A few questions on the content of the previous lecture

slido

Modern eye-trackers work by shining ... towards the participant's eyes.

ⓘ Start presenting to display the poll results on this slide.

slido

(Choose all that apply)
Calibrating an eye-tracker has the purpose of locating the participant's ...

ⓘ Start presenting to display the poll results on this slide.

slido

The concept of "just noticeable difference" (JND) comes from the field of ... and represents ...

ⓘ Start presenting to display the poll results on this slide.

Peripheral psychophysiological measures

Dr. Lavinia Carmen Uscătescu

March 25th , 2024

Outline

1. Overview

2. Modern psychophysiological recordings

   (a) Skin conductance response (SCR)

   (b) Heart rate

Overview

Nervous system subdivisions

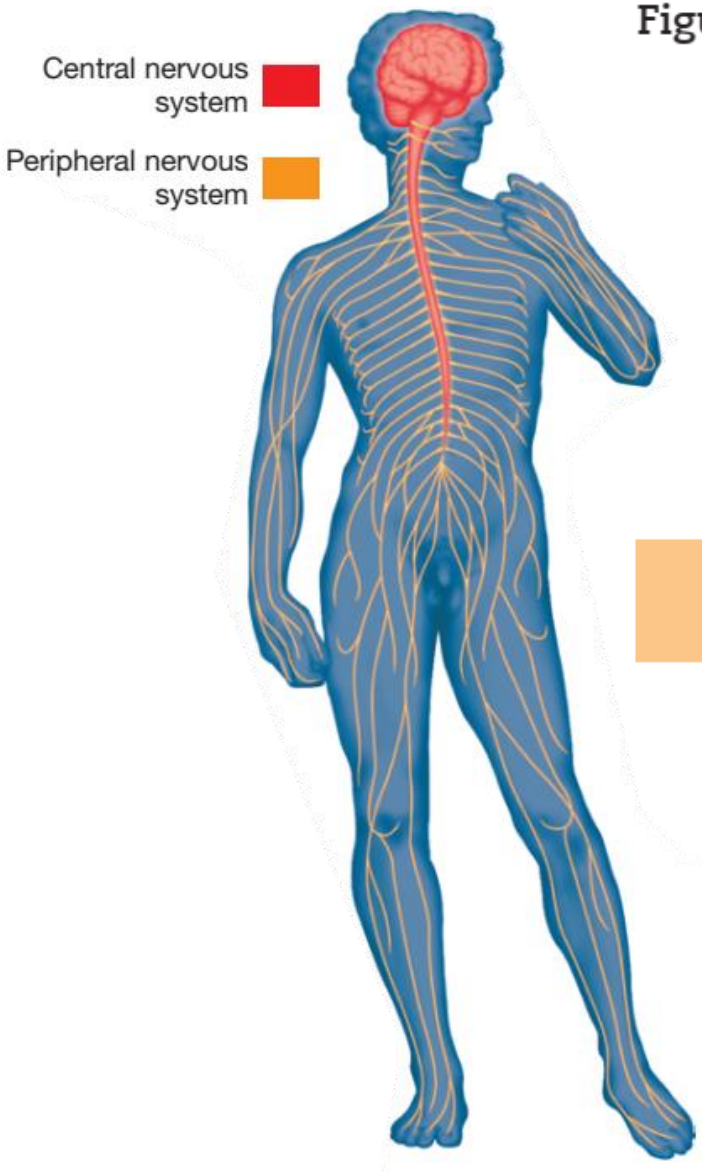
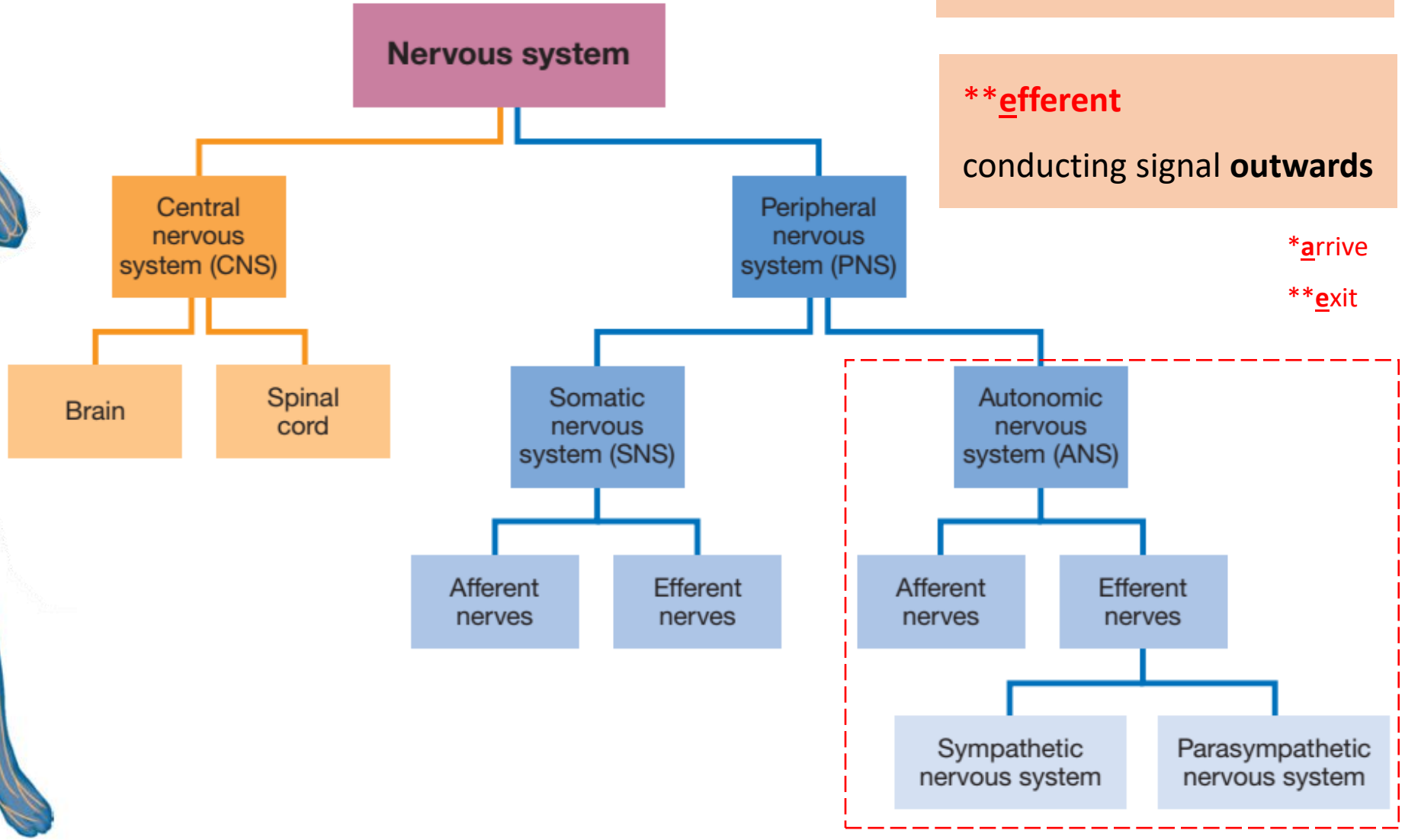


Figure 3.2 The major divisions of the nervous system.



Pinel & Barnes, (2001), pp. 74-75

***afferent**

conducting signal **inwards**

****efferent**

conducting signal **outwards**

*arrive

**exit

Psychophysiology – the beginnings

ON THE UNION OF CRANIAL AUTONOMIC (VISCERAL) FIBRES WITH THE NERVE CELLS OF THE SUPERIOR CERVICAL GANGLION.

By J. N. LANGLEY, D.Sc., F.R.S., *Fellow of Trinity College, Cambridge.*

CONTENTS.

INTRODUCTION.

IN an earlier Paper[1], I have shown that the nerve fibres of the cervical sympathetic after they have been cut, can re-make connections with the nerve cells of the superior cervical ganglion, and I have given reason to believe that one class of nerve fibre, say pupillo-dilator, may make connections with nerve cells of a different class, such as pilo-motor.

