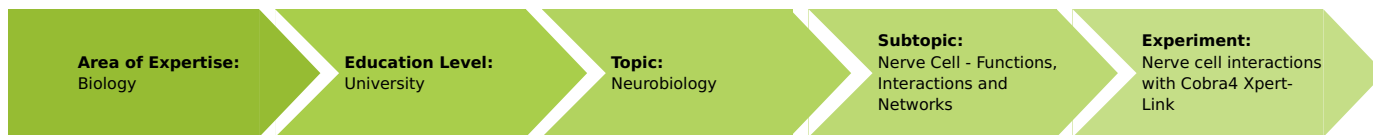


Nerve cell interactions with Cobra4 Xpert-Link

(Item No.: P4010864)

Curricular Relevance



Difficulty



Difficult

Preparation Time



10 Minutes

Execution Time



2 Hours

Recommended Group Size



2 Students

Additional Requirements:

- PC
- Flashlight

Experiment Variations:

Keywords:

Renshaw inhibition, Conditioned reflex, Lateral inhibition, Contrast improvement, Motoneuron

Task and equipment

Introduction

First, perform the experiment "The nerve cell" (P4010764), using the equipment of this experiment.

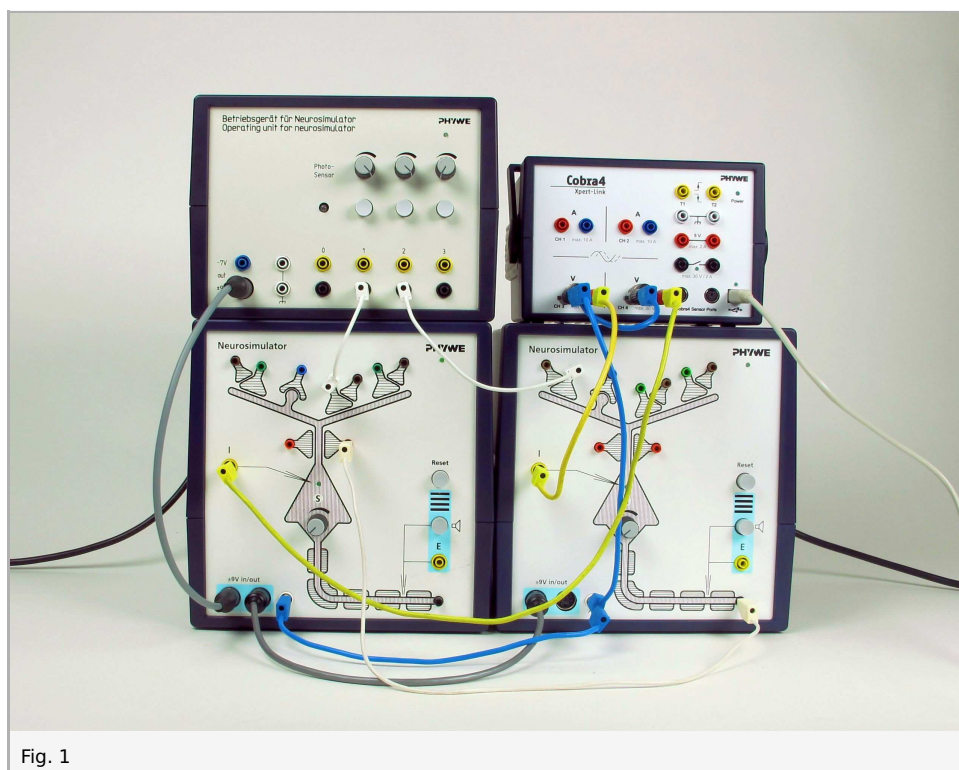


Fig. 1

Function and Applications

The neuron unit Neurosimulator simulates a generalised nerve cell with an apical dendrite and its synaptic contacts, a cell body (soma) and a nerve fibre (axon) with myelin sheathes and a Ranvier's ring.

The operating unit comprises the power supply of up to four neuron units, three touch simulators with a variable stimulating intensity and an optical sensor.

The Cobra4 Xpert-Link is the perfect measurement device for all experiments. Up to 3 values can be measured: 2 values using the two internal voltage channels and optionally, for even more sophisticated experiments not documented here, 1 value via the Cobra4 Sensor Port. (To use the Sensor Port, a Cobra4 Sensor-Unit Electricity (12644-00) and a Cobra4 Xpert-Connect (12625-01) are needed additionally.)

