

# \* EmotionSense™

An Adaptive Emotion Recognition System  
Based on Wearable Smart Devices

Zhu Wang · Zhiwen Yu · Bobo Zhao · Bin Guo  
Chao Chen · Zhiyong Yu

## Professors

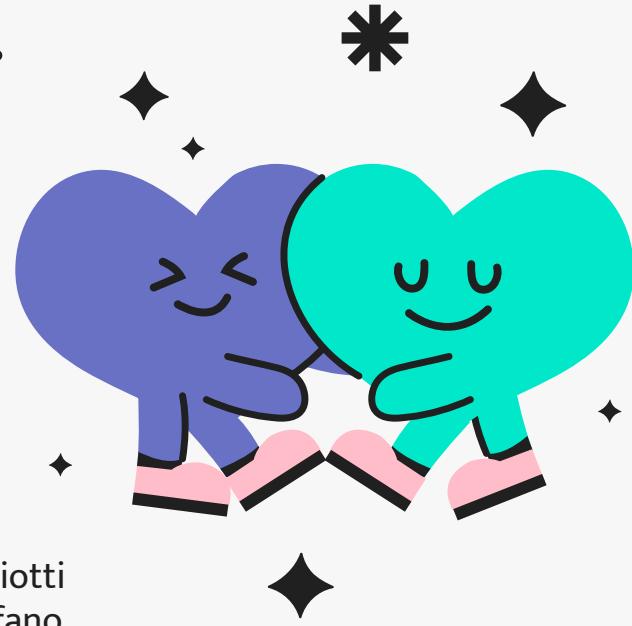
Marco Avvenuti  
Alessio Vecchio



UNIVERSITÀ DI PISA

## Students

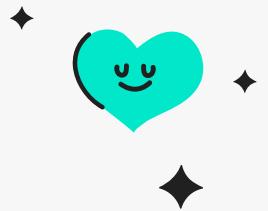
Nicola Ramacciotti  
Tommaso Califano





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- 04. Adaptive Emotion Recognition System**
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01. \*

# Introduction ≈



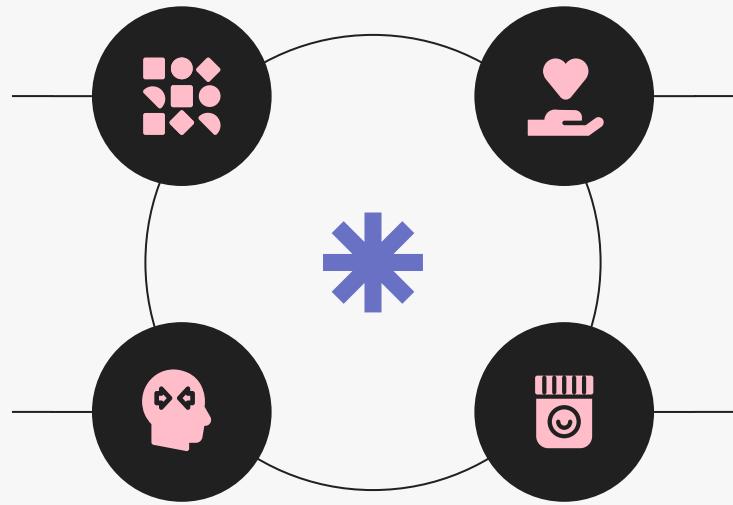
# The Importance of Emotions

## Shape daily life

Psychophysiological responses tied to mood, personality, and motivation, triggered by conscious or unconscious stimuli.

## Dual impact

Emotions drive internal processes that affect both behavior and bodily states.



## Mental health relevance

Poor emotional states can signal or contribute to mental illness, affecting overall well-being.

## Public safety

For roles like drivers or pilots, emotional instability can pose serious safety risks.

# Emotion Recognition System

## Traditional limitations

- Emotions can be **intentionally masked** (e.g., poker face).
- Require **expensive** and **impractical equipment** for daily use.
- Physiological responses are influenced by **multiple factors** (activity, context, culture).

## Proposed solution

- Based on a sensor-rich **smartwatch** collecting non-invasive physiological data.
- **Context-aware**, adapting to the user's real-time activities.
- Exploits **multi-modal physiological signals** to extract fine-grained features and improve recognition accuracy.

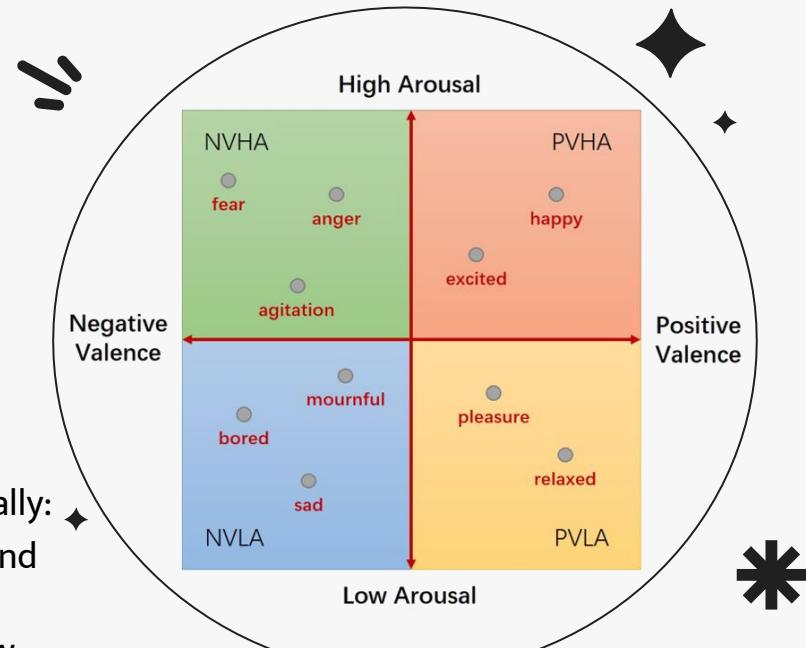
# Emotion classification

## Discrete Emotion Models

- Emotions are labeled using **predefined categories** (e.g., joy, fear, sadness, anger).
- **Limitation:** cannot capture **blended** or culturally **nuanced** emotions

## Dimensional Emotion Models

- Emotions are mapped on continuous scales, typically:
  - **Valence:** pleasantness of emotions (positive and negative).
  - **Arousal:** represents the level of emotions (low and high).

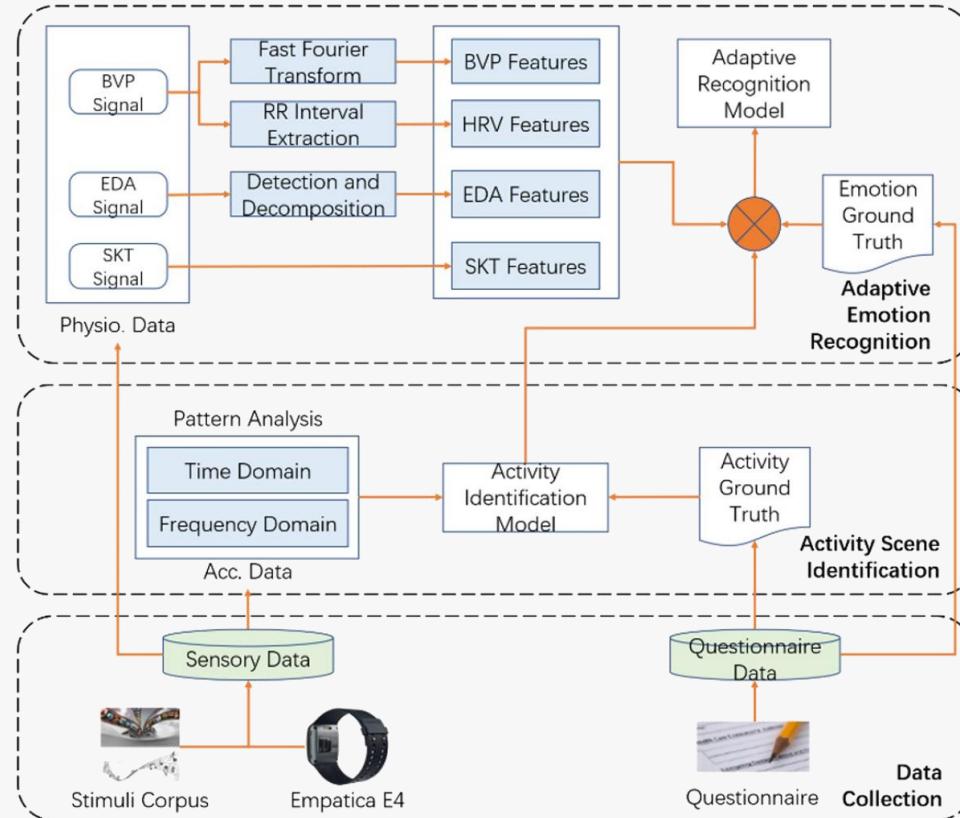


# 02.\*

# System Overview



# \* Proposed Adaptive Emotion Recognition System 😊



Extract emotional features from physiological **data change patterns**, classified using an SVM.

Sliding window segmentation for extracting time and frequency domain information from **accelerometer** data.

