

# How to Set Up a Psychophysical Experiment

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## Academic background



Degree in  
Computational  
Maths

Erasmus  
exchange

Master in  
Big Data

Phd in  
Computational  
Neuroscience

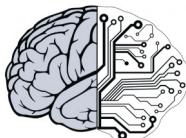
## Experience



Data Scientist  
Trading Algorithms



Data Engineer  
ETL & SQL



Computational neuroscience  
NEURO-ML: Machine learning  
through bio-inspired models

## Research

## Interests

Deep Learning

NLP

Neuroscience

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# Introduction

# Psychophysics

**Psychophysics** quantitatively investigates the relationship between physical stimuli and the sensations and perceptions they produce

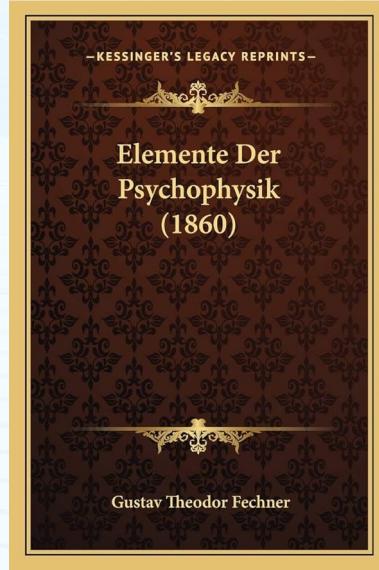


# Gustav Fechner



German physicist, philosopher, and experimental psychologist

Fechner's law:  $S = c \log R$



Fechner established the **principles of psychophysics**, describing various procedures to delineate the relationship between matter and mind

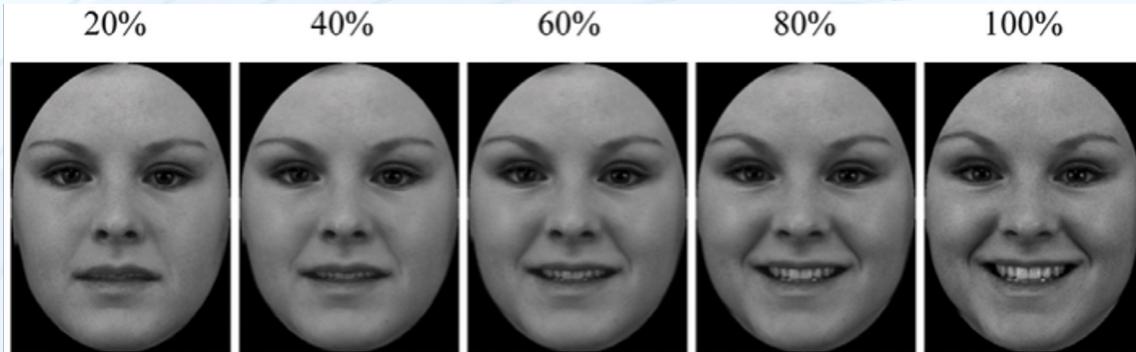
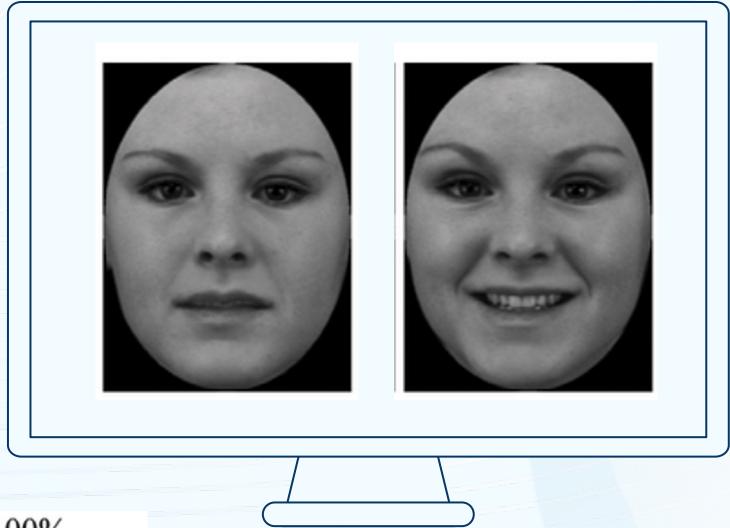
02

