objects touch each other so that they form the figure shown in Diagram 6b, all the subjects experience that the oscillations of the obtuse angles cease. The bases of the triangles (the two – from a physical point of view – parallel lines) are experienced either as distorted (curving like vibrating strings that have remained in the furthest positions of the oscillations, cf. the experience of the simple Hering Illusion), or as oscillating slightly (with small lateral movements). The following description by a subject of such an experience may be taken as an example: "As soon as the triangles touched, the oscillations "froze", and the bases were experienced as curved, but when the triangles drew apart once more the oscillations at once began again."

It may be noted that a number of subjects expressed their experiences by saying that the oscillations "froze". We will not make use of this term, but will say that the subjects experience that an oscillating line stops at one extreme point of the oscillation movement, as a curved line (distorted straight line). We can talk of a distortion of a straight line in the sense that a physical stimulus, namely a straight line, has a corresponding experience, namely a curved line.

It looks as though the obtuse angle is a decisive factor in experiencing oscillations of a straight line which is the base of an obtuse-angled triangle. This view is further supported by the following additional experiments: We showed the base of the triangle mentioned in Section A on the screen. As a rule in these conditions the subjects experienced only extension and abbreviation of the line, occurring in the usual rhythm, namely approximately 0·7 c/s. The subjects drew the changes of length experienced on a drawing of the line: they were generally about two cm, or a little more. When we thereafter projected an obtuse angle beside the straight line, so that the triangle mentioned in Section A was formed, the subjects generally experienced oscillation of the straight line. A future task will be the closer investigation of our experiences with a straight line projected onto a screen in various experimental conditions.

The accounts of their experiences given by the subjects taking part in experiments with the simple Hering Illusion have revealed that there is a connection between experienced oscillation of the straight line and experienced distortion (curved line): the oscillation may stop at distortion. Can we now conversely arrange experimental conditions in which the subjects experience that the distorted straight lines (experienced curved lines) of the Hering Illusion begin to oscillate? This will be discussed in Section IV.

C. Experiments with polarized light

Using the method described in Section II, we found that the subjects experienced oscillations with the same qualitative and quantitative peculiarities as in the basic experiments. The accounts given by the subjects showed, however, that experiments with polarized light involved certain difficulties, particularly in the beginning. Thus one subject said: "Sometimes the obtuse angle suddenly rose from the surface of the screen, so that it was seen as being at right angles to the screen. If I exerted enough will-power, however, I could make it lie flat again."

Two stimuli reach the eyes of the subject: one eye is subjected to the obtuse angle, and the other to the straight line. But in the experience these are united to form a triangle. What happens is that what is received by one eye is affected by what is received by the other eye; and this must take place at some central point. The results suggest that the oscillations experienced derive from central processes. The question of whether the decisive factors in the oscillation experienced are peripheral or central must be left in abeyance for the present – a problem has been raised. We shall return to these questions in another paper.

IV. Oscillation Experienced in the Perception of Figures Illuminated by Stroboscope

This section is an account of experiments made in a dark optical box with figures illuminated by stroboscopic light with a flash frequency of 10·5 c/s, cf. Section II: Stroboscopic experiments. Stroboscopic light is used because experience shows that rhythmical visual stimuli of for instance a frequency of 10·5 c/s produce corresponding electrical rhythms in the cerebral cortex. This point will be dealt with further in Section VI, B in discussing the stroboscopic experiments. As we had expected, the subjects generally experienced marked oscillation of the figures.

The figures used in the experiment were the Hering Illusion (and the simple Hering Illusion), cf. Diagrams 5 and 6, and a triangle. Section V will give an account of comparative experiments, the above-mentioned figures being shown in the optical box in two different conditions, namely, under constant illumination at the number of lux measured under flashlight, and under stroboscope light conditions. The results of experiments in these conditions will then be compared.

A. Experiments with the Hering Illusion

Of the thirty-one subjects who took part in the experiment all except one had also taken part in the basic experiments. With one exception, all the subjects saw oscillations of the parallel lines in the Hering Illusion.

We gave the subjects drawings of the Hering Illusion, and asked them to insert on these the oscillation they had experienced. Diagram 7 shows typical examples. The form of oscillation experienced most frequently by the subjects is one in which the parallel lines move outwards simultaneously, and then inwards simultaneously, i. e. the figure "breathes".

What is the significance of the lines added to the drawing by the subjects? An explanation is given in the following account by a subject in connection with Diagram 7 a: "The innermost line appears to me as a straight line. The outermost expresses my experience of the line as curved. When I have the task of drawing what I have seen, I am in a paradoxical position, in that I have

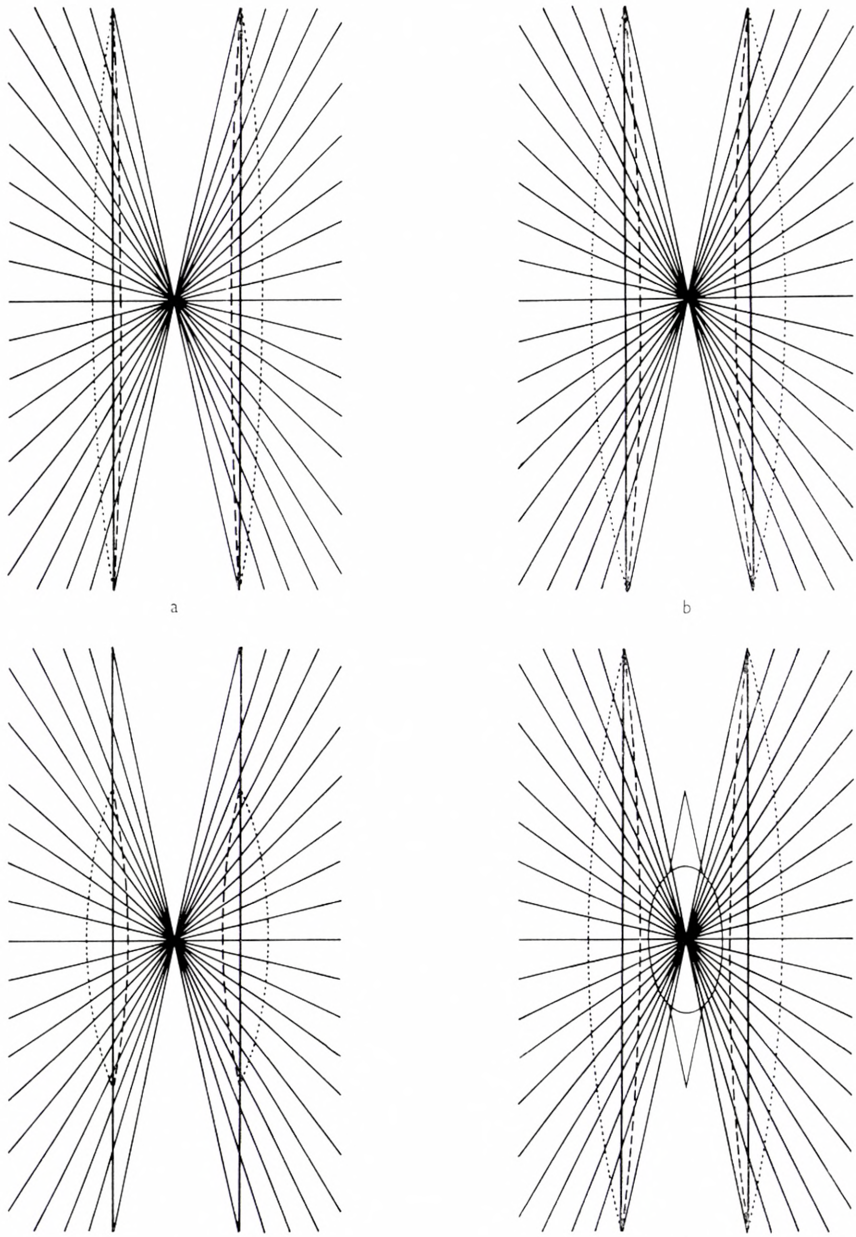

Diagram 7. Examples of the oscillations experienced by the subjects in the Hering Illusion.

to draw a straight line next to a line which I know is in fact straight, but which I experience as curved."

