An eye for art
From visual perception to visual art
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1. The eye, the visual brain and visual perception: Basic principles
Overview

The eye is not a perfect optical instrument

The visual brain is mostly organized in a modular and hierarchical way

But the dynamics are very important (the importance of feedforward and feedback iterations)

Main stages in visual information processing:
  – Low level
  – Mid level
  – High level

Key idea: visual perception is not the exact registration of the physical reality but a subjective reconstruction (cf. illusions)
The eye is not a perfect optical instrument
The eye consists of several components but is not a perfect optical instrument.
For instance, the light-sensitive receptors (cones and rods) are at the back of the retina.
The cones are concentrated in the fovea, the rods are less suitable for details.

The sharpness decreases drastically in the periphery.

Moreover, there is a large blind spot in both eyes where the optic nerve starts.

This is why we need to make frequent saccadic eye movements (2 to 4 x per sec).
DEMONSTRATION:
Close your right eye
Fixate on the consecutive numbers
When looking at one of the numbers the yellow circle will disappear
Maybe you will need to move your head backwards or forwards

REASON:
At that specific viewing distance the yellow circle is projected on the blind spot of your left eye
What we think we see:
What is really seen in the retinal image:
The visual brain is mostly organized in a modular and hierarchical way.
• The input of the visual system is not an image but a collection of neurons firing
• The brain needs to process or decode the information
• About one third of the brain is being used for visual information processing
• Several areas have their own specialization. For instance:
  – Four lobes with several subregions (Brodmann areas)
  – Two streams (“what” and “where”) with several processing stages
  – Retinotopy (coding of location in the retinal image) mostly in the “low” areas
Four lobes with several subregions

Brodmann areas
Two streams ("what" and "where") with several processing stages

1 = ventral (inferior-temporal) stream for "wat" information (e.g., recognition)

2 = dorsal (parietal) stream for "where" information (e.g., visually guided action)
Visual field and retinotopy

For a person with normal sight:

For a person without peripheral vision:

Van Baelen et al., in preparation
So, the visual brain is mostly organized in a modular and hierarchical way but:

- with many interconnections: feedforward ("bottom-up") and feedback ("top-down")
- interactions and dynamics are also very important (e.g., re-entrant processing: combination of top-down and bottom-up information)
Processing can lead to awareness but not necessarily

functional specialization and cortical hierarchy

complex connectivity with feedforward and feedback

Grill-Spector & Malach, 2004

Felleman & Van Essen, 1991
Serre et al., 2007
Dynamics of information processing and diffusion across the cortical network may or may not lead to conscious visual perception.

Del Cul et al., 2007
Consequences for visual perception

Visual perception is not the exact registration of the physical reality but a subjective reconstruction (cf. illusions)

- based on complex information processing
- broken down in several steps
- with interaction between “bottom-up” image information and “top-down” knowledge and expectations
Main stages in visual information processing

• “low level”
  – registration of “input” (stimulation of retinal receptors)
  – decoding of responses: single features within the receptive field of one cell (e.g., orientation of border)

• “mid level”
  – perceptual grouping
  – figure-ground organization
  – depth perception
  – 2-D and 3-D form perception

• “high level”
  – meaning (identification, categorization, semantic associations, ...
Example

object one looks at

representation of the input (early processing)

2-D form perception

3-D form perception
Role of perceptual organization

- Perceptual grouping
- Figure-ground organization
- Symmetry
Role of feedforward and re-entrant processing
2. Perceptual organization and shape perception: basic principles and relevance to art
Visual perception is not the exact registration of the physical reality but a subjective reconstruction
Visual illusions

http://www.michaelbach.de/ot/ : the classics

Some less known examples
look at the dot in the middle and move your head forward and then backwards (keep looking at the dot)
Difficult construction process

please note: once you’ve seen what there is to see, you can’t see it differently anymore
Pareidolia

Sometimes the visual system exaggerates by creating things that aren’t there, this is often the case with faces or living beings (*e.g.*, *animals in clouds or rocks*)
Perceptual ambiguities

saxophone player vs. profile of a woman

vase vs. faces

duck vs. rabbit

old vs. young woman
Impossible figures

Subjective contours

Kanizsa square

Often used in art

Escher, Dali, Vasarely and “op art” (“optical art”) ...
Experimental psychologists usually study these phenomena by:

- careful construction of well controlled stimuli (in which certain factors can be manipulated)
- careful registration of measurable responses (e.g., % correct responses and reaction time) in a certain task (e.g., detection, discrimination, identification)

On the PCs in this room you can find several examples of this kind of experiments:

- do-it-yourself experiments ("Visuolympics")
- for more information: brief explanation with demos
Example

Small spots with controlled gray scale ("Gabor patch")

\[
\text{Gauss blob} \times \text{sine wave} = \text{Gabor patch}
\]

Ideal stimulus for a neuron in the lowest visual areas
With these stimuli we can slow down the normal visual processes and make them measurable, e.g.

