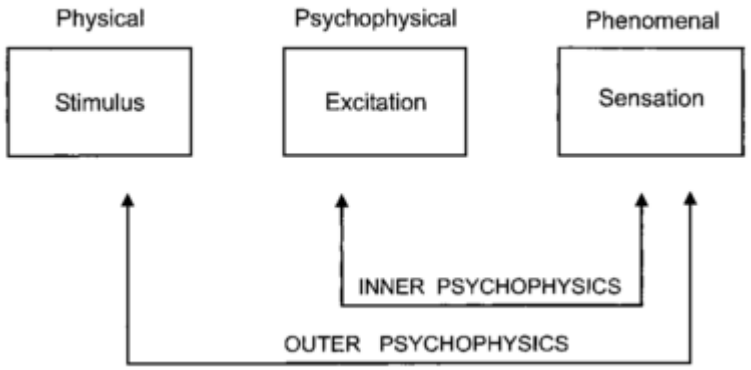
Psychophysics

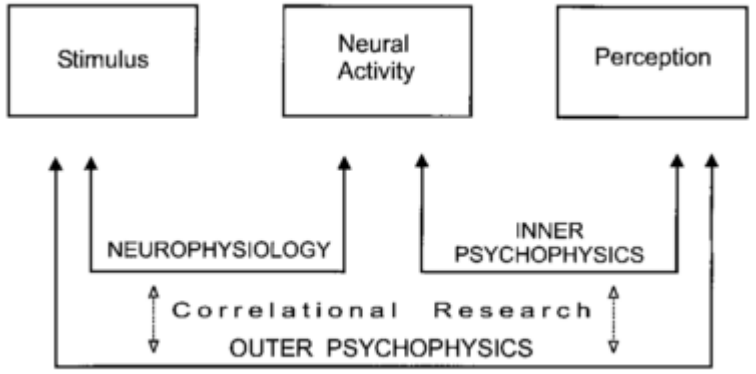
Dichotomies in psychophysics

History

- Fechner
  - Inner and outer psychophysics



- Modern approach
  - Inner psychophysics is not dependent on methodology



Ehrenstein, W. H., & Ehrenstein, A. (1999). Psychophysical methods. *Modern techniques in neuroscience research*, 1211-1241.

Weber law

- JND – Just noticeble difference

$$\frac{(JND)dS}{S} = \text{constant}$$

Stimulus	Weber constant
Sound frequency	0.003
Sound intensity	0.15
Light intensity	0.01
Smell concentration	0.07
Taste concentration	0.20
Pressure intensity	0.14

Weber law

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If I put 1 teaspoon (5.7g) of salt into soup, how much salt should I add to make the meal noticable salter?

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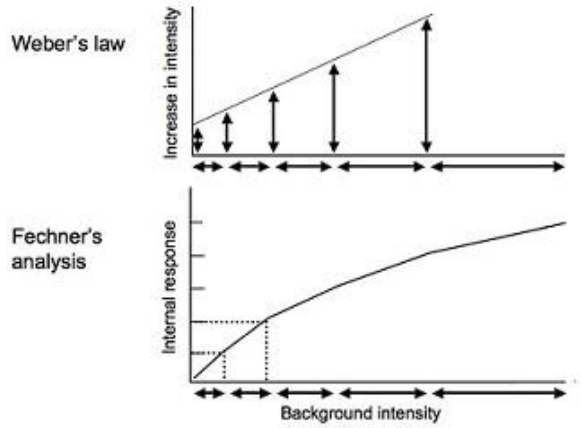
If I put 1 teaspoon (5.7g) of salt into soup, how much salt should I add to make the meal noticable salter?

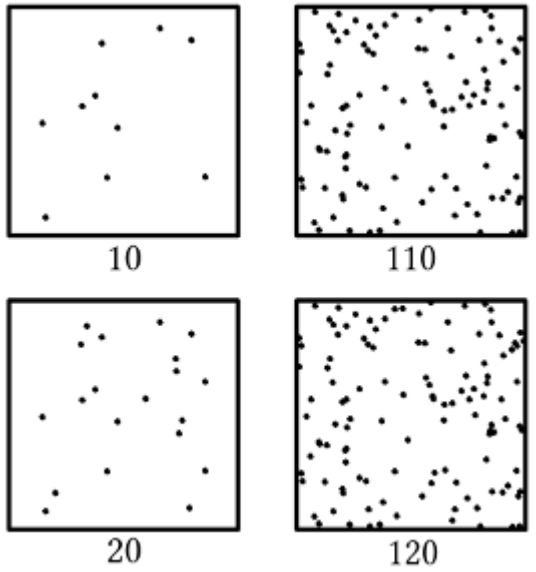
$$\frac{dS}{5.7} = 0.2$$

dS = 1.14g

Weber-Fechner law

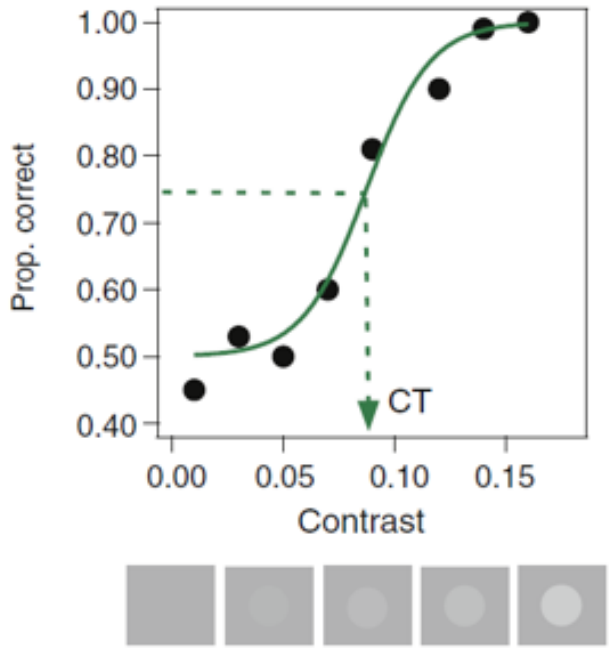
- $p = k \ln (S/S_0)$
  - p: perceptual response
  - k: constant dependent on modality
  - S a S_0: intensity and baseline level of intensity

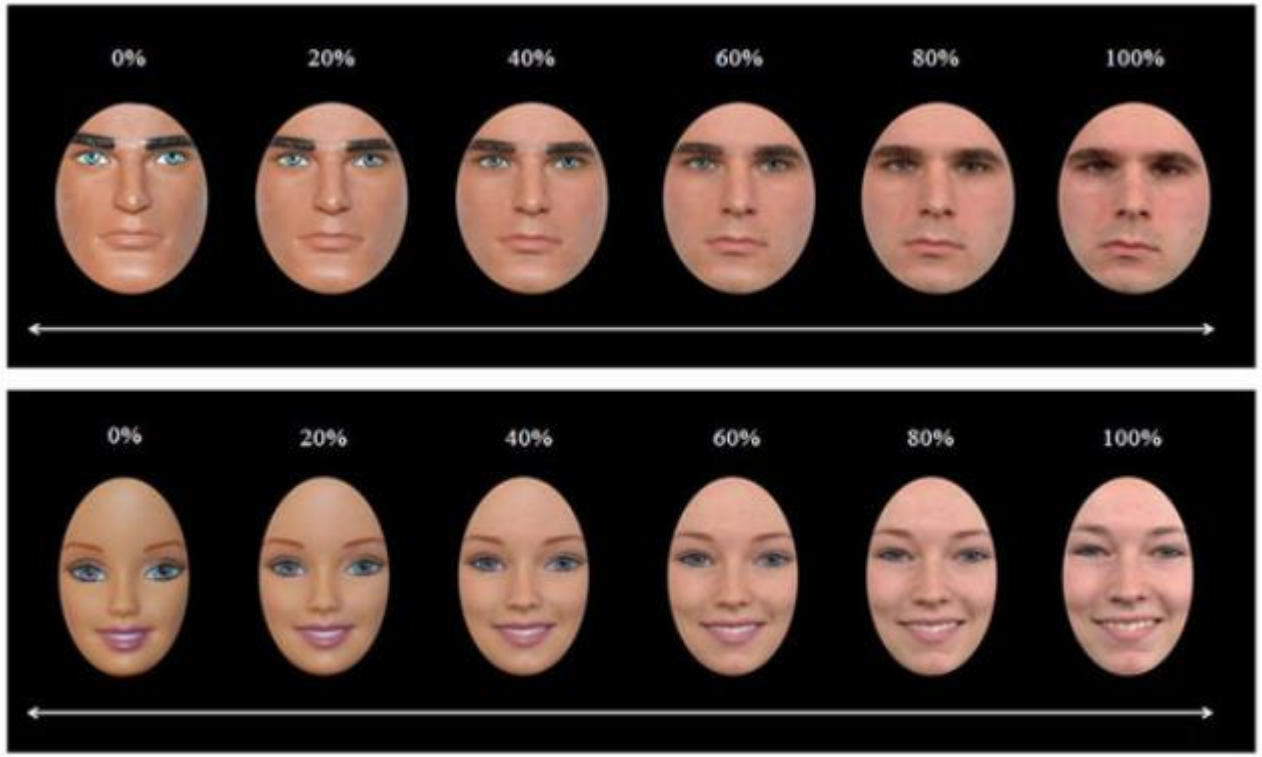




Modern approach

- What typically interest us
  - Threshold – the level of the stimulus, when the perception is translated into another state



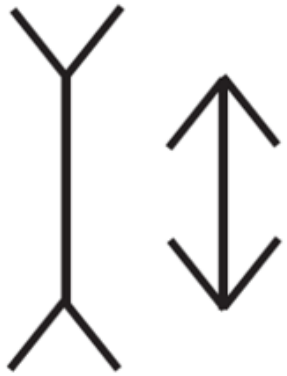


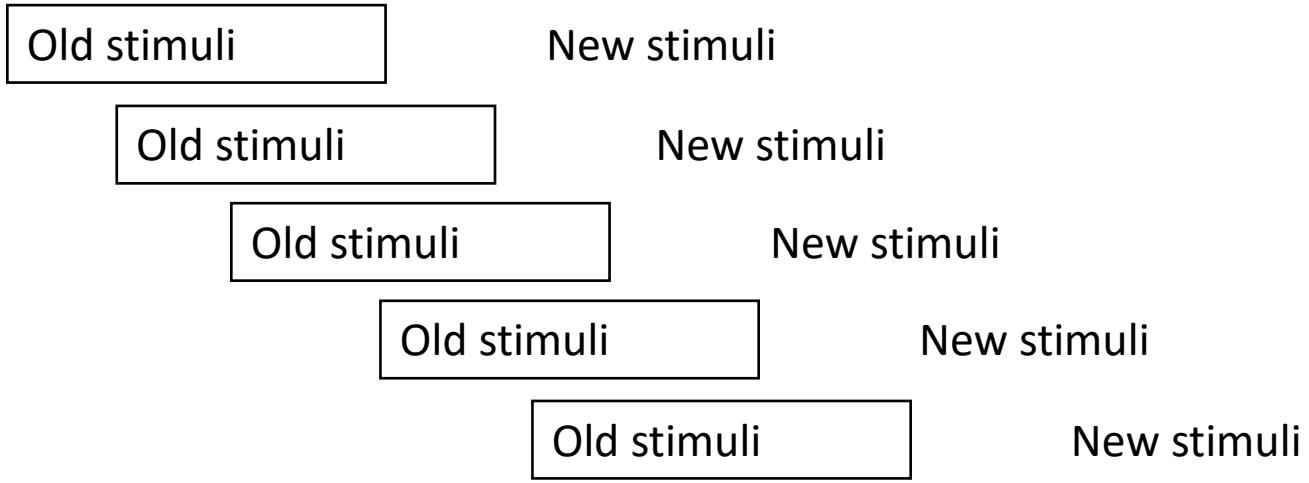
Modern approach

- What typically interest us
  - Threshold – the level of the stimulus, when the perception is translated into another state
  - Sensitivity – how sensitive is participant for given stimuli (e.g. in percentages of correct responses)