In their experiences of oscillation, the subjects fall into roughly three groups. In all three groups – a, b, and c, – most of the subjects experience the movement as a kind of breathing, but a few cannot synthetize the movement of the two parallel lines, and occasionally experience movement only of one line. The majority experience the oscillation as sketched on Diag. 7a: the distorted straight lines make a movement inwards, so that they are experienced as being straight and parallel. They then swing outwards again, and are experienced as curved. Experiences of types b and c are almost equally frequent. The effect of oscillation is greater both in b and c than in a – the lines pass through the position where they appear straight and are experienced as curving inwards before they swing outwards. Types b and c differ in that the subjects in group b experience oscillation of the lines as a whole, while the subjects in group c experience oscillation of the middle section of the lines only – i. e. that section of the lines where the illusion is also strongest. The subjects' experience of oscillation includes what we call distortion or deformation of the parallel lines by the Hering Illusion.

One subject, who recurs in Diagram 8g, had in addition to an experience of type b the following experience: She fixated the middle of the figure, and saw an ellipse, which moved on the same plane and grew larger or smaller, and, above and below the ellipse, two acute angles, as shown on Diag. 7 d. Both the ellipse and the angles appeared as *white* figures, i. e. in contrast to the black colour of the Hering Illusion. The two ray pencils form two acute angles; it is to be noted that these and the experienced white acute angles point in opposite directions. Since the conclusion (for the time being) of the experiments, the above-mentioned phenomena have been noted by yet another subject, but with a remarkable development. The subject saw four concentric, "slightly oval", *white* rings encircling the centre of the Hering pattern. These white rings, having a linear width of approximately 1·5 mm, and extending (the distance between them increasing) over 3/4 of the width of the Hering pattern, appeared once or twice in the course of the experiment for a few seconds at a time. Further investigations of related subjects are going on and will be published later.

The large majority of the subjects fixate either the centre of the figure (where the pencils meet), or the figure as a whole. A few vary between fixation of the centre and of the whole figure. One subject gave the following account: "The oscillations occurred both when I fixated the centre of the figure, and when I "moved out" to the parallel lines." Practically all these subjects experience the movements of the parallel lines as breathing. Five subjects fixate one of the parallel lines, two of them the right line, and three the left. One of these subjects states: "It was easier to make the left line move. I could not see any movement when I looked at both lines at once." Three subjects fixate the right and the left line alternately.

Of the 31 persons who took part in the experiment, 25 provided a basis for quantitative measurements.

The oscillations experienced most frequently occur almost immediately, or a few seconds after the beginning of the experiment. As was sometimes also the case in the basic experiments, it is often necessary for the subjects to settle down a little before quantitative determination can be made; they can often tell themselves when they have gained the necessary calmness. The leader of the experiment would instruct them, for instance, to relax the muscles of their shoulders, and breathe regularly.

The sound method can be very valuable, not least in stroboscopic experiments: the subjects can concentrate on the oscillation experienced, and compare it with the rhythm heard, while the ticking of the stroboscope fades into the background. The subjects often demand a minute change in the sound rhythm before they are satisfied. They find it easy to tap out the frequency of the oscillation experienced, and to say when it agrees with the rhythm marked by the sound method. The result of the quantitative measurements can be seen in Figure 2.

The diagram in Fig. 2 shows the results of the stroboscope experiments with the Hering Illusion.

A subject having two results at different levels is indicated by ×. Practically all the ten subjects who repeated the experiment most frequently (3–6 times) gave very similar results.

The results of the basic experiments and the stroboscopic experiments with the Hering Illusion agree, cf. Fig. 1. This shows that the optical system is so constituted that we experience oscillation of the parts of a triangle, cf. III A, with the same frequency, about 0.7 c/s, as we experience oscillation of the parallel lines in the Hering Illusion when these are made to oscillate by means of stroboscopic light whose frequency corresponds to the basic electric rhythm of the brain (the alpha frequency: 8–13 c/s).

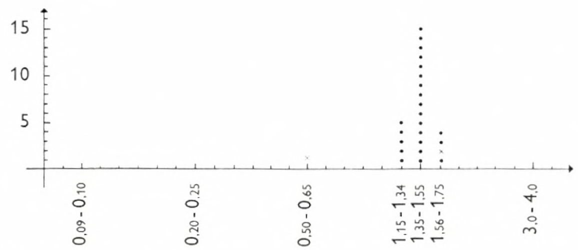

Figure 2. Distribution of the subjebts over oscillation times with the Hering Illusion by stroboscopic light.

Abscissa: Oscillation time in seconds.
Ordinate: Number of subjects taking part.

We then examined the simple Hering Illusion. In this we have of course two triangles, each resembling the triangle of the basic experiments. In the simple Hering Illusion an angle of 135° results in distortion, i. e. the parallel lines are experienced as being curved.

It appeared from these investigations that the subjects experience oscillation. The distorted straight lines (i. e. lines experienced as curved) of the simple Hering Illusion proved to oscillate. The frequency of the oscillation was on the same level as those described above in the classical Hering Illusion.

B. Experiments with a triangle

In the experiments now to be described an isosceles triangle with a vertical angle 135° was used; it was drawn with Indian ink on ordinary drawing-paper, its dimensions being 16 cm, and was placed in the frame of the optical box. The experimental figure was in the same position, and of roughly the same size and shape, as in the basic experiment in Section III A.

With a few exceptions, all the subjects had also taken part in the basic experiment. A summary of the results is given below, Table 2.

TABLE 2. Percentage of the 25 subjects listed in Fig. 3 who see oscillation or deformation of the parts of the triangle.

Any oscillation of the parts of the triangle	Base oscillating or curved	Oscillation experienced of vertical angle 135°	"Breathing" – simultaneous oscillation of base and vertical angle
25 = 100 %	22 = 88 %	23 = 92 %	11 = 44 %

All the subjects taking part in this experiment saw oscillation of the parts of the triangle, and only 5 were unable to supply quantitative results. Of the 22 subjects who experience oscillation or deformation of the base only one sees the base as curved, while all the rest experience oscillation of the base.

If we compare this table with Table 1, we see – taking into consideration the larger number of subjects in the basic experiment – that the corresponding figures in the two tables agree.

We gave the subjects drawings of the triangle, and asked them to sketch on these their oscillation experiences. The two curves drawn by the subjects indicate the two extreme positions of the oscillation.