# Components of a psychophysics experiment

# Components of an experiment

We present the two images in the screen to the observer

**Stimulus:** any physical object, event, or situation that elicits a sensory or perceptual response in the observer



# Components of an experiment

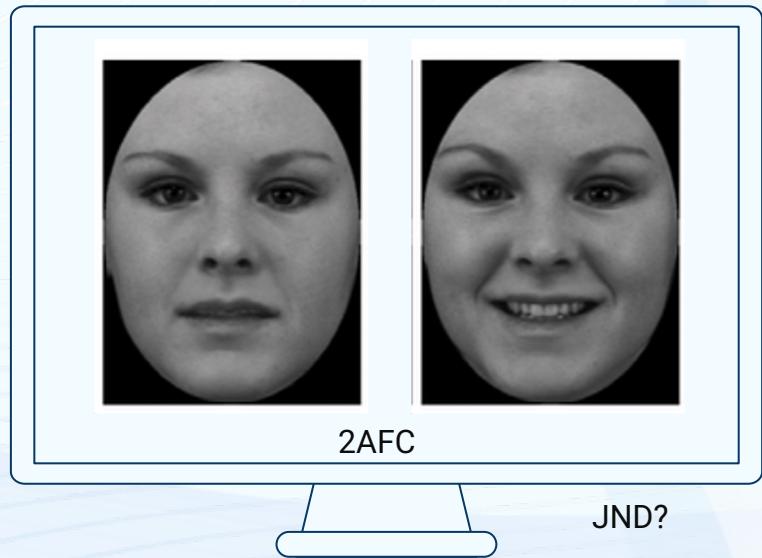
**Stimulus:** two images with different degrees of happiness of the person

**Task:** the activity or judgment assigned to the observer to perform

**Method:** the experimental procedure used to collect data

**Analysis:** the process of converting collected data into meaningful measurements

**Measure:** the result or specific metric of interest



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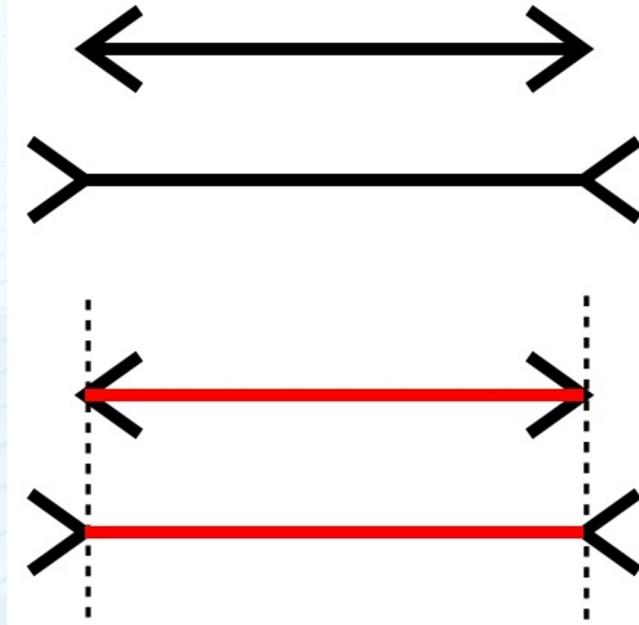
# Classifying Psychophysical Experiments

# Dichotomies

## “Type 1” versus “Type 2”

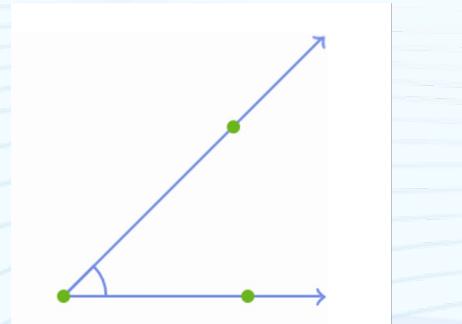
Psychophysical tasks that have correct and incorrect responses are termed Type 1, and those that do not are termed Type 2

Muller – Lyer illusion

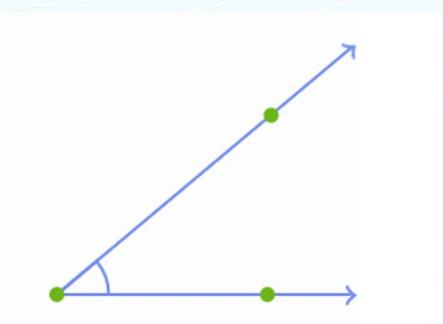


# Dichotomies

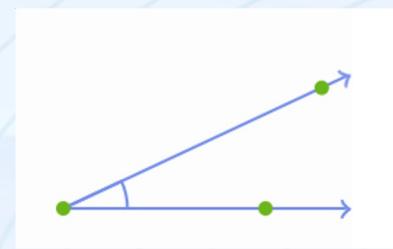
“Performance” versus “Appearance”