Moderní pojetí

- What typically interest us
  - Threshold – the level of the stimulus, when the perception is translated into another state
  - Sensitivity – how sensitive is participant for given stimuli (e.g. in percentages of correct responses)
  - Bias – whether participant is biased to any direction





Dichotomy Class A vs class B

- Class A – The two stimuli are perceptually indistinguishable
- Class B – everything else

Class A

Stimulus A -> Neural answer X -> Percept Y

Stimulus B -> Neural answer X -> Percept Y

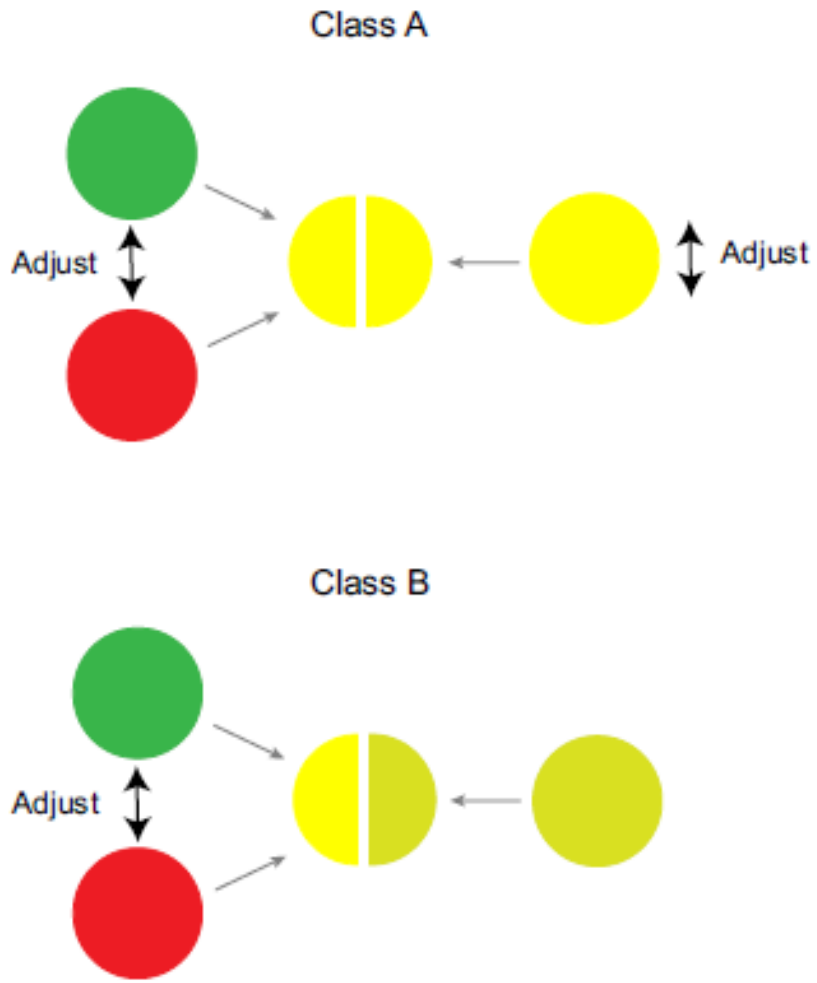
Třída B

Stimulus A -> Neural answer X -> Percept Y

Stimulus B -> Neural answer Q -> Percept R

Rayleigh match

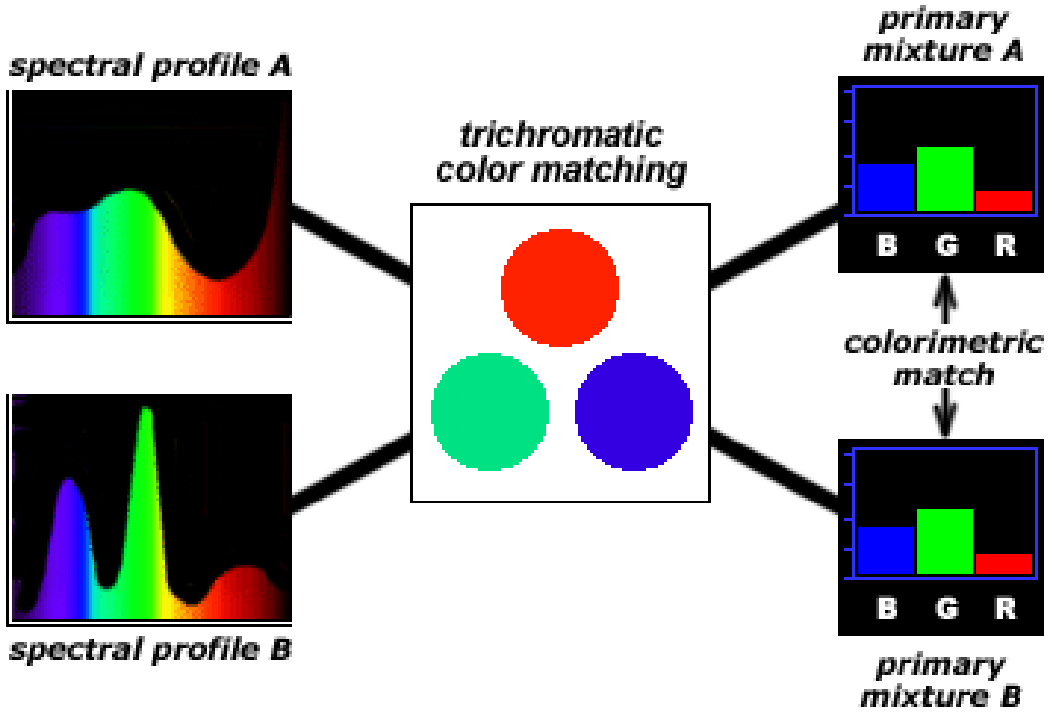
- To determine the deficit in colour perception
- We adjust the ratio of red/green and intensity: třída A
- Alternatively, we could only change the ratios
- Is class B weaker than class A?



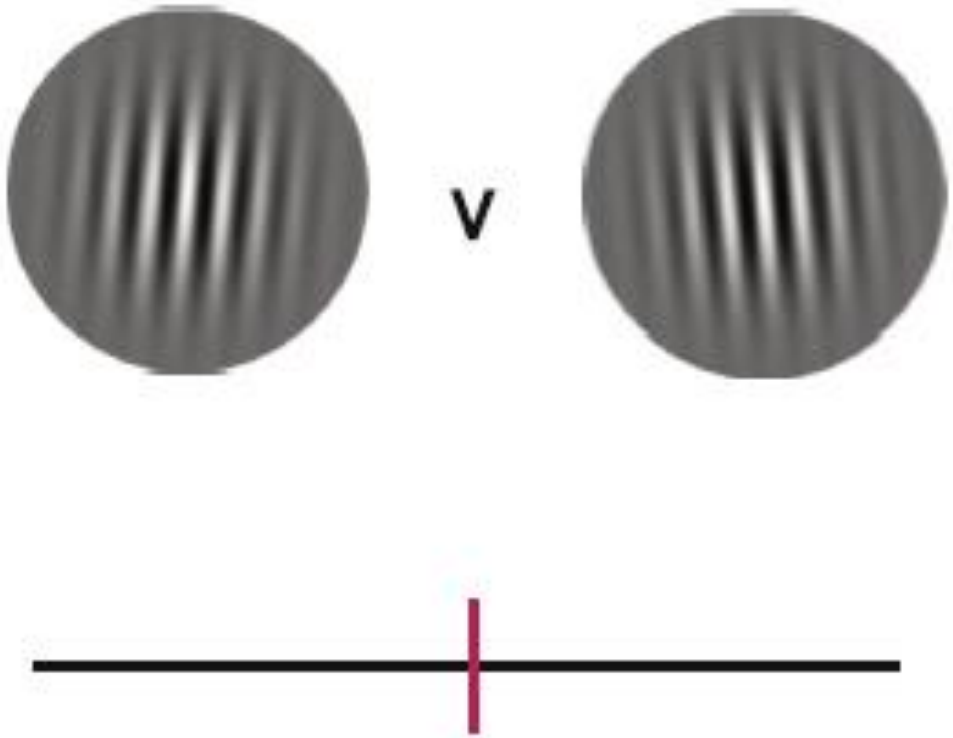
Sanocki, E., Teller, D. Y., & Deeb, S. S. (1997). Rayleigh match ranges of red/green color-deficient observers: psychophysical and molecular studies. *Vision research*, *37*(14), 1897-1907.

Metamers

- Metamers – colours that appear the same even though they have different spectral profiles