The drawings made by the subjects of the oscillations experienced can be classified in characteristic types, cf. Diagram 8. The following points may be noted in explanation of the figures: a: Experience of a breathing movement. While some subjects experience the vertex as rounded in the outward position, others experience it as absolutely pointed, the sides of the angle on the other hand being rounded. Similarly, the angle may be experienced as more or less rounded in the inward position. b: Again experience of breathing, but with the important difference that the vertical angle becomes more acute. c: Experience of movement of the whole triangle, which cannot however be described as breathing. The movement occurs to a greater or lesser extent in

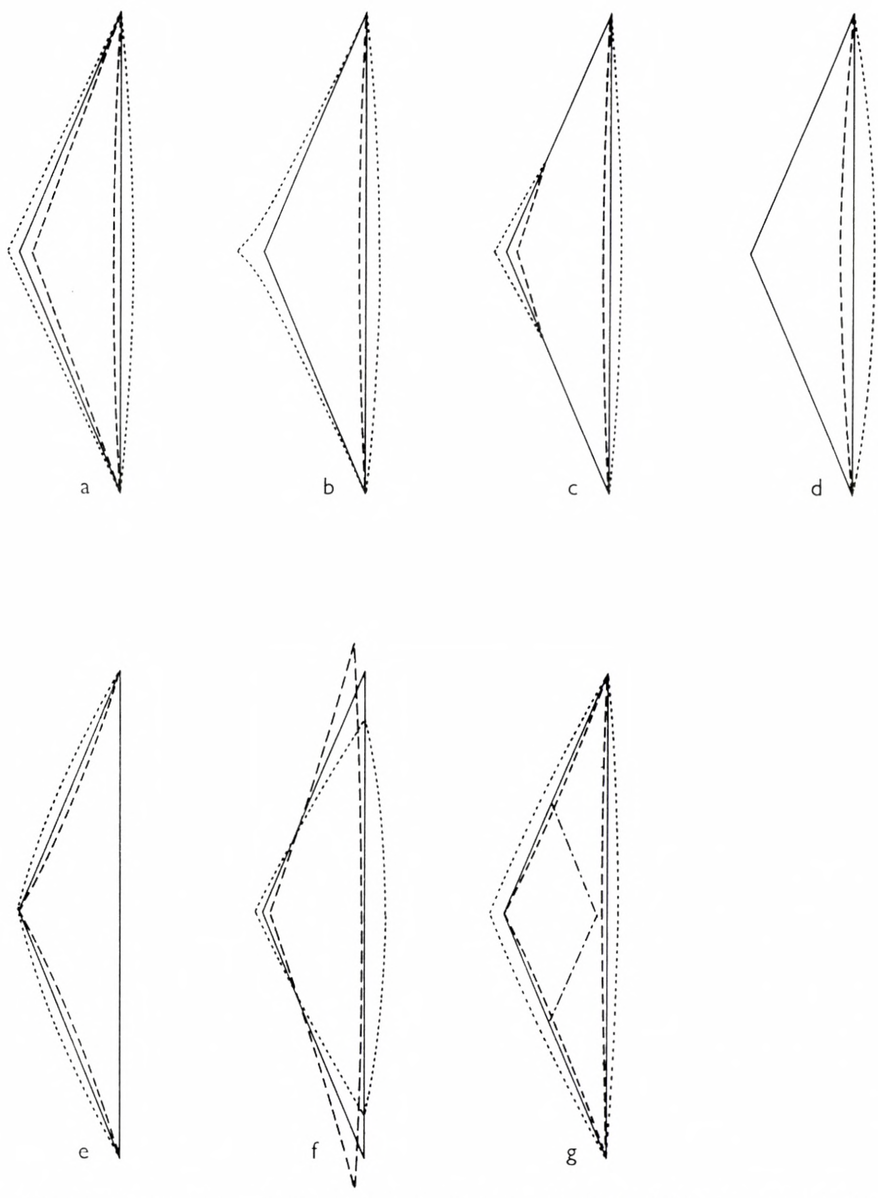

Diagram 8. Examples of the oscillations of the parts of the triangle experienced by the subjects.

both the sides and the base. The whole of the base in particular may oscillate. d: Only the base is experienced as oscillating, while the rest of the triangle remains motionless. e: The sides of the triangle are experienced as oscillating. Fig. f shows a special type, to be found in the primary experiment also. Simultaneously with the inward movement the subject experiences the long dimension of the triangle as growing longer. The subject expressed it thoughtfully as follows: "Perhaps the fact that the length increases when the width diminishes, and the length diminishes when the width increases amounts to a kind of experienced area constancy." Fig. g is also remarkable. Here in addition to breathing of the triangle the subject experienced the formation of a rhombus inside the triangle. This was composed of the obtuse angle of the triangle, and a *white* angle symmetrical with this – in fact a sort of contrast to the black angle. One notes that the directions of the white angle experienced and the black obtuse angle are opposite (cf. Section A, Diagram 7, Fig. d). Of the types of oscillation shown, a is the commonest, and then c; b, d, and e are more or less equally common, while f and g are exceptional.

Comparison with Diagram 4 shows that in general the types are the same as those in the primary experiments. Taken singly most of the subjects also have the same qualitative experiences in the two series of experiments.

In these experiments the subjects experience oscillation of the triangle or its parts having a frequency, cf. Fig. 3, roughly on a level with those mentioned earlier, cf. Figs. 1 and 2. The quantitative measurement results are on the same level for the different qualitative types. In the main, therefore, the subjects experience oscillation of the parts of the triangle in the same way as in the experiments discussed in Section III A; but as a rule the oscillation occurs more rapidly and easily in the stroboscopic experiments.

The results from practically all the 11 subjects, who have repeated the experiment 3–7 times, proved in the large majority of cases to be identical.

There is the same connection between the point of fixation and the oscillation experiences as in the basic experiment. Here also there are a number of subjects who fixate the vertical angle and the base alternately, either because they find it very difficult to synthetize the movements of these two parts, or because they cannot synthetize them at all. Some of them think that this difficulty may be due to the flashing of the stroboscope. One subject says: "I could not concentrate on both the base and the vertical angle. The flashes confused me." In general, however, the stroboscopic light seems to help oscillation experience, since oscillation has proved to occur more rapidly and

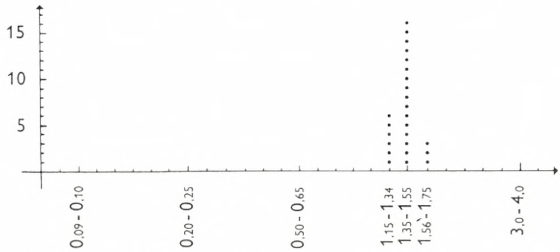

Figure 3. Distribution of the subjects over the oscillation times using a triangle in stroboscopic light.
Abscissa: Oscillation time in seconds.
Ordinate: Number of subjects taking part.

easily in the stroboscopic experiments than in the basic experiments.

Let us finally consider the situation in which the base is experienced in the course of oscillation as curved in a direction away from the apical direction of the vertical angle: in other words, one of the two extreme positions of the oscillation experienced. We then have a distortion of the straight line corresponding to what we have termed deformatum$^+$ (cf. Terminology, Section II). At an earlier date (cf. our work of 1960 and 1961) we made experiments in which the physical objects corresponding to respectively the vertical angle and the base were shown to the subjects with a time interval. Deformatum$^+$ was likewise experienced in these conditions. It therefore appears that this distortion can occur in two different conditions: a) when the physical stimuli occur simultaneously for a very short time several times running (in connection with oscillation), and b) when the physical stimuli occur with an interval of time (unconnected with oscillation). A task to be undertaken in the future is the exact connection between distortion and oscillation in the two different conditions described above.

V. Comparative Experiments

The following is an account of experiments made in the optical box, the figures used being the Hering Illusion, the simple Hering Illusion, and a triangle. The figures, which were placed as usual in the frame of the optical box, were the same as had been used in the stroboscopic experiments, Section IV. The figures were shown partly under constant illumination, partly by stroboscopic light with a flash frequency of 10·5 c/s. When measured with a luxmeter (type PLx 300/3000 F, Metrawatt) the experimental conditions had the same lux total, approximately 25.