Benefits

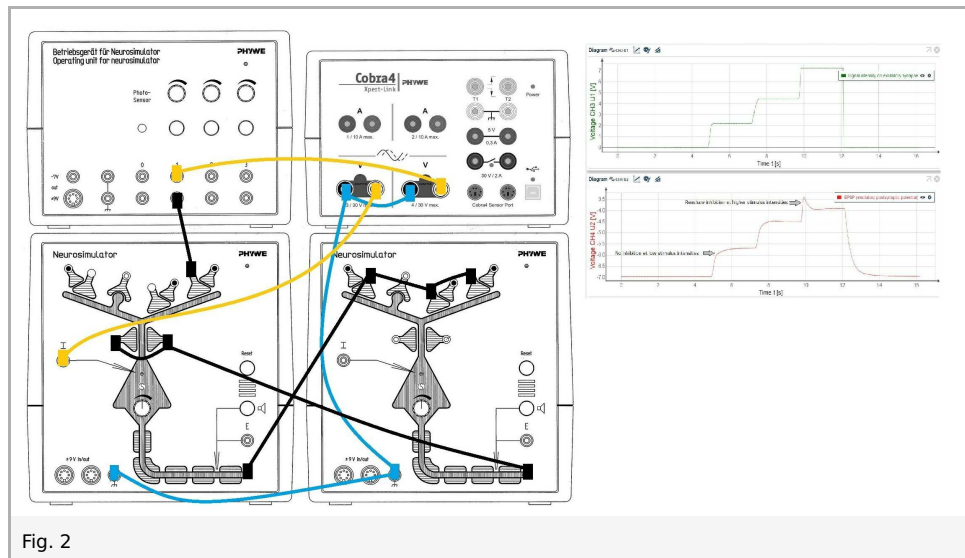
- The dendrite comprises exciting, inhibiting, presynaptic and Hebbian synapses which are marked by the corresponding colours of the sockets
- here the axons end in presynaptic buttons
- these are represented together with a part of the (afferent) fibre providing the signal
- the connection between the (efferent) axon of a neuron unit which leads away or the stimulus output socket of the operating unit and a synapse is established by means of a white cable which is inserted into the desired synapse socket
- the yellow sockets serve for the derivation of the state of excitement of the simulated neuron
- they must be connected to the computer interface Xpert-Link
- the action potentials can be made audible with the aid of the integrated acoustic monitor
- the turning knob "S" serves for setting the "firing threshold" of the neuron.

Equipment

Position No.	Material	Order No.	Quantity
1	Neuro-simulator, power supply	65963-93	1
2	Neuro-simulator	65963-00	2
3	Cobra4 Xpert-Link	12625-99	1
4	Adapter, BNC-plug/socket 4 mm	07542-26	2

1. Renshaw inhibition

Introduction



The Renshaw cell, a special neuron, protects a motoneuron and the muscle fiber, which is driven by the motoneuron, from hyper-excitation. Its circuit causes negative feedback of the excitory stimulation of the motoric neuron.

The circuit can be realized with two Neurosimulator modules, whereby one is the motoneuron and one the Renshaw cell. The stimulus to the motoneuron is amplified by spatial summation.

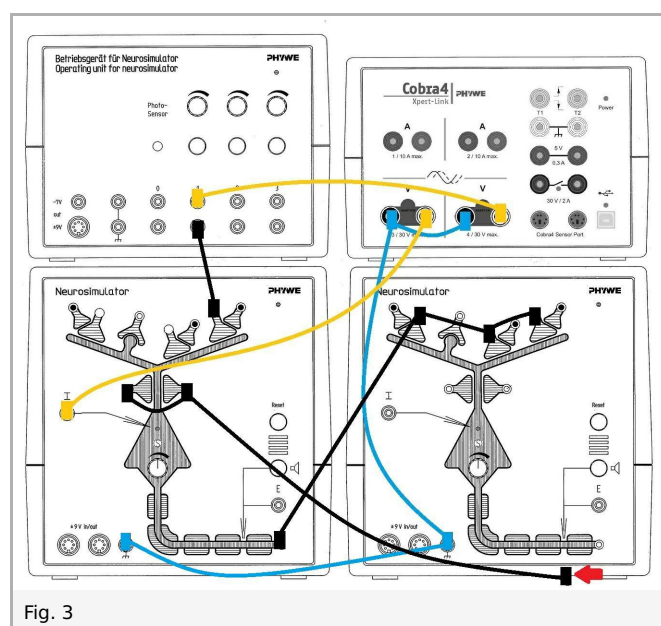
The Renshaw cell is also found in the spinal cord of vertebrates.

Set-up and procedure

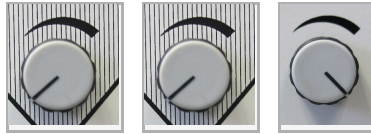
Connect the Xpert-Link to the PC. Two BNC-adapters (plug/socket 4 mm) are needed for voltage measurement.

1. Motoneuron signals without and with recurrent inhibition by Renshaw cell

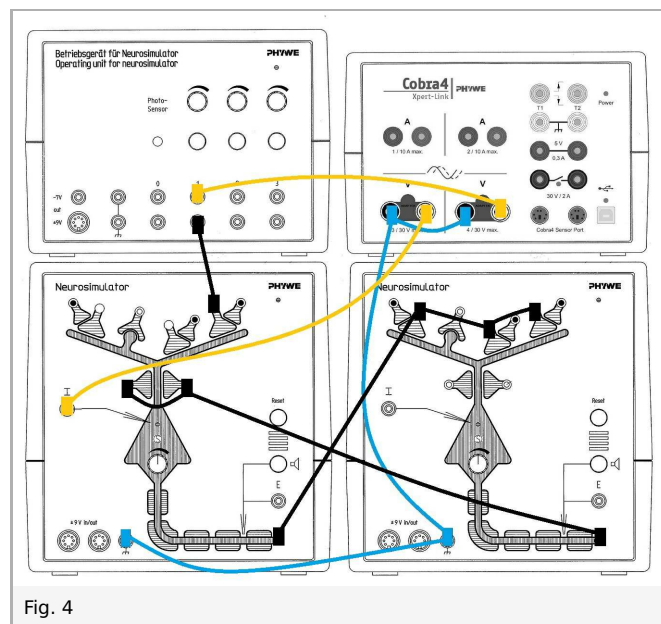
The experiment is set up as per Fig. 3. Leave one cable unplugged (red arrow).