**Stimuli** designed to trigger emotional changes, validated through questionnaire (ground truth)

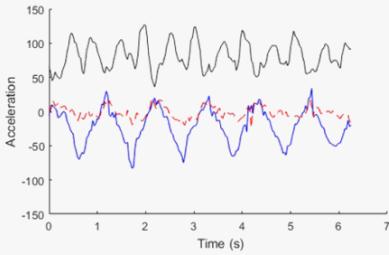
03.\*

# Data Analysis

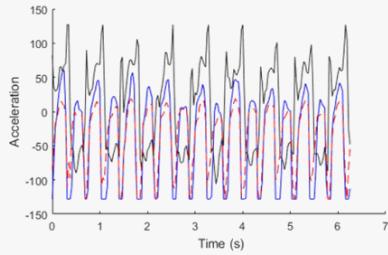


# Activity Identification

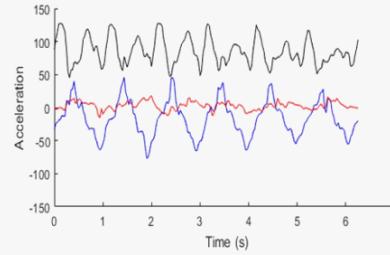
## Accelerometer



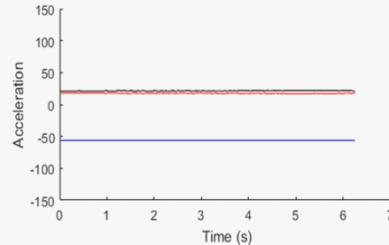
(a) Walking



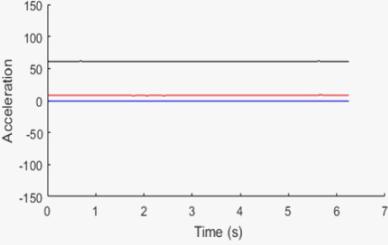
(b) Running



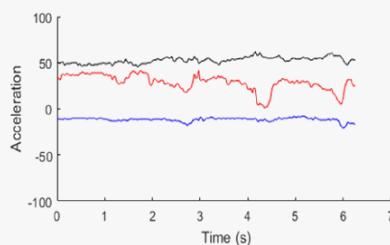
(c) Going upstairs



(d) Standing



(e) Sitting



(f) Riding bicycle

**Y-axis   X-axis   Z-axis**

- **Different activities** → Distinct fluctuation patterns analyzed in **Time domain**
- **Arm swing variations** → Analyzed in the **frequency domain**

# Emotion Recognition

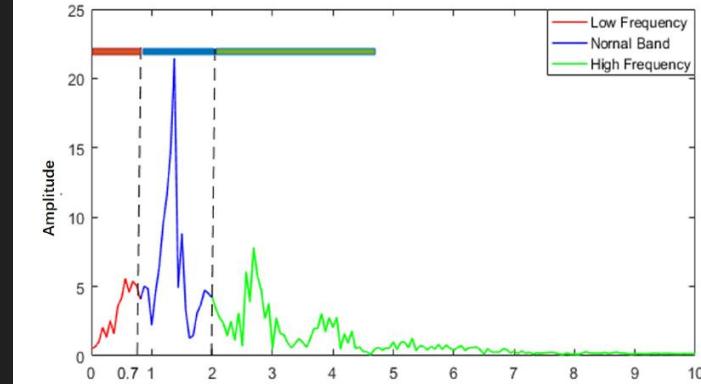
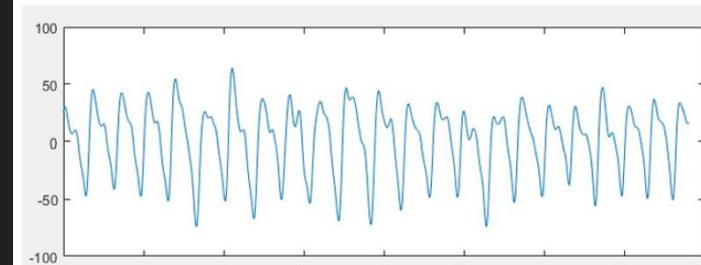
## Photoplethysmography



**PPG Sensor:** Captures Blood Volume Pulse signal from blood volume changes due to heartbeats.

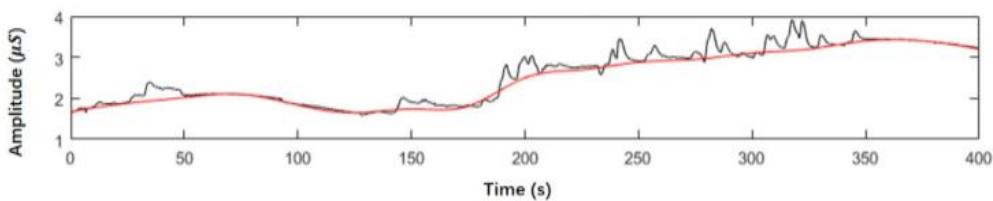
**Frequency Analysis:** FFT splits BVP into LF, MF, and HF sub-bands; MF (normal heart rate) has the highest energy.

**HRV Features:** Extracted from RR intervals using overlapping sliding windows; sensitive to emotional changes.



# Emotion Recognition

## Electrodermal Activity

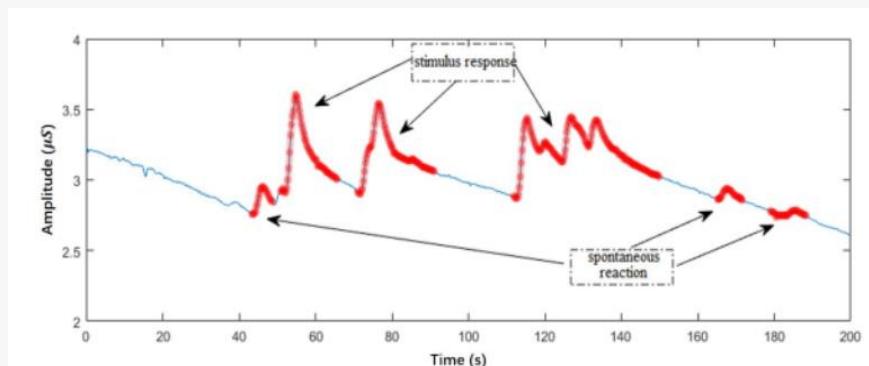


EDA

SCL: Baseline value of physiological activity in a resting state.

SCR: Transient, rapid signal changes from physiological activation due to stimulation.

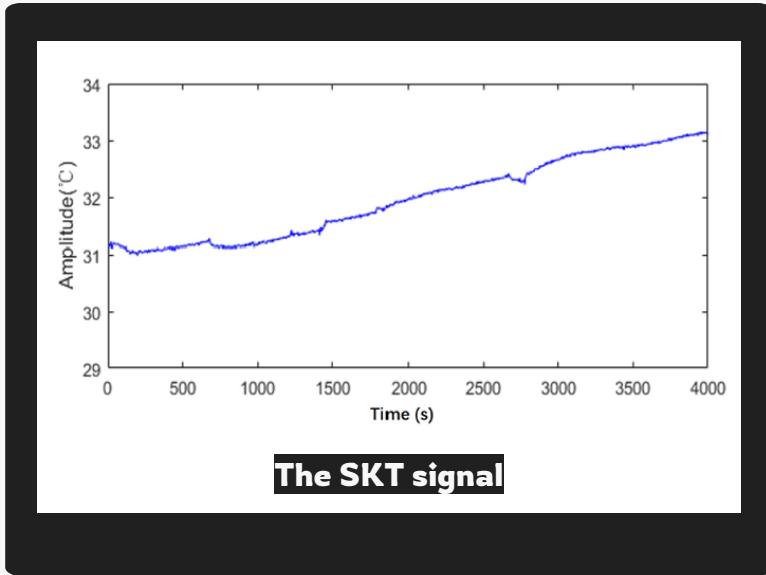
- Emotional changes → Skin electrical response (3–10 s)
- Two types:
  - **Stimulus response** → Higher peaks
  - **Spontaneous response** → Lower peaks
- Detection algorithm based on *short-term energy & zero-crossing rate*:
  1. Remove baseline (3rd-order Butterworth filter)
  2. Divide signal into overlapping segments
  3. Compute signal energy per segment
  4. Detect start and end points of responses



# Emotion Recognition



## Skin Temperature



- Skin temperature varies due to **blood flow changes**
- Blood flow is affected by:
  - **Vascular resistance** (regulated by smooth muscle tone)
  - **Arterial blood pressure** (controlled by autonomic nervous system)
- Temperature changes reflect **autonomic nervous system activity**
- Effective indicator of **emotional state**