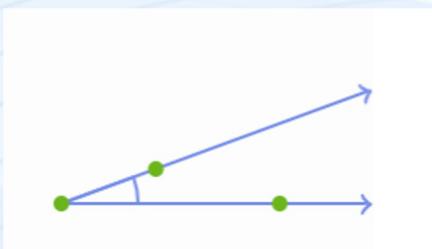
45°



40°



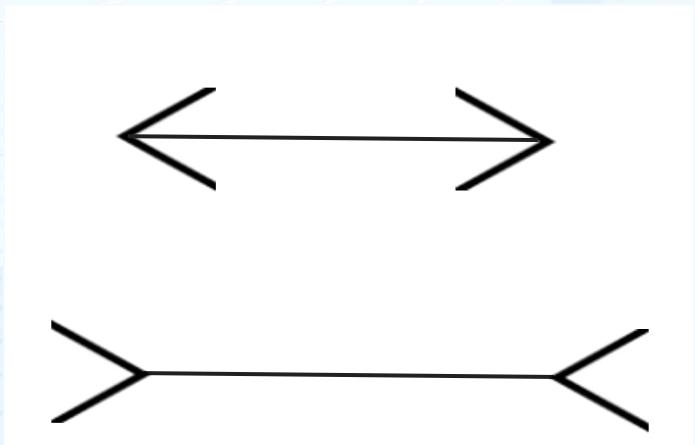
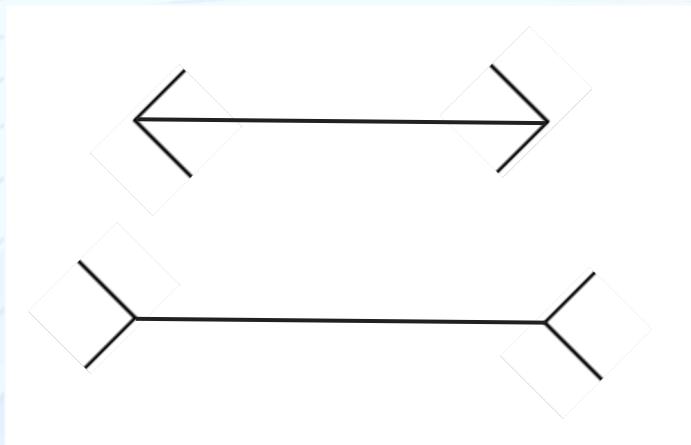
25°



20°

# Dichotomies

“Performance” versus “Appearance”

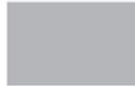


# Dichotomies

## “Forced-Choice” versus “Non-forced-Choice”

**Non-forced-choice:** Observers may not be constrained to choose from pre-specified alternatives

**Forced-choice:** the observer is presented with predetermined response options and is required to select one of them on each trial

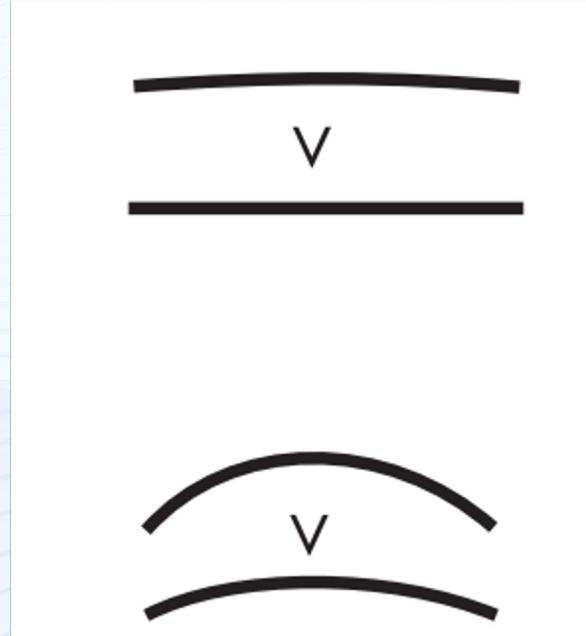
|        | trial 1  | trial 2   | trial 3   | trial 4   | etc.  |
|--------|--|---|---|---|---|
| Yes/No |  |  |  |  |  |
|        | “yes”  | “no”  | “yes”   | “yes”   |   |
| 2AFC   |  |  |  |  |  |
|        | “left”   | “right”   | “right”   | “left”  |   |

# Dichotomies

## “Detection” Versus “Discrimination”

**Detection tasks:** involve determining the presence or absence of a stimulus. The primary goal is to identify whether a sensory signal is present or not.