The subjects were inter alia instructed to fixate each of the figures in the same way in the above-mentioned two different conditions. Any differences in the oscillations experienced by the subjects will throw light on the part played by the differing feature in the two experiments, namely the appearance of light with the flash frequency 10·5 c/s.

Twelve persons took part in the experiments, of whom half made the experiment with all three figures, two with two figures, and four with one figure. 26 experiments were made altogether, 7 with the Hering Illusion, 9 with the simple Hering Illusion, and 10 with the triangle. The frequencies of the oscillations experienced were in general on a level with those discussed in Sections III and IV.

The results of the experiments provided a basis for quantitative comparisons, since every subject was asked to sketch the extreme positions of the oscillation experienced both by constant illumination and by stroboscopic light on the same drawing, cf. Diagram 9. In all 26 cases the oscillations experienced in stroboscopic light proved to be much greater than in constant illumination. In the case of 8 subjects, where oscillation was experienced in constant illumination, the oscillation in stroboscopic light was up to 6 times greater. The remaining 4 subjects saw no oscillation in constant illumination, but experienced pronounced oscillation in stroboscopic light.

To illustrate the difference between oscillation experienced in constant illumination and in stroboscopic light we have chosen two representative examples, which are reproduced in Diagram 9.

The red and green lines indicate the amplitude of the oscillations

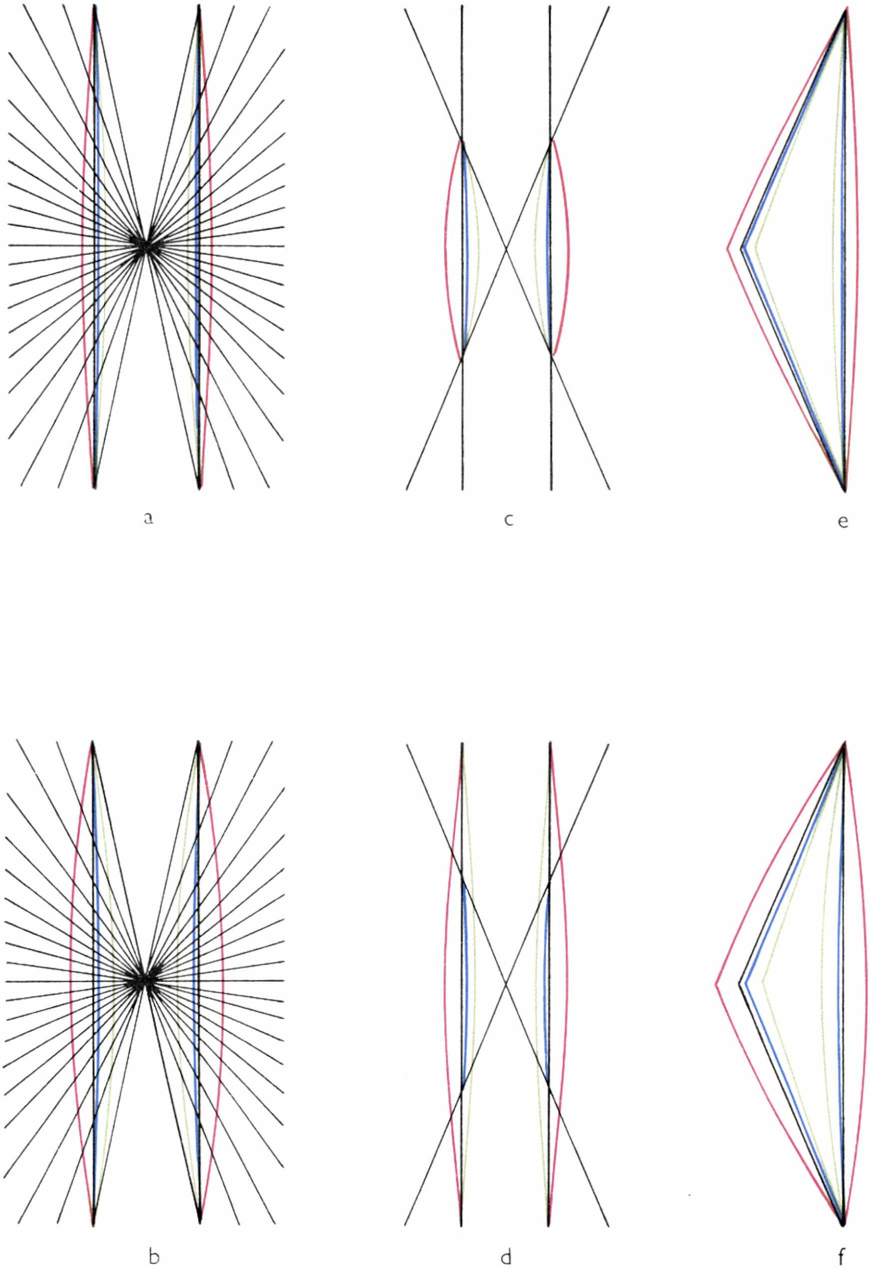

Diagram 9.

in stroboscopic light, while the yellow and blue lines indicate the amplitude of the oscillations when the figures are studied in constant illumination.

As can be seen, in every case the subject experiences a slighter oscillation in constant illumination than in stroboscopic light. The figures also showed that those subjects who experience the most pronounced oscillation (with the furthest extreme points) in stroboscopic light also frequently experience the strongest oscillation in constant illumination.

In the case of the simple Hering Illusion there are two common types, namely c, where the movement takes place solely in that part of the parallel lines cut off by the obtuse angles, and d, where a small part of the oscillation takes place in the parallel lines beyond the angles.

Thus stroboscopic light emphasizes the oscillation which can be experienced in constant illumination.

The comparative experiments have shown that the fact that the light occurs with a flash frequency (namely 10·5 c/s) is of decisive importance for the subject's experience of oscillation.

VI. Discussion

A. Basic experiments

In the basic experiments the base of the triangle was vertically oriented. We also made experiments in which the base was horizontally oriented, and the vertical angle pointed respectively upwards or downwards. These experiments showed that the oscillations are most marked when the vertical angle points upwards. But taken as a whole the best result (the widest and most marked oscillations) was obtained with a vertical base, i. e. with the particular figure selected by us. We furthermore found that the subjects also experienced oscillations of the same frequency when the vertical angle was 90°, 45°, and 22 $^1/_2$°. In general, however, the selected angle of 135° proved to be the best for the subjects' experience of oscillation of parts of the triangle.

It must be left to future experiments to make a closer examination of other parameters, both in these and in the other experiments: the size and thickness of line of the figure, illumination levels, colours, etc. Investigations using other figures, e. g. a quadrangle, must similarly be the task of future experiments.

B. Stroboscopic experiments

The experiments showed that the flashing of the stroboscope had a marked effect, but the oscillation frequency experienced was generally entirely different from the flash frequency of the stroboscope (10·5 c/s). There is however agreement as to the experienced oscillation frequencies (c. 0·7 c/s) in the stroboscopic experiments and the basic experiments. This agreement in frequencies, together with the fact that the frequencies experienced with stroboscopic light came more quickly and easily, and showed a greater degree of oscillation than in experiments using constant light, indicates that stroboscopic light promotes those frequencies which are experienced without stroboscopic light.