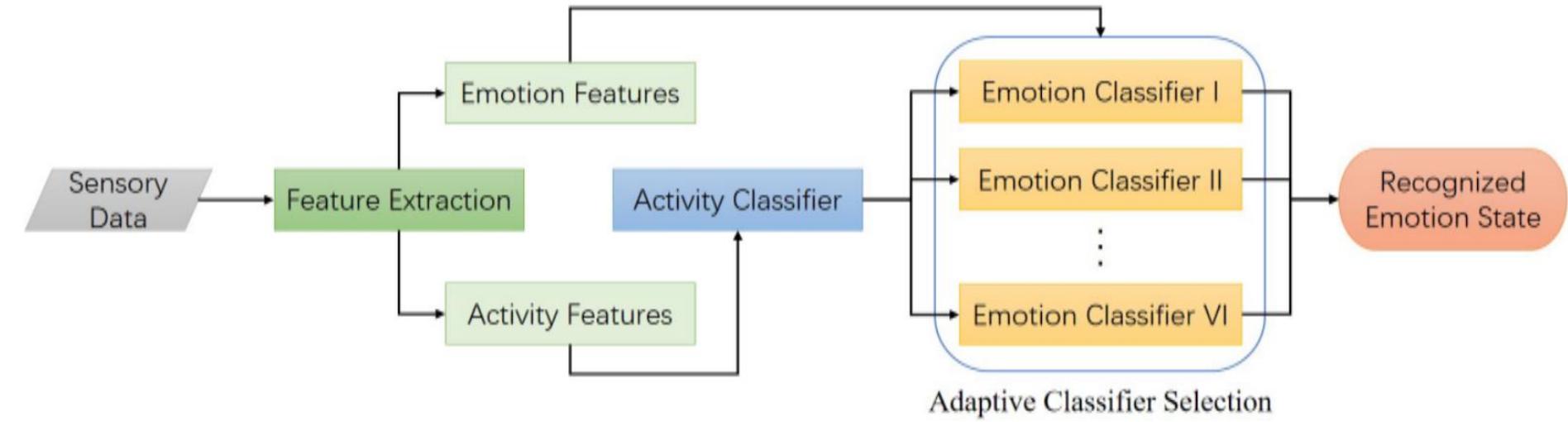
04.\*

# Adaptiove Emotion Recognition



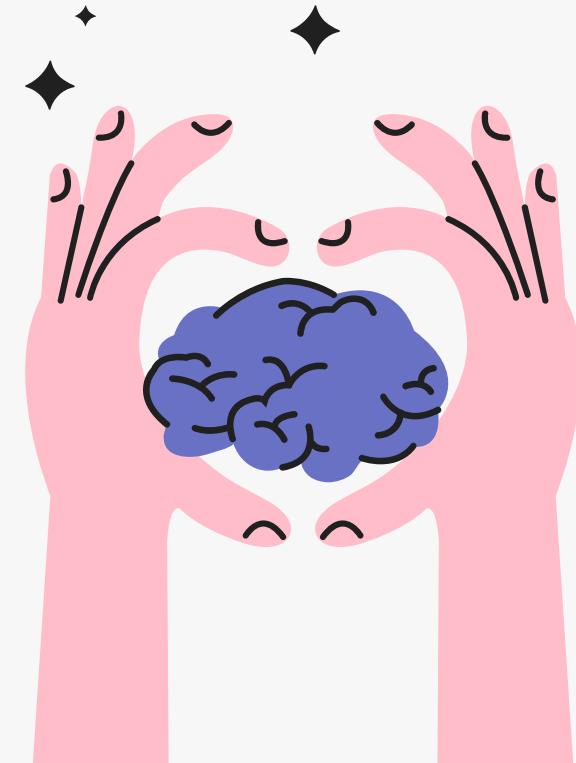


# Adaptive Emotion Recognition System



# 05.\*

# Performance Evaluation



# Experimental Setup

## Emotion Stimuli Corpus



20 Clips (5 minutes long) selected by participants to evoke specific emotions (happiness, sadness, fear, anger, neutrality)



## Experiment 1

- 15 participants watched clips in a **sitting position**
- After each clip, filled out a **questionnaire** about their emotional state
- Resulted in 1,800 samples (**Data Set I**)

## Experiment 2

- 30 participants in **6 different activity groups** (walking, running, cycling, etc.)
- Clips played after 1 minute of activity to evoke emotions
- Resulted in 3,600 samples (**Data Set II**)

Part. ID	Four type of emotions(%)	Arousal(%)	Valence(%)
1	73.00	79.67	74.67
2	81.33	81.33	83.00
3	83.00	88.00	84.67
4	74.67	79.67	78.00
5	86.33	93.00	89.67
6	84.67	89.67	86.33
7	81.33	86.33	83.00
8	86.33	84.67	88.00
9	91.33	93.00	94.67
10	89.67	91.33	86.33
11	84.67	91.33	79.67
12	86.33	89.67	91.33
13	83.00	78.00	83.00
14	84.67	86.33	79.67
15	86.33	93.00	86.33
<b>Average</b>	<b>83.78</b>	<b>87.00</b>	<b>84.56</b>

# Emotion Recognition Performance Data Set I

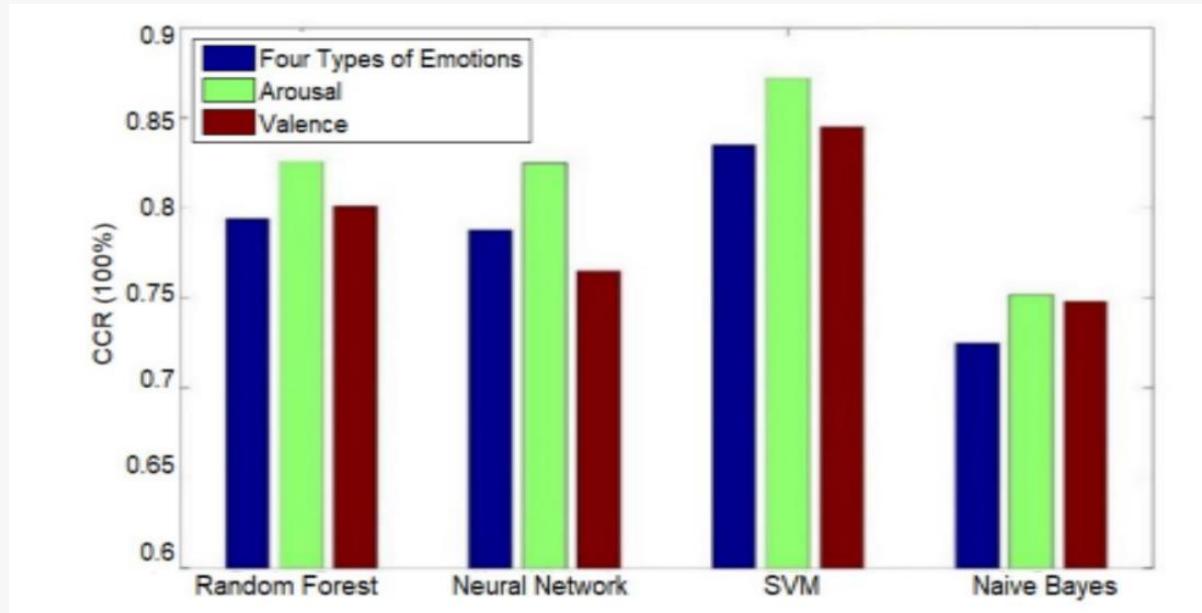
- **Classifier:** Individual SVM trained per participant.
- **Emotion Model:** 4 sub-groups based on 2D model (LANV, LAPV, HANV, HAPV).
- **Arousal CCR:**
  - Average: 87.00%
  - Best: Participant 9 (93.00%)
  - Worst: Participant 13 (78.00%)
- **Valence CCR:**
  - Average: 84.56%
  - Best: Participant 9 (94.67%)
  - Worst: Participant 1 (74.67%)
- **Insight:** Arousal recognition outperformed valence  
→ arousal changes more detectable.

$$CCR = \frac{TP + TN}{TP + TN + FP + FN} \times 100\%.$$



# Comparison of Different Classification Methods

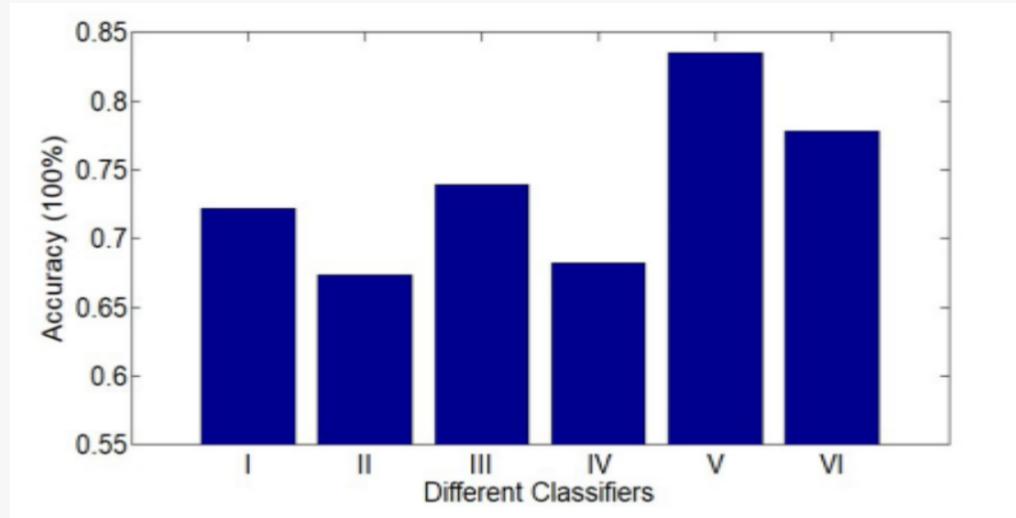
## Data Set I



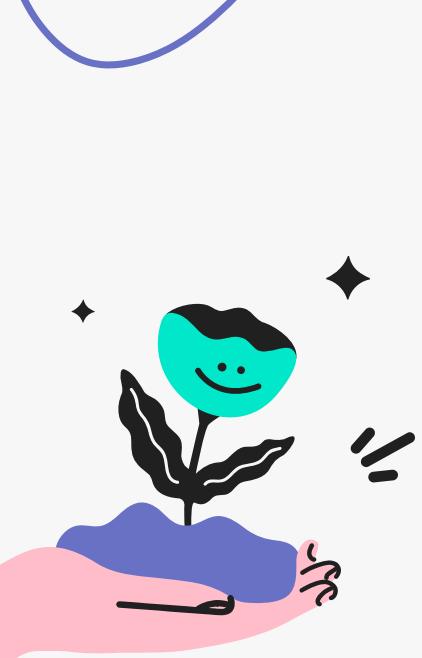
Leave-one-out cross validation

# Performance of Adaptive Emotion Recognition Data Set II

- I : walking
- II: running
- III: riding a bycicle
- IV: going upstairs
- V: sitting
- VI: standing



	Precision	Recall	AUC
Adaptive Method	0.743	0.771	0.769
Non-Adaptive Method	0.461	0.483	0.502



# Thanks!



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# **05.\***

# **Conclusion**

# **& Discussion** ≈



# 02.\*

# System Overview



# \* Proposed Adaptive Emotion Recognition System 😊

# Contents of this template

You can delete this slide when you're done editing the presentation

<b>Fonts</b>	To view this template correctly in PowerPoint, download and install the fonts we used
<b>Used and alternative resources</b>	An assortment of graphic resources that are suitable for use in this presentation
<b>Thanks slide</b>	You must keep it so that proper credits for our design are given
<b>Colors</b>	All the colors used in this presentation
<b>Icons and infographic resources</b>	These can be used in the template, and their size and color can be edited
<b>Editable presentation theme</b>	You can edit the master slides easily. For more info, click <a href="#">here</a>

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# **Template with color filter on photos**

If you want to apply the same filter as the pictures already included in the template, follow these instructions:

1. Insert the picture into the slide
2. Select the photo
3. Click right mouse button
4. Go to “Format options” > “Recolor”. Choose the color you need!