**Discrimination tasks:** involve distinguishing between different stimuli or different features of a stimulus. Both stimuli are usually non-null

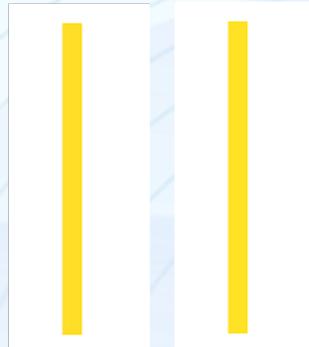


# Dichotomies

## “Threshold” Versus “Suprathreshold”

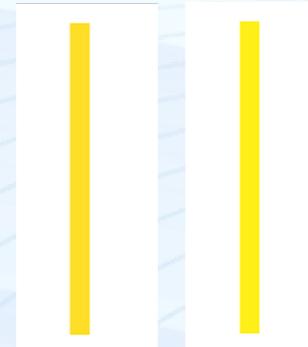
### Threshold (Contrast Discrimination) Task

Bar 0      Bar 1



Contrast  
increase  
→

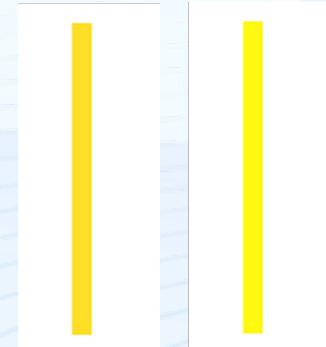
Bar 0      Bar 1



Contrast  
increase  
→

Observer perceive a difference  
in contrast

Bar 0      Bar 2



# Dichotomies

## “Threshold” Versus “Suprathreshold”

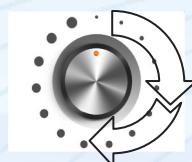
### Suprathreshold (Contrast-Matching) Task

Match the perceived contrast of the adjustable Bar 1 to that of the constant Bar 3