In the basic experiments where the triangle was shown on the screen we found that a few subjects experienced both the slow frequency of about 0·7 c/s and a rapid oscillation with a frequency of about 10·5 c/s – the latter being in fact the flash frequency of the stroboscope. As a rule this frequency was not experienced in the stroboscopic experiments. But it appeared that under special conditions the subjects were able to experience the above-mentioned quick frequency in stroboscopic experiments also. These experiments, which will be more fully described in another paper, took place as follows: we carried out the usual stroboscopic experiments with figures, e. g. the Hering Illusion, in the optical box, the stroboscope being set at a flash frequency of 10·5 c/s. With the aid of special apparatus we were able to limit the number of flashes given by the stroboscope, i. e. we could have 1 or 2 or 3 . . . n flashes on the figure, as we wished. The experiments showed that the subjects did not experience oscillation with the smallest (1, 2 . .) number of flashes. Oscillation of the figure was experienced only with about 6 flashes. This experienced oscillation had a quick frequency, namely c. 10·5 c/s. But at a slightly greater number of flashes – generally after quite a short time – the oscillation experienced suddenly switched to the usual slow oscillation with a frequency of about 0·7 c/s. It thus appears that under special circumstances the subjects are able to experience oscillation of the figures with the same frequency (10·5 c/s) as the stroboscopic flash.

The converse is not the case, however: a stroboscope set at the experienced frequency (about 0·7 c/s) does not have the particular effect of making the subjects experience an oscillation with the frequency of 0·7 c/s. The connection between stroboscope frequency and experienced frequency thus seems to be somewhat complicated.

It appears from the above that the stroboscope frequency 10·5 c/s is more effective than 0·7 c/s in producing experienced oscillation. After preliminary (exploratory) experimentation we chose the stroboscope frequency 10·5 c/s because it proved to lie on a frequency level (corresponding roughly to the alpha-frequency area in the electro-encephalogram, 8–13 c/s) which taken as a whole produced greater effects as regards experienced oscillation (with a frequency of 0·7 c/s) than either higher or lower frequencies. This preliminary experimentation at the beginning of the stroboscopic experiments has been followed by more systematic, but as yet uncompleted, experiments with numerous subjects, an account of which will be given in a later paper. So far, these more systematic experiments have mainly confirmed the findings of the preliminary experiments, which suggested an optimum effect of stroboscopic light at about a frequency of 10·5 c/s with regard to producing experienced oscillation with the frequency of about 0·7 c/s. How complicated this is, and how individual differences emerge, is shown inter alia by the above-mentioned experiment with 1, 2, 3 . . . n flashes, where one subject proved able to continue to see the rapid frequency of approximately 10·5 c/s in a stroboscopic light lasting several seconds or minutes. Before this series of experiments the subject experienced the usual frequency of 0·7 c/s when the stroboscope flashed at 10·5 c/s. Some subjects are able (within certain limits) to follow the flashing of the stroboscope, i. e. they experience the frequency at which the stroboscope is flashing.

The stroboscopic experiments have revealed connections between stroboscope frequencies – rhythmical visual stimuli – and the frequencies of experienced oscillations. Connections between rhythmical visual stimuli and the rhythmical nerve discharges of the cerebral cortex have been discussed in the literature on this subject. But the necessity of elucidating the connections between the frequencies of experienced oscillations, rhythmical visual stimuli, and the electrical discharges of the cerebral cells creates new problems in the field of research.

Concerning this connection between the electrical activity of the brain and rhythmical visual stimuli Grey Walter (1950) states (p. 75): "Rhythmic physiological stimulation of the visual pathway evokes electrical activity not only in the visual areas of the cortex, but also in remote regions of the brain when the frequency of the stimulus is appropriate." This subject had already engaged the attention of Adrian and Matthews (1934), who inter alia used stroboscopic light with a flash frequency of 8–25 c/s; they conclude as follows (p. 384): "... the frequency of the rhythm can be altered by exposing the eyes to a uniform field which flickers at varying rates .. The waves then tend to occur with the same frequency as the flicker."

A direct connection of this kind (frequency correspondence) between the frequencies of the visual stimuli administered and the cerebral frequencies has proved not to apply to visual stimuli with slow frequencies – about 1 c/s. Here there is a frequency divergence. Barlow's interesting investigation (1960) – cf. Fig. 4 A, p. 320 – shows that for instance a flash rate of 1·0 and 1·25 produces after-discharge frequencies of 10·9 c/s and 10·6 c/s (lying within the alpha-frequency area). But a number of questions as to this frequency divergence remains unanswered. Barlow's remarks on this frequency relation are inter alia on negative lines; in his Summary and Conclusion, for instance, he says: "... the frequency of the after-discharge is not related harmonically to the flash frequency." This stage in our understanding of frequency connections can, it seems, be compared to our lack of positive knowledge as to the relation between experienced oscillation frequencies of about 0·7 c/s and stroboscope frequencies in the alpha-frequency area.

C. Quantitative determination of experienced oscillations

There may possibly be some misgivings beforehand as to the use of the sound method. Some may feel that the heard rhythm will compel the subject to see a corresponding oscillation of the figure. Experience shows, however, that only a few subjects are suggestionized by the sound. The tap method was generally useful to such subjects. In support of the sound method it may further be added that the subjects are able to keep an experienced oscillation in mind and reproduce it by tapping on the table with a pencil, even when we set the impulse shaper at a sound rhythm that was either too quick or too slow. And if the subjects had obediently seen an oscillation corresponding to the sound rhythm given they would presumably not so eagerly have asked the leader to make minute changes in the speed of the sound rhythm, sometimes a little faster, sometimes slower, before they stated that the experienced oscillation corresponded to the heard rhythm.

The sound method was generally suitable for those subjects who said that they were distracted by the additional task of having to tap while they were concentrating intensely on observing the oscillations. It may be mentioned in addition that the tap method could not be used when the subjects experienced an oscillation with a frequency of about 10·5 c/s, because they were unable to tap 10–11 taps per second. The correct sound rhythm could however easily be obtained. Finally, the sound method is of use when the oscillations disappear quickly.

Lastly, it must be stressed that the two methods of determining the oscillations experienced by the subjects generally showed a close correspondence. Altogether, experience showed that in our experiments the two methods often supplemented each other most satisfactorily, and acted as mutual means of checking.

D. Experienced oscillation

The series of experiments under discussion comprised experiments with various figures. As physical objects these figures have a number of geometrical characteristics.

Under perception the figures (experienced as oscillating or immobile) have a number of phenomenological characteristics. These characteristics – often seen in relation to the figures as physical objects – may be classified in the following groups, to which a few examples have been attached. 1. Deformation, referring to the shape of the experienced figures: curved, rounded, etc. 2. Extension or abbreviation (possibly changes in distance): the base of the triangle may be experienced as becoming longer and/or shorter. 3. Changes in position or situation: the vertex of the obtuse angle of the triangle changes its position. 4. Changes of area: when the oscillation of the triangle is experienced as "breathing" its area in the two extreme positions can for instance have the ratio circa 1:2, or 1:4. 5. Movement – immobility: during the oscillation experienced some subjects may experience a short pause during the oscillation. 6. Change of direction: direction of deformation of the base of the triangle viewed in relation to the apical direction of the obtuse angle. 7. Depth: the lines of the triangle may be experienced as having depth also. 8. Contrasts: colour contrasts. The abundance of the experiences (not merely the iterative feature), of which this classification gives a slight impression, must constantly be borne in mind when seeking a deeper understanding of experienced oscillation.

In connection with our use of the term deformation, it must be stressed that this can signify both a feature of an oscillation sequence (an extreme position, a phase), and a feature of an immobile figure (part of a figure), e. g. the base of the triangle curving away from the apical direction of the angle. In connection with the above-mentioned 8 groups it may be noted that certain features reappear constantly in the subjects' experiences; this applies not least to deformation. The drawings made by the subjects of the experienced extreme positions of the figures show important features in the repetitions experienced during oscillation. These experienced iterative features form the basis of the quantitative results.