# Whoa!

This can be the part of the presentation where you introduce yourself, write your email...



01. \*

# Emotional dependence

You can enter a subtitle here if you need it



# Divide the content in four ideas



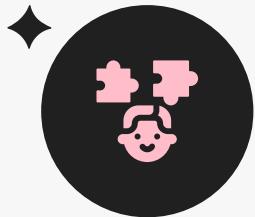
## Mars

Mars is actually a very cold place



## Venus

Venus has extremely high temperatures



## Jupiter

Jupiter is the biggest planet of them all



## Saturn

Saturn is a gas giant and has several rings

01. \*

# Emotional dependence

You can enter a subtitle here if you need it



# **Do you need longer text?**

## **Emotional dependence**

Mercury is the closest planet to the Sun and the smallest one in the entire Solar System. This planet's name has nothing to do with the liquid metal, since Mercury was named after the Roman messenger god. Despite being closer to the Sun than Venus, its temperatures aren't as terribly hot as that planet's. Its surface is quite similar to that of Earth's Moon, which means there are a lot of craters and plains

## **About relationships**

Speaking of craters, many of them were named after artists or authors who made significant contributions to their respective fields. Mercury takes a little more than 58 days to complete its rotation, so try to imagine how long days must be there! Since the temperatures are so extreme, albeit not as extreme as in Venus, and the solar radiation is so high, Mercury has been deemed to be non-habitable for humans

# Emotion Recognition System

## Traditional limitations

- Emotions can be **intentionally masked** (e.g., poker face).
- Require **expensive** and **impractical equipment** for daily use.
- Physiological responses are influenced by **multiple factors** (activity, context, culture).

## Proposed solution

- Based on a sensor-rich **smartwatch** collecting non-invasive physiological data.
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- Exploits **multi-modal physiological signals** to extract fine-grained features and improve recognition accuracy.

# The slide title goes here!

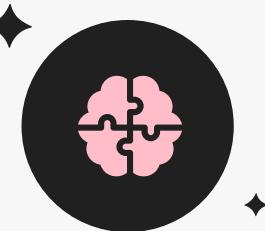
Do you know what helps you make your point crystal clear? Lists like this one:

- They're simple
- You can organize your ideas clearly
- You'll never forget to buy milk!

And the most important thing: the audience won't miss the point of your presentation



# Divide the content into two ideas



## Mercury

Mercury is the closest planet to the Sun and the smallest one in the Solar System

## Venus

Actually, Venus has a beautiful name and is the second planet from the Sun

# Here are three important ideas



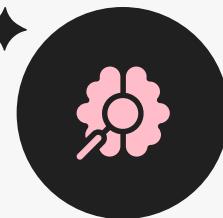
## Mercury

Mercury is the closest planet to the Sun and the smallest of them all



## Venus

Venus has a beautiful name and is the second planet from the Sun



## Mars

Despite being red, Mars is actually a cold place. It's full of iron oxide dust

# Divide the content in four ideas



## Mars

Mars is actually a very cold place



## Venus

Venus has extremely high temperatures



## Jupiter

Jupiter is the biggest planet of them all



## Saturn

Saturn is a gas giant and has several rings

# Reviewing concepts is a good idea



## Mars

Mars is actually a very cold place



## Venus

Venus has extremely high temperatures



## Neptune

Neptune is the farthest planet from the Sun



## Mercury

Mercury is the closest planet to the Sun



## Saturn

Saturn is a gas giant with several rings



## Jupiter

Jupiter is the biggest planet of them all

# Awesome words \*





“This is a quote, words full of wisdom  
that someone important said and can  
make the reader get inspired.”



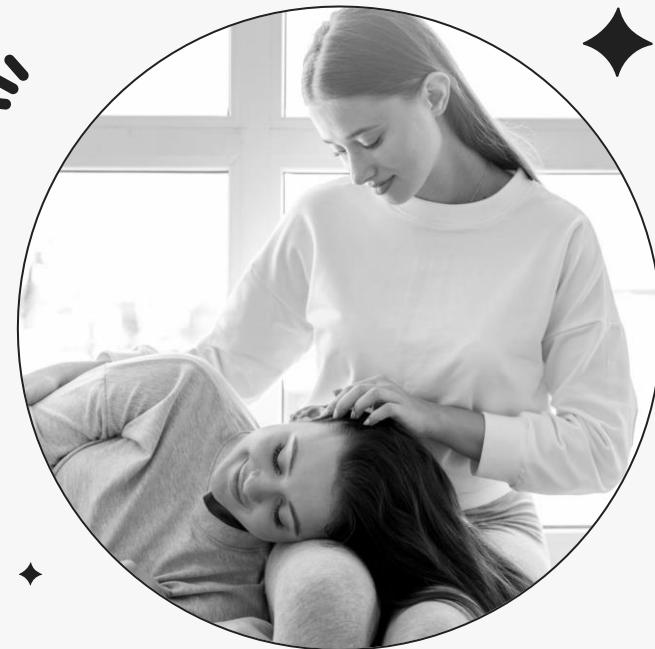
**—Someone Famous**

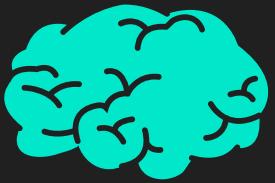
**A picture is worth a  
thousand words \***



# A picture always reinforces the concept

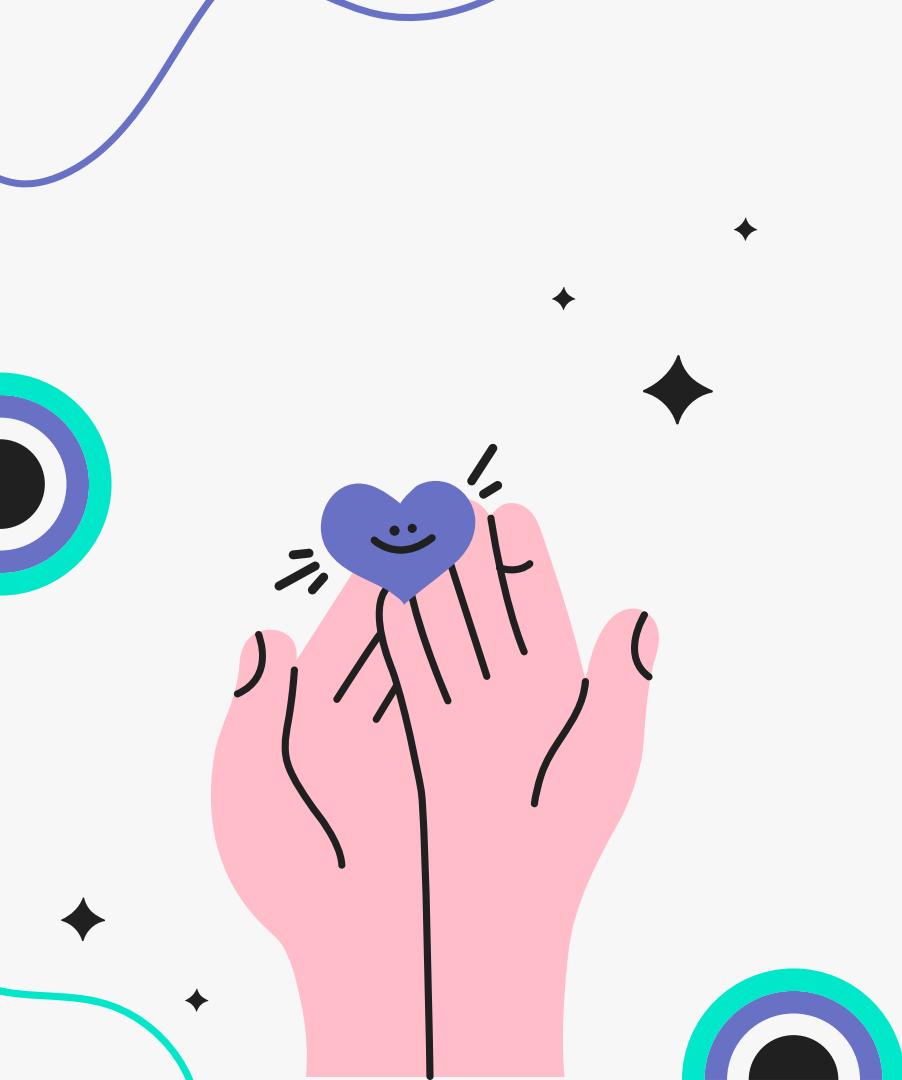
Images reveal large amounts of data, so remember: use an image instead of a long text. Your audience will appreciate it