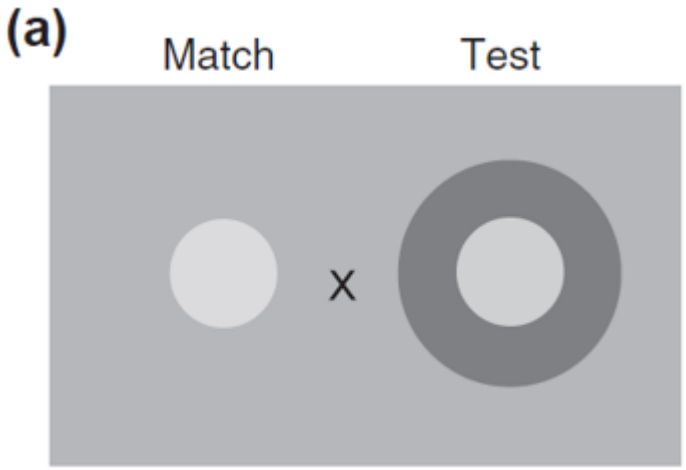


Class A examples



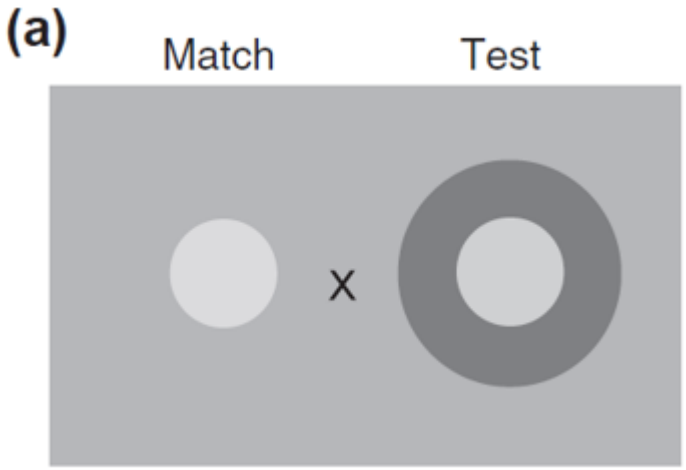
Class B examples

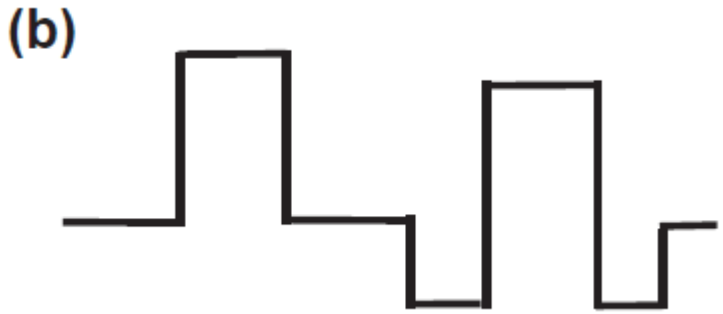
- Brightness matching



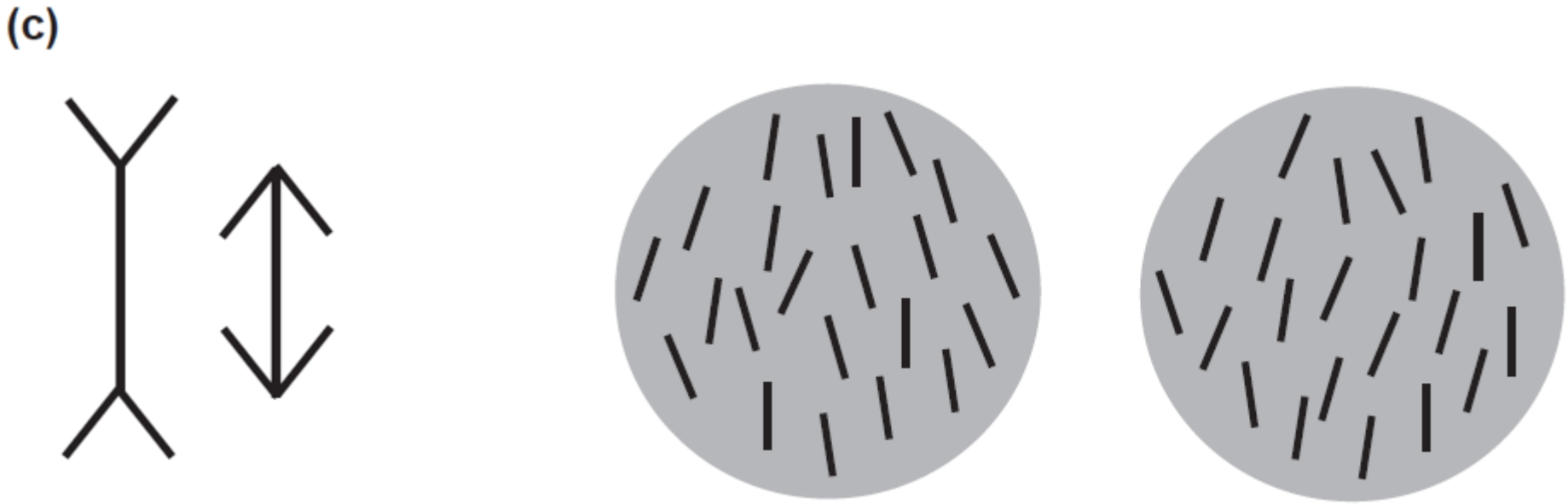
Class B examples

- Brightness matching





How about this?



Class A or class B?

- Participants are shown five faces. They are asked to select which of the five alternatives is the face presented in the previous part

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- Deciding whether a particular purple is more red or more blue

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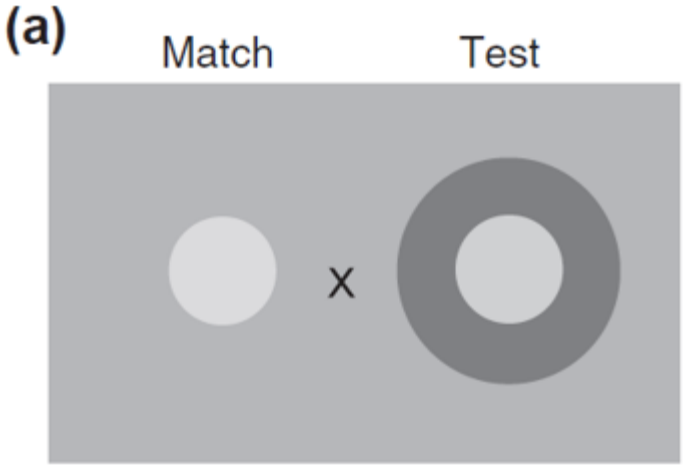
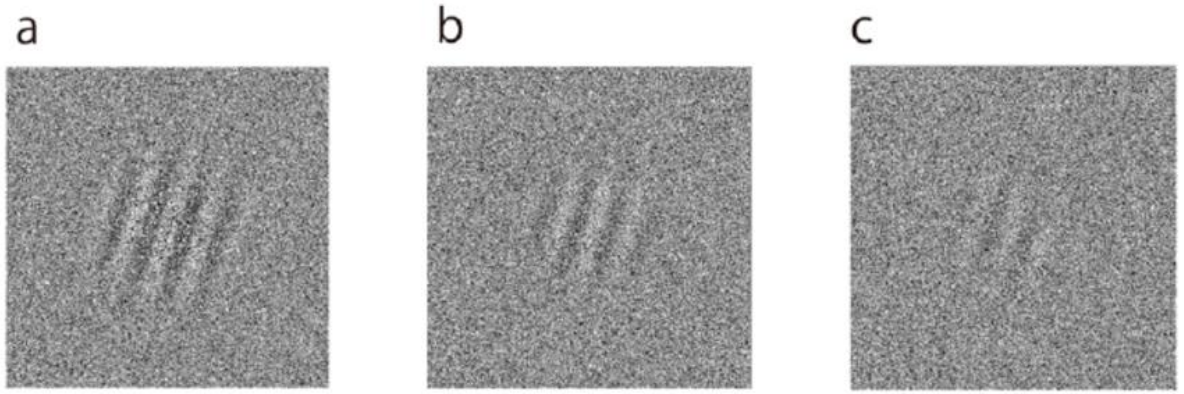
- Participants are shown five faces. They are asked to select which of the five alternatives is the face presented in the previous part
- Deciding whether a particular purple is more red or more blue
- Naming the face of a famous celebrity that was shown for a few seconds

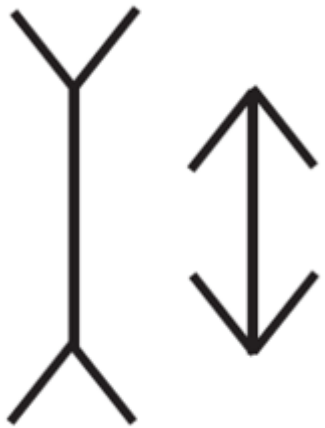
Type 1 vs Type 2

- Type 1 – there is a correct answer
- Type 2 – there is no correct answer





Type 1 or Type 2?

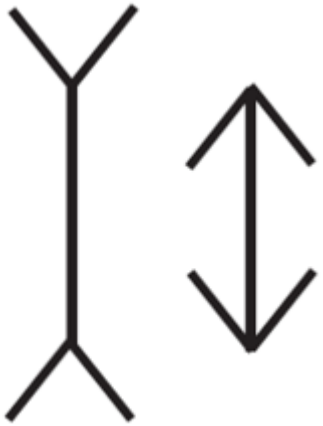


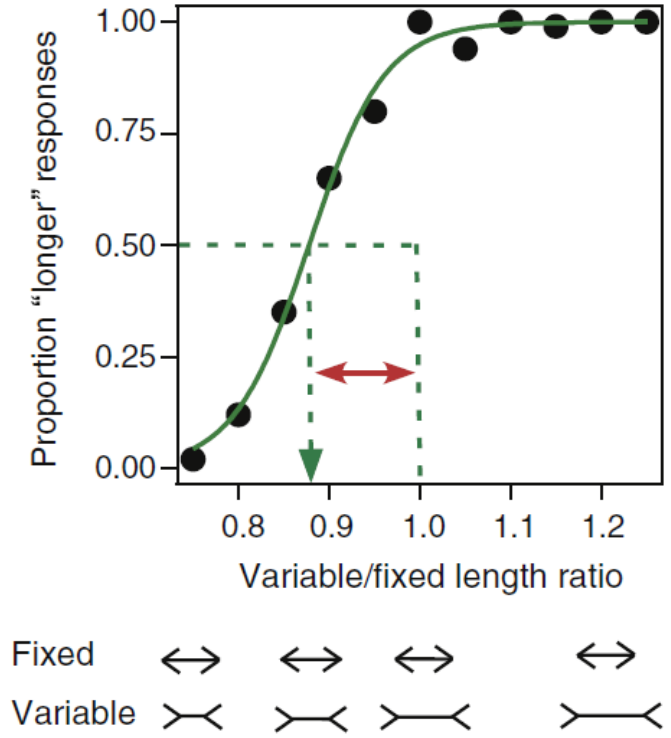
Same

Arrow is longer

Type 1 or Type 2?