- Neurosimulator 1, knob threshold: 0%
- Neurosimulator 2, knob threshold: 0%
- Operating unit, knob stimulation intensity 1: 100%



- Start measurement in the measurement window.
- Press the stimulation button 1 for approximately 3-5 seconds. Wait until the voltage of EPSP (now CH3) has reached the initial value.
- Plug the loose cable back into the black socket (Fig. 4).



- Press the stimulation button 1 for approximately 3-5 seconds.
- Finish the measurement as soon as the voltage of EPSP has reached the initial value.
- Save and evaluate the results.

2. Functional characteristics of Renshaw inhibition

The experiment is set up as per Fig. 4.

- Neurosimulator 1, knob threshold: 50%
- Neurosimulator 2, knob threshold: 0%
- Operating unit, knob stimulation intensity 1: 0%



- Start measurement in the measurement window.
- Press the stimulation button 1. Keep this button pressed!
- Wait for approximately 2 seconds, keep this button pressed and increase the stimulation intensity step by step every 2 seconds.



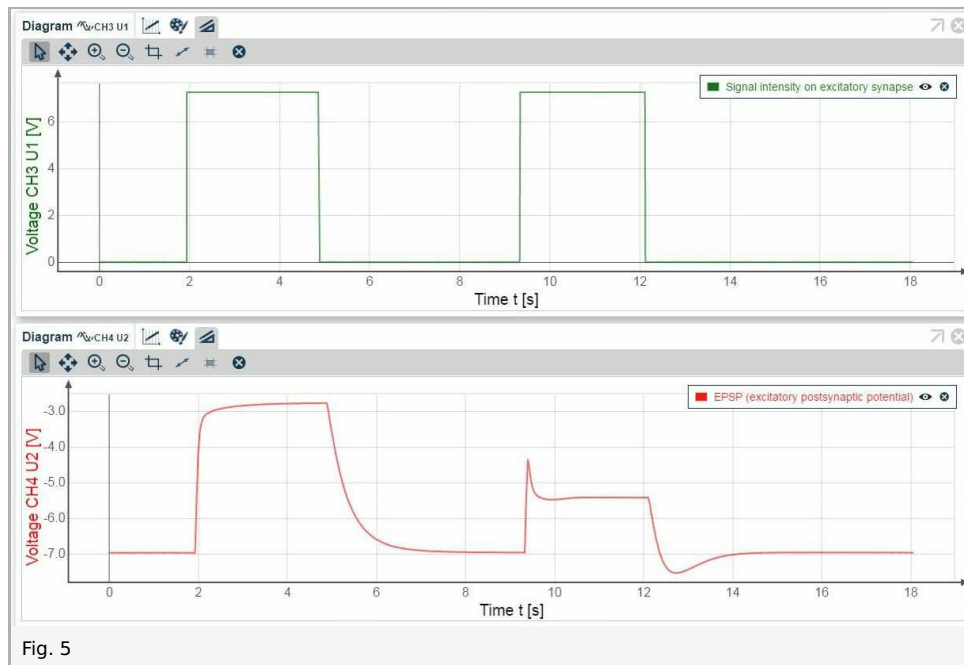
- After the last step keep the button pressed for 2 sec.
- Finish the measurement as soon as the voltage of EPSP has reached the initial value.
- Save and evaluate the results.

Results and evaluation

1. Motoneuron signals without and with recurrent inhibition by Renshaw cell

Left: Motoneuron signals without recurrent inhibition by Renshaw cell.

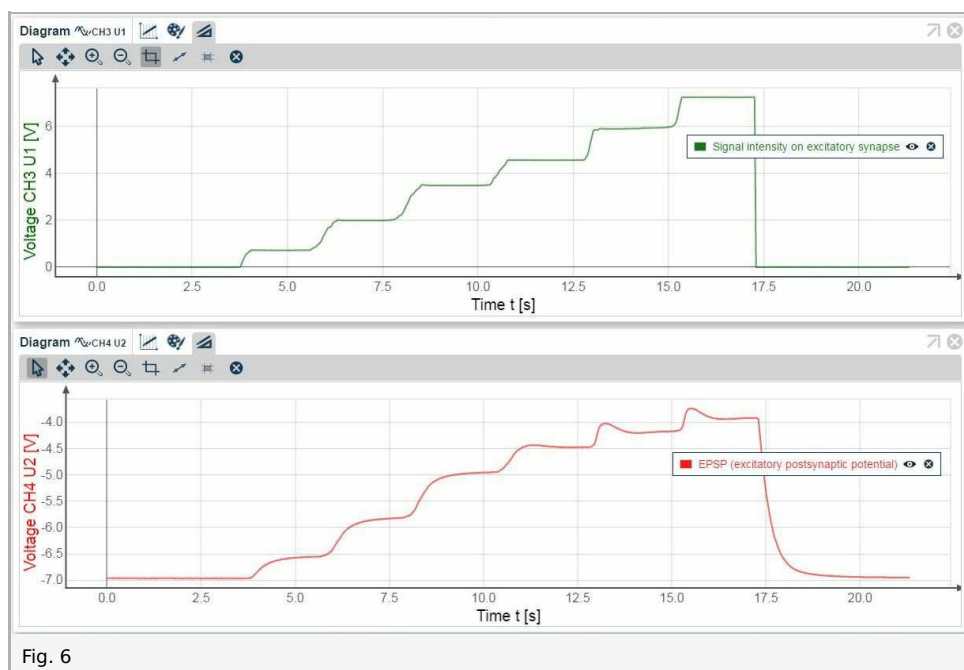
Right: Motoneuron signals with recurrent inhibition by Renshaw cell.