It often seems to be difficult to say exactly what it is that oscillates, still more to say what it is that keeps its identity during oscillation. As a rule a specific figure or object is not experienced as moving, changing position, or making rhythmical movements, like, for instance, the straw-press in a threshing-machine. The experiences are more in the nature of rapid development or growth, where changes are constantly taking place. For example, when the obtuse angle oscillates there is a constant change of form between the extreme positions.

In the attempt to arrange and classify the phenomenological features and peculiarities, and to compare the characteristics of the figures as physical objects with their phenomenological characteristics, we have for the moment in this paper stopped at the above-mentioned 8 groups. The last-mentioned aspect is more commonly expressed by saying that there is a geometrical-optical illusion. For the sake of convenience this expression can still be used, provided that one realizes that it is insufficient, and can be unfortunate or confusing – not least if the term optical deception is used instead. One would after all hardly think of describing colour experiences as optical deceptions because there is a striking difference between colours as physical stimuli and as experiences.

Further elucidation of the concepts discussed in Section II, D, and of the factors affecting experienced oscillation – illumination levels, light flashes, the structure of the figures, the physical and mental condition of the subjects, etc. – will be the task of future investigations.

E. The Hering Illusion

In our papers of 1960 and 1961 we reached the conclusion that one aspect of the Hering Illusion can be traced back to the simple deformation phenomenon in which an angle deforms a straight line into a curved line, in such a way that the direction of deformation is away from the apical direction of the angle. The explanation of this deformation may perhaps be that the curved line is one of the two extreme positions of an experienced oscillation, i. e. that the line has oscillated from side to side, but has stopped.

The results of the experiments with both the Hering Illusion and the simple Hering Illusion tend to confirm this view as a working hypothesis. If this view proves after further experiments to be tenable, we shall have advanced a short step further in our understanding of the Hering Illusion, because we shall then be able to view it in a wider context.

The next problem to be investigated will then be why the oscillations generally stop in the form of deformator^{+} and not in the form of deformator$^{\div}$. Can this feature be classified with similar phenomena, so that a further step can be taken in our understanding of the Hering Illusion?

F. Movements of the head and eyes

Can the experienced oscillations be due to movements of the eyes? What is needed is exact analysis of the frequencies characteristic of the "frequency spectra" connected with the movements of the eyes, for instance during fixation. The frequencies quoted in recent literature are often given within wide margins, and inconsistently, e. g. 5–10 c/s, see ADLER (1950) p. 393; 30–80 c/s, see DITCHBURN and GINSBORG (1953) p. 6; 30–150 c/s, see DITCHBURN (1956 b) p. 467; in fact, right up to 200 c/s, see DITCHBURN (1959) p. 123. As regards the regular rhythms mentioned, it can at present be stated that they are most frequently quicker than the frequencies characteristic of the oscillations experienced by the subjects in the perception of figures. DITCHBURN (1956 a) p. 615 however gives a slow rhythm of about 1 c/s. But in a letter to me (30.3.61) concerning his experiments in progress at Reading University Professor DITCHBURN says: "We cannot measure down to 0·7 c/s". It seems natural to look for a connection between the experienced oscillations of approximately 10·5 c/s and a frequency of eye movement of about 10 c/s (cf. ADLER (1950)). As opposed to this, DITCHBURN says of optic frequencies, in his letter of 30.3.61: "There is none at the alpha rhythm frequency" (8–13 c/s).

Registration of eye movements under the conditions applied in the experiments would probably throw light on the question of the connection between experienced oscillations and the frequency of eye movements. It is possible that eye movements in some as yet unknown way help to bring about the experienced oscillations. One could reasonably imagine arguments *against* this hypothesis, including the following: 1) The subjects sometimes find that the oscillations suddenly cease, and after a time begin again with equal suddenness. This would therefore mean that the eye movements also cease; not necessarily all the eye movements, however, but only that/those within the frequency spectrum which helps to create the experienced oscillations. 2) Subjects are able to experience the oscillation described as "breathing" with one eye only; and one eye cannot move in two different directions at the same time. An experience of this kind – depending upon eye movements – also seems unlikely when the subjects are using both eyes. This argument seems convincing; but it must on the other hand be remarked that it is quite possible that the amplitudes of a rapid eye movement, e. g. one of 67 c/s, might vary in size so that the very frequency corresponding to the experienced oscillation – approximately 0·7 c/s – is obtained. Such a circumstance is of course similar to the modulation envelope encountered in radio engineering. 3) If the experienced oscillations were caused by eye movements one would not expect the wide individual differences in quality. Such individual differences might however also occur in eye movements.

Those who hold the view that eye movements may be of significance in experiencing geometrical-optical illusions may argue that eye movements probably formed a factor in our experiments dealing with geometrical-optical illusions. This argument might perhaps be weakened by the following: In his work of 1958 Pritchard investigated geometrical-optical illusions in conditions which excluded the effect of eye movements, the images striking the same spot on the retina, and found that the illusions were experienced in the usual way.

As we found the usual methods of immobilizing the subject's head – chin supports, etc. – unsatisfactory, we had two strong symmetrical steel devices made. Each of these consists of a cylinder (to be attached to the table) equipped with a movable arm, which is adjustable both vertically and horizontally. The two arms each end in a solid, specially constructed "alligator clip", for fastening a spectacle frame of a suitable size. This device ensures that the subject's head remains still in a certain position, held by the spectacle frame. But the results of the experiment showed no significant difference from the results obtained when the subject was free to move his head – a condition which we for several reasons prefer to the above-mentioned artificial restriction.

G. Biological rhythms – experienced oscillations

Many biological functions are marked by rhythms, e. g. the electrical discharge of the cerebral cells. These biological rhythms have in many cases been insufficiently investigated, and are vaguely formulated from a quantitative point of view.

We have only a slight knowledge of the relation between the features of our experiences and the features of the structure and function of our bodies, especially of the central nervous system. Similarly, we know next to nothing of the regular connection between biological rhythms and experienced oscillations. As regards this connection, it may be noted that one subject said that she found that the flashing stroboscopic light affected the rhythm of her breathing. Experiments are at present being carried out in the laboratory to investigate connections between the subjects' respiration and experienced oscillations in the perception of figures.

To our knowledge no experimental results exist which may be compared with ours. Our observations are therefore at present isolated. In this situation we have found it convenient to aim at experimental results in which the level or order of magnitude of the oscillations is given in c/s and frequency times. These preliminary results regarding experienced oscillation have been obtained with subjects of whom the majority – approximately 75 $^0/_0$ – were university trained (students, graduates, professors, etc.). All the subjects were adults (male and female) with the exception of a girl of 7 $^1/_2$, whose utilized results in this connection did not differ significantly from those of the adults. A far wider field of human types and social groups will be needed in order to form a basis for more general quantitative regularities of experienced oscillation in the perception of figures. It may however be mentioned that the comparatively few subjects who did not belong to the main academic group experienced oscillations in the same way, both qualitatively and quantitatively.

The task of future experiments must therefore be: 1) to experiment with a larger number of subjects, 2) to obtain numerous results from a number of individual subjects, both for a short period, e. g. 24 hours, and for a longer period. As described in Sections III and IV, we have already repeated the experiments with a number of subjects. These showed that the oscillations experienced by the subjects are more or less constant when repeated, both qualitatively and quantitatively. It is possible, however, that the experienced oscillations may be dependent on time in the sense of being subject to rhythmical variation, e. g. in connection with the 24-hour rhythm.