≈ 4,498,300,000 ≈

Big numbers catch your audience's attention



**9h 55m 23s**

Jupiter's rotation period

**333,000**

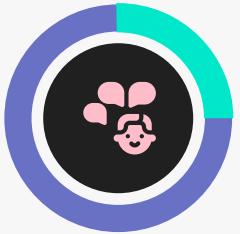
The Sun's mass compared to Earth's

**386,000 km**

Distance between Earth and the Moon

# Let's use some percentages

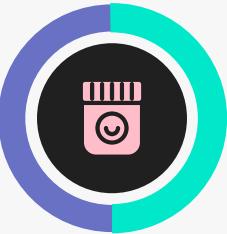
25%



## Mercury

Mercury is the closest planet to the Sun and the smallest of them all

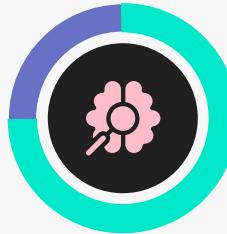
50%



## Venus

Venus has a beautiful name and is the second planet from the Sun

75%

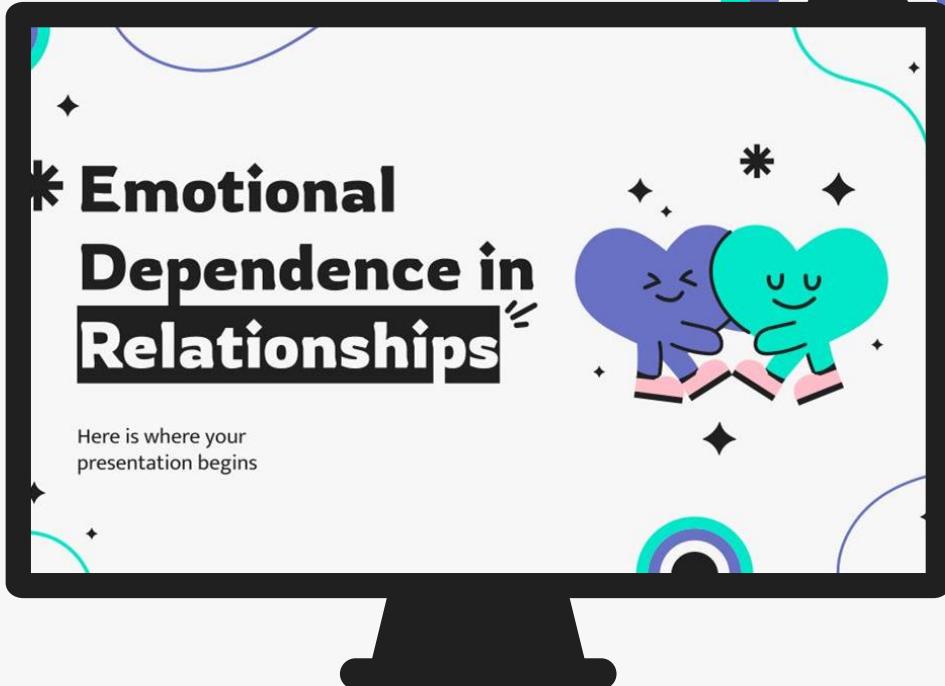


## Mars

Despite being red, Mars is actually a cold place. It's full of iron oxide dust

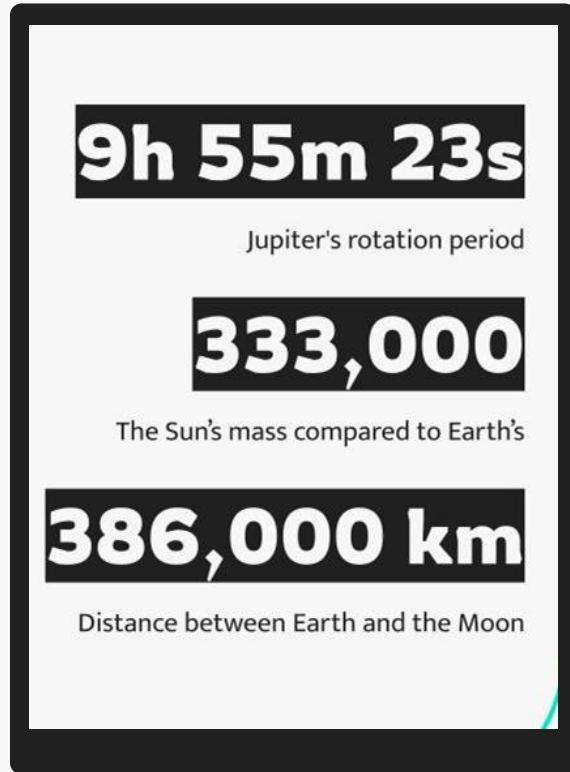
# Computer mockup

You can replace the image on the screen with your own work. Just right-click on it and select “Replace image”



# Tablet mockup

You can replace the image on the screen with your own work. Just right-click on it and select “Replace image”



# Phone mockup

You can replace the image on the screen with your own work. Just right-click on it and select “Replace image”



# This is a map

## \* Mars

Mars is actually a very cold place

## \* Jupiter

Jupiter is the biggest planet of them all

## \* Saturn

Saturn is a gas giant and has several rings



# A timeline always works well

## Venus

Actually, Venus has extremely high temperatures

## Neptune

Neptune is the farthest planet from the Sun

1°

2°

3°

4°

5°

## Mercury

Mercury is the closest planet to the Sun

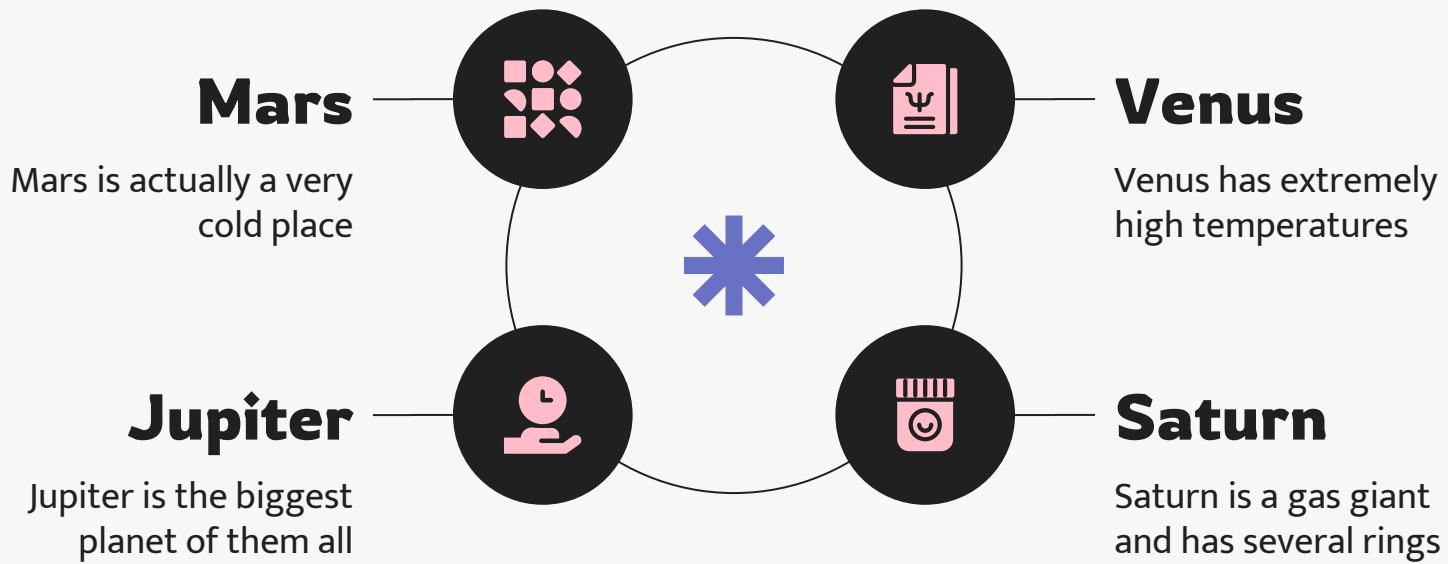
## Saturn

Saturn is a gas giant with several rings

## Jupiter

Jupiter is the biggest planet of them all

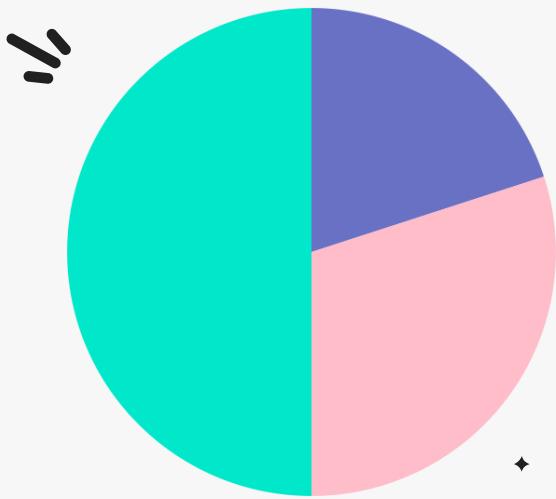
# Infographics make your idea understandable



# Tables Represent Your Data In A Clear Way

Emotions	Description	Characteristics
<b>Emotion 1</b>	Venus is the second planet from the Sun	Despite being red, Mars is a cold place
<b>Emotion 2</b>	Jupiter is the biggest planet of them all	Actually, Neptune is far away from Earth
<b>Emotion 3</b>	Mercury is the closest planet to the Sun	Saturn is composed of hydrogen and helium

# You can use this graph



**20%** \* **Venus**

Actually, Venus has extremely high temperatures

**30%** \* **Mercury**

Mercury is the closest planet to the Sun

**50%** \* **Saturn**

Saturn is a gas giant with several rings

Follow the link in the graph to modify its data and then paste the new one here. [For more info, click here](#)