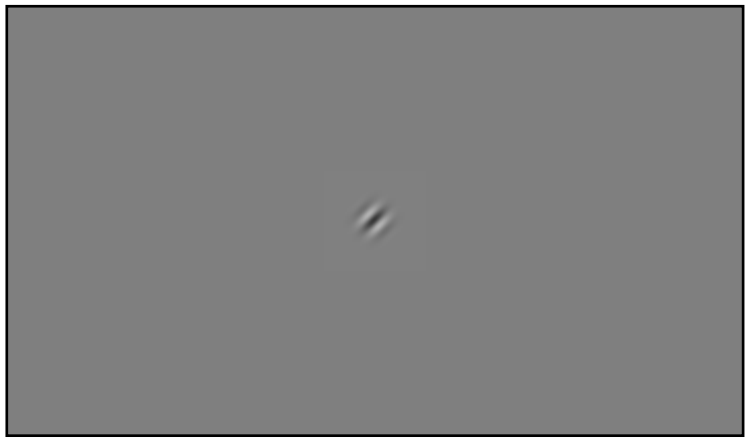
- PSE – point of subjective equivalence





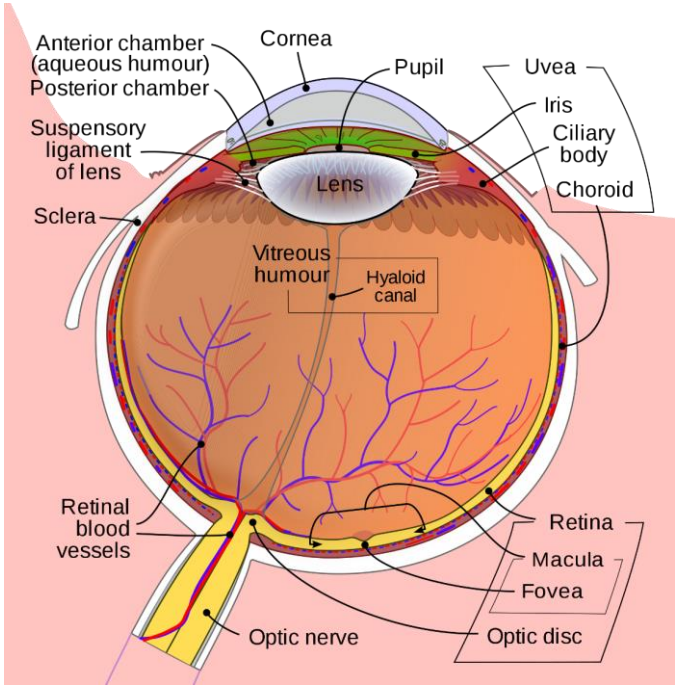
„Performance“ vs „appearance“

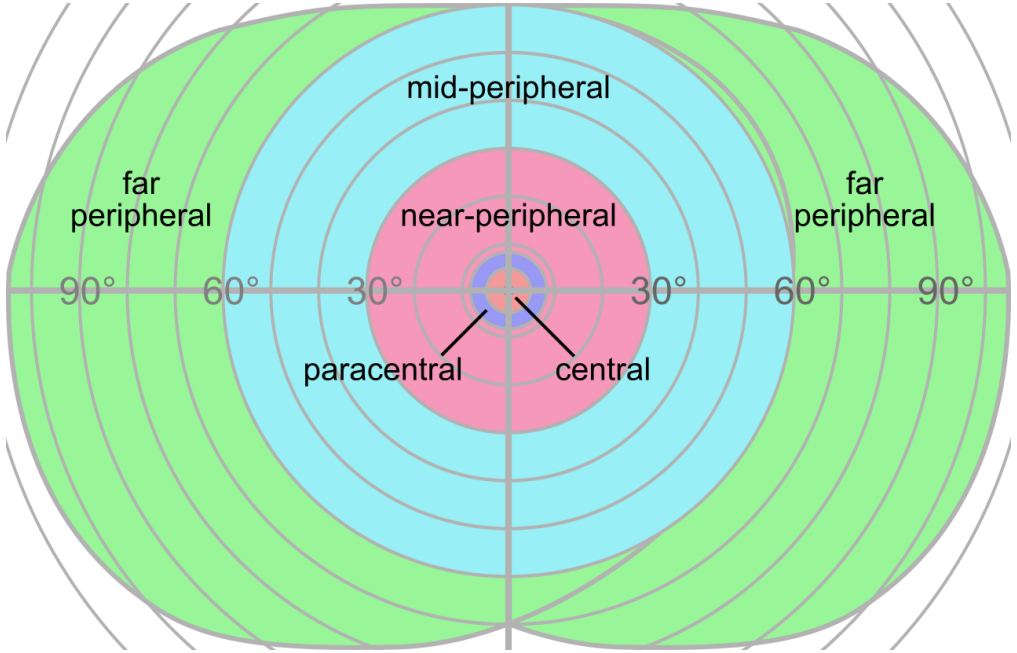
- Performance – We measure how good the observer is at the task
- Appearance – We measure how we perceive a given stimulus

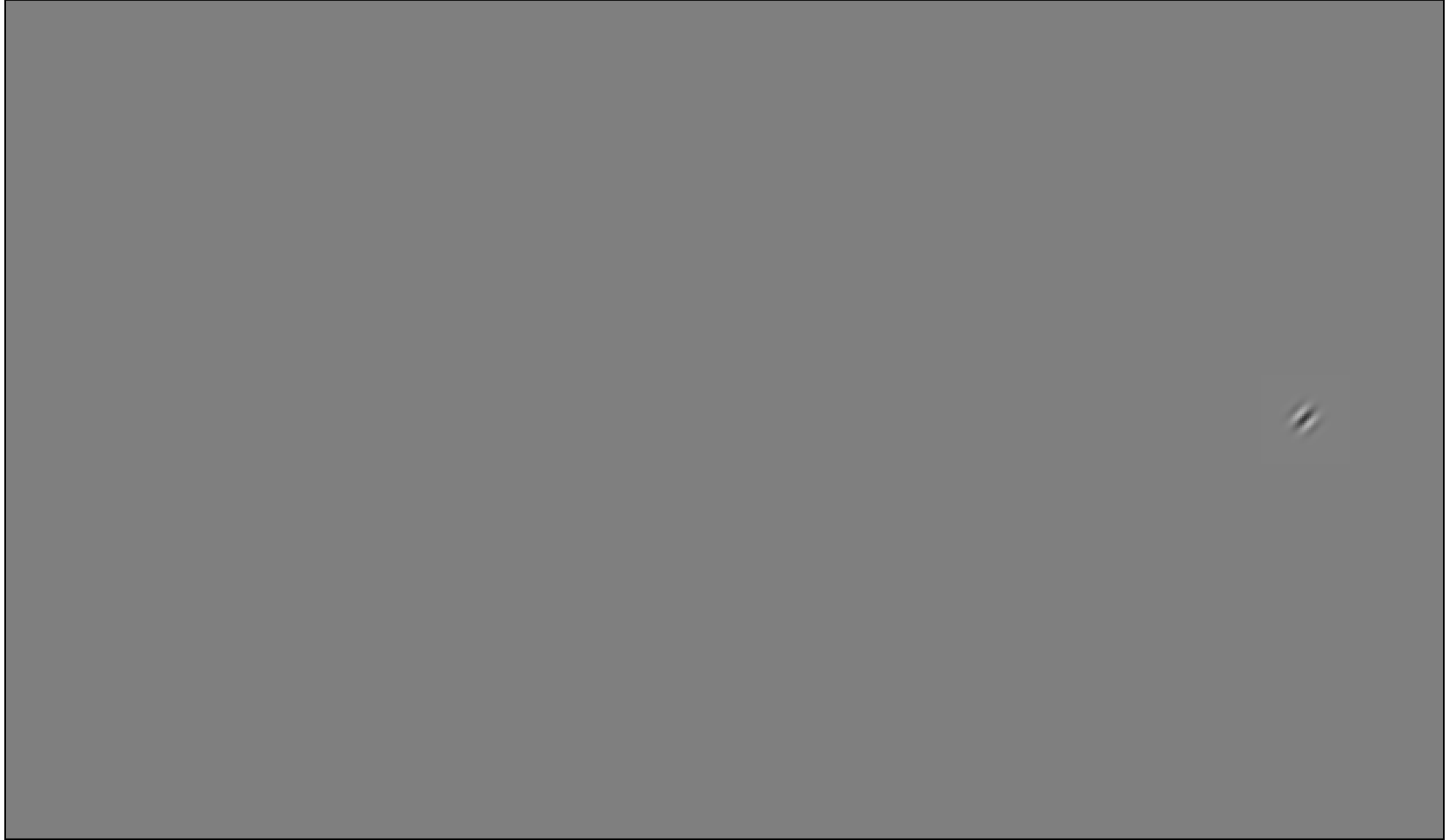


Performance - example

- Do we detect the target better in the fovea (area of sharp vision) or in the periphery? 

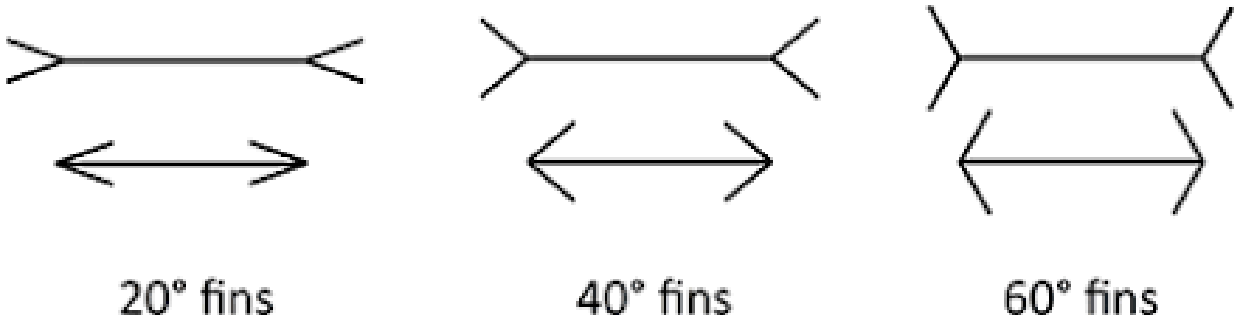






Appearance

- Does the Müller-Lyer illusion depend on the orientation of the arrows?

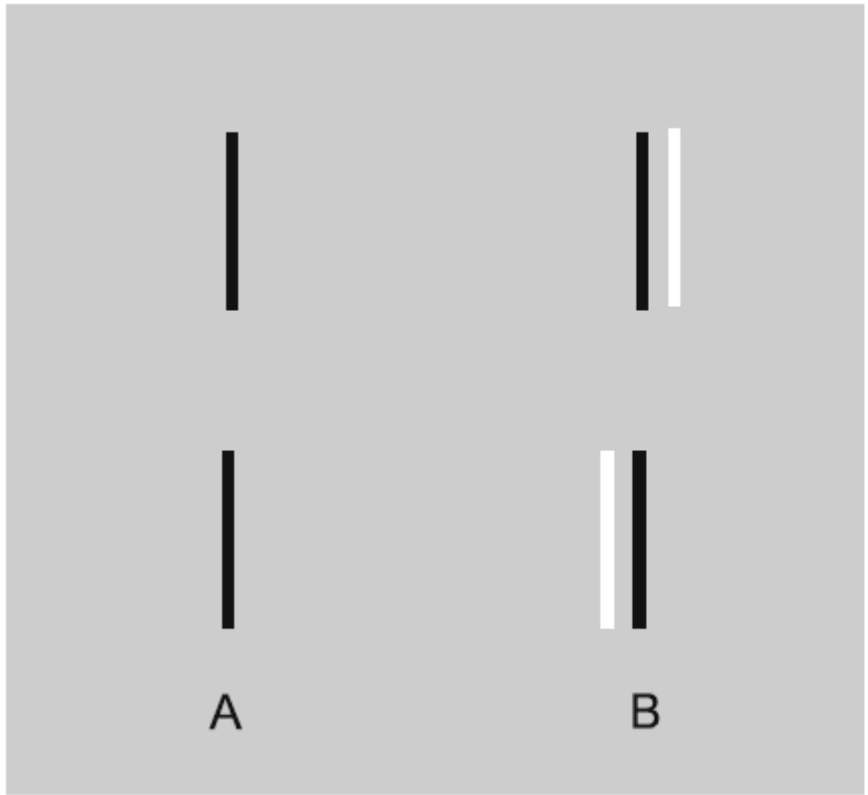


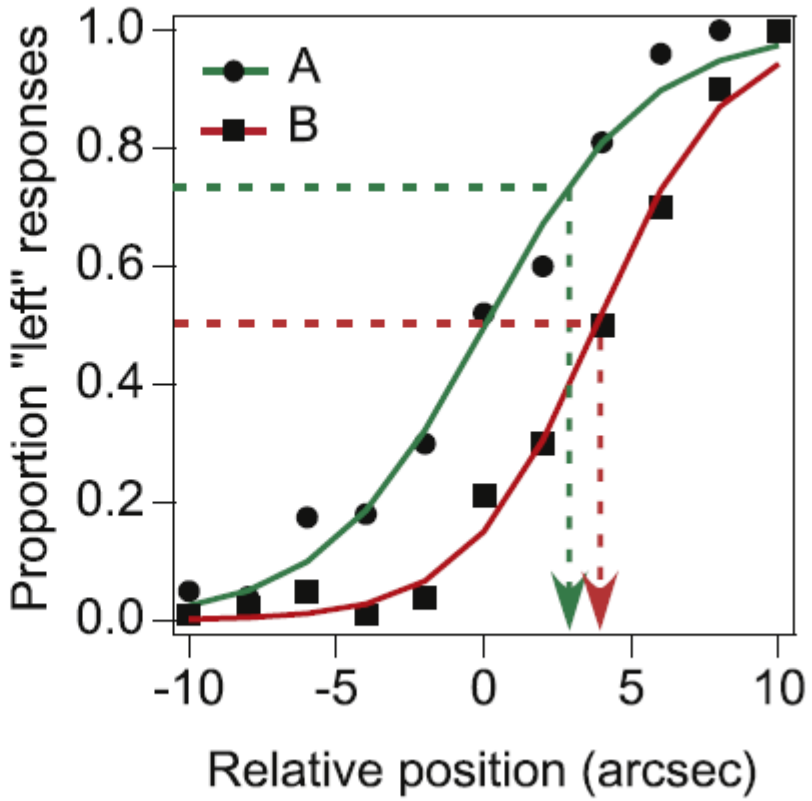
Vernier accuity

- Ability to recognize that two lines are not aligned
- Develops rapidly in newborns, then more slowly
- Declines much faster in the periphery than in the fovea

https://michaelbach.de/ot/lum-hyperacuity/index.html

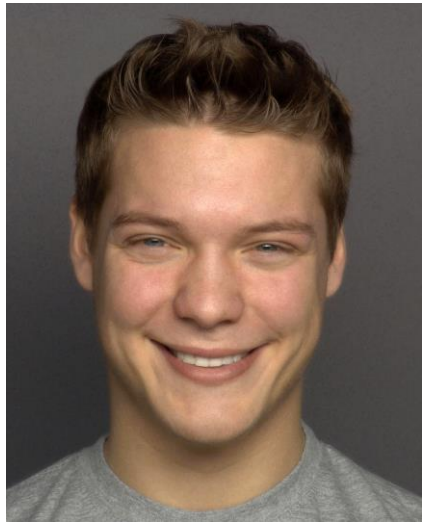
Vernier alignment task-Same task, two types