Perhaps the experienced oscillations will prove to be dependent on temperature, like for instance the alpha-rhythm of the electroencephalogram.

In further research into the problems discussed here – in connection with efforts to improve methods and apparatus – the experimental apparatus might possibly be extended to register a large or small number of the biological rhythms of the subjects simultaneously with the registration of the experienced oscillations. Among biological rhythms of special interest one may mention the EEG-rhythm, the respiratory rhythm, and the rhythmical movements of the eyes, which are at present being studied in detail at the J. J. Thomson Physical Laboratory, Reading University; a number of important results of this investigation are as yet unpublished, including those dealing with the frequency analysis of the "spectrum" of the eye- rhythms.

VII. Summary and Conclusion

1. We have described both qualitatively and quantitatively oscillations in the perception of figures experienced in a series of experiments, the figures being sometimes projected onto a screen, sometimes illuminated by stroboscopic light in a dark optical box. New experimental devices and methods were used.

2. In the basic experiments the physical stimulus used was an isosceles triangle with a vertical angle of 135°, projected onto a screen in a dim light. The large majority of the total number of subjects experienced oscillation of parts of the triangle or the triangle as a whole. These oscillations have been qualitatively described on a basis of drawings made by the subjects; the descriptions fall into different characteristic types.

We have ascertained that it is possible to determine the frequency of the experienced oscillations quantitatively by means of a tap method and a sound method. As a preliminary experimental result, giving the level or order of magnitude of the oscillation period, we have found approximately 1·45 sec., corresponding to a frequency of approximately 0·7 c/s. The quantitative results for each of the oscillation types experienced are on the same level.

3. The basic experiment can be varied by prolonging the three sides of the triangle and supplementing this figure with another symmetrical with it. When these two symmetrical halves of the simple Hering Illusion, which were to begin with separate, are brought into contact with each other at the obtuse vertices, the experienced oscillations of these angles cease. The parallel lines, on the other hand, stop at the extreme positions of the oscillation as deformed (outward curving) lines, or oscillate slightly. An explanation – expressed as a working hypothesis – of the deformation of the parallel lines in the simple Hering Illusion may perhaps be that the deformed lines are the extreme positions of lines which oscillate, but which have stopped at these extreme positions.

4. Experiments with polarized light suggest that the experienced oscillations are partly a result of central processes. The question of whether the factors producing experienced oscillation are peripheral or central may be left open; a problem has been raised.

5. Experiments were made in a darkened optical box, in which the subjects saw figures, black line drawings, lit by stroboscopic light which flashed with the frequency 10·5 c/s. This frequency was chosen on a basis of preliminary experiments. These showed that frequencies on this level gave greater degrees of oscillations (in connection with an experienced frequency of approximately 0·7 c/s) than either higher or lower frequencies. The figure used first was the Hering Illusion. The oscillations experienced by the subjects fell into characteristic types. The following are some of the characteristics of the oscillations experienced: 1) curved lines (what we term geometrical-optical illusion: deformed straight lines in the Hering Illusion), and 2) straight lines.

The oscillation frequency of each type of oscillation experienced is on the same level. This level is in general the same as in the basic experiments.

Similar results were obtained with the simple Hering Illusion.

6. In the above-mentioned experimental conditions experiments were made, using stroboscopic light, with a triangle of the same size as that used in the basic experiments. In general, the subjects experienced the oscillations as in the basic experiments; but as a rule they occurred sooner and more easily. The qualitative oscillation types were in the main the same in the two experimental conditions, and the oscillation frequencies were

roughly on the same level; this was also the case with the quantitative results of the individual oscillation types.

In the basic experiments without stroboscopic light and the experiments with stroboscopic light respectively, where three different figures – the Hering Illusion, the simple Hering Illusion, and the triangle – were used, the frequencies of the experienced oscillations were on much the same level.

7. Comparative experiments were made in the optical box with the above-mentioned figures – the Hering Illusion, the simple Hering Illusion, and the triangle. The figures were shown both in a constant light, and in a stroboscopic light with a flash frequency of 10·5 c/s. When measured with a luxmeter the two experimental conditions showed the same number of lux, approximately 25. In every case the subjects experienced far more marked oscillation by stroboscopic light than by constant light. On the other hand, the frequencies of the oscillations experienced were on much the same level. These comparative experiments have shown that the fact that the light appears with a flash frequency of 10·5 c/s is of decisive importance for the subjects' experience of oscillation. The flash frequency of the stroboscopic light produces a marked increase in the oscillation that can be experienced in a constant light.

Preliminary experiments, to be discussed in detail in a later paper, have shown that under special conditions, namely when the stroboscope flashes a few times (but with the usual frequency) the subjects experience an oscillation frequency, of approximately 10·5 c/s, corresponding to the flash frequency of the stroboscope. But we found that a few subjects may experience such a rapid oscillation (c. 10·5 c/s) in a constant light also, namely in the basic experiments.

The flash frequency 0·7 c/s does not produce experienced oscillation with the frequency c. 0·7 c/s. The experienced oscillation frequency of approximately 0·7 c/s is not directly initiated by the flash frequency of the stroboscope, but is a feature of the method of functioning of the optical system. On the other hand the experienced oscillations are increased by a stroboscopic frequency of 10·5 c/s, as described above.

8. In both the basic experiments and the experiments with stroboscopic light success was obtained when the subjects used only one eye; and the qualitative experience is the same, this

being also the case when the subject experiences "breathing" (the experienced oscillating parts of the figure draw together and move apart).

9. A small group of subjects experienced internally (in the head) a frequency corresponding to the oscillation experienced in the perception of the figure. A single subject recognized the experienced oscillation from certain types of headache, and was able to tap the frequency with her eyes shut. The experiments have revealed a number of individual differences in the whole way in which the subjects tackle the tasks imposed by the experiments; this may be of significance in the field of differential psychology.

10. In perception the figures (experienced as oscillating or motionless) have a number of phenomenological characteristics. These have been compared with characteristics of the figures as physical objects and in this connection the divergences have been stressed. These divergences and the above-mentioned phenomenological characteristics have been classified and named. We have in particular used the term deformation, in connection with divergences of form.

11. It has been ascertained in the course of the experiments that the experienced oscillation frequency differs from the pulse frequency of the subjects. We have not found that the oscillations are dependent on movements of the eyes or head.

Preliminary experiments (more systematic experiments are as yet uncompleted) suggest that the chosen frequency 10·5 c/s has the optimum effect. This frequency (in an optimum frequency area) is of the same magnitude as the fundamental electric frequency of the brain, viz. the alpha-rhythm. The question of the connection between the experienced oscillations, the rhythmical visual stimuli, and the cerebral electric rhythms may be left open, as a problem for further research.

12. Some of the experiments made have also been aimed at increasing our understanding of the Hering Illusion in connection with experienced oscillation. The results obtained have led us to continue the investigations taking this view as a working hypothesis, and extending the investigation to other classic geometrical-optical illusions.

Acknowledgements

My best thanks are due to Professor F. Brandt, Ph. D., and Professor Lárus Einarson for valuable support and inspiration during the writing of this article.

My thanks are also due to W. Grey Walter, M. A., Sc. D., Mrs. Walter, and other collaborators, for discussions and demonstrations at the Burden Neurological Institute, Bristol.

I likewise wish to thank my helpful and loyal collaborators, and the subjects who so readily placed themselves at my disposal for the experiments.

Lastly, I am indebted for financial support to the Carlsberg Foundation and the King Christian X Foundation.

Address: The Psychological Laboratory, Copenhagen University, Dyrkøb 3, Copenhagen K, Denmark.