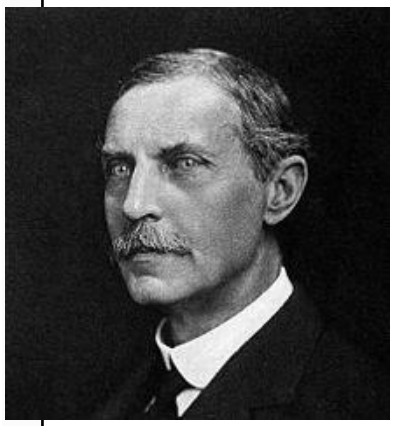
There are, it is well known, nerve fibres in the cranial and sacral nerves, which are allied to the sympathetic nerve fibres and the question naturally arises whether these allied fibres are capable of becoming connected with sympathetic nerve cells.

A word or two on nomenclature is here necessary.

By many of the earlier observers, the spinal ganglia and the various peripheral ganglia on the course of the spinal and cranial nerves, were

[1] This *Journal*, XXII. p. 215. 1897.

https://pubmed.ncbi.nlm.nih.gov/16992456/



John Langley (1852 – 1925)

Eur Neurol. 2008;60(4):215-6. doi: 10.1159/000148695. Epub 2007 Sep 28.

'Autonomic' nervous system

Don Todman [1]

From the *Oxford English Dictionary:* 'autonomic' is the adjective derived from 'autonomy' meaning self-governing or independent [1]. With respect to physiology, autonomic nervous system is that part which functions independently of the will. John Newport Langley (1852–1925), the Cambridge physiologist, first applied the term in 1898 in a paper in the *Journal of Physiology*: 'The autonomic nervous system means the nervous system of the glands and of the involuntary muscle … I propose the term autonomic nervous system for the sympathetic nervous system and the allied nervous system of the cranial and sacral nerves, and the local nervous system of the gut' [2].

The concept that an independent part of the nervous system coordinates body functions had its origin in the works of Galen (129–199), who proposed that nerves distributed spirits throughout the body. From animal dissections he concluded that there were extensive interconnections from the spinal cord to the viscera and from one organ to another. He proposed that this system fostered a concerted action or 'sympathy' of the organs. Little changed until the Renaissance when Bartolomeo Eustacheo (1545) depicted the sympathetic nerves, the vagus and adrenal glands in anatomical drawings. Jacobus Winslow (1669–1760), a Danish-born professor working in Paris, popularised the term 'sympathetic nervous system' in 1732 to describe the chain of ganglia and nerves which were connected to the thoracic and lumbar spinal cord [3].

https://pubmed.ncbi.nlm.nih.gov/18667826/

psychophysiology

the field of research that studies **how** individual **mental functions** relate to **physiological signals**

"**Autonomic** outflow is orchestrated in a **feedback-dependent hierarchy** from local **end-organ** or **spinal reflexes**, proximate **autonomic nuclei within medulla**, **pons** and **lateral hypothalamus**, up to higher subcortical and cortical brain regions, including **amygdala**, **insula**, orbital and medial **prefrontal**, **cingulate** and even **primary motor** cortex, which couple the regulation of bodily state to **motivational behaviors**." *Gray et al., (2009)* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2741582/#bib70

The precise *psychological significance* of peripheral physiological signals is continuously **debated**!

ambulatory monitoring

> IEEE Trans Biomed Eng. 2010 May;57(5):1243-52. doi: 10.1109/TBME.2009.2038487. Epub 2010 Feb 17.

A wearable sensor for unobtrusive, long-term assessment of electrodermal activity

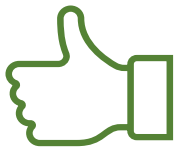
Ming-Zher Poh [1], Nicholas C Swenson, Rosalind W Picard

https://pubmed.ncbi.nlm.nih.gov/20172811/

Neuroimage. 2009 Sep; 47(3-8): 1105–1115.
doi: 10.1016/j.neuroimage.2009.05.033

Physiological recordings: Basic concepts and implementation during functional magnetic resonance imaging

complements **other methods**



Marcus A. Gray,[a,*] Ludovico Minati,[a] Neil A. Harrison,[a] Peter J. Gianaros,[b] Vitaly Napadow,[c] and Hugo D. Critchley[a]

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2741582/#bib70

Modern psychophysiological recordings

BIOPAC® Systems, Inc.

BIONOMADIX Wireless Physiology Monitoring Devices

PHYSIOLOGY WHERE, WHEN, AND HOW YOU WANT

https://www.biopac.com/product-category/research/bionomadix-wireless-physiology/

(a) Skin conductance response (SCR)

also called *“electrodermal activity”* (EDA) or *“galvanic skin response”* (GSR)

SCR/ EDA/ GSR

measures small **variations** in the **electrical conductivity** of our **skin** in response to **stimuli**

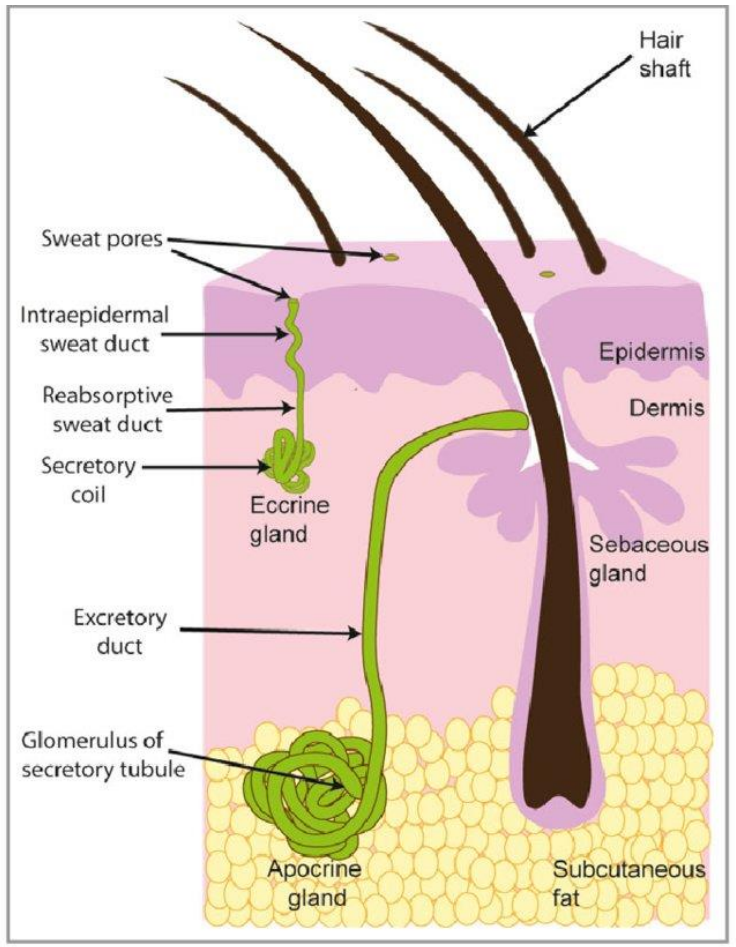


Fig 1. Basic structure of sweat glands.

*The **eccrine** **sweat gland** is made of tubular epithelia comprising the secretory coil and a reabsorptive sweat duct (RSD). The RSD comprises a straight segment (traversing the dermal layer) and the **intraepidermal sweat duct**, which **opens directly onto the skin surface**. Apocrine glands are located in the subcutaneous fat deep in the dermal layer and are composed of a glomerulus of secretory tubules that funnel toward an excretory duct that opens into the hair follicle.*

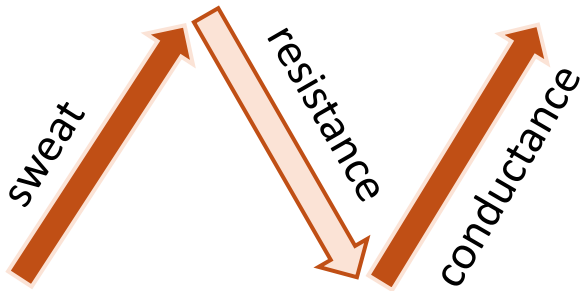
***Apocrine sweat glands** do not usually open directly onto the surface of the skin as eccrine sweat glands do. Instead, these glands open and secrete sweat into the hair follicles’ pilary canals.*

Converse et a., (2018)
https://pubmed.ncbi.nlm.nih.gov/28714085/

The eccrine sweat glands— phylogenetically newer and found **only in primates**—occur in **nearly all regions** of the skin, yet they are **most numerous in the soles, palms, and scalp**.