- perceptual grouping of elements within a border (“contour”)
- perceptual segregation between groups of elements belonging together (contour or surface) and background elements (extraction of a “signal” out of “noise”)

We can manipulate the factors that make perception harder or easier

We can examine the interactions between these processes, e.g.

- outer border vs. texture of the surface within
- the role of recognizability of the figure
Research areas

“low level”:
- contrast perception
- how a population of neurons can decode the “input”

“mid level”:
- perceptual grouping
- figure-ground organization
- perceptual multi-stability
- symmetry perception
- transformations and invariants
- depth perception
- 2-D and 3-D shape perception

“high level”:
- 2-D and 3-D object and face perception
- emotion perception
- perception of biological motion
- scene perception

applications
- perception and appreciation of visual arts
- visual perception in autism
Research tools

Experimental psychology
  - see demonstrations on the PCs
  - also eye-movement registration (see elsewhere in room 1, 2 and 5)

Psychophysics

Modeling

Neuroimaging
  - mostly ERP and fMRI
  - see also room 4 (“A brain for art”)

Examples of parallels between our scientific research and what artists already knew in their own way

- Textures and slant in depth
- Repetition and symmetry
- Transformations and invariances
- Perceptual grouping and figure-ground organization
- Perceptual ambiguity of figure-ground organization
- Contour vs. surface
Scientists:
Research:

Textures & slant in depth

Artists:
Ruth Loos

study of loose pages: paraffin on lime paper
“sea of stories - fairy tales”
press through alphabet pages and dried coral
**Scientists:**
Research:

<table>
<thead>
<tr>
<th></th>
<th>symmetry</th>
<th>repetition</th>
</tr>
</thead>
<tbody>
<tr>
<td>one object</td>
<td><img src="image1.jpg" alt="Image 1" /></td>
<td><img src="image2.jpg" alt="Image 2" /></td>
</tr>
<tr>
<td>two objects</td>
<td><img src="image3.jpg" alt="Image 3" /></td>
<td><img src="image4.jpg" alt="Image 4" /></td>
</tr>
</tbody>
</table>

Repetition & symmetry

**Artists:**
Ruth Loos
**Scientists:**

**Research:**

A  B  C  
\[\begin{array}{c}
\text{\textbull{}} \\
\text{\textbull{}} \\
\text{\textbull{}} \\
\end{array}\]

D  E  F  
\[\begin{array}{c}
\text{\textbull{}} \\
\text{\textbull{}} \\
\text{\textbull{}} \\
\end{array}\]

G  
\[\begin{array}{c}
\text{\textbull{}} \\
\text{\textbull{}} \\
\text{\textbull{}} \\
\end{array}\]

**Transformations & invariances**

**Artists:**

Wendy Morris
**Scientists:**

Research:

- Square
- Rectangular
- Centered Rectangular
- Hexagonal
- Oblique

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**Perceptual grouping and figure-ground organization**

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**Artists:**

Anne-Mie Van Kerckhoven
Scientists:
Research:

Perceptual ambiguity of figure-ground organization

Artists:
Anne-Mie Van Kerckhoven
**Scientists:**

**Research:**

**Contour vs. surface**

**Artists:**

Anne-Mie Van Kerckhoven
3. Experimental psycho-aesthetics: examples of different lines of research
Introduction

“De gustibus non est disputandum” or can we?

Experimental psycho-aesthetics = a scientific discipline that tries to understand which factors determine/influence aesthetic evaluation.