# Our team



**Sofia Hill**

You can speak a bit about this person here



**Timmy Harris**

You can speak a bit about this person here

# Emotional dependency



## Causes:

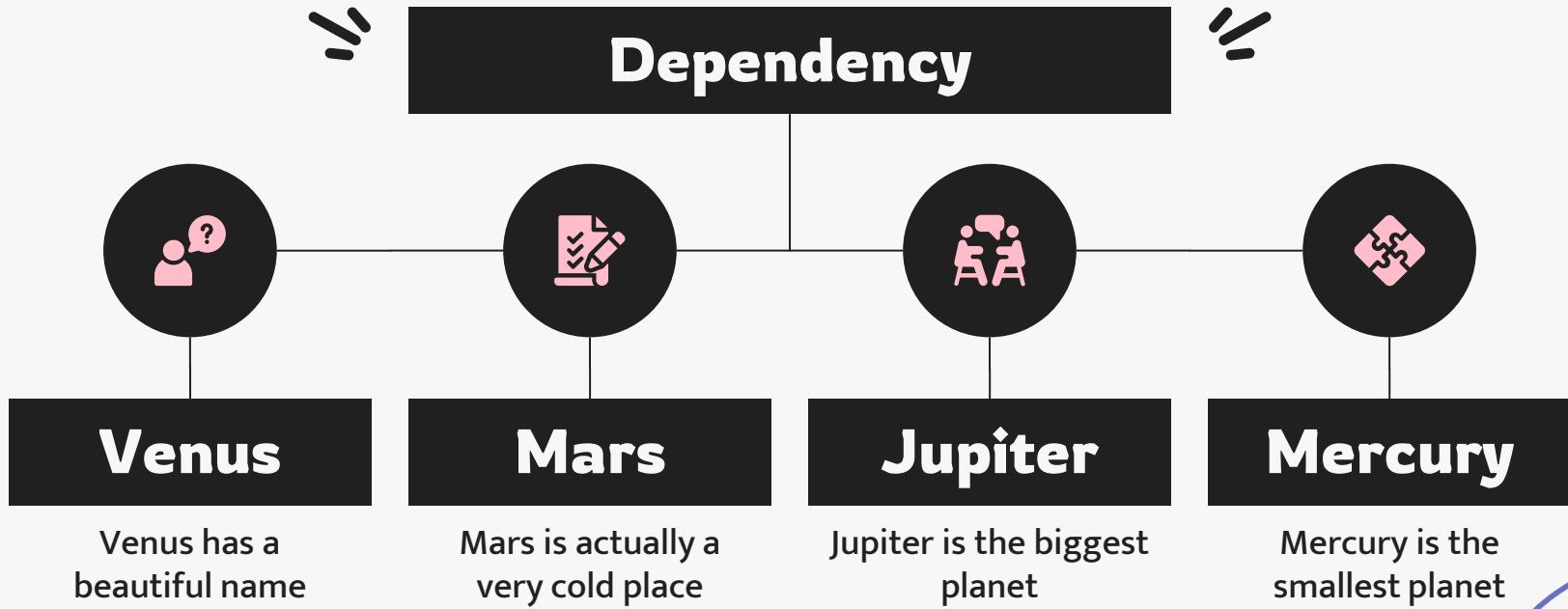
- Romantic love clichés
- Parental overprotection
- Cognitive vulnerability
- Neglectful caregiving



## Symptoms :

- Idealisation of the other
- Complacency and conflict avoidance
- Distress or exaggerated fear of separation
- Low self-esteem

# About dependency



# Signs of emotional dependency

◆ 1°

## Mars

Despite being red, Mars is actually a cold place

◆ 2°

## Saturn

Saturn is composed of hydrogen and helium

◆ 3°

## Jupiter

Jupiter doesn't have a solid surface

◆ 4°

## Neptune

Neptune is the farthest planet from the Sun

◆ 5°

## Earth

Earth is the beautiful planet we all live on

◆ 6°

## Venus

Venus has extremely high temperatures

# Signs of emotional dependency



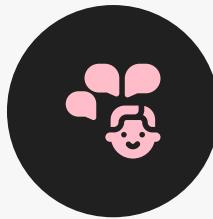
\*



\*



\*



## Always feel insecure

Venus has a beautiful name

## Immense fear of losing love

Mars is actually a very cold place

## Need constant attention

Actually, Jupiter is the biggest planet

## Anxious in social circles

Mercury is the smallest planet

# ♦ Emotional dependency: treatment



**Psychological  
treatment**

**Learning to  
love yourself**

**Meaningful  
bonds**

— Actually, Venus has a beautiful name and is the second planet from the Sun

— Saturn is a gas giant and has several rings. It's composed mostly of hydrogen and helium

— Mercury is the closest planet to the Sun and the smallest one in the Solar System

# Stop your emotional dependence

## Saturn

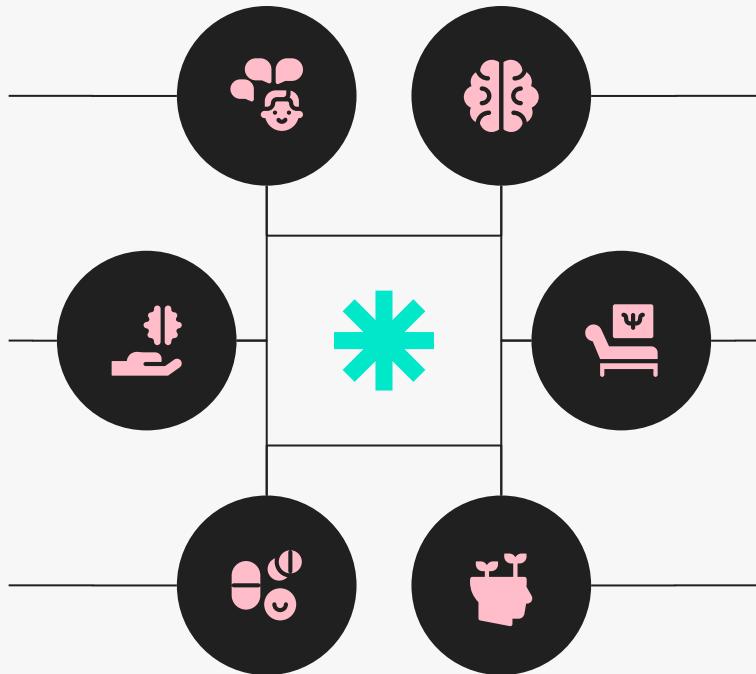
Saturn is composed of hydrogen and helium

## Mars

Despite being red, Mars is actually a cold place

## Jupiter

Jupiter doesn't have a solid surface



## Venus

Venus has extremely high temperatures

## Earth

Earth is the beautiful planet we all live on

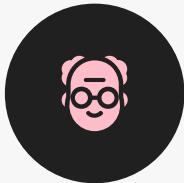
## Neptune

Neptune is the farthest planet from the Sun

# Testimonials



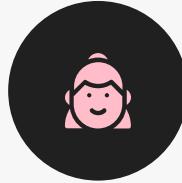
**Jenna Doe**



**John James**

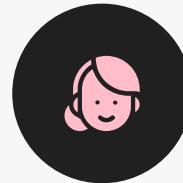
“Neptune is the fourth-largest planet by diameter in the entire Solar System”

“Saturn is the ringed planet. It’s composed mostly of hydrogen and helium”

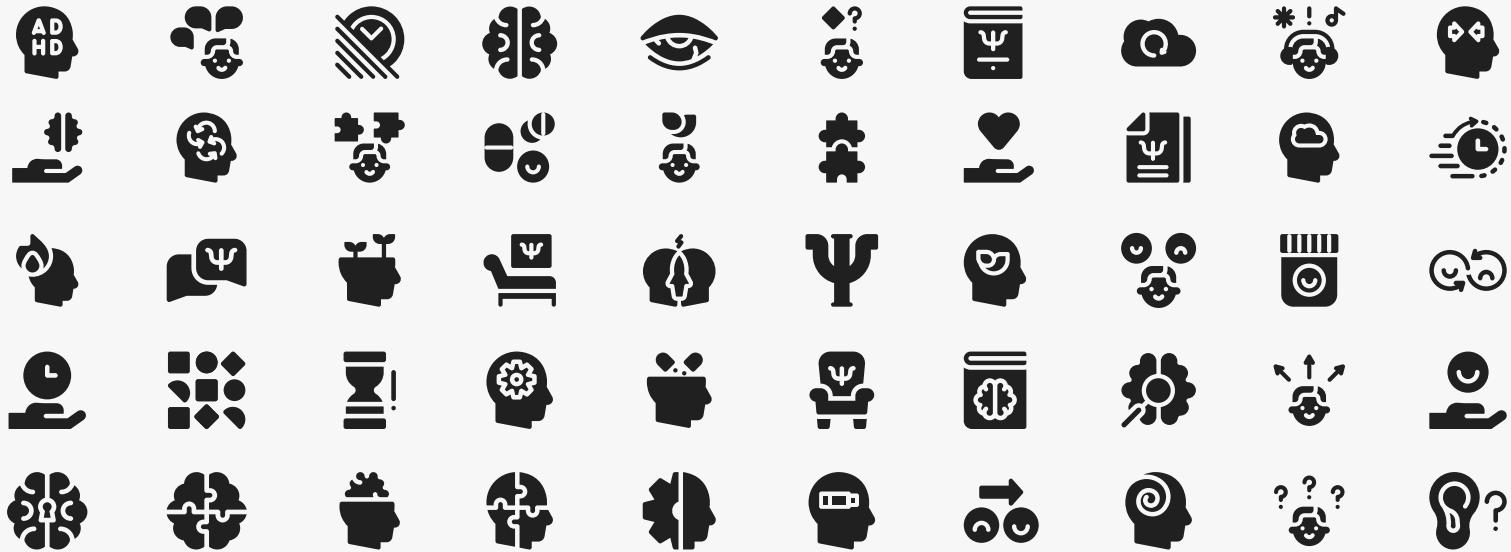


**Susan Bones**

“Mercury is the closest planet to the Sun and the smallest one in the Solar System”