The apocrine sweat glands —phylogenetically older — are far **less numerous** and are located primarily in the **axilla** and **perianal** areas.

When active, the **intraepidermal sweat ducts** of the **eccrine sweat glands fill with sweat** => **variations** in **conductivity**. The ***resistance*** of a given **gland duct** to the **passage** of an **applied current** is **inversely proportional** to the **amount of sweat in the duct**. To understand observed changes in overall conductivity across thousands of gland ducts, it is useful to conceptualize the **sweat glands as variable resistors** wired in parallel. **Overall conductance**, therefore, is quite simply the **sum** of all the individual conductances.



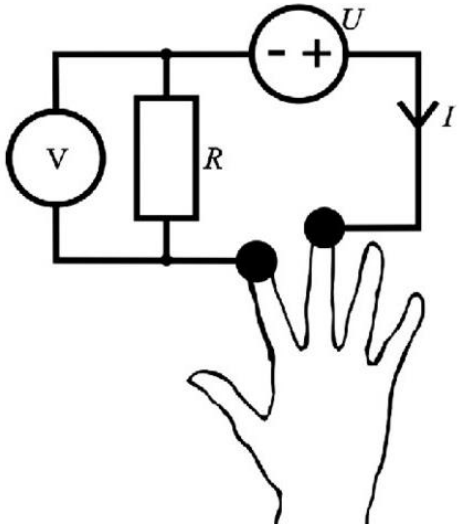
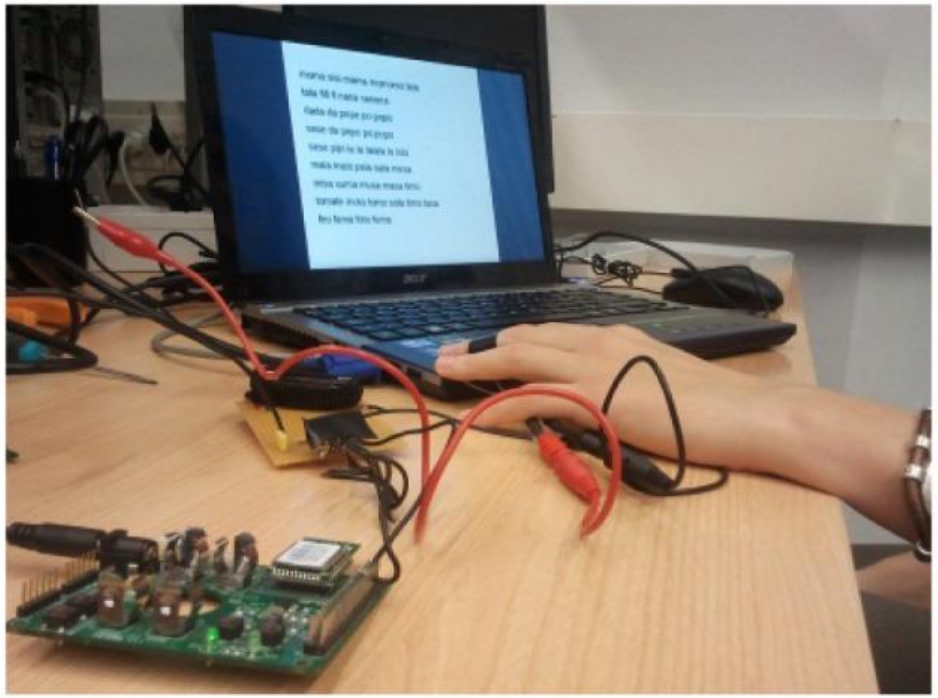


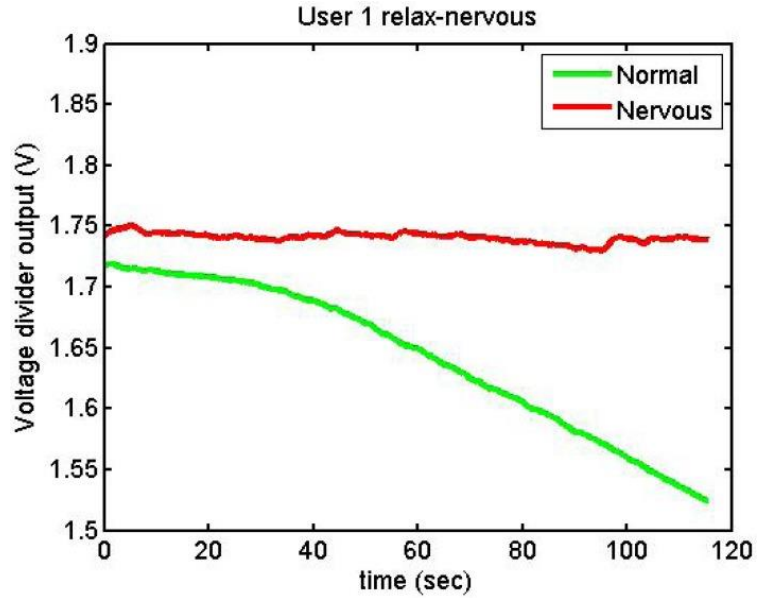
Fig. 1. Basic principle of skin conductance measurement. ***Direct-current*** *voltage U is* ***applied*** *between two electrodes (black circles). Current I runs* ***through the skin*** *and is* ***measured*** *indirectly as* ***voltage drop*** *on resistor R using a voltmeter V.*

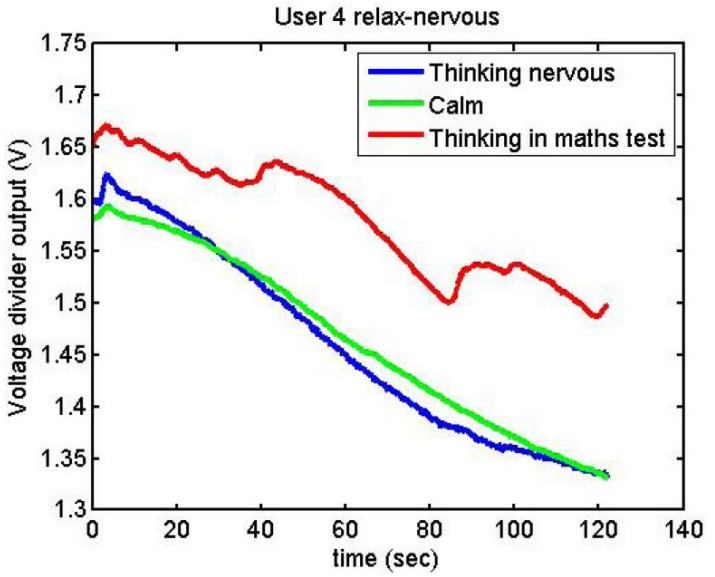
Ogorevc et al., (2013)
https://www.sciencedirect.com/science/article/pii/S0263224113002571

