Time resolving capability of the human eye (Item No.: P4070300)

Curricular Relevance

Area of Expertise: Biology
Education Level: University
Topic: Human Physiology
Subtopic: Visual Sense
Experiment: Time resolving capability of the human eye

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	1 Hour	1 Student

Additional Requirements:

Experiment Variations:

Keywords:

Perimeter, Time-related resolving power, Flicker fusion frequency, Light/dark adapted eye

Overview

Principle

Theory

As excitation of the light-perceptive cells of the retina always takes a little longer than the light stimulus, only a limited number of stimuli per unit of time can be processed (time-related resolving power of the eye). If a light source is switched on and off periodically in increasingly rapid sequence the eye at first perceives the individual flashes, then the appearance of flicker occurs and finally the impression of a continuous light (fusion of the flicker). The frequency of stimulation at which the latter occurs, the flicker fusion frequency, is related to the intensity, wave length and also the direction of incidence of the light. By adapting to the surrounding light intensity, the eye can change the intensity of light entering through the open (darkened room) or nearly closed (heavily lit room) iris.

Principle

The flicker fusion frequency, the frequency at which the impression of a continuous light source just occurs, is measured to study the time resolving capacity of the human eye. A perimeter is used to study the relation between the light's incidence angle and the flicker fusion frequency.


Fig.1: Experimental set-up with digital function generator

Equipment

Position No.	Material	Order No.	Quantity
1	PHYWE Digital Function Generator, USB, incl. Cobra4 software	13654-99	1
2	Perimeter, diameter 60 cm	65984-00	1
3	Stimulant light source	65985-00	1
4	Support base, variable	02001-00	1
5	Bench clamp PHYWE	02010-00	1
6	Stand tube	02060-00	1
7	Table top on rod	08060-00	1
8	Boss head	02043-00	1
9	Support rod, stainless steel, 500 mm	02032-00	1

Tasks

1. Measure the flicker fusion frequency for all incidence angles between -90° and 90° for the left and the right eye.

2. Repeat the measurements in a darkened room to study the effect of the eye’s adaption to light.

3. Repeat the measurements from task 1 and 2 with another signal-amplitude which corresponds to a different light intensity.

Set-up and procedure

Set-up

The perimeter is fixed to the edge of a table using a bench clamp, a support rod and a right angle clamp so that the aperture is directed away from the window. The perimeter must be fixed in a precisely hori-zontal position. A small table top attached to a support base by a stand tube is adjusted to locate the eye to be tested exactly in the centre of the perimeter. The digital function generator is placed on the bench so that the frequency display cannot be seen by the test subject. As is shown in Fig. 1 he source of the light stimulus is connected directly to the generator output.

Attention: turn up the amplitude only to max. 3 V, otherwise the source of the stimulating light can be destroyed!

Procedure

The test subject should position him/herself so that he/she can hold his/her head on the head support for a long period without moving. Adjust the chair height if necessary. The eye being tested must be fixed on the centre of the inside of the perimeter throughout the experiment. A white mark is fixed in the centre as an aid to focusing. The other eye remains closed. The stimulant light source is brought to the centre of the inside of the perimeter and held by a magnet from the outside. On the digital function generator (Fig. 2) the frequency is set to 10 Hz, the offset is set to 1.5 V and the amplitude is turned up to max. 3 V.

Fig. 2

The frequency is now slowly increased by the experimenter until the test subject’s impression of a flickering light just disappears (flickering merges to continuous light). This flicker fusion frequency is recorded in a table. The stimulant light source is then moved horizontally 10° from the centre and the flicker fusion again measured as described above, starting from 10 Hz. The eye must remain fixed on the focusing mark in the centre of the perimeter permanently. The measurement is repeated at 10° intervals first to the right of the centre until the light source disappears from the field of vision, then to the left. For all angles the frequency is recorded. The measurements are repeated for the other eye.

Note: For a detailed description of the operation of the digital function generator please refer to the manual.

Results and evaluation

Results

In the following the evaluation of the obtained values is described with the help of example values. Your results may vary from those presented here.

Task 1: Analyze the relationship between incidence flicker fusion frequency and incidence angle of the light.

In Fig. 3 the fusion frequency is depicted as a function of the incidence angle of the light (red). There is a sharp peak for an incidence angle of 0° (centered light source) with a slow descent for higher incidence angles both to the left and right from the center position. Towards the retinal periphery, time-related power of resolution is sharply reduced. At 30° the fusion frequency is often lowered to nearly the half.

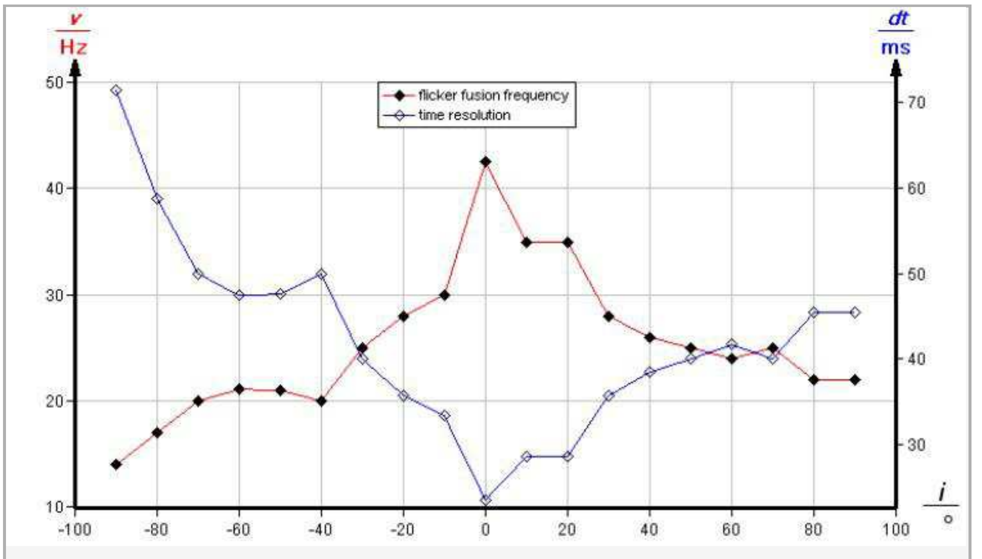

Fig. 3: Flicker fusion frequency and time resolution for different incidence angles of the stimulating light.

The time *dt* is related to the flicker fusion frequency ν as shown in equation (1)

$$dt = \frac{1}{v} \qquad (1)$$

Fig. 3 also shows the relationship between time resolution of the eye and the light's incidence angle (blue). The results may vary for the left and right eye.

Task 2: Analyze the relationship between incidence flicker fusion frequency and surrounding light intensity.

To study the effect of the eye's adaption to light intensities, compare the results from task 1 with the re-sults obtained in the darkened room. Consider commonalities and variations. The values for the inci-dence angle of 0° (incidence of light on the fovea) vary between 20 Hz for the dark adapted eye up to 70 Hz in light adaption.

Task 3: Analyze the relationship between incidence flicker fusion frequency and the intensity of the sti-mulating light source.

An alternative to study the effect of the intensity of the incidenting light is to directly manipulate the ampli-tude of the signal from the digital function generator. A high amplitude corresponds to an widely opened iris of the eye: in both cases more light can enter the eye. Accordingly a lower amplitude corresponds to highly lit surroundings, resulting in a more closed iris. Comparison with the results from task 1 should produce similar findings as task 2.