# Pupillary System & Task-Evoked Pupillary Responses

12627 S/E: Neurocognitive Psychology
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## Content Pupillary System

**1. the eye**
- 1.1 anatomy of the eye
- 1.2. function of the eye

**2. pupillary system**
- 2.1 anatomy and physiology of the pupillary system
- 2.2 functions of the pupil
- 2.3. reflexes

**3. measuring of the pupillary responses**
- 3.1 photographic pupillometry
- 3.2 electronic video – based pupillometry

“It is said that the eye is a window to the soul, however, the pupil provides psychophysiology with a window to the brain“

Beatty, J. (1986). chapter three: the pupillary system, 43

# 1. the eye

# 1.1 anatomy of the eye

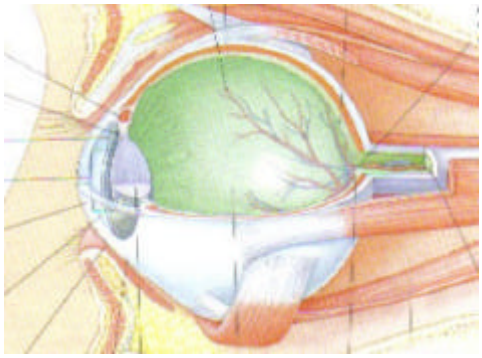


illustration 1: anatomy of the eye
reference: Dr. Goldmann, D.R. (2002),*Medizin & Gesundheit*, 567

- a spherical structure
- 3 tissues:
  cornea
  choroidea
  retina

# 1.2 function of the eye

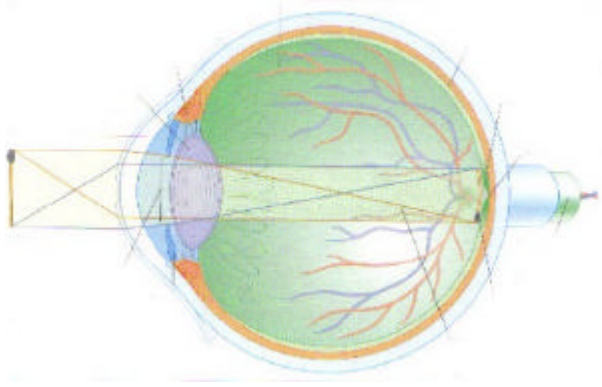


illustration 2: function of the eye
reference: Dr. Goldmann, D.R. (2002),*Medizin & Gesundheit*, 568

# 2. pupillary system

## 2.1 anatomy and physiology of pupillary system

- regulation of pupillary diameter by 2 groups of smooth muscles:

  ***- the dilator pupillae***

  ***- the sphincter pupillae***

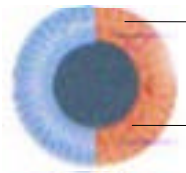



illustration 3+4: pupillary activity
reference:Dr. Goldmann, D.R. (2002),*Medizin & Gesundheit*, S. 568

## 2.2 functions of the pupil

- pupillary diameter ->
  environmental illumination
- changes of the pupillary diameter ->
  controll of the depth of field of the eye
- reducing pupillary diameter ->
  aberrations of the eye´s optical system

Beatty,J. (1986), chapter three: the pupillary system, 43-44

## 2.3 reflexes

- **the light - reflex:**
  principal determinant of pupillary diameter
- **the near - reflex:**
  - link with the activity of the ocular - motor system
  - constriction -> increasing the depth of the field of the visual system
- **the psychosensory reflex:**
  dilation -> mental processes

Beatty, J. (1986), chapter three: the pupillary sytem, 46-47

# 3. measuring of pupillary responses

## 3.1 photographic pupillometry

- the older, simpler and less expensive one
- beginning:
  - photographing the pupil of one eye
  - using a macro - focusing motion picture camera
- 16 mm - film or 35mm - film
- also infrared film
- the developed film -> projecting the image of the eye onto a large surface
  - measuring the pupil -> ordinary yardstick

Beatty, J. (1986), chapter three: the pupillary system, 48-49

# 3.2 electronic video - based pupillometry

- high - resolution linear infrared video camera
- series of hardware pattern recognition circuits -> extraction of boundary separating iris and pupil
- pupil area or vertical pupillary diameter -> computed electronically
- acquisition of pupillometric data, on – line artifact detection and response averaging