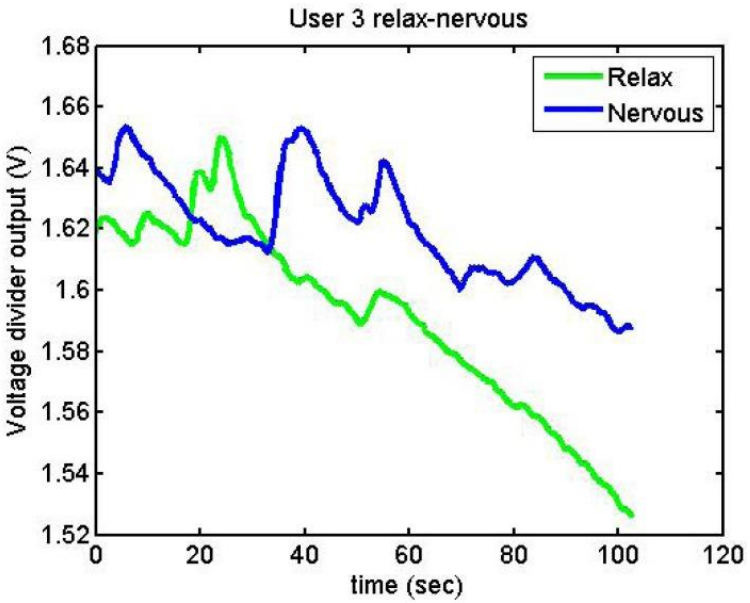
Example

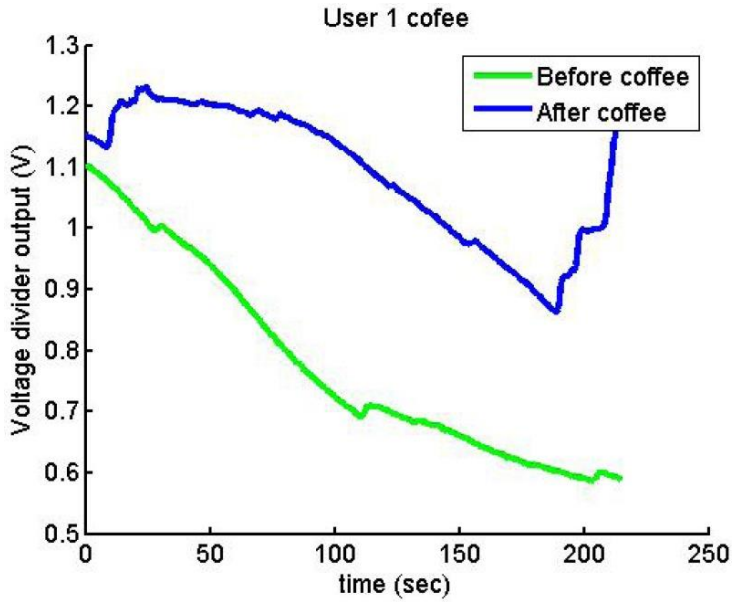


Villarejo et al., (2012)
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3386730/









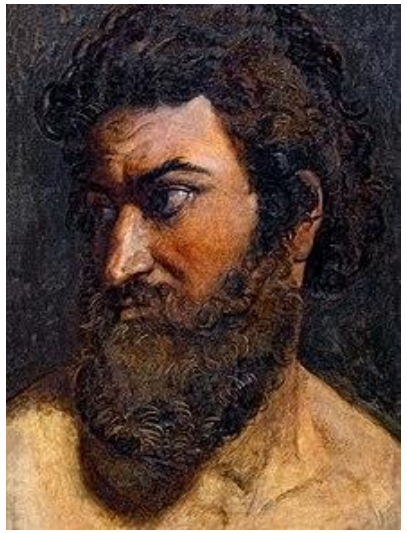
Example of SCR in consumer research

https://www.youtube.com/watch?v=YodW4rz65bY

Example of SCR and Heart Rate with BIOPAC

https://www.youtube.com/watch?v=rjyiIZA8teY

(b) Heart rate



Erasistratos
(c. 304 – c. 250 BC)

Psychophysiology. 1972 Sep;9(5):546-51. doi: 10.1111/j.1469-8986.1972.tb01810.x.

The diagnosis of love-sickness: experimental psychophysiology without the polygraph

M M Mesulam, J Perry

PMID: 4561675 DOI: 10.1111/j.1469-8986.1972.tb01810.x

ABSTRACT

Psychophysiological concepts and methodology are central to the practices of Erasistratos, Galen, and Avicenna, great physicians of antiquity whose lives span a period in history from the third century, B.C., to the eleventh century, A.D. This point is illustrated by means of a diagnostic vignette common to all three physicians' clinical experience, namely, the discovery of a concealed love object by monitoring changes in pulse rate. Within the context of these case sketches can be found the seeds of modern concepts in psychophysiology and psychosomatic medicine. Some of the texts examined are new translations of Greek and Latin originals.

DESCRIPTORS: Erasistratos, Galen, Ibn Sina (Avicenna), Ancient psychophysiology, Pulse rate, Love.

https://pubmed.ncbi.nlm.nih.gov/4561675/

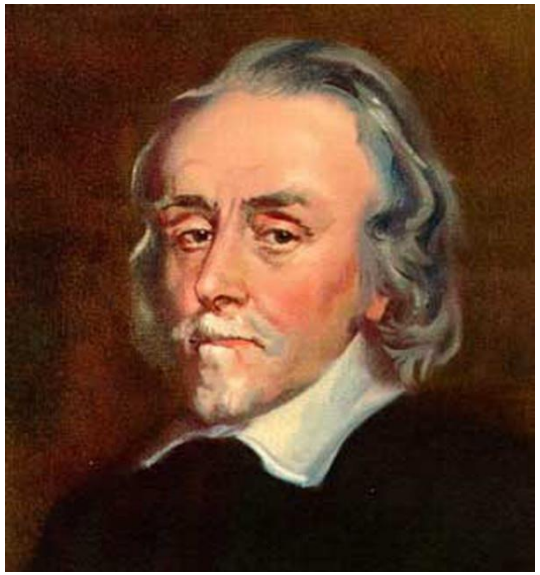
Galen
(129 – 216 AD)

Ibn Sina (Avicenna)
(980 – 1037 AD)

At the beginning of the third century, B.C., Seleucus, one of Alexander's generals and among the ablest of his successors, married a woman named Stratonice.[1] Antiochus, his son by a previous marriage, had the misfortune to fall in love with his new stepmother. Recognizing the illicit character of his love, and the hopelessness of its consummation, Antiochus resolves not to show his feelings. Instead, he falls sick and strives his hardest to die.

We may be sure that many doctors attended the young prince, but to no avail it seems, until the celebrated Greek physician Erasistratos concludes that, in the absence of bodily disease, the boy's malady must stem from some affliction of the mind, "through which the body is often strengthened or weakened by sympathy." (Appian, 2nd century, A.D.) Since he is convinced that mind and body are intimately coupled, Erasistratos decides to observe Antiochus' physiological reactions to the people who come to visit him, in the hope of divining some clue to the boy's mysterious ailment.

Wishing to discover who was the object of his passion (a matter not so easy to decide), he would spend day after day in the young man's chamber, and if any of the beauties of the court came in, male or female, he would study the countenance of Antiochus, and watch those parts and movements of his person which nature has made to sympathize most with the inclinations of the soul. Accordingly, when any one else came in, Antiochus showed no change, but whenever Stratonice came to see him, as she often did, either alone or with Seleucus, lo, those tell-tale signs of which Sappho sings were all there in him—stammering speech, fiery flashes, darkened vision, sudden sweats, irregular palpitations of the heart, and finally, as his soul was taken by storm, helplessness, stupor, and pallor. (Plutarch, 1st century, A.D.)