# Icon pack

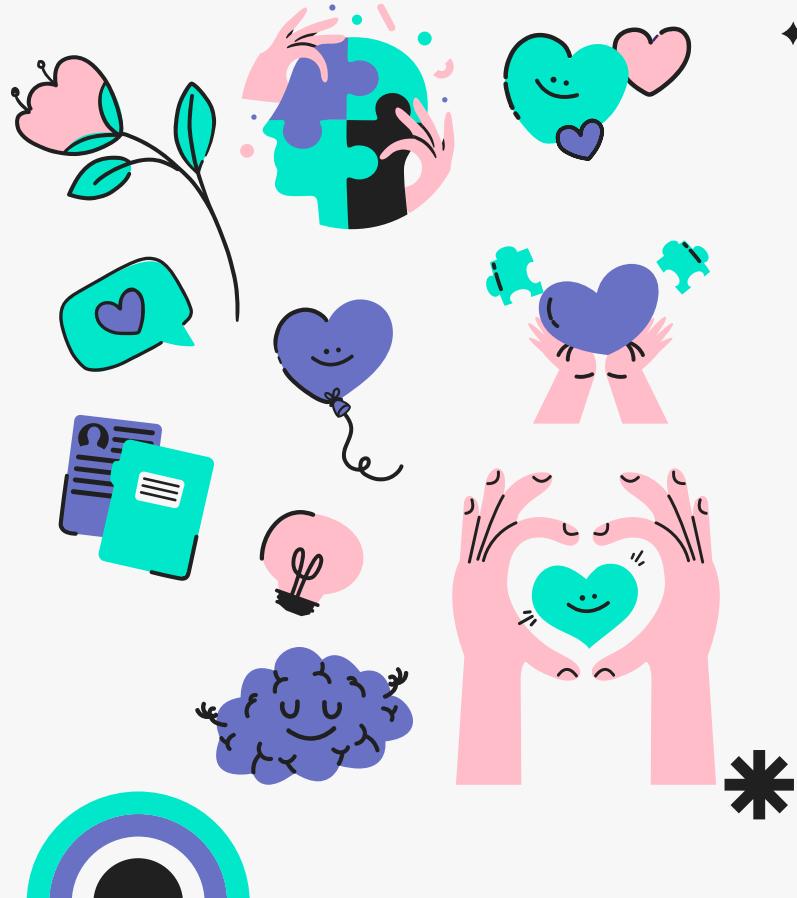


# Alternative resources

Here's an assortment of alternative resources whose style fits the one of this template:

## Vectors

- Psychologist help instagram stories template
- Mental health awareness
- Valentine's day background
- Mental health stickers
- Psychologist labels



# Resources

Did you like the resources on this template? Get them for free at our other websites:

## Vectors

- Psychologist landing page
- Psychologist labels

## Icons

- Icon Pack: Therapy

## Photos

- Young person with anxiety talking to specialist
- Pretty blonde caressing girlfriend
- Nomad couple enjoying time in nature
- Psychologist consulting a patient
- Smiling beautiful female psychologist holding black eyeglasses in hand

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If you have a free account, in order to use this template, you must credit Slidesgo by keeping the Thanks slide. Please refer to the next slide to read the instructions for premium users.

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This presentation has been made using the following fonts:

## **Rowdies**

(<https://fonts.google.com/specimen/Rowdies>)

## **Mukta**

(<https://fonts.google.com/specimen/Mukta>)

#202020

#f7f7f7

#6871c4

#00e7ca

#ffbcc9

# Storyset

Create your Story with our illustrated concepts. Choose the style you like the most, edit its colors, pick the background and layers you want to show and bring them to life with the animator panel! It will boost your presentation. Check out [how it works](#).



Pana



Amico



Bro



Rafiki



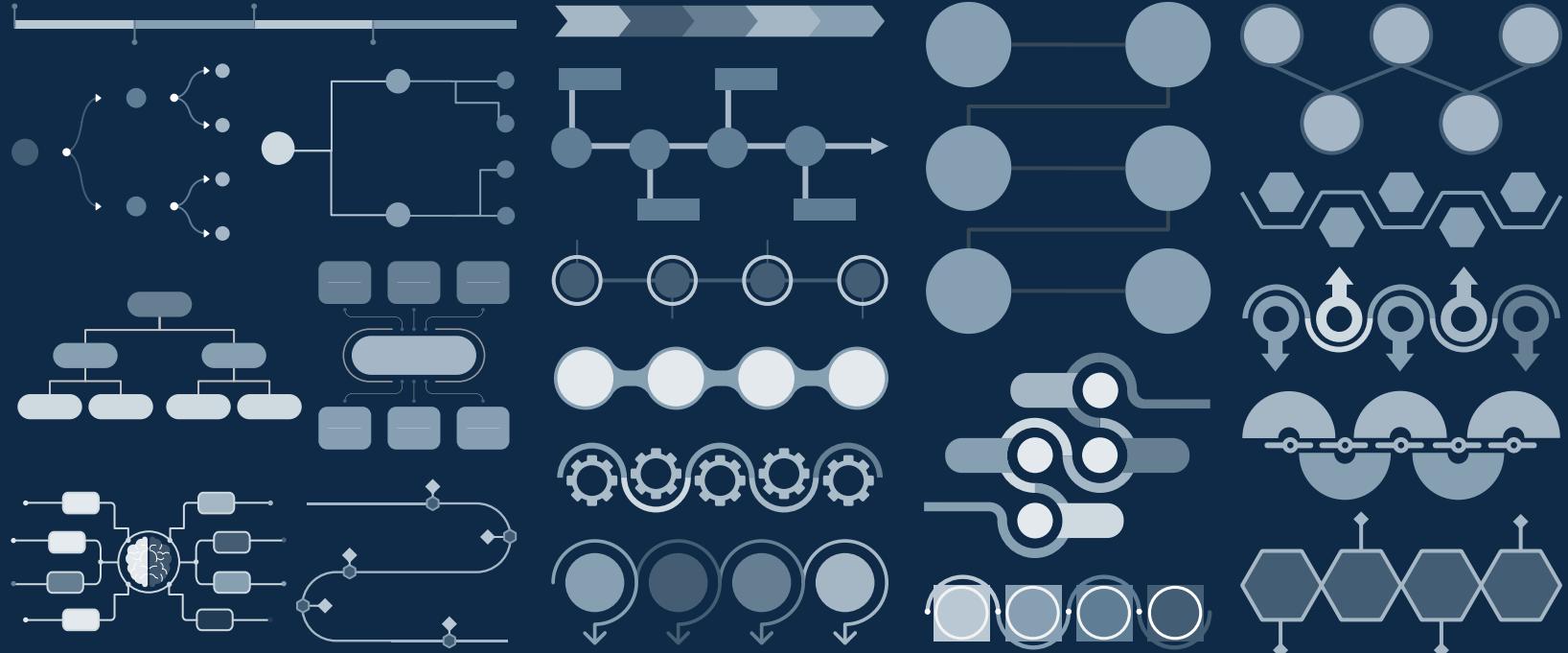
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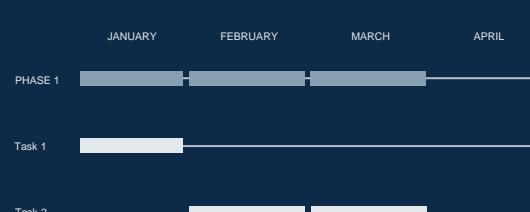
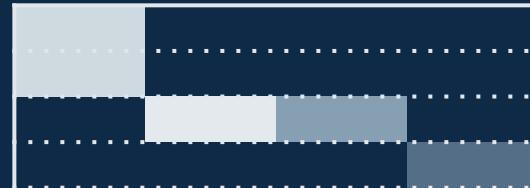
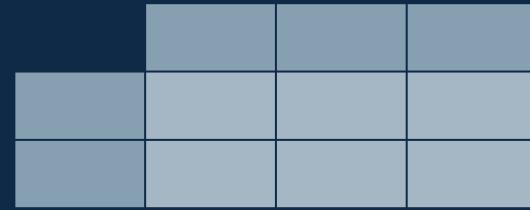
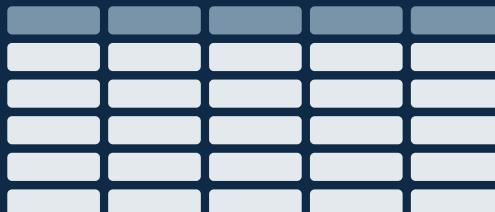
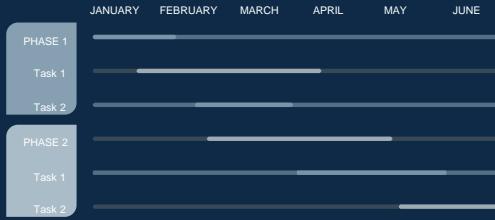
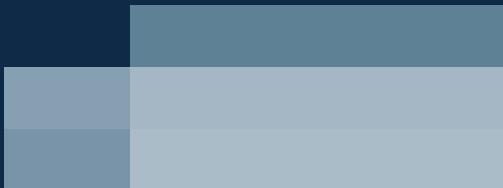
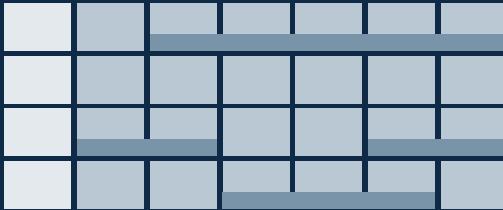
# Use our editable graphic resources...