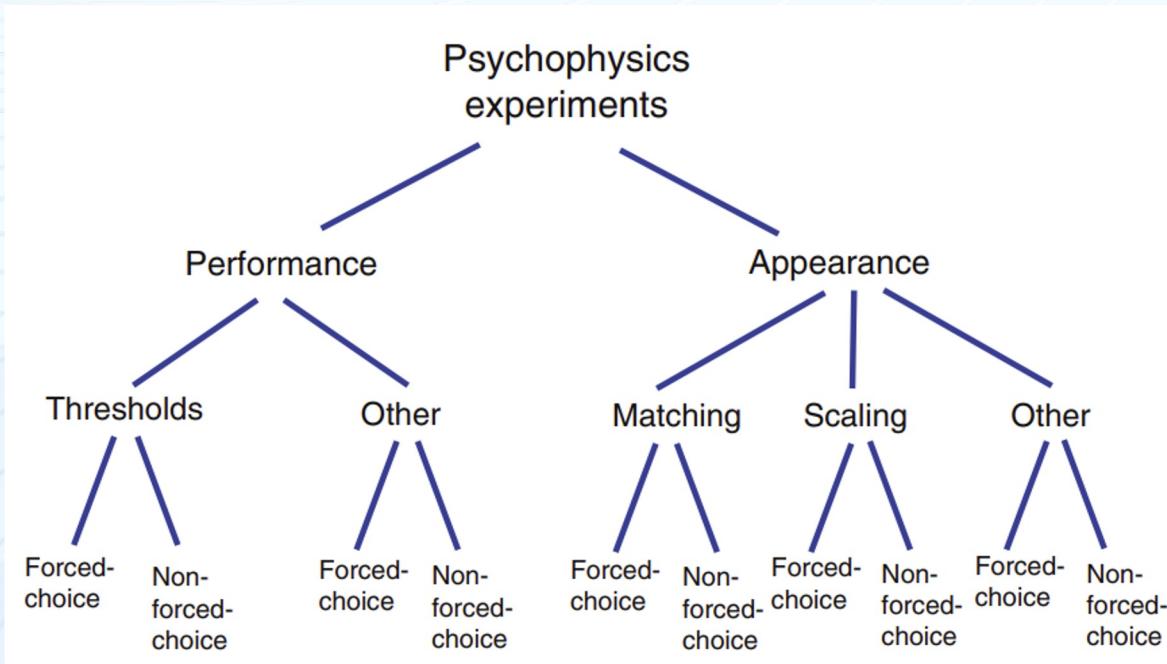
Bar 1



Bar 3



# Classification of experiments



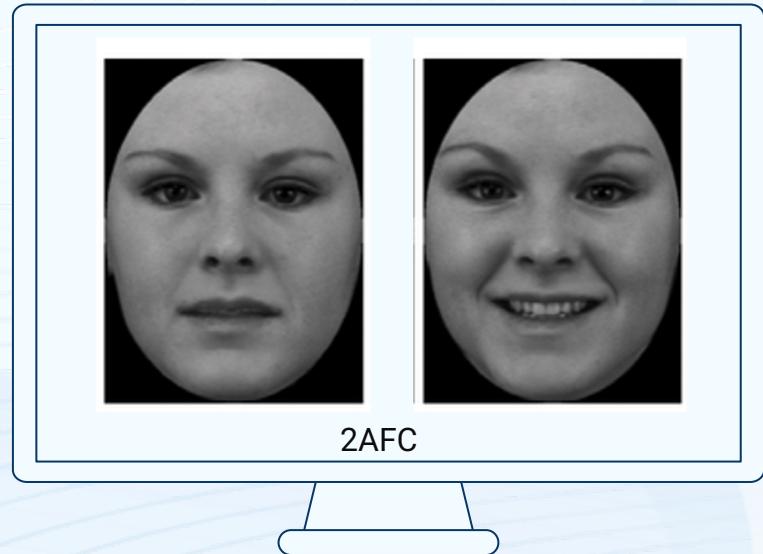
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# Methods and Procedures

# Method of Constant Stimuli

The method of constant stimuli involves presenting stimuli of varying magnitudes randomly selected from a predefined set during an experimental session.

It is a versatile approach used to investigate both performance and appearance aspects in forced-choice experiments.

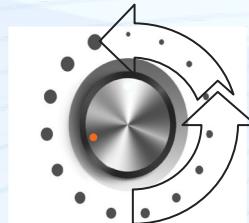


# Methods Based on Threshold Measurements

## Method of Adjustment



The goal is to decrease the luminance until it becomes imperceptible to the observer

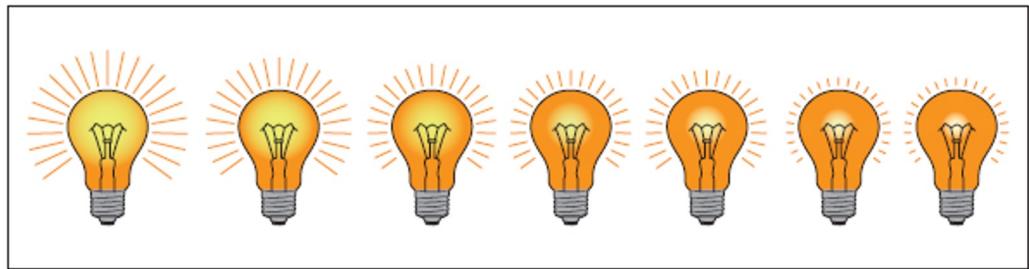


# Methods Based on Threshold Measurements

## Method of Limits

The stimuli are presented in ascending or descending order.

The participant responds when they detect or stop detecting the stimulus.