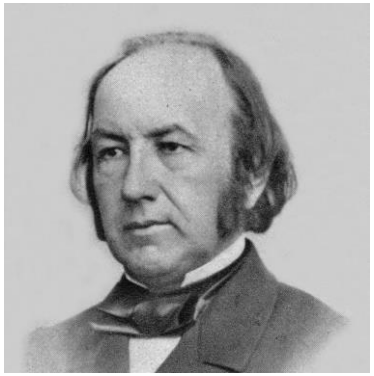
William Harvey
(1578 –1657)

"Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus" - published in Latin at Frankfurt in 1628

*"Harvey focused much of his research on the **mechanics of blood flow** in the human body. Most physicians of the time felt that the **lungs** were responsible for moving the blood around throughout the body."*

*"By observing the notion of the heart in living animals, he was able to see that **systole** was the active phase of the heart's movement, pumping out the blood by its muscular contraction. […] he was able to show that the **valves** in the **veins** permit the blood to flow only in the direction of the heart and to prove that the **blood circulated around the body and returned to the heart**."*

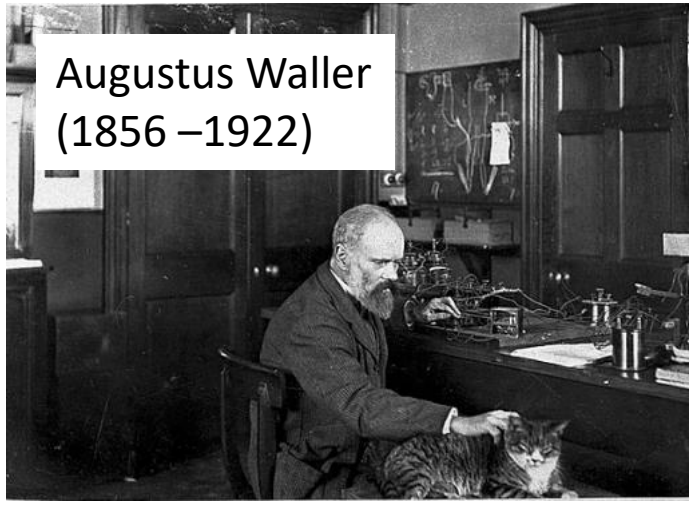
Ribatti, (2009)
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2776239/

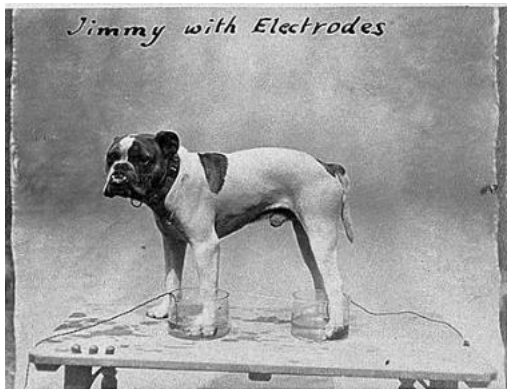


Claude Bernard
(1813 – 1878)

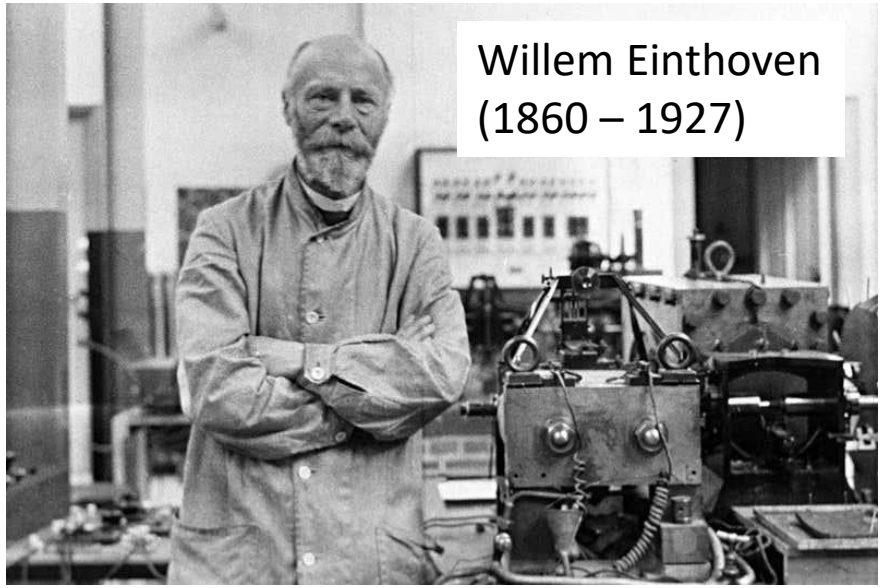
"Claude Bernard also repeatedly insists, and this deserves especial notice, that when the heart is affected it reacts on the brain; and the state of the brain again reacts through the pneumo-gastric (vagus) nerve on the heart; so that under any excitement there will be much mutual action and reaction between these, the two most important organs of the body" (Darwin, 1999, pp. 71–72, originally published in 1872).

Thayer & Lane, (2009)
https://pubmed.ncbi.nlm.nih.gov/18771686/





Created the first practical ECG machine with **surface electrodes** (his dog, Jimmy, being his subject).



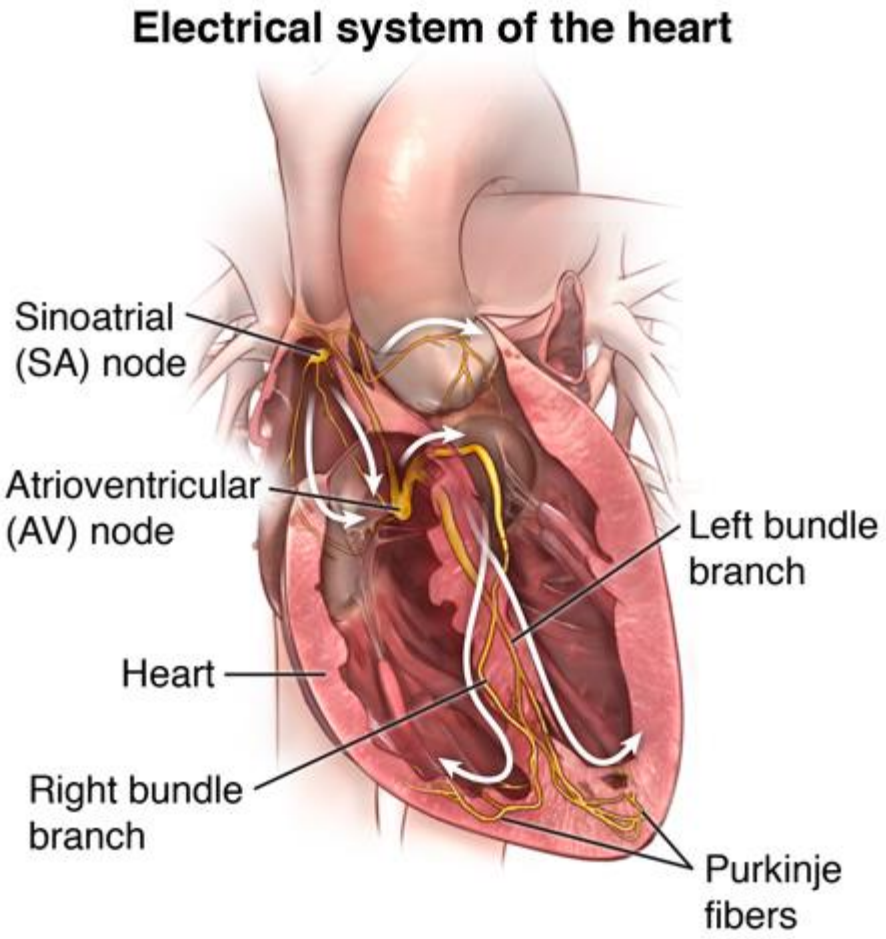
Willem Einthoven
(1860 – 1927)

Invented the first clinically applicable **electrocardiograph (ECG or EKG)** in 1895 and received the **Nobel Prize in Physiology or Medicine** in 1924 for it ("for the discovery of the mechanism of the electrocardiogram“).

In the early years, Einthoven used the Lippmann capillary electrometer like Waller, but was dissatisfied with it despite improving its distortion mathematically. Consequently he devoted a lot of effort to correct its problems. He was however, able to register a fairly good representation of the ECG which was subsequently further improved with his introduction of the string galvanometer. By calibrating and correcting the records from the capillary electrometer, Einthoven eventually predicted an ECG signal not much different from the “classic” one obtained with the string galvanometer [31] (Figure 1). Thus, the basic wave forms of the ECG were characterized by Einthoven before the beginning of the twentieth century and the advent of the string galvanometer. Based on examination of many ECG recordings with the improved capillary electrometer, Einthoven in 1900 concluded that the bioelectric signal of the diseased heart might differ from the normal [32]. This belief spurred Einthoven to develop an improved method of registering the ECG.

In 1895 Einthoven coined the term electrocardiogram (Elektrokardiogramm) but it appears that he attributed it to Waller as a token of respect for his colleague [2,16]. During these early years, Einthoven introduced the PQRST designation for the several electrocardiographic deflections as it is known today.