Beatty, J. (1986), chapter three: the pupillary system, 48-49

# reference


- Beatty, J.(1986),*Chapter three: Pupillary System, 43 – 50*
- Dr. Goldmann, D.R.(2002), *Medizin & Gesundheit*,Starnberg: Dorling Kindersley Verlag GmbH, 566 - 570

# Task-Evokes Pupillary Responses and Processing Load

## A Review of experimental data

- **Content**



# 1. Task-Evoked pupillary response as a tool for measuring human cognitive processes - Possible?

- Pupillary dilations that accompany cognitive processes occur at short latencies following the onset of processing and subside quickly once processing is terminated
- The magnitude of pupillary dilation appears to be a function of processing load required to perform a cognitive task
- These facts led Kahneman (1973) to rely on the task-evoked pupillary response as the primary measure of processing load

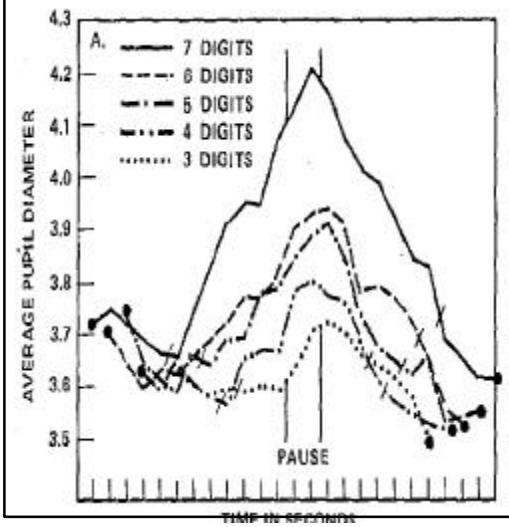
## 2. Kahneman's 3 criteria for any physiological indicator of processing load

1. It should be sensitive to within-task variations in task demands, produced by changes in task parameters
2. It should reflect between-task differences in processing load elicited by qualitatively different cognitive operations
3. It should capture between-individual differences in processing load

## 2.1 Within-Task Variations in processing load, 1st criteria

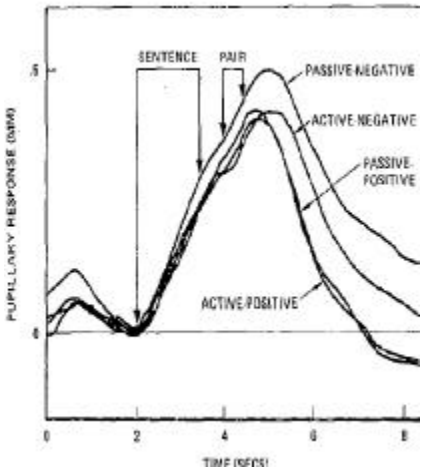
- Task-Evoked pupillary responses have been obtained for a wide variety of cognitive processes like
  - sensory detection
  - memory
  - language processing
  - attention
  - complex reasoning

## 2.1.1 Within-Task Variations in processing load
## Task-Evoked Pupillary Responses in Short-term memory tasks




- Kohneman and Beatty (1966):
- Strings of 3 – 7 digits were auraly presented at the rate of 1 per second
- After a 2-sec. pause, repeat the digit string at the same rate
- pupillary diameter increases with presentation of each digit
- during report, pupillary diameter decreases with each digit spoken and reaching baseline levels after final digit

## 2.1.2 Within-Task Variations in processing load
## Task-Evoked Pupillary Responses in Language processing tasks




**Study of processing meaningful sentences of different complexity (Ahern, 1978)**

- Presented Sentences: „A follows B“ or „B precedes A“
- Following exemplar „AB“ or „BA“
- **Task**: was to determine whether the sentence correctly described the exemplar
- Peak during the decision intervall