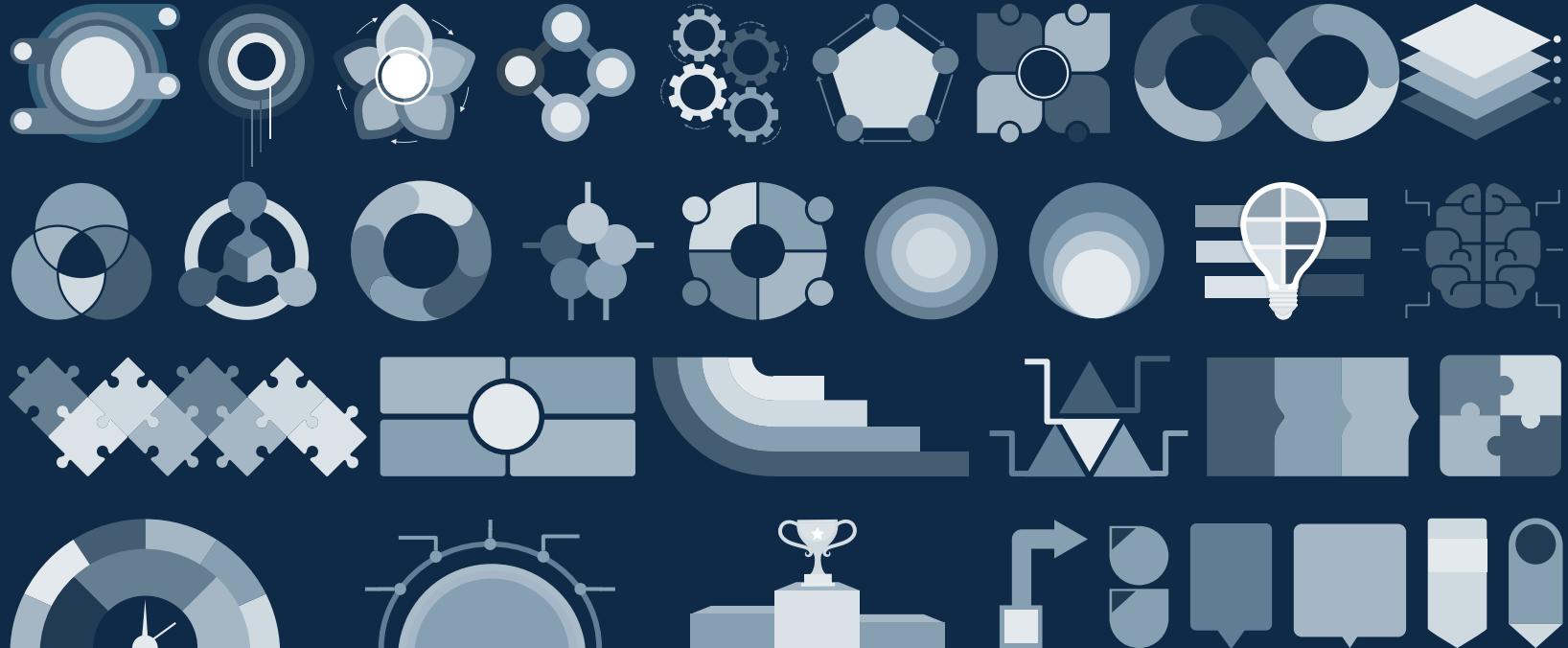
You can easily **resize** these resources without losing quality. To **change the color**, just ungroup the resource and click on the object you want to change. Then, click on the paint bucket and select the color you want. Group the resource again when you're done. You can also look for more **infographics** on Slidesgo.

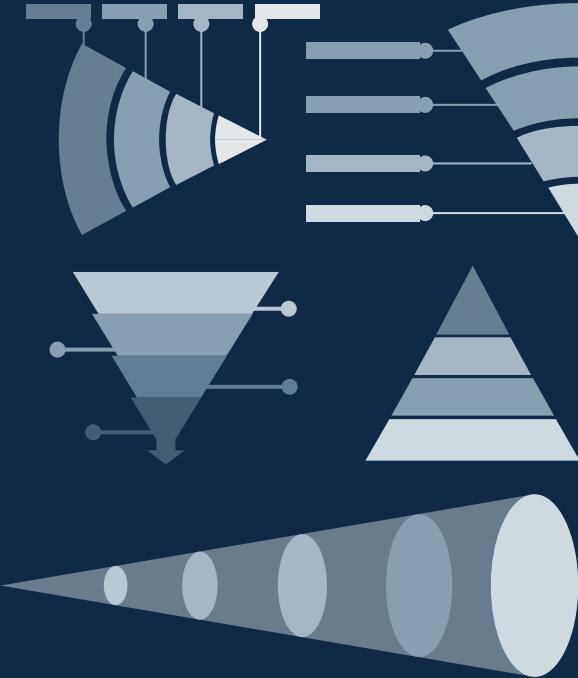
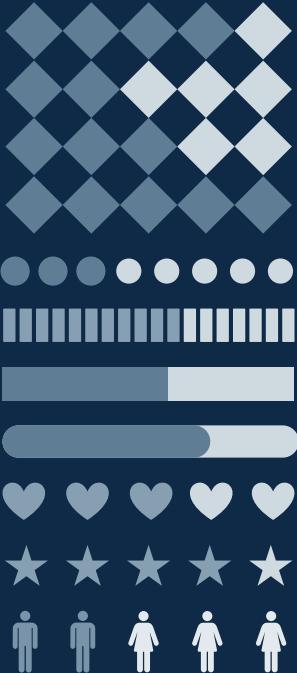
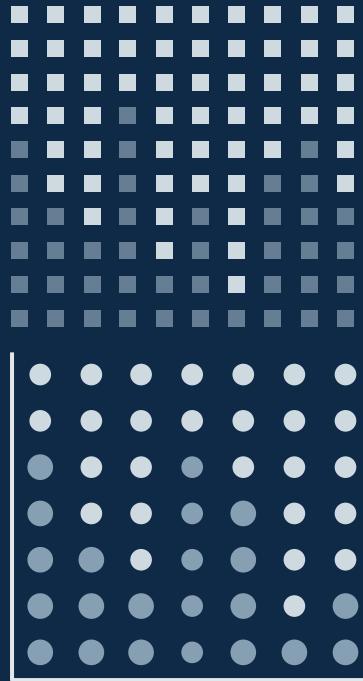












...and our sets of editable icons

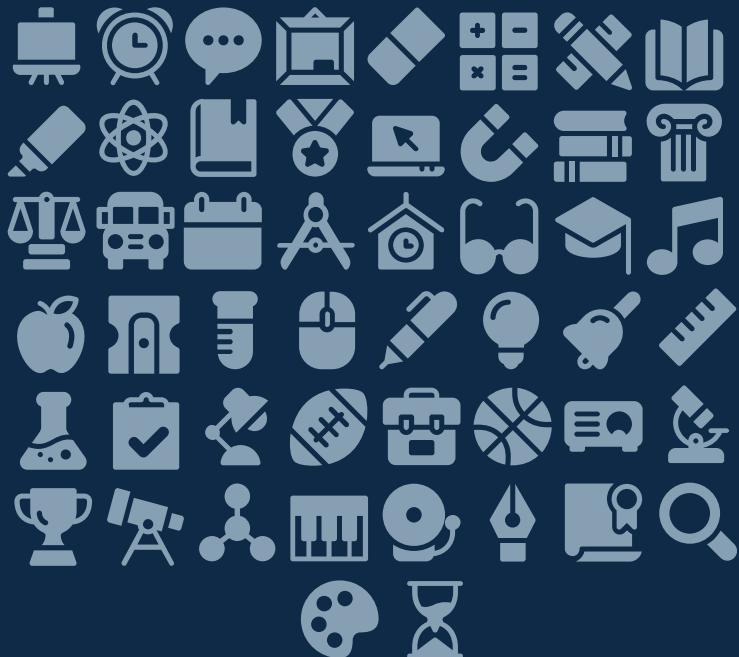
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You can change the stroke and fill color; just select the icon and click on the paint bucket/pen.

In Google Slides, you can also use Flaticon's extension, allowing you to customize and add even more icons.



## Educational Icons



## Medical Icons



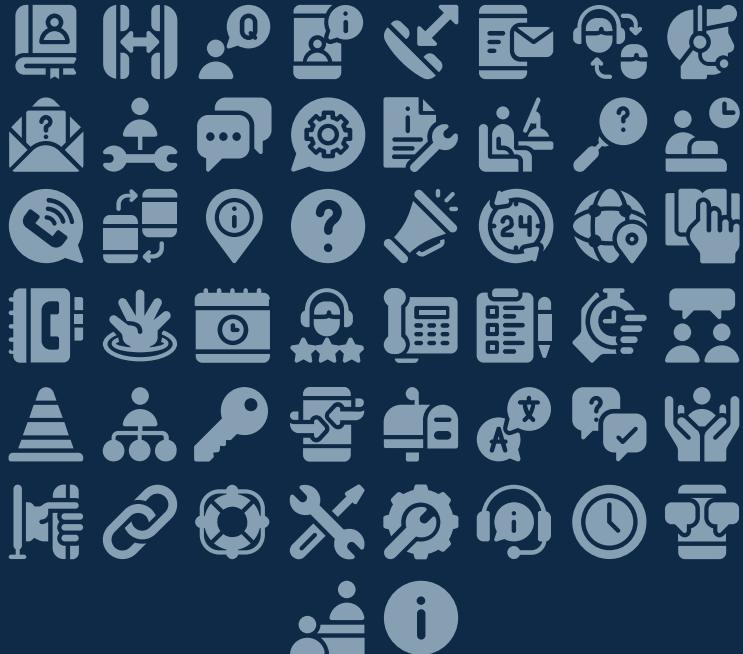
# Business Icons



# Teamwork Icons



# Help & Support Icons



# Avatar Icons



# Creative Process Icons



# Performing Arts Icons



# Nature Icons



# SEO & Marketing Icons