Barold, (2003)
https://pubmed.ncbi.nlm.nih.gov/12766530/



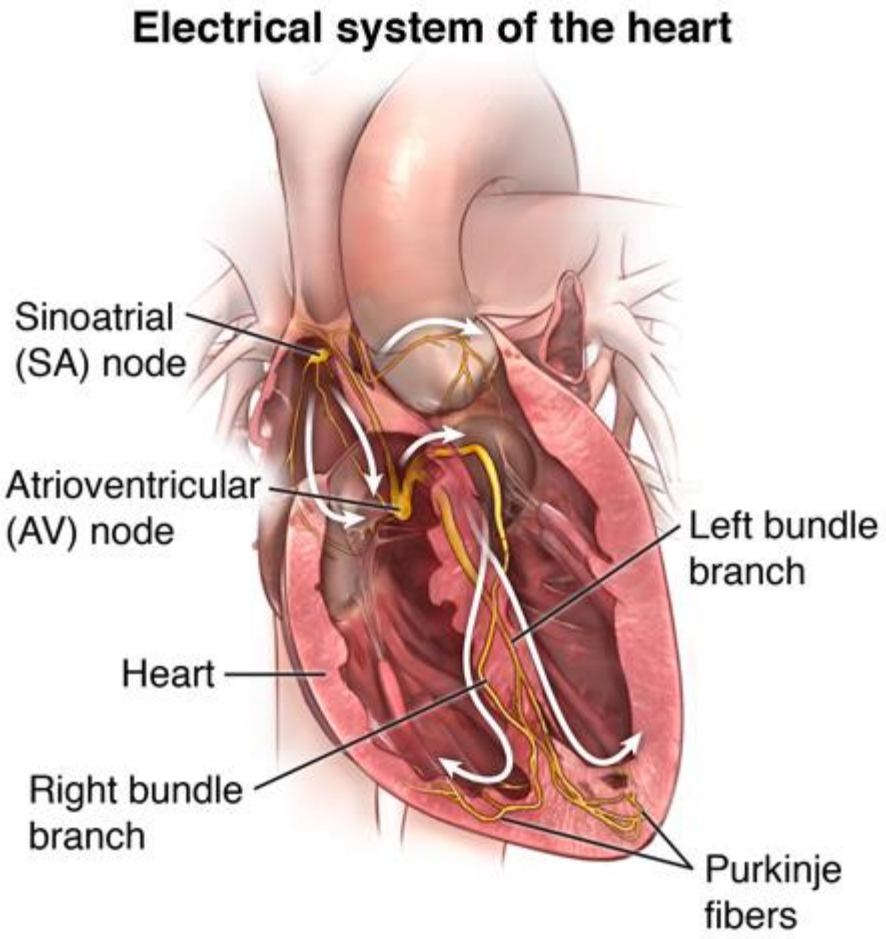
https://tinyurl.com/2br73a4h

An **electrical stimulus** is generated by the sinus node (also called the **sinoatrial node**, or **SA** node). This is a small mass of specialized tissue located in the right upper chamber (atria) of the heart.

The sinus node generates an **electrical stimulus regularly**,

60 to 100 times per minute under normal conditions.

The **atria** are then **activated**. The electrical stimulus travels down through the conduction pathways and causes the heart's **ventricles** to **contract and pump out blood**. The 2 upper chambers of the heart *(atria) are stimulated first* and contract for a short period of time *before the 2 lower chambers* of the heart (*ventricles*).

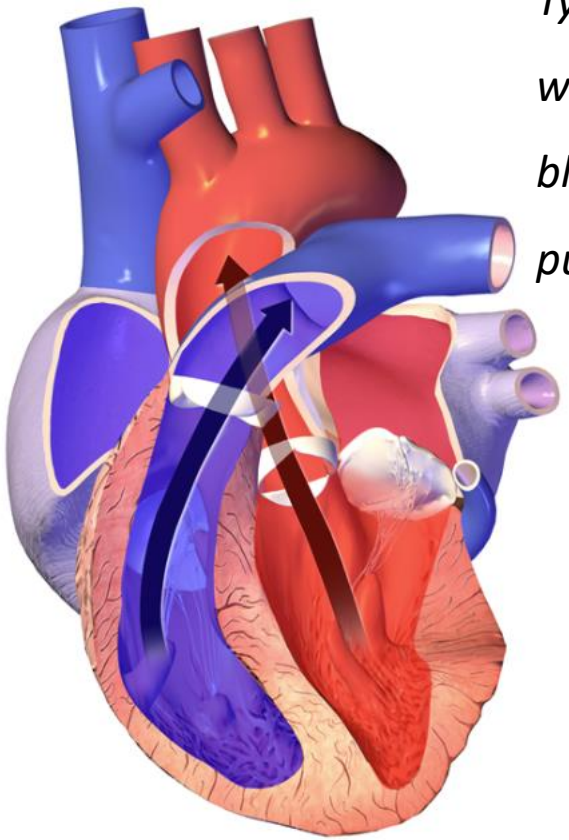


https://tinyurl.com/2br73a4h

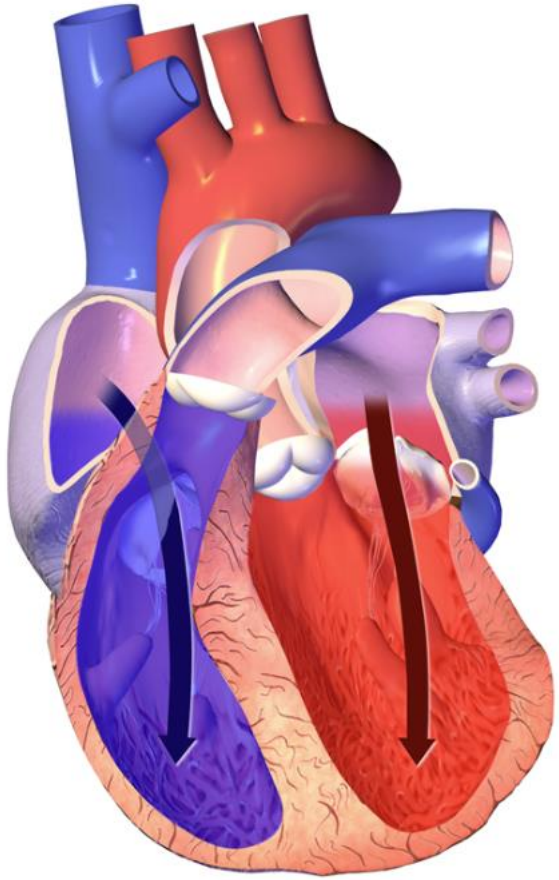
The **electrical impulse travels** from the sinus node **to the atrioventricular node** (also called **AV** node). There, impulses are slowed down for a very short period, then continue down the conduction pathway via **the bundle of His** into the ventricles. The bundle of His divides into right and left pathways, called **bundle branches**, to stimulate the right and left ventricles.

Each contraction of the ventricles represents **one heartbeat**. The atria contract a fraction of a second before the ventricles, so their blood empties into the ventricles before the ventricles contract.

*Typically refers to **ventricular systole**, during which the **ventricles are pumping** (or ejecting) blood **out of the heart** through the aorta and the pulmonary veins.*

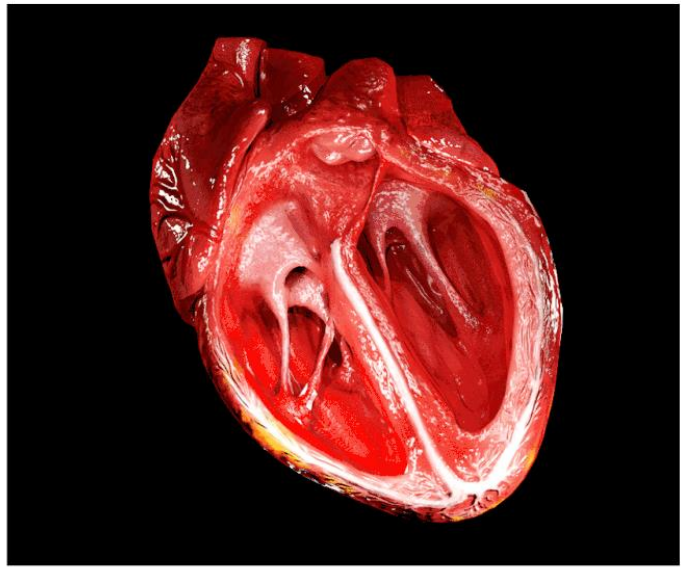


Systole
(pumping)



Diastole
(filling)

CARDIAC CYCLE



*Atria and ventricles at **relaxation** and **expansion** together—while refilling with **blood returning to the heart**.*

https://en.wikipedia.org/wiki/Cardiac_cycle

The electrocardiogram (ECG) measures the **electrical** activity of the **heart**.