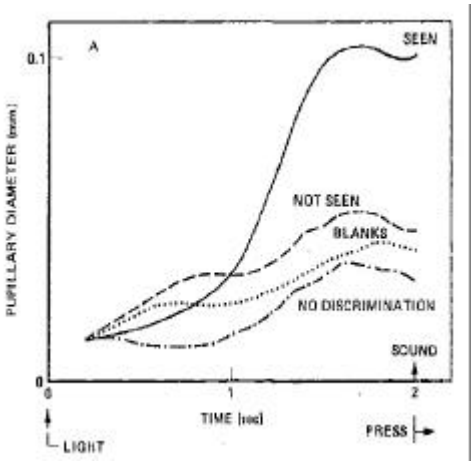
## 2.1.3 Within-Task Variations in processing load

### Task-evoked pupillary responses in Mental Arithmetic Tasks as indicator for Reasoning

- Hess an Polt (1964) measured pupillary diameter as 5 subjects solved 4 multiplication problems, ranging in difficulty from 7x8 to 16x23
  - for each of the problems the pupillary diameter increased from the moment of problem presentation until the point of solution
  - percentage of dilation was perfectly ordered by diffculty of the problem

## 2.1.4 Within-Task Variations in processing load

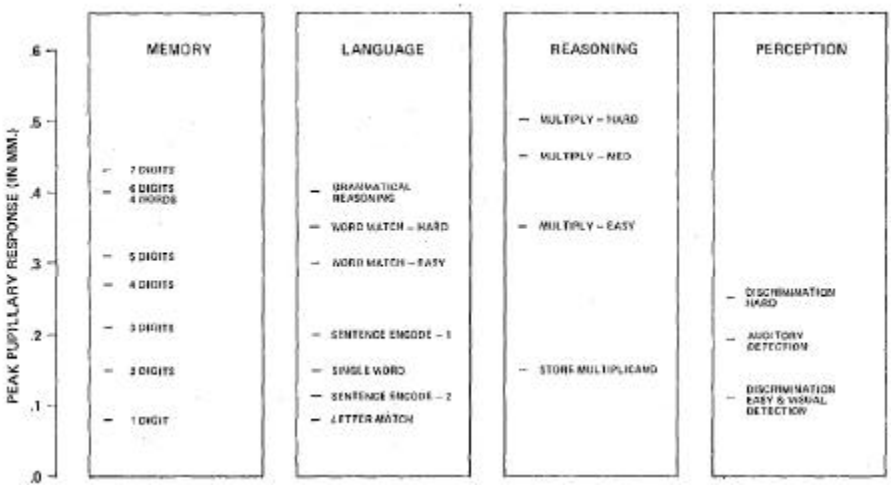
### Task-evoked pupillary responses in Perceptual Detection Tasks



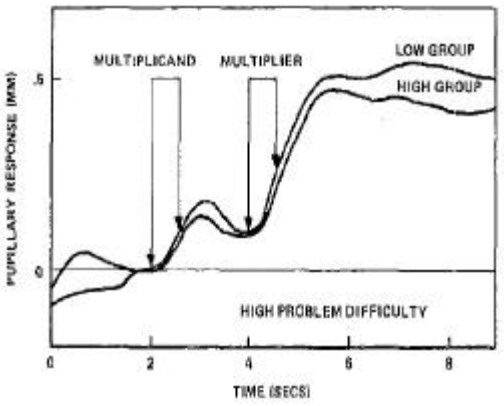

**Study of processing load in perceptual signal detection (Hakerem, Sutton; 1966)**

- Uniform visual field on which brief increments in luminance could be imposed as pupillary diameter was measured
- clear pupillary dilation of approximately .10 mm was observed, if a presented target was detected

## 2.2 Between-Task Variations in Processing Load; the 2nd




## 2.3 Between-Individual Variations in Processing Load, 3rd and last




**Task-evoked pupillary responses as an index of between-subject variations of processing load imposed (Ahern, Beatty; 1979)**

- **2 groups (low an high intelligence) of university undergraduates, differed in by SAT measured intelligence**
- **4 tasks**
- **the more difficult tasks elicited larger pupillary responses**

## 5. Conclusion

- Task-evoked pupillary response as a reliable measure method...
- In each of the experiments and checked criterias described, there appears to be an orderly relationship between the processing demands imposed by a cognitive task and the amplitude of the task-evoked pupillary response.
  - The proof, at least for Beatty, is given

## 6. Reference


- Beatty, J., Task-Evoked Pupillary Responses, Processing Load, and the Structure of Processing Resources; Psychological Bulletin 1982, Vol. 91, No. 2, 276-292