2. Functional characteristics of Renshaw inhibition

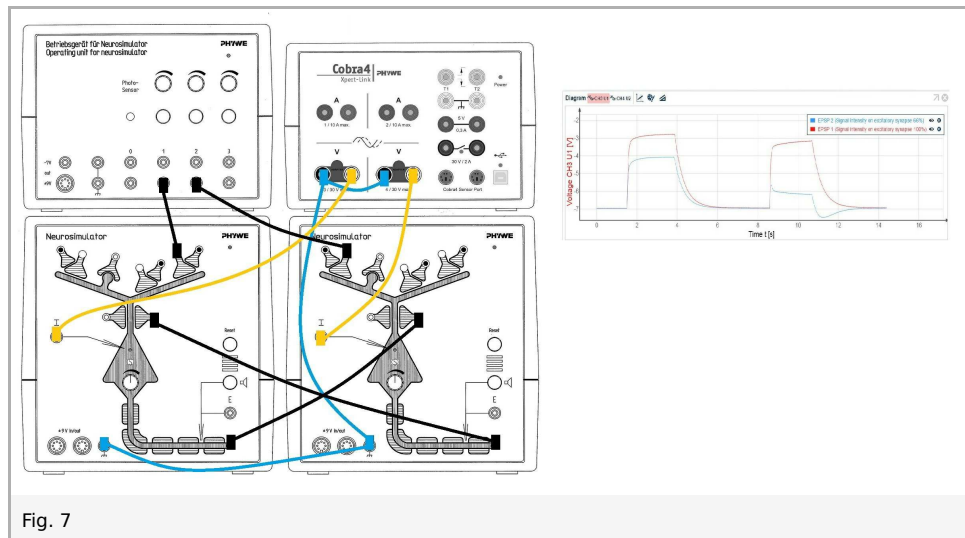
Step 1-3: No inhibition at low stimulus intensities

Step 5-6: Evident Renshaw inhibition at higher stimulus intensities



2. Lateral inhibition

Introduction



Lateral inhibition is a useful function of the nervous system in brain and sensory organs. It serves to intensify differences in the stimulation of neighboring elements and so to increase the resolving power. E.g., it causes an improvement in the contrast between adjacent areas in the visual system.

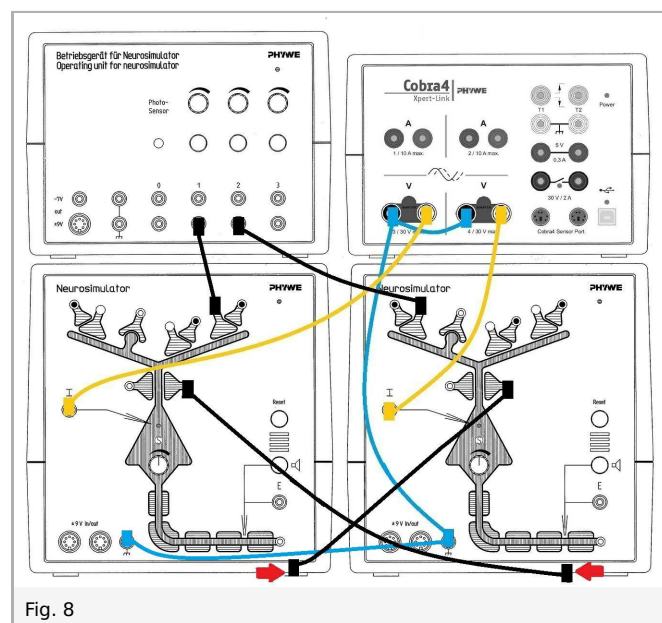
The following experiments can be performed:

1. Lateral inhibition
2. Contrast improvement

Set-up and procedure

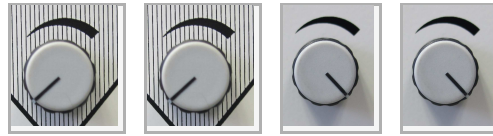
1. Lateral inhibition

The experiment is set up as per Fig. 8. Leave two cable unplugged (red arrows).