Bibliography

Adler, Francis Heed: 1950. Physiology of the eye. St. Louis.

Adrian, E. D., and Matthews, B. H.: 1934. The Berger rhythm: potential changes from the occipital lobes in man. Brain, 57, 355–385.

Aubert, H.: 1887a. Die Bewegungsempfindung. Arch. f. d. ges. Physiol. 40, 459–480.

— 1887b. Nachtrag zu den Artikel "Die Bewegungsempfindung", ibid. 623–624.

Barlow, John S.: 1960. Rhythmic activity induced by photic stimulation in relation to intrinsic alpha activity of the brain in man. EEG Clin. Neurophysiol., 12, 317–326.

Bourdon, B.: 1902. La Perception Visuelle de L'espace. Paris.

Charpentier, A.: 1886. Sur une illusion visuelle. Comptes rendus des séances de l'académie des sciences, 102, 1155–1157.

Ditchburn, R. W.: 1956a. Eye-movements in relation to retinal action. Problems in contemp. optics, 609–623.

— 1956b. Eye-movements and visual perception. Research, 9, 466–471.

— 1959. Physical methods applied to the study of visual perception. Bulletin of the institute of physics, 121–125.

Ditchburn, R. W., and Ginsborg, B. L.: 1953. Involuntary eye movements during fixation. J. Physiol., 119, 1–17.

Ditchburn, R.W., and Pritchard, R. M.: 1960. Binocular vision with two stabilized retinal images. Quart. J. exp. Psychol., 12, 26–32.

Edwards, Ward: 1954. Autokinetic movement of very large stimuli. J. exp. Psychol., 48, 493–495.

Exner, Sigmund: 1896. Über autokinetische Empfindungen. Zs. Psychol. und Physiologie der Sinnesorgane, 12, 313–330.

Guilford, J. P., and Dallenbach, Karl M.: 1928. A study of the autokinetic sensation. Amer. J. Psychol., 40, 83–91.

Holt-Hansen, Kr.: 1960. Herings illusion. Festskrift til E. Tranekjær Rasmussen, 47–57. København.

— 1961. Hering's Illusion. Brit. J. Psychol. (revised version in English of the abovementioned work).

Von Humboldt, Alexander: 1800. Nachrichten aus Süd-Amerika. Fr. v. Zach's monatlische Correspondenz zur Beförderung der Erd- und Himmelskunde. I, 392–425.

— 1814. Voyage aux régions équinoxiales du nouveau continent. Tome I, 125 f. Paris.

— 1850. Kosmos. Dritter Band. Stuttgart und Tübingen.

Karwoski, Theodore F., Redner, Harold, and Wood, W. O.: 1948. Autokinetic movement of large stimuli. J. general Psychol., 39, 29–37.

De Montmollin, Germaine: 1956. L'effet autocinétique comme phénomène et comme instrument. L'année psychologique, 2, 461–474.

Pritchard, R. M.: 1958. Visual illusions viewed as stabilized retinal images. Quart. J. exp. Psychol., 10, 77–81.

Schweizer, G.: 1857. Über das Sternschwanken, I. Bulletin de la société impériale des naturalistes, Tome 30, No. IV, 440–457. Moscou.

— 1858. Über das Sternschwanken, II. Bulletin de la société impériale des naturalistes, Tome 31, No. II, 477–500. Moscou.

Walter, W. Grey: 1950. Features in the electro-physiology of mental mechanismes. 67–78 in Perspectives in Neuropsychiatry. (ed. D. Richter).

Færdig fra trykkeriet den 14. juni 1962.

Det Kongelige Danske Videnskabernes Selskab

Historisk-filosofiske Meddelelser

(Hist. Filos. Medd. Dan. Vid. Selsk.)

Bind **37** (kr. 80,00)

		kr. ø.
1.	RUBOW, PAUL V.: Trold kan tæmmes (The Taming of a Shrew). 1957	6,00
2.	KORNERUP, BJØRN: Lector Theologiæ Jens Poulsen Windings Vita. Et Bidrag til Belysning af de lærde Udenlandsrejser i det 17. Aarhundrede. With an English Summary. 1957	10,00
3.	SZÖVÉRFFY, JOSEF: Volkskundliches in Mittelalterlichen Gebetbüchern. Randbemerkungen zu K. M. NIELSENS Textausgabe. 1958	5,00
4.	JOHANSEN, J. PRYTZ: Studies in Maori Rites and Myths. 1958.	22,00
5.	FERDINAND, KLAUS: Preliminary Notes on Hazāra Culture. (The Danish Scientific Mission to Afghanistan 1953–55). 1959.	10,00
6.	RUBOW, PAUL V.: Kong Henrik den Sjette. 1959	6,00
7.	THODBERG, CHRISTIAN: The Tonal System of the Kontakarium. Studies in Byzantine Psalticon Style. 1960	14,00
8.	AABOE, ASGER: On the Tables of Planetary Visibility in the Almagest and the Handy Tables. 1960	4,00
9.	RUBOW, PAUL V.: King John. 1960	3,00

Bind **38** (kr. 70,00)

1.	BLINKENBERG, ANDREAS: Le problème de la transitivité en français moderne. Essai syntacto-sémantique. 1960	40,00
2.	DIDERICHSEN, PAUL: Rasmus Rask og den grammatiske tradition. Studier over vendepunktet i sprogvidenskabens historie. Med tillæg fra Rasks og N. M. Petersens papirer. Mit einer deutschen Zusammenfassung. 1960	30,00

Bind **39**

(*uafsluttet/in preparation*)

1.	NEUGEBAUER, O.: A New Greek Astronomical Table (P. Heid. Inv. 4144 + P. Mich 151). 1960	3,00
2.	ASMUSSEN, JES PETER: The Khotanese Bhadracaryādeśanā. Text, Translation, and Glossary, together with the Buddhist Sanskrit Original. 1961	18,00
3.	HJELHOLT, HOLGER: On the Authenticity of F. F. Tillisch' Report of November 24th, 1849, Concerning Conditions in Slesvig under the Administrative Commission. 1961	3,00
4.	JOHANSEN, K. FRIIS: Ajas und Hektor. Ein vorhomerisches Heldenlied? 1961	11,00

6. HAMMERICH, L. L.: Zwei kleine Goethestudien. I. Der frühe West-östliche Divan. – II. Grossherzogin Louise von Sachsen-Weimar – eine politische, keine schöne Seele. 1962 9,00
7. HOLT-HANSEN, KRISTIAN: Oscillation Experienced in the Perception of Figures. 1962 9,00

From Vol. 37, No. 1, 1957 the designation *Historisk-filologiske Meddelelser* is changed into *Historisk-filosofiske Meddelelser*. The numbering of the volumes will continue regardless of the change of name. The publications will besides the subjects treated up till 1957, include papers on Philosophy, Archeology, and Art History

On direct application to the agent of the Academy, EJNAR MUNKSGAARD, Publishers, 6 Nörregade, Köbenhavn K., a subscription may be taken out for the series of *Historisk-filosofiske Meddelelser*. This subscription automatically includes the *Historisk-filosofiske Skrifter* in 4to as well, since the *Meddelelser* and the *Skrifter* differ only in size, not in subject matter. Papers with large formulae, tables, plates, etc., will as a rule be published in the *Skrifter*, in 4to.

For subscribers or others who wish to receive only those publications which deal with a single group of subjects, a special arrangement may be made with the agent of the Academy to obtain the published papers included under the head: *Archeology and Art History*, only.

Printed in Denmark.
Bianco Lunos Bogtrykkeri A/S.