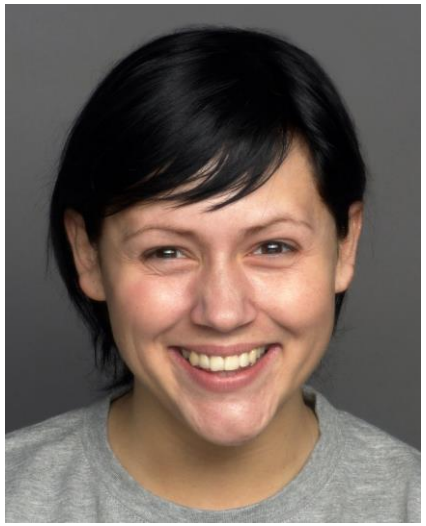
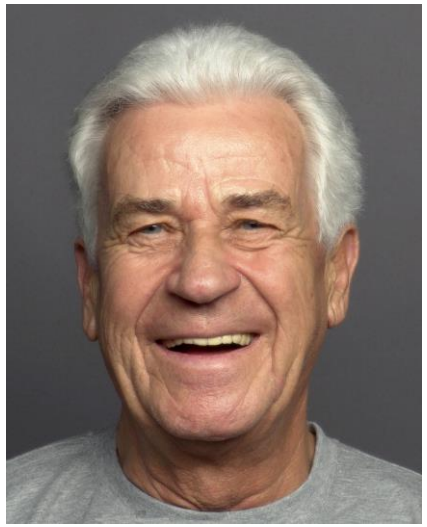




Examples of experiments

- Participants are shown five faces. They are asked to select which of the five alternatives is the face presented in the previous part
- Class A / Class B? Appearance / Performance?
- Sensitivity? Bias? Threshold?

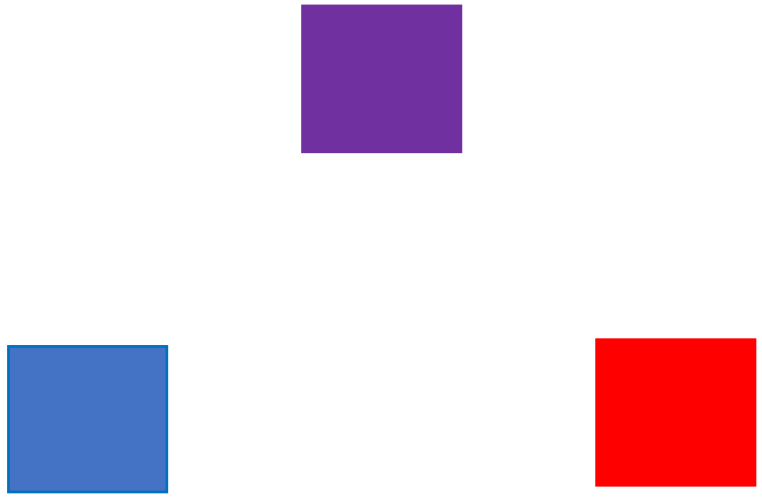



Examples of experiments

- Deciding whether a particular purple is more red or more blue

- Class A / Class B
- Appearance / Performance?
- Sensitivity?
- Bias?
- Threshold?



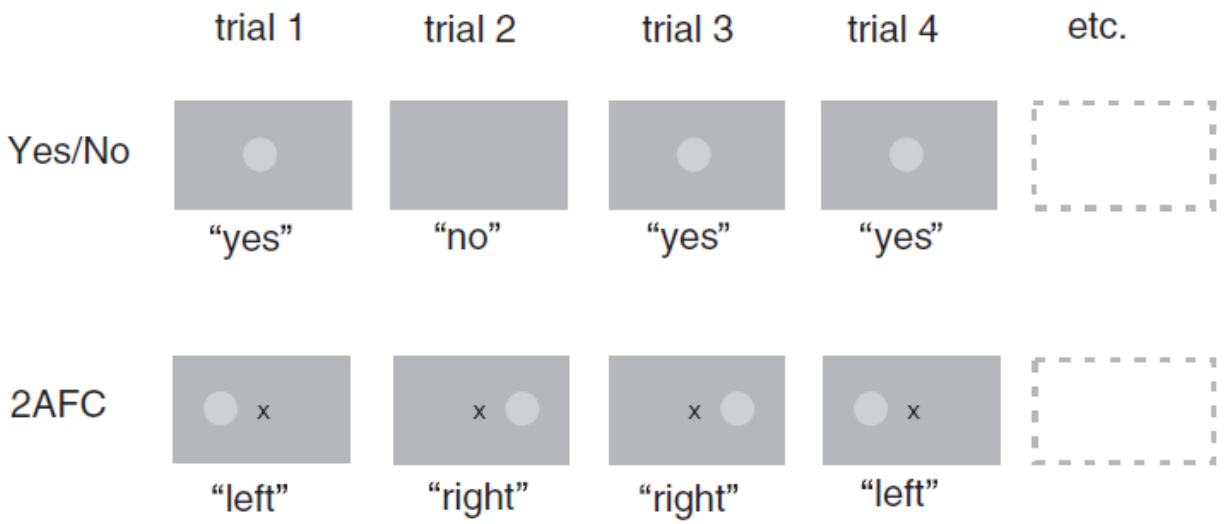
Examples of experiments

- Naming the face of a famous celebrity that was shown for a few seconds

- Class A / Class B
- Appearance / Performance?
- Sensitivity?
- Bias?
- Threshold?

Forced choice vs non-forced choice

- Forced choice – I'm choosing from several options
- Non-forced choice – the answer is not limited
- Alternative
  - Yes/no – only one stimulus is always presented and it is answered whether it is the target or not
  - M-AFC – the answer is M choices, one of which is correct



Terminology for AFC

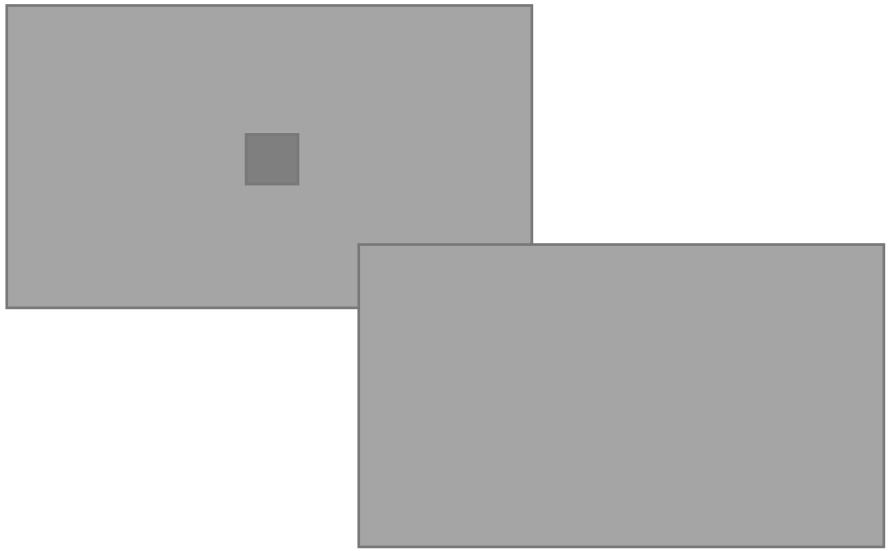
- M – number of alternatives for the stimulus
- m – number of alternatives for answers (usually M=m)
- N – number of stimuli displayed per trial (usually N=M=m)

- m is guessing rate (what the success rate will be if I guess)

- Other division
  - AFC – several alternatives in one trial side by side
  - IFC – several alternatives in succession

Differences between AFC prefixes

M = 2, m = 2



First or second?

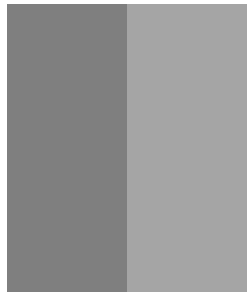
M = 1, m = 2

Left or right?

Schofield’s paradox

2AFC

1AFC



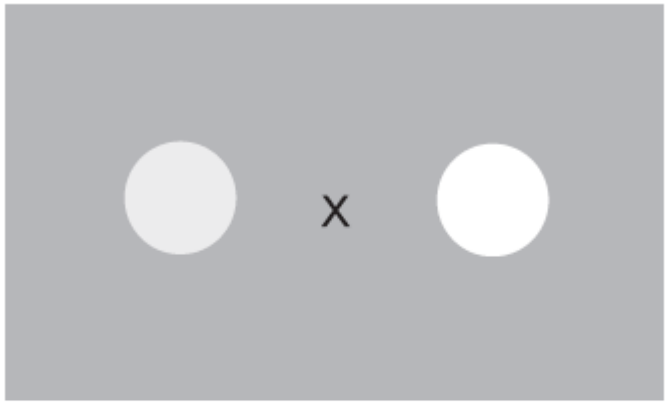
Criterion free vs criterion dependent

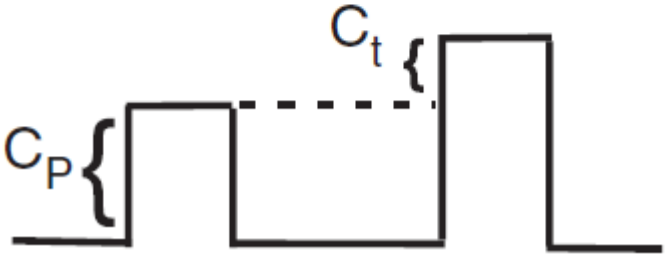
- Criterion dependent
  - the answer depends on some internal criterion to answer
  - Typically Yes/No
  - We may have set some internal bias for certain stimulus levels
- Criterion free
  - Independent of the criterion
  - Typically M-AFC/M-IFC