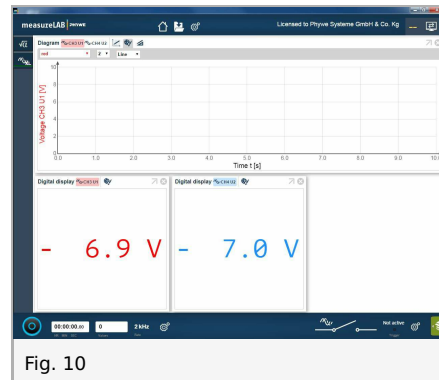
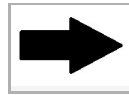


- Neurosimulator 1, knob threshold: 0%
- Neurosimulator 2, knob threshold: 0%
- Operating unit, knob stimulation intensity 1: 100%

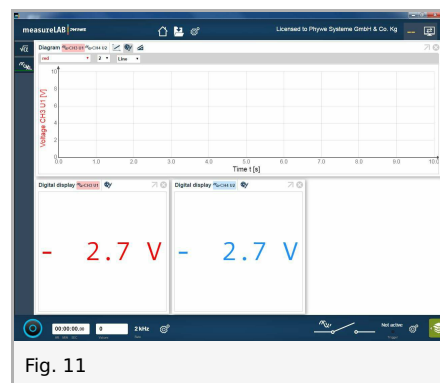
- Operating unit, knob stimulation intensity 2: 100%



Before the measurement the stimulation levels of both modules need to be calibrated so that they are identical. Open the digital display for the voltage channels:



While pressing both stimulation buttons, turn one of the two stimulation knobs so that the digital displays of both analog channels are identical (i.e. depolarization of both Neurosimulators is equally strong, for example -2,7V or similar):



- Start measurement in the measurement window.
- Press the stimulation button 1 and 2 for approximately 3 seconds. Wait until the voltage has reached the initial value.
- Plug the loose cables back into the black sockets (Fig. 12).

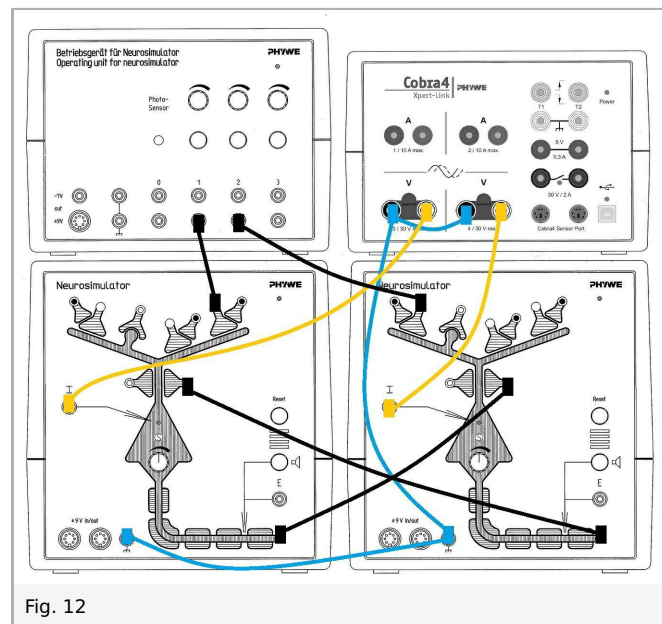


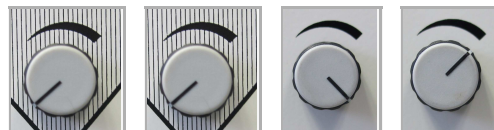
Fig. 12

- Press the stimulation button 1 and 2 for approximately 3 seconds. Wait until the voltage has reached the initial value.
- Finish the measurement as soon as the voltage has reached the initial value.
- Save and evaluate the results.

2. Contrast improvement

One of the two stimuli is reduced and the measurement is repeated.
The experiment is set up as per fig. 11. Leave two cable unplugged (red arrow).

- Neurosimulator 1, knob threshold: 0%
- Neurosimulator 2, knob threshold: 0%
- Operating unit, knob stimulation intensity 1: 100%
- Operating unit, knob stimulation intensity 2: 66%



Repeat the steps of measurement of part 1.

- Start measurement.
- Press the stimulation button 1 and 2 for approximately 3 seconds. Wait until the voltage has reached the initial value.
- Plug the loose cables back into the black sockets (Fig. 12).
- Press the stimulation button 1 and 2 for approximately 3 seconds. Wait until the voltage has reached the initial value.
- Finish the measurement as soon as the voltage has reached the initial value.
- Save and evaluate the results.

Results and evaluation

1. Lateral inhibition

The diagram shows that depolarization without lateral inhibition (left) and with lateral inhibition (right):

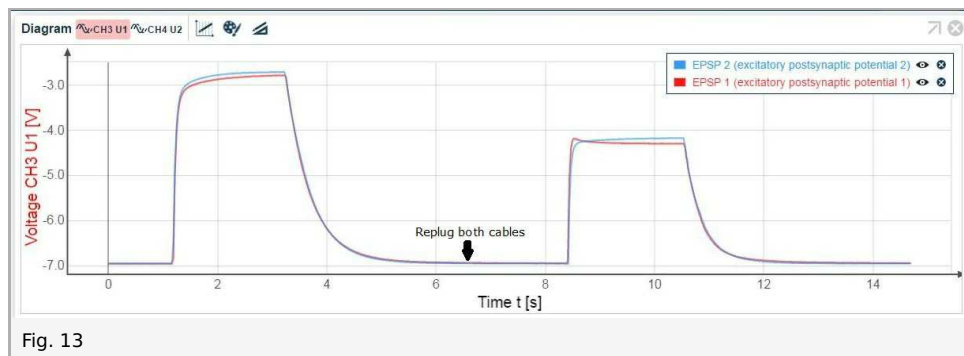


Fig. 13

2. Contrast improvement

The diagram shows that the depolarization of both Neurosimulator depends on signal intensity (left). The difference is greater with lateral inhibition (right).