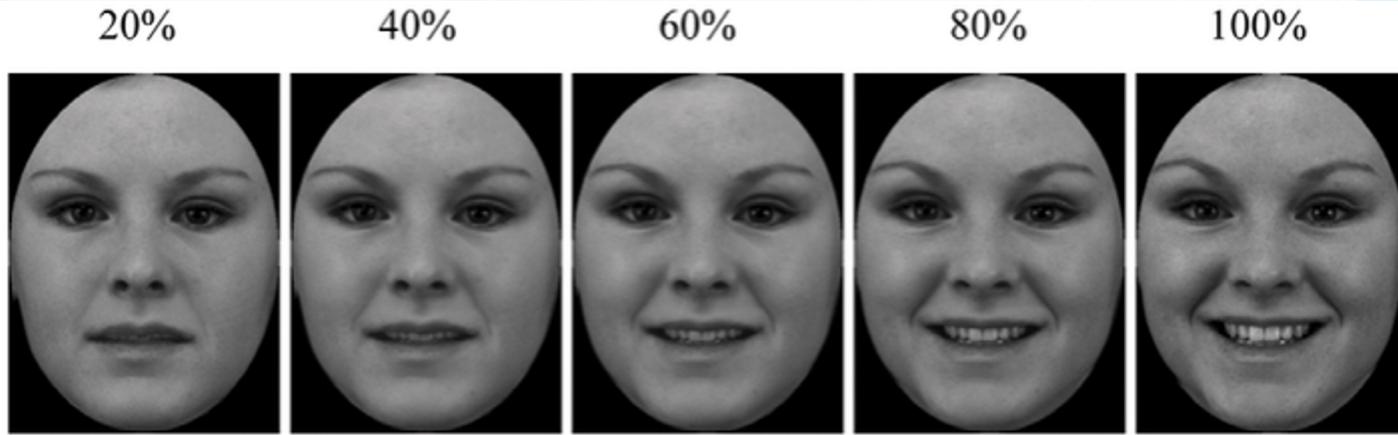


■ **FIGURE 2.4** Absolute threshold.

Illustration of the detection of absolute thresholds through the method of descending limits. Each light is more dim than the one to its left.

# Forced-Choice Methods

## Paired Comparisons



# Forced-Choice Methods

## Method of Triads

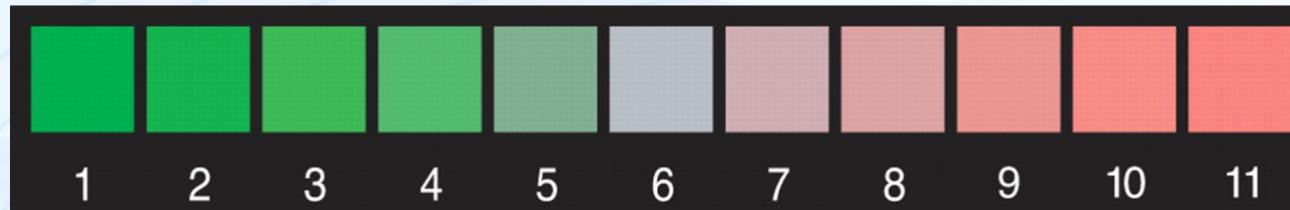
°TID 2008 is an example



# Forced-Choice Methods

## Method of Quadruples

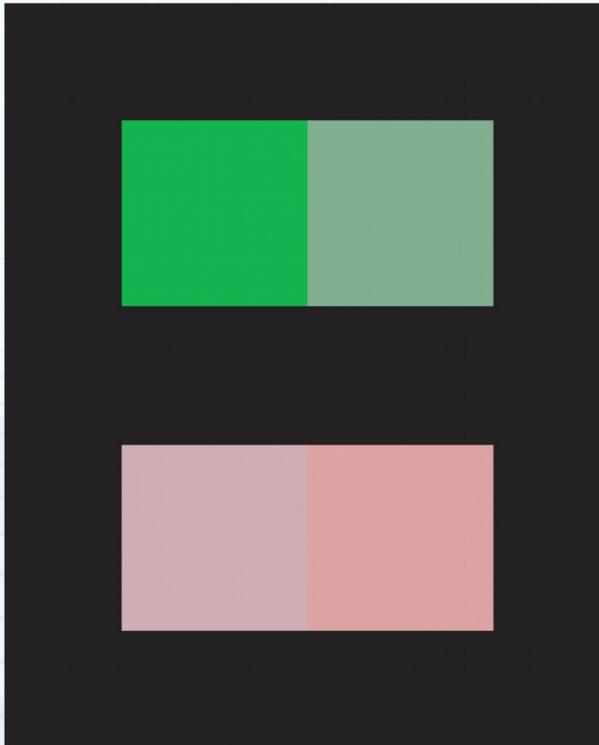
Method of Quadruples



# Forced-Choice Methods

## Method of Quadruples

Which is the most different pair?