- Criterion dependent tend to be type 1, criterion free type 2

Detection vs discrimination

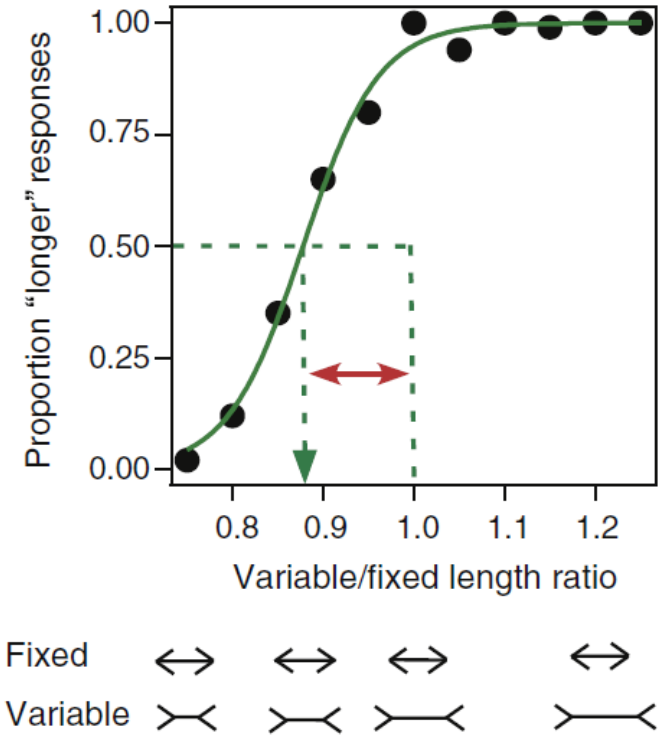
- Detection – we compare against zero incentive
- Discrimination – we compare against a non-zero stimulus
- Terminology is not clear





Threshold a suprathreshold

- Threshold – Threshold - when the state of perception changes from A to B
  - Absolute threshold – when are we able to detect the target at all
  - Relative threshold – difference change detection
- Suprathreshold – several definitions
  - Anything that does not measure threshold (i.e. contrast discrimination would not be suprathreshold)
  - Anything above the individual threshold (i.e. contrast discrimination would be contrast threshold)



Demonstration of psychophysics in practice

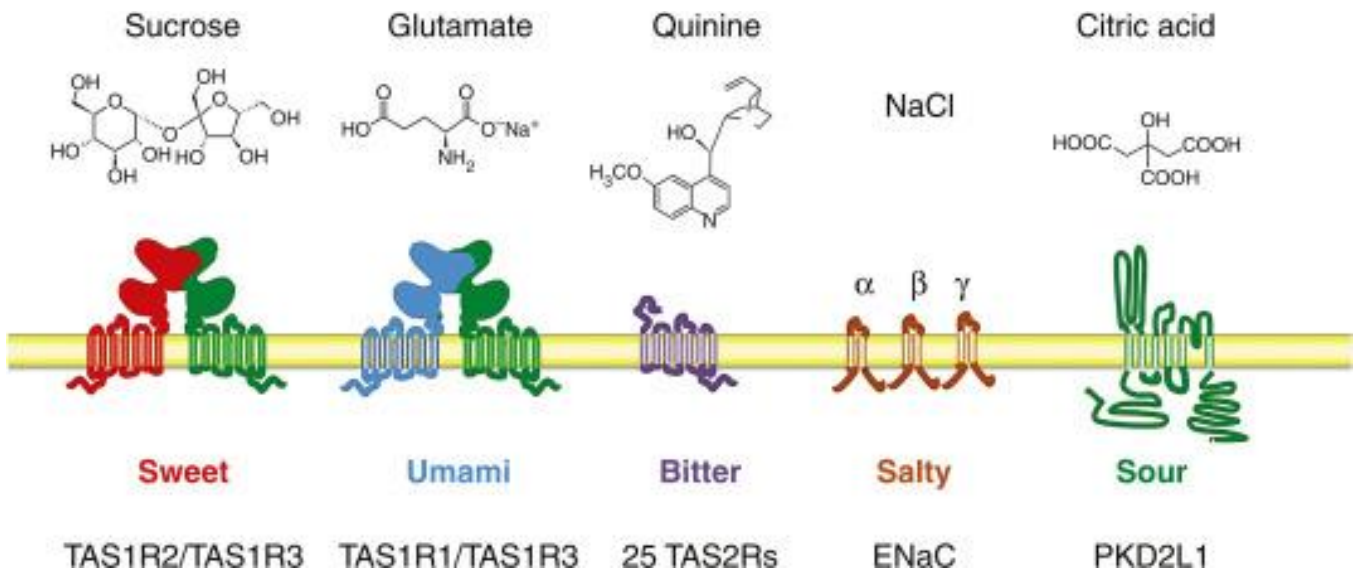
Rejection Thresholds in Solid Chocolate-Flavored Compound Coating

Meriel L. Harwood, Gregory R. Ziegler, and John E. Hayes

Abstract: Classical detection thresholds do not predict liking, as they focus on the presence or absence of a sensation. Recently however, Prescott and colleagues described a new method, the rejection threshold, where a series of forced choice preference tasks are used to generate a dose-response function to determine hedonically acceptable concentrations. That is, how much is too much? To date, this approach has been used exclusively in liquid foods. Here, we determined group rejection thresholds in solid chocolate-flavored compound coating for bitterness. The influences of self-identified preferences for milk or dark chocolate, as well as eating style (chewers compared to melters) on rejection thresholds were investigated. Stimuli included milk chocolate-flavored compound coating spiked with increasing amounts of sucrose octaacetate, a bitter and generally recognized as safe additive. Paired preference tests (blank compared to spike) were used to determine the proportion of the group that preferred the blank. Across pairs, spiked samples were presented in ascending concentration. We were able to quantify and compare differences between 2 self-identified market segments. The rejection threshold for the dark chocolate preferring group was significantly higher than the milk chocolate preferring group ($P = 0.01$). Conversely, eating style did not affect group rejection thresholds ($P = 0.14$), although this may reflect the amount of chocolate given to participants. Additionally, there was no association between chocolate preference and eating style ($P = 0.36$). Present work supports the contention that this method can be used to examine preferences within specific market segments and potentially individual differences as they relate to ingestive behavior.

Keywords: bitterness, food preference, methodology, psychophysics, rejection threshold

Types of flavours



Someone likes it bitter!

- Detection threshold
  vs Rejection threshold

- The problem with detection is that knowing the threshold gives us a wrong description of the suprathreshold
- In other words, how much bitterness is too much?

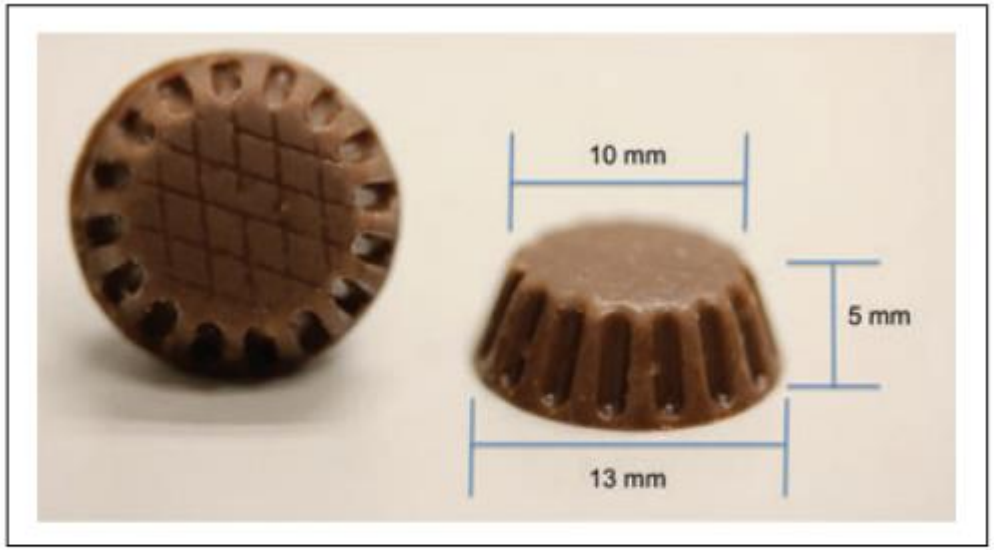


Figure 1–Sample dimensions. (1) Shape and measurements: one sample piece is shown from above and another is shown from a side-view with references for the dimensions of the samples, which are 10 mm × 13 mm × 5 mm. Each sample piece was approximately 0.63 g.

How we eat chocolate

- They had the participants eat chocolate and measured via EGG (vocal cord measurement) and EMG (tongue muscle activity measurement)
- They then performed a cluster analysis
- Typology of chocolate consumers
  - Fast chewers – they chew and swallow quickly
  - Thorough chewers – thoroughly chew
  - Suckers

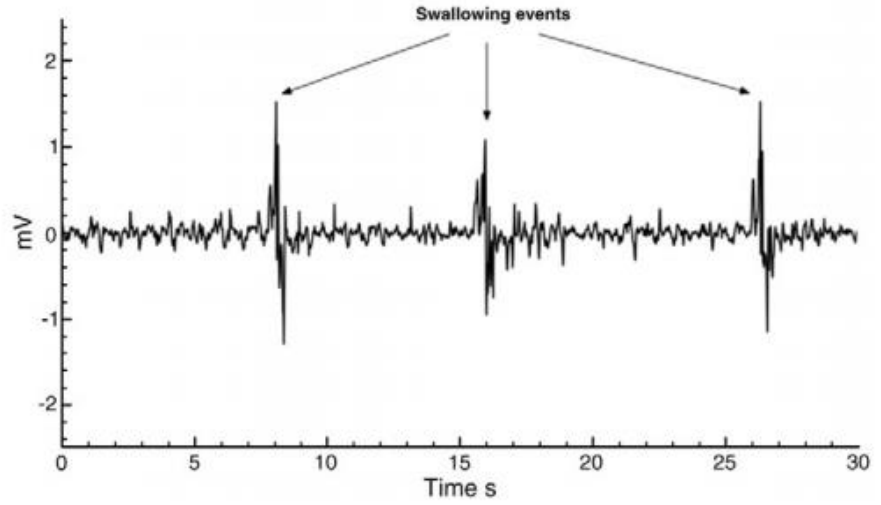


Fig. 4. Electroglottography (EGG) trace from a subject eating a sample of chocolate A.

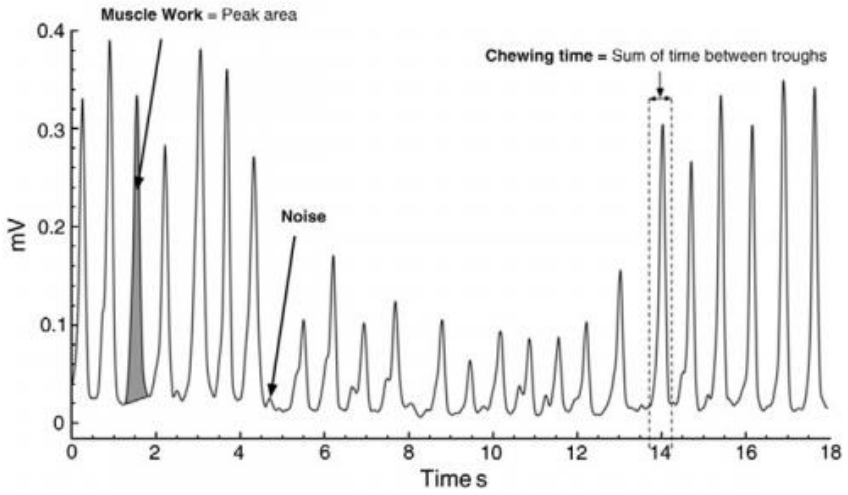


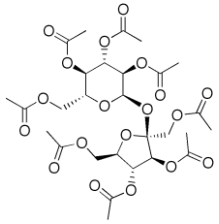
Fig. 2. Electromyography (EMG) trace from left masseter muscle while subject is eating a sample of chocolate A.