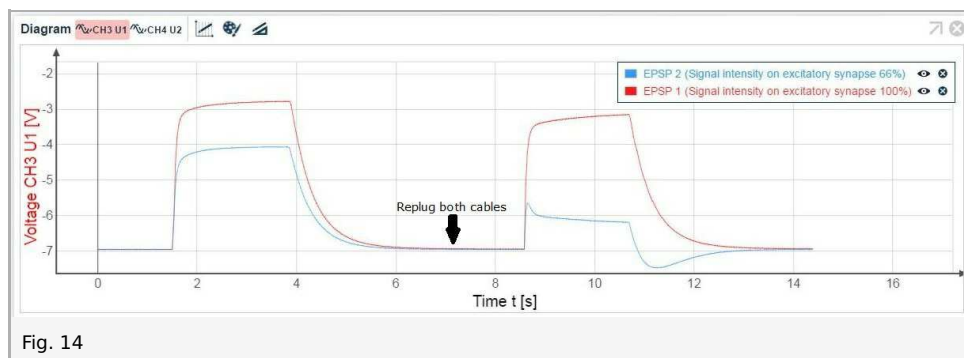
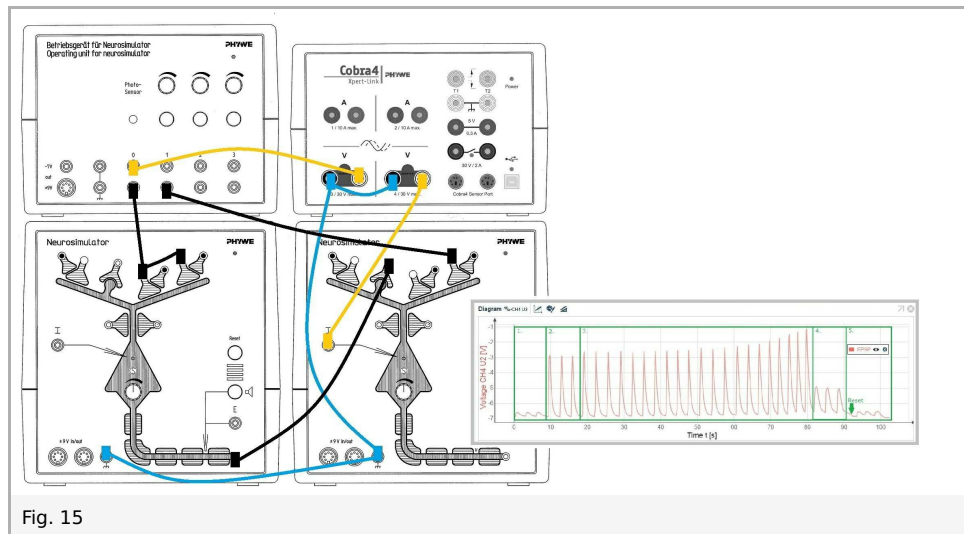


Fig. 14

3. Neuronal principles of classic conditioning

Introduction



Pavlov's dog experiment is no doubt the most well-known example of classic conditioning. The sound of a bell becomes associated with the smell of food and salivary excretion follows as reaction. The perception of the smell of food and the salivary secretion that results from it is called an (inborn) unconditioned reflex. The reaction to the sound of the bell that is associated with the unconditioned reflex as a result of learning is called a conditioned reflex.

In all experiments on classic conditioning, it is absolutely necessary that the stimulus for the conditioned reflex lies before that for the unconditioned reflex in time. Should this succession in time be reversed, then conditioning is impossible.

In the first experiment the experiment is shown with the proper time sequence of conditioning. In the second experiment it is shown that proper sequencing is essential for the conditioned reflex to be brought about.

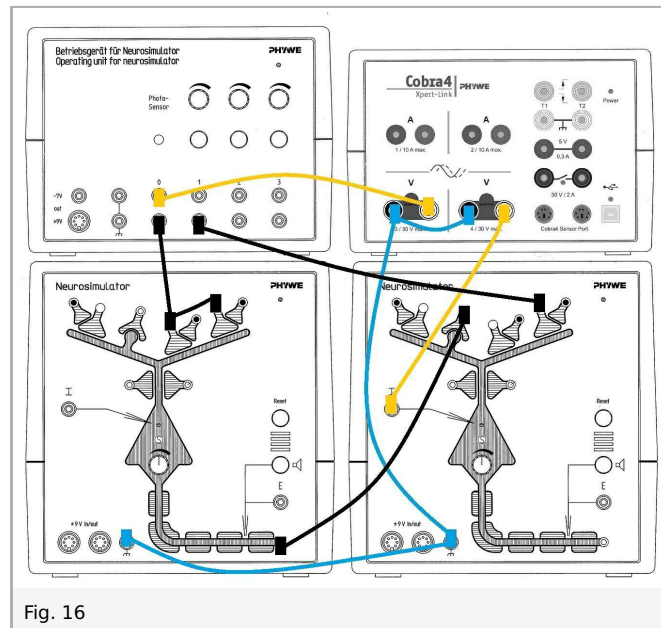
Additional information: The value „stimulation intensity 1“ can be measured additionally by using a Cobra4 Sensor Port. To use the sensor port, a Cobra4 Sensor-Unit Electricity (12644-00) and a Cobra4 Xpert-Connect (12625-01) are needed additionally.