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# Scaling Methods

# MLDS

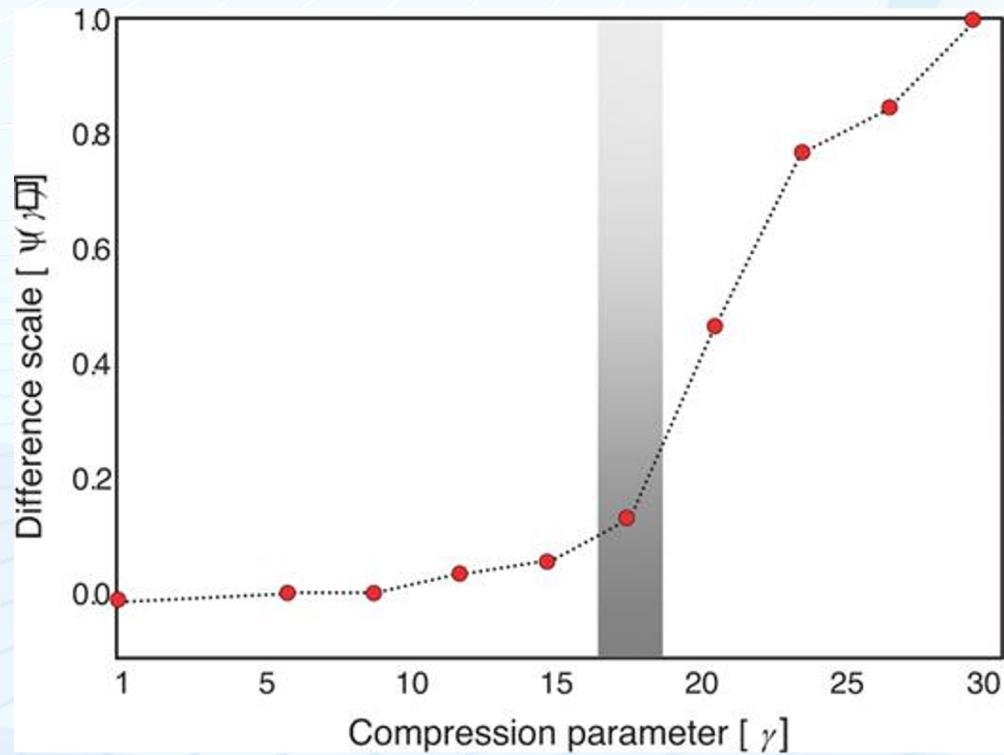
- We apply an image compression algorithm (vector quantization) on ‘image quality’ task
- The degree of compression is controlled by an arbitrary, univariate parameter,  $\gamma$ , that ranges from 1 (‘no compression’) to 30 (‘maximum compression’).



# MLDS

The nominal value plotted on the horizontal axis is  $\gamma$ .

The values plotted along the vertical axis are scale values assigned to the 10 compressions of the same image by a maximum likelihood difference scaling



# MLDS

## What is being used for the MLDS?

- Obein et al. (2004) for measuring gloss
- Lindsey et al. (2010) used MLDS to estimate perceptual intervals between color stimuli to search for (and not find) evidence of categorical color boundaries
- Radonjić et al. (2019) developed a variation that extends MLDS to two-dimensional physical scale values rather than a unidimensional scale
- Knoblauch et al. (2020) investigated luminance and chromatic contrast response using MLDS in normal and anomalous trichromats

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# Conclusions

# Conclusions

## Summary of key findings

|                  |   |
|------------------|---|
| <b>Finding A</b> | Carefully designing the experiment is fundamental   |
| <b>Finding B</b> | Appropriate methods should be selected and control variables that could influence the results |
| <b>Finding C</b> | Use appropriate statistical techniques to analyze the collected data                          |
| <b>Finding D</b> | Results should be interpreted cautiously, taking into account possible biases and limitations |

## Potential future advancements we are working on

- How are the rotation, translation and zoom transformations perceived by the humans?

# Resources

Maximum likelihood difference scaling | JOV | ARVO Journals

Nikolay Ponomarenko homepage - TID2013

Psychophysics | ScienceDirect

Measuring and Modeling Visual Appearance | Annual Review of Vision Science

# Thanks for your attention!

Do you have any questions?

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