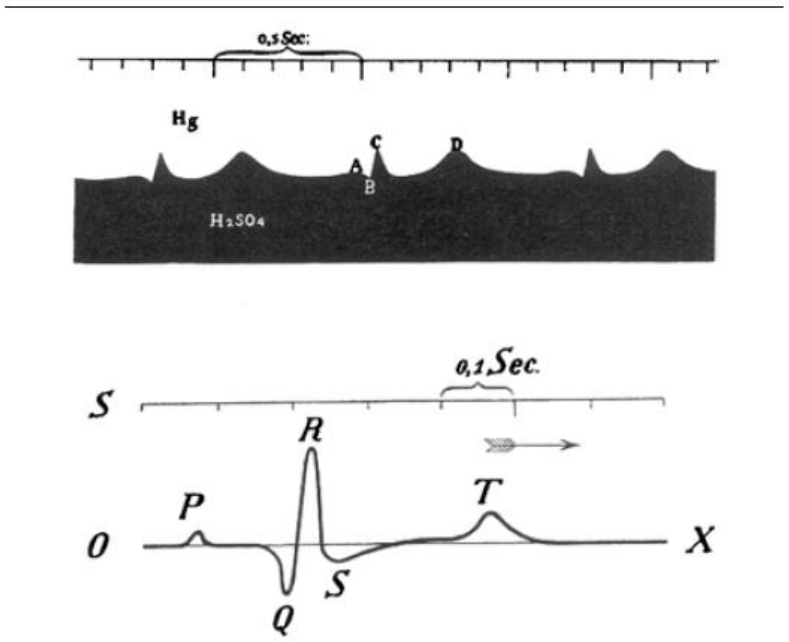
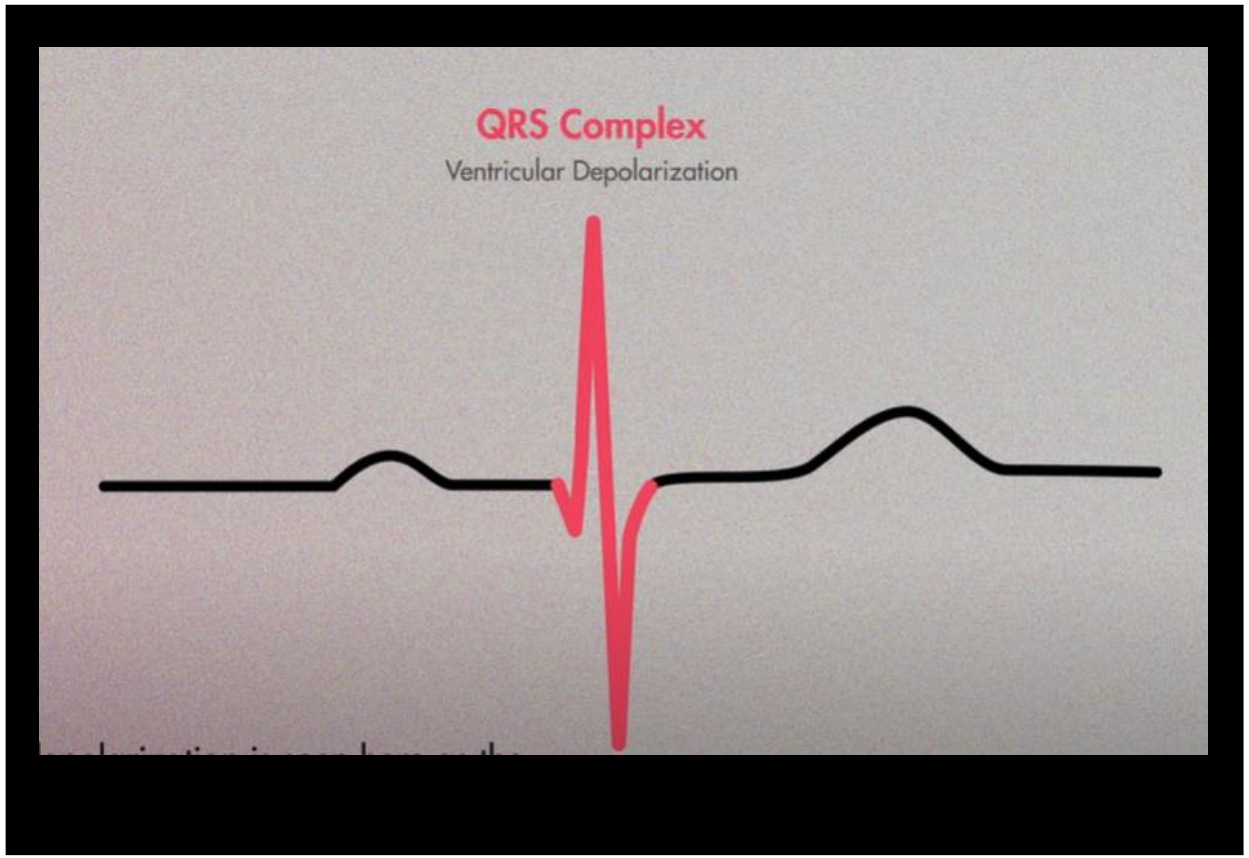


Fig. 1. Improved recording of the ECG by Einthoven with the modified capillary electrometer. The lower tracing which is the reconstructed ECG corrected mathematically, bears a close resemblance to subsequent tracing obtained with the string galvanometer.

Barold, (2003)
https://pubmed.ncbi.nlm.nih.gov/12766530/

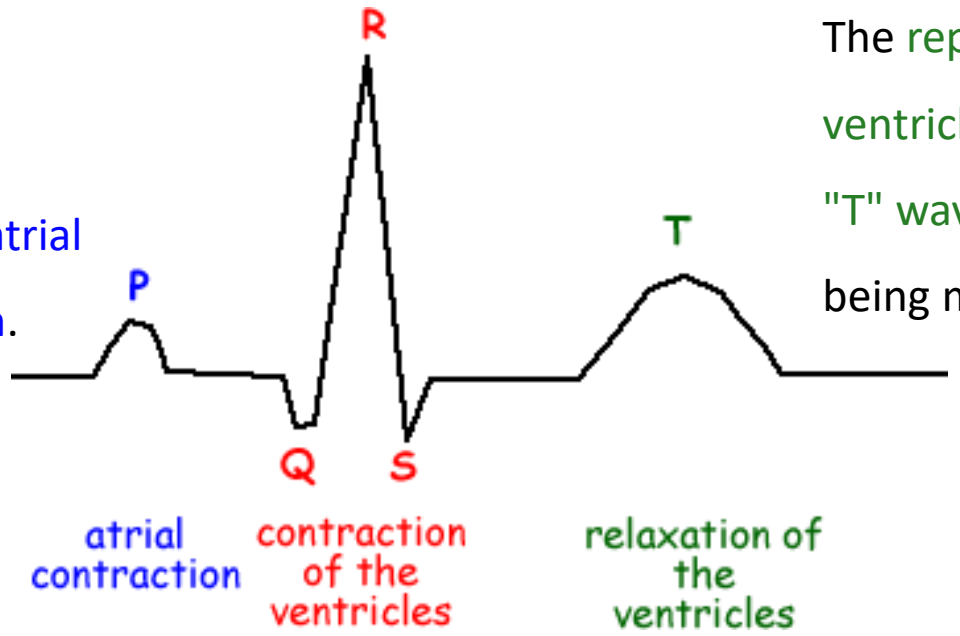
The Cardiac Cycle on an EKG (P-QRS-T Waves)



https://www.youtube.com/watch?v=gqiqcO6AiWc

The "QRS" complex relates to the depolarization and contraction of the ventricles, it is much larger than the "P" wave due to the *relative muscle masses of the atria and ventricles* - and masks the repolarization and relaxation of the atria.