Set-up and procedure

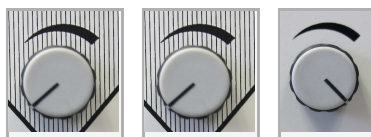
NOTE: In dim light, the sensor gives a permanent signal. In this case the sensor should be illuminated with a flashlight.

1. Conditioned reflex

The experiment is set up as per Fig. 16. Two BNC-adapters (plug/socket 4 mm) are needed for voltage measurement.



- Neurosimulator 1, knob threshold: 0%
- Neurosimulator 2, knob threshold: 0%
- Operating unit, knob stimulation intensity 1: 100%



NOTE: Between each button press, covering the photosensor, or simultaneous action on both elements, the voltage should reach the initial value (approx. -7V).



NOTE: Too much light passes through the fingers. Therefore, for covering the photosensor, please use an object which does not let light through.

- Press the reset button on Neurosimulator 2 (to set Hebbian synapse to default).



- Start measurement in the measurement window.
1. Cover the photosensor three times for approximately one second.
(Activation of the Hebbian synapse)
 2. Press the stimulation button 1 three times for approximately one second.
(Activation of the excitatory synapse)
 3. First **briefly cover the photosensor** (for 1/2 s) and immediately after that briefly press the stimulation button 1 (for 1/2 s). Wait until the voltage has reached the initial value. Repeat this procedure twenty times.
(Successive activation of the Hebbian and excitatory synapses)
 4. Cover the photosensor three times for approximately one second.
(Activation of the Hebbian synapse)

5. Press the reset button on Neurosimulator 2 to unlearn the conditioned reflex. Cover the photosensor three times for approximately one second.
(Activation of the Hebbian synapse)
- Finish the measurement as soon as the voltage has reached the initial value.
 - Save and evaluate the results.

2. Reversed stimulus

Repeat the same procedure as in the experiment about the conditioned reflex above, but this time press the button first, then cover the photo sensor.

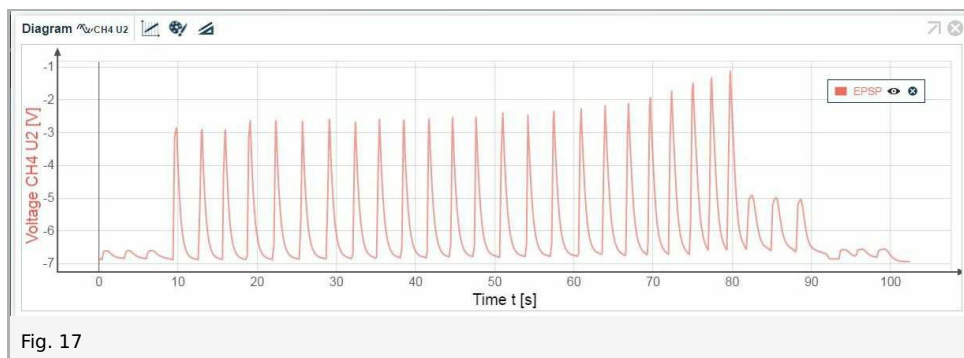
Notes: Between each button press, covering the photosensor, or simultaneous action on both elements, the voltage should reach the initial value (approx. -7V).

- Start measurement in the measurement window and perform almost the same actions as before:
1. Cover the photosensor three times for approximately one second (activation of the Hebbian synapse).
 2. Press the stimulation button 1 three times for approximately one second (activation of the excitatory synapse).
 3. First **briefly press the stimulation button** (for 1/2 s) and immediately after that briefly cover the photosensor. Wait until the voltage has reached the initial value. Repeat this procedure twenty times (successive activation of the excitatory and Hebbian synapses).
 4. Cover the photosensor three times for approximately one second (activation of the Hebbian synapse).
 5. Press the reset button on Neurosimulator. Cover the photosensor three times for approximately one second (activation of the Hebbian synapse).
- Finish the measurement as soon as the voltage has reached the initial value.
 - Save and evaluate the results.

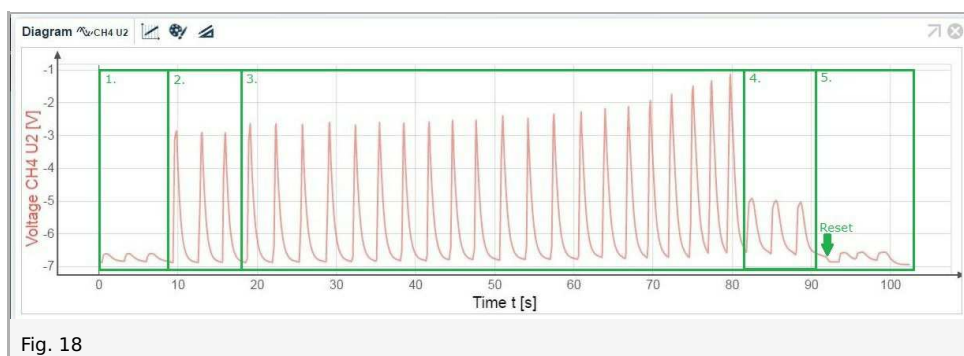
Results and evaluation

1. Conditioned reflex

Two neurosimulators simulate the interneuron-associative neuron pair. In the experiment, the associative neuron is conditioned to increase its level of intracellular potential (depolarization) without involvement by the interneuron.