Carvalho-da-Silva, A. M., Van Damme, I., Wolf, B., & Hort, J. (2011). *Characterisation of chocolate eating behaviour. Physiology & Behavior, 104(5), 929–933.* doi:10.1016/j.physbeh.2011.06.001

Method

+

Sucrose octacetate



SOA
(simulate bitterness)

0 µM

7.5 µM

15 µM

30 µM

60 µM

120 µM

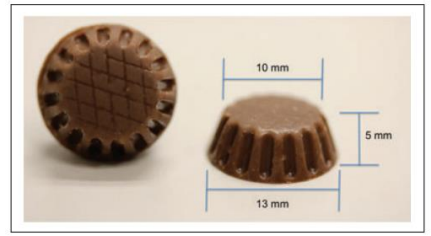


Figure 1–Sample dimensions. (1) Shape and measurements: one sample piece is shown from above and another is shown from a side-view with references for the dimensions of the samples, which are 10 mm × 13 mm × 5 mm. Each sample piece was approximately 0.63 g.

Method 2

Which one do you prefer?

0 µM

x µM

0 µM

x µM

0 µM

x µM

Results

Table 1–Rejection thresholds by group.

Group	*n*	Rejection threshold (μM)	*P*-value
All participants	85	81.5	n/a
Milk chocolate preferring	43	43.9	0.011[a]
Dark chocolate preferring	42	113.5	
Thorough chewers	45	70.0	0.144
Quick chewers	8	–	
Melters	32	93.3	

[a]Statistically significant across the respective groups.

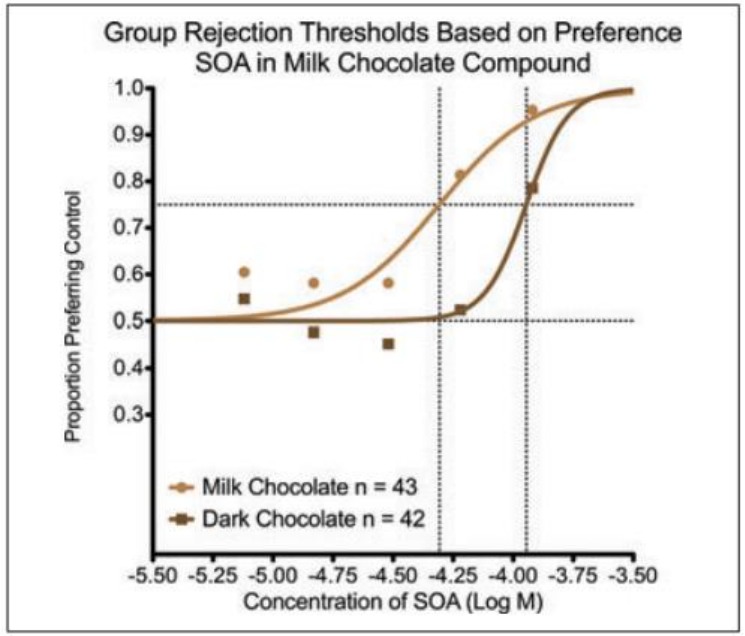


Figure 2–Group rejection thresholds based on preference for SOA in solid chocolate. Proportion of participants preferring the un-spiked samples is plotted against concentration of SOA in the spiked sample. The circles (light brown) represent individuals who prefer milk chocolate when eating solid chocolate; the squares (dark brown) represent those who prefer dark chocolate. The chance-corrected concentration at which 50% of participants preferred the control, the rejection threshold, was significantly higher for those who prefer dark chocolate ($P = .01$).

Problems

- What is and is not psychophysics in this study?

Psychological units of seriousness of crime

Question of scaling

Bulletin of the Psychonomic Society
1982, Vol. 19(5), 275-278

Psychophysical measurement of the judged seriousness of crimes and severity of punishments

GEORGE A. GESCHEIDER, EDGAR C. CATLIN, and ANNE M. FONTANA
Hamilton College, Clinton, New York 13323

Ratio scaling techniques of magnitude estimation and cross-modality matching were used to establish psychological scales of the seriousness of 22 crimes and the severity of their associated punishments. The judged seriousness of crimes and judged severity of punishments were related to the physical duration of punishment by the same nonlinear function. Judged seriousness of crimes and severity of punishments were both power functions with an exponent of .5 of the duration of prison term. The results suggest that, in most cases, the punishment fits the crime when both are expressed in psychological units.

- What is a proper punishement for a given crime?
- Sellin and Wolfgang (1964) – Steven's power law with coef 0.7 – are these subjective ratings valid?

Gescheider, G. A., Catlin, E. C., & Fontana, A. M. (1982). Psychophysical measurement of the judged seriousness of crimes and severity of punishments. *Bulletin of the Psychonomic Society*, *19*, 275-278.

Table 1
Crimes and Associated Maximum Sentences (in Years in Jail)

	Sentence	Scale Value
Murder I	Life	23.5
Kidnapping I	Life	15.8
Arson I	25	13.2
Robbery I	25	11.5
Rape I	25	17.0
Forgery I	15	6.4
Assault I	15	13.2
Arson II	15	8.5
Perjury	7	5.1
Robbery III	7	5.6
Bribery for Public Office	7	6.3
Gambling I	4	3.0
Criminal Usury	4	5.2
Child Abandonment	4	12.3
Criminal Trespass II	1	1.7
Petit Larceny	1	3.7
Resisting Arrest	1	2.7
Issuing Bad Checks	.25	2.5
Disclosure of Grand Jury	.25	3.9
Misconduct of Corporate Official	.25	5.2
Harassment	.04	2.6
Prostitution	.04	1.2

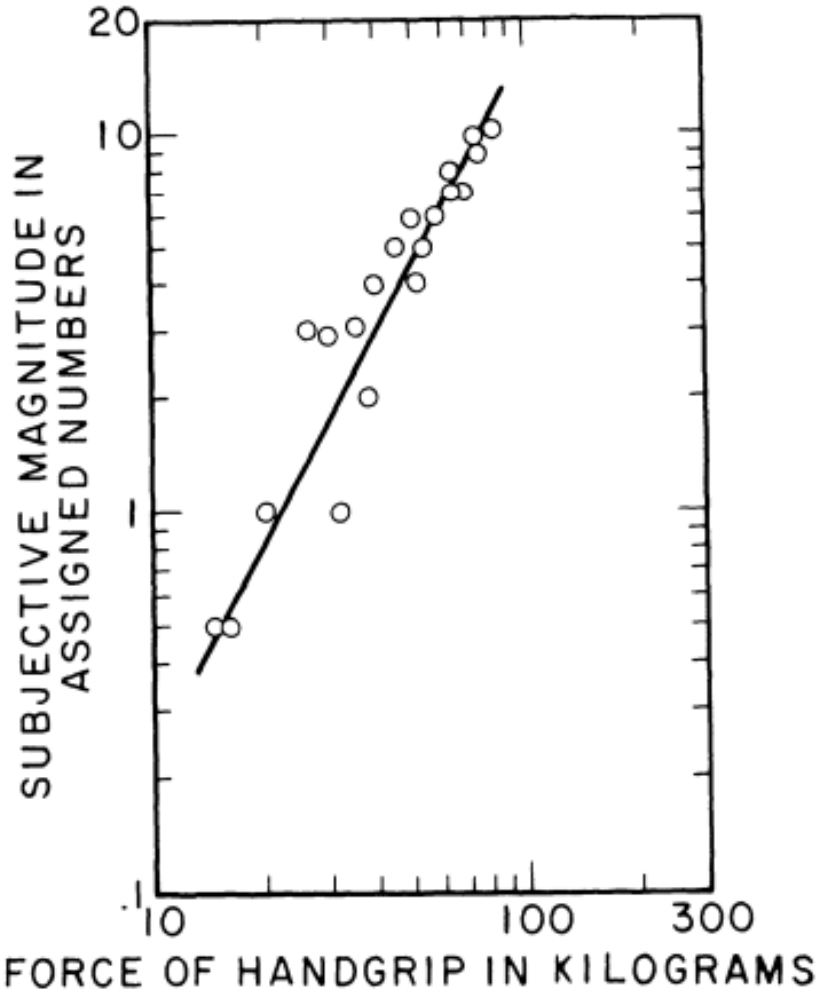


Figure 1. Magnitude estimations of subjective effort as a function of force of handgrip.

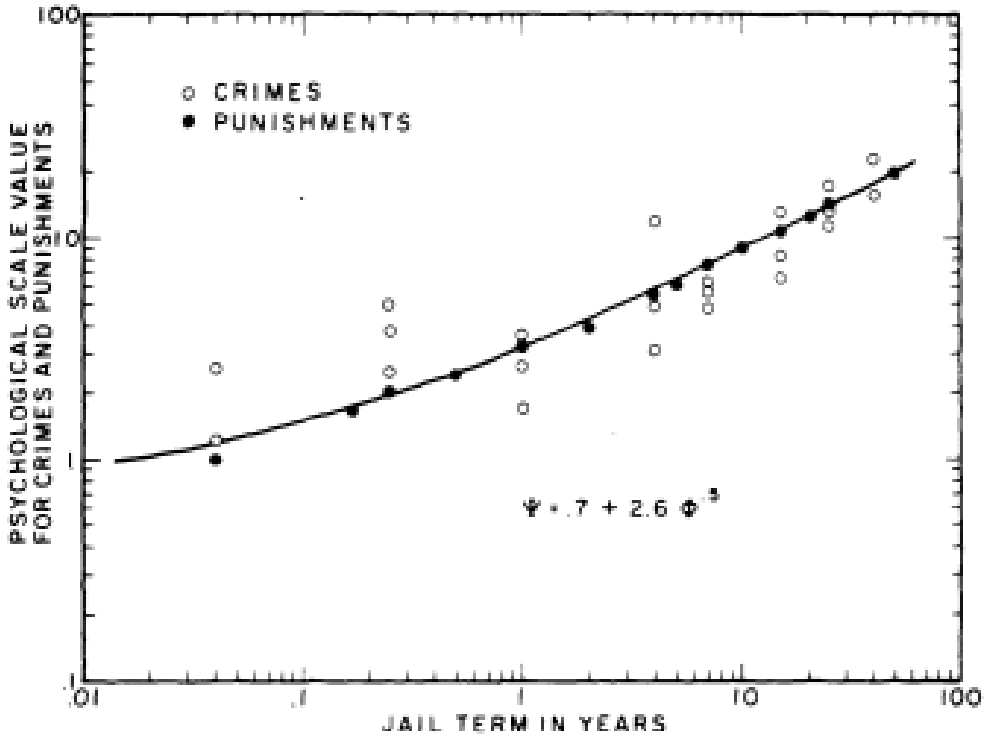
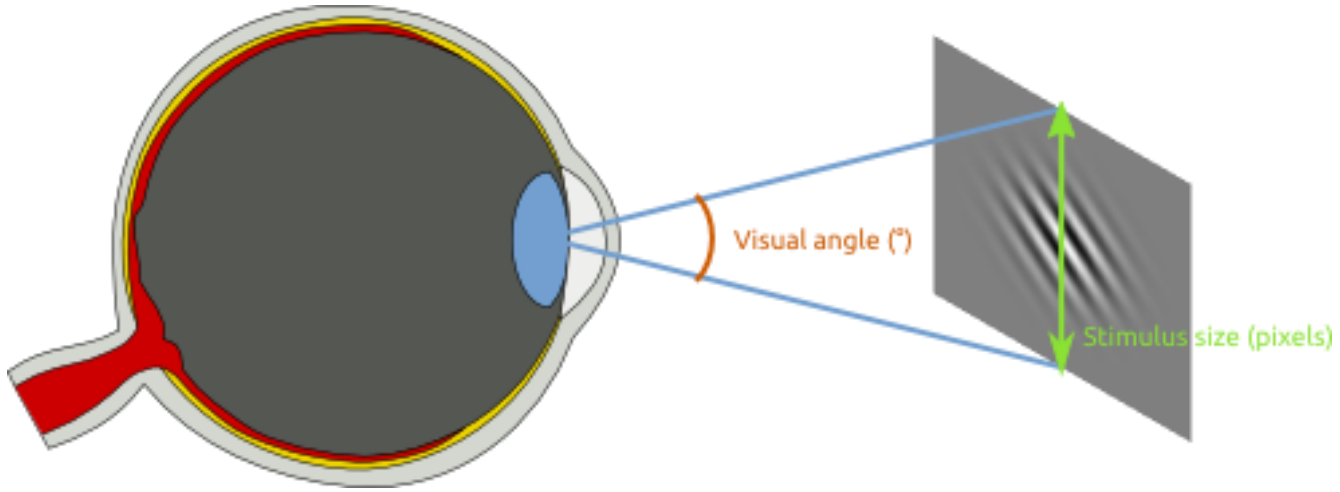


Figure 2. Geometric means of scale values of judged seriousness of crimes and judged severity of punishments as a function of jail term. By plotting the data on logarithmic coordinates, the applicability of the power law could be evaluated.