The "P" wave corresponds to atrial depolarization and contraction.



The repolarization and relaxation of the ventricles can be seen in the form of the "T" wave, the repolarization of the atria being masked by the "QRS" complex.

https://www.cyberphysics.co.uk/topics/medical/heart/PQRST.html

The **total time** from initiation of the impulse by the SA node to depolarization of the last ventricular muscle cell is about **0.3 to 0.4 s**. The entire sequence of complete contraction and relaxation of the heart chambers is known as the **cardiac cycle**.

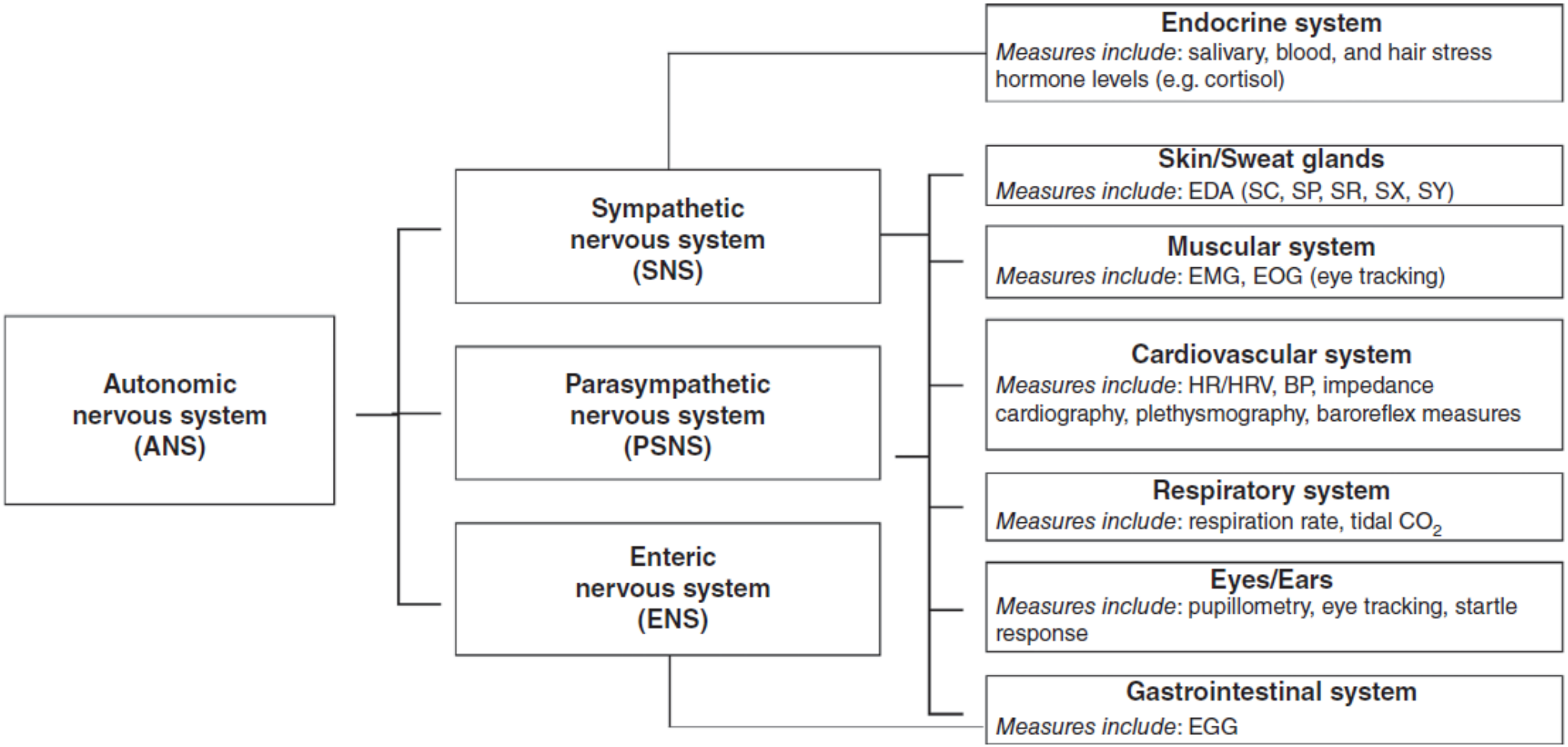
The time for one complete heart cycle, usually measured from one R-wave to the next and expressed in milliseconds, is the **heart period** or **inter-beat interval (IBI).**

Heart rate (HR) is expressed in beats per second and is related to IBI as follows: HR = 60,000/IBI.

So, the HR value for t1 will be 60000 ms (i.e., 60 s, or 1 minute) divided by the value of t1 IBI.

The most frequently reported psychophysiological index measured with the ECG is **heart rate variability (HRV)**, which represents the changes in the time intervals between consecutive IBIs.

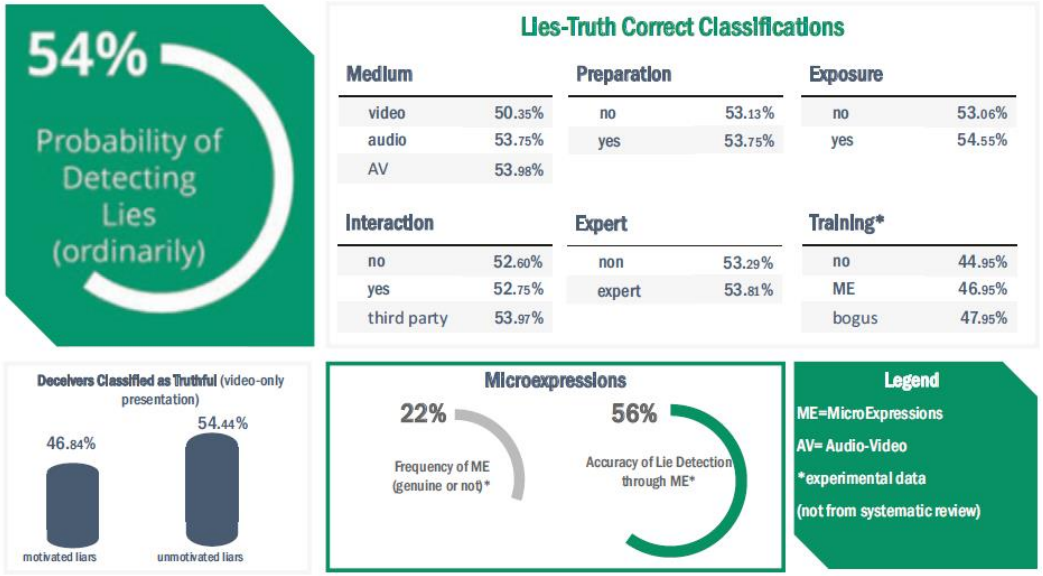
There are many more psychophysiological measures



Tassinary et al. (2012), p. 119

Further reading

Fig. 11.3 Inaccuracy of lie detection courses.
*Data highlight that courses on lie detection are **inefficient** since they do not seem to improve students' abilities.*



11.8 A Past to Remember, a Present to Oversee, a Future to Build

History highlights the difficulty of being able to unmask those who lie. Thinkers, scholars, and past researchers have tried to develop effective lie-detection systems. They started from different assumptions: some relied on physiology, others on visible aspects of behavior, and others on noticeable leaks in people's speech. So far, no approach gives guarantees; indeed, it is easy to run into false positives. What seems clear is the complexity of the phenomenon of lying. Besides, scientists still need to find reliable verbal or nonverbal clues (Vrij et al., 2010).

Despite the incompleteness of current knowledge, several people take for granted some concepts' scientific value. Perhaps, they learned them in a course, read them in a book, or acquired them through the media. The problem is that these ideas are often as unreliable as they are popular.

Chapter 11
"Lie Detection"
by Maurizio Oggiano