Explanation:



1. Activation of the Hebbian synapse before conditioning.
The neutral stimulus (bell) produces no specific response.



2. Activation of the excitatory synapse before conditioning.
The unconditioned stimulus (food) produces an unconditioned response (salivation = an unlearned reflex response).



3. Successive activation of the Hebbian and excitatory synapses during conditioning (**Hebbian** synapse first).
The neutral stimulus (bell) is paired with an unconditioned stimulus (food). The unconditioned stimulus (food) produces an unconditioned response (salivation). The neutral stimulus (bell) becomes a conditioned stimulus.

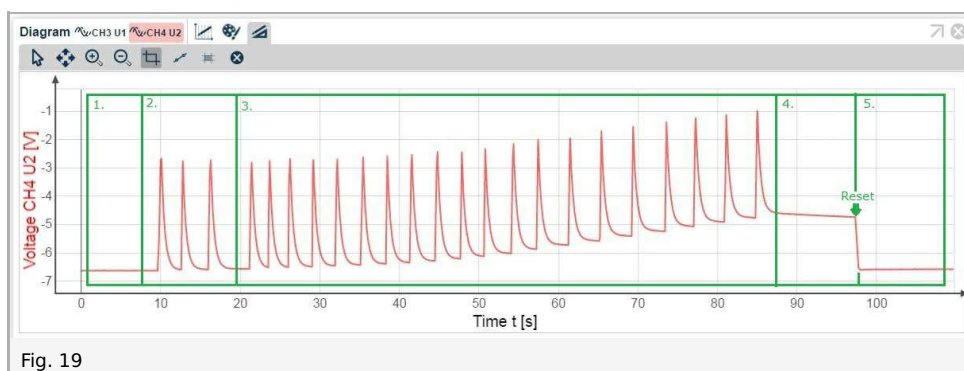


4. Activation of the Hebbian synapse after learning / after conditioning (conditioned reflex).
The conditioned stimulus (bell) produces a conditioned response (salivation). The conditioned response is similar to the unconditioned response.



5. Activation of the Hebbian synapse after unlearning of the conditioned reflex (reset button).

NOTE: In dim light, the graph may look like fig. 19: The Hebbian synapse is continuously active. An explanation like the one above is not possible in this case. The condition leads to a continuous excitation of the membrane potential. Repeat the experiment by using a flashlight.

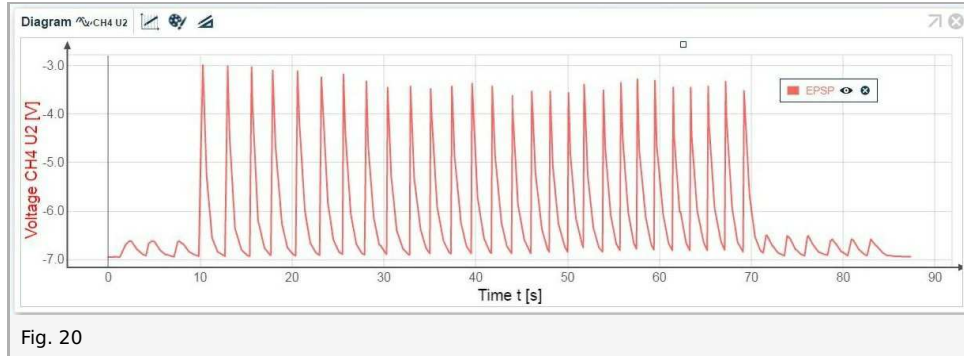


1. Activation of the Hebbian synapse.
2. Activation of the excitatory synapse.
3. Successive activation of the Hebbian and excitatory synapses (**Hebbian** synapse first).

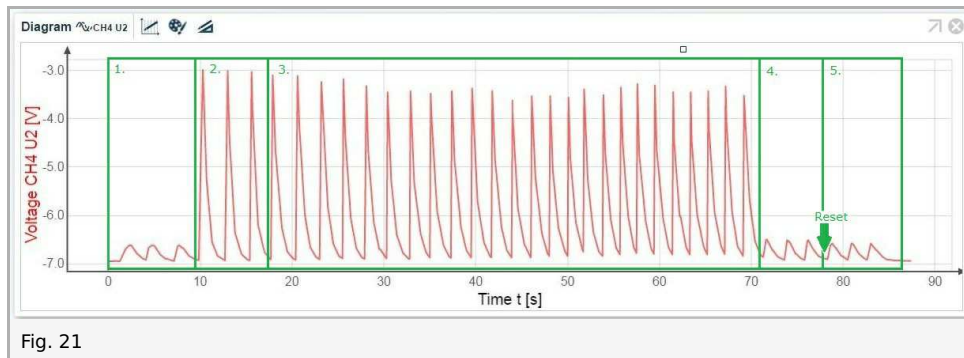
4. Activation of the Hebbian synapse.
5. Activation of the Hebbian synapse after pressing the reset button.

2. Reversed stimulus

Reversed stimulus succession does not bring about a conditioned reflex:



Explanation:



1. Activation of the Hebbian synapse.
2. Activation of the excitatory synapse.
3. Successive activation of the excitatory and Hebbian synapses (**Excitatory** synapse first).
4. Activation of the Hebbian synapse (no conditioned reflex).
5. Activation of the Hebbian synapse after pressing the reset button.