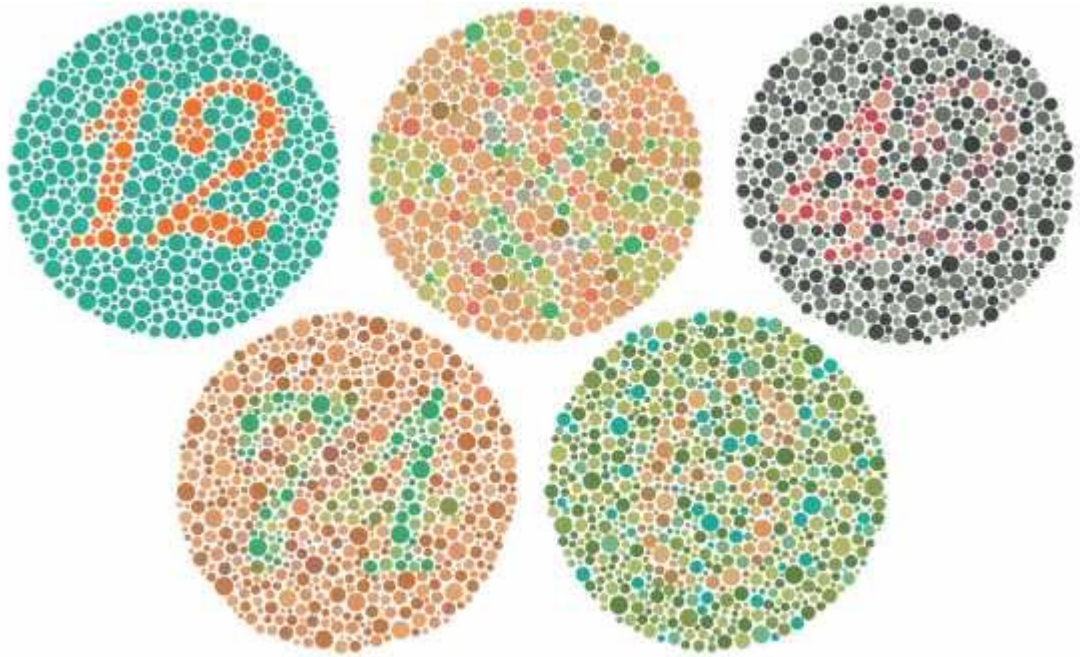
Individual participant measurements

- We are working on individual level – we need to check individual settings in order to have precisely calibrated models



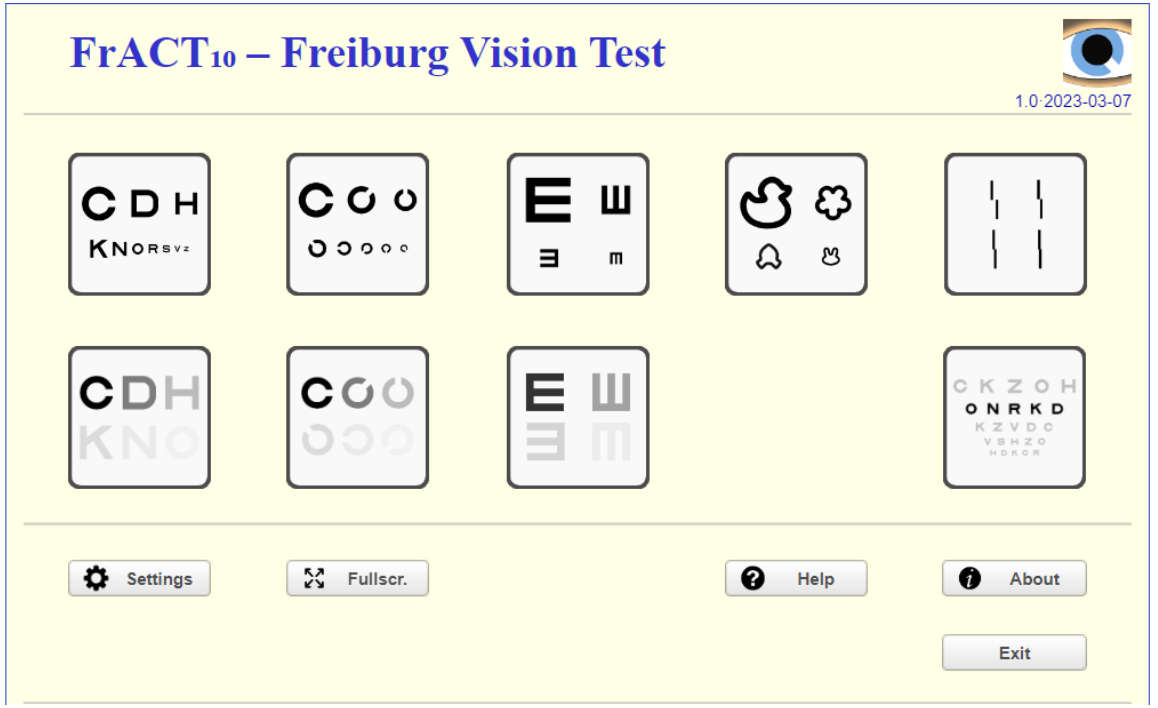
Individual participant measurements

- Isihara test



Individual participant measurements

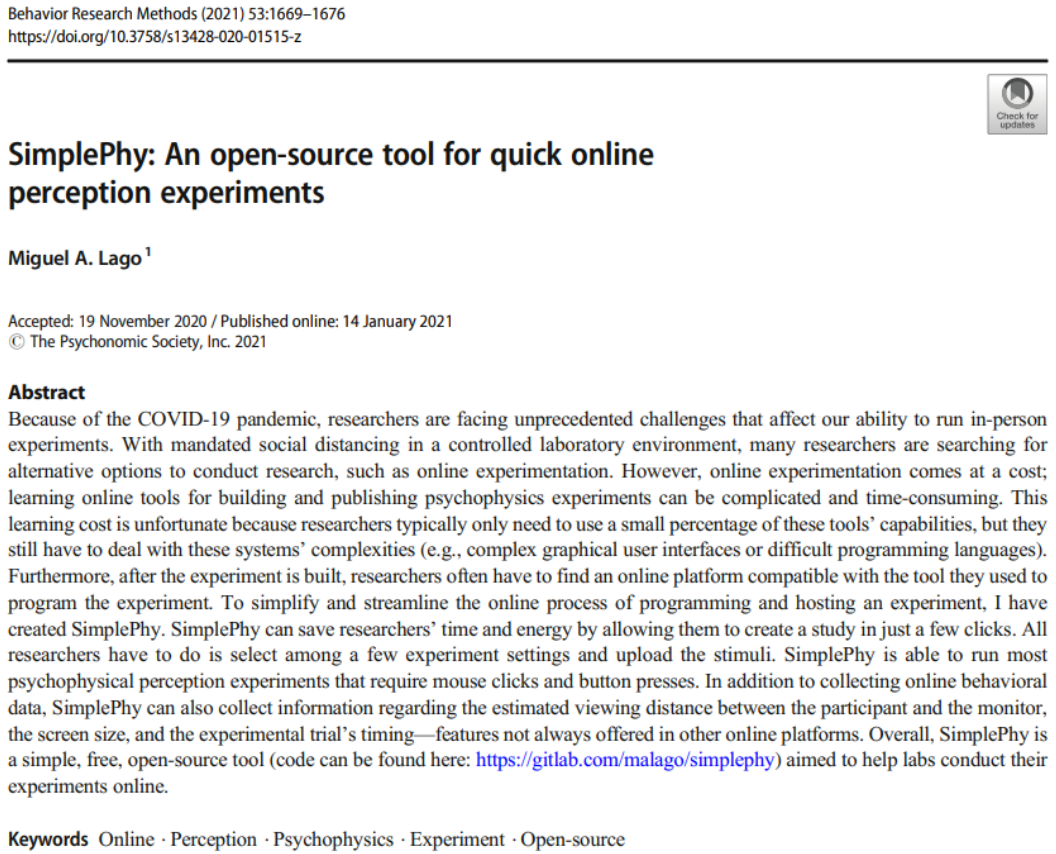
- https://michaelbach.de/fract/



Lago, M. A. (2021). SimplePhy: An open-source tool for quick online perception experiments. *Behavior Research Methods*, 1-8.

Individual participant measurements

- https://simplephy.psych.ucsb.edu/



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SimplePhy: An open-source tool for quick online perception experiments

Miguel A. Lago [1]

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Abstract
Because of the COVID-19 pandemic, researchers are facing unprecedented challenges that affect our ability to run in-person experiments. With mandated social distancing in a controlled laboratory environment, many researchers are searching for alternative options to conduct research, such as online experimentation. However, online experimentation comes at a cost; learning online tools for building and publishing psychophysics experiments can be complicated and time-consuming. This learning cost is unfortunate because researchers typically only need to use a small percentage of these tools' capabilities, but they still have to deal with these systems' complexities (e.g., complex graphical user interfaces or difficult programming languages). Furthermore, after the experiment is built, researchers often have to find an online platform compatible with the tool they used to program the experiment. To simplify and streamline the online process of programming and hosting an experiment, I have created SimplePhy. SimplePhy can save researchers' time and energy by allowing them to create a study in just a few clicks. All researchers have to do is select among a few experiment settings and upload the stimuli. SimplePhy is able to run most psychophysical perception experiments that require mouse clicks and button presses. In addition to collecting online behavioral data, SimplePhy can also collect information regarding the estimated viewing distance between the participant and the monitor, the screen size, and the experimental trial's timing—features not always offered in other online platforms. Overall, SimplePhy is a simple, free, open-source tool (code can be found here: https://gitlab.com/malago/simplephy) aimed to help labs conduct their experiments online.

Keywords Online · Perception · Psychophysics · Experiment · Open-source

Lago, M. A. (2021). SimplePhy: An open-source tool for quick online perception experiments. *Behavior Research Methods*, 1-8.