Historical starting point:
“Vorschule der Aesthetik” (1876)
by Gustav Theodor FECHNER
(1801-1887)

More recent examples:
- Rudolf ARNHEIM  “Art and visual perception” (1974)
  “The power of the center” (1988)
- Ernst GOMBRICH  “Art and illusion” (1980)
Experimental methods:
- Manipulation of stimulus attributes
- Measurement of aesthetic response

Problems:
- Not everything can be manipulated
- Choice of measures: what questions can we ask subjects? (How beautiful? How interesting? etc. – see study on “aesthetic vocabulary” elsewhere in this room)
Large variation in types of research

From (a) really simple, strongly reduced (far away from real art) to (b) very complex, little controlled (closer to real art)

(a) Example: the role of the golden ratio (present in several artworks, e.g. Leonardo da Vinci, Le Corbusier, Mondriaan) is often investigated with simple rectangles (which of those two do you prefer/is the most beautiful?)

(b) Example: analysis of shape related aspects of a composition in existing artworks, e.g., Leyton “Symmetry, causality, mind” (1992) (merely theoretical/speculative)
Leyton (1992)
“Symmetry, causality, mind”

Shape perception = reconstruction of its history
  - causal explanation of shape by breaking down asymmetries
  - looking at the processes

Aesthetical response = evaluation of a causal explanation (as a solution of a problem)
Example of an analysis
“Les Demoiselles d'Avignon”

*Pablo Picasso (1907)*

Process 1: “Stretching”

Process 2: “Overcoming rigidity”

Process 3: “Overcoming resistance”

Process 4: “Pulling open”

Process 5: “Branching out”

Process 6: “Tearing apart”
Large variety in research types

(c) In between:

- Influence of frame and element-shape on composition

- ‘Visual rightness’ theory of image composition

- Microgenesis of art perception
Influence of frame and element-shape on composition (Cornelis et al., 2000)

Students in architecture create compositions in a certain frame (rectangle or circle) and with certain elements (right-angled triangles, isosceles triangles, scalene triangles; trapezia, rectangles and irregular quadrangles)
Large variety in research types
In between – example 2


The organizational structure of a “visually good” composition:
- is visually striking
- is appreciated better than a variant

Tested with 16 existing paintings (both figurative and abstract) in several experiments (with different kinds of subjects)

Large variety in research types
In between – example 2

Experiment 1
- “Naive” subjects (50 psychology-students)
- Preference for the original in 55% of all cases
- “Goodness rating” (General= +0.37, Figurative= +0.54, Abstract = +0.19)

Experiment 2
- “Expert” subjects (12 art-teachers)
- Preference for the original in 64% of all cases
- “Goodness rating” (General= +0.83, Figurative = +0.73, Abstract = +0.92)
Large variety in research types
In between – example 2

Experiment 3
- “In between” subjects (187 design-students)
- Placing of the “free” element

Experiment 4
- “Naive” subjects (100 psychology-students)
- Choice amongst 3 versions: Original, Slightly modified, Strongly modified
Large variety in research types
In between – example 3

Microgenesis of art perception (Augustin et al., 2008)

How does the percept of an artwork evolve in time? How strong do style and content determine the perceived similarity of pairs of shortly presented artworks?

→ Similarity/difference of content is more relevant than style (as of 10 ms)
→ Processing of style is generated later on (as of 50 ms) but becomes stronger with longer presentations
→ Processing of style can be based on quickly available information

4. Eye movements and the use of eye movements in experimental psycho-aesthetics
Eye movements

The eye can only discern visual details in the central part of the retina (fovea). Peripheral vision is blurred (see “the eye”, first pages of this presentation book).

This is why we need to make constant eye movements (2 to 4 x per sec). The scan path consists of a sequence of fixations and eye movements (saccades).

We can register the eye movements with an eye tracking device.
Scan path

The image on the right page shows a scan path, registered with the EyeLink II (during the exhibition this equipment will be present during several periods, see flyer on participation in our research).

Every fixation is represented by a circle with
- a diameter proportional to the duration of the fixation
- fixation time in numbers
- ranking number of the fixation

Saccades are represented with arrows
When several scans of an image are gathered (of one person, or of several persons) fixation distributions can be drawn:

- Where can we find the most / longest fixations?
- Which parts draw the most attention?

The fixation distributions can be represented in several graphic ways:

- fixation reliefs in a 3-D plot in which more / longer fixations (more interest) are shown as higher peaks
- Fixation contours or “heat maps” in which more viewing and more interest are shown as more intense or brighter colors
- Interest filters where longer viewing and more interest are represented by brightening, vivifying, making the spot in the original image more visible
Evolution of the fixation preferences in time
Eye movement equipment

In the Laboratory of Experimental Psychology we have two kinds of eye movement equipment:

– **EyeLink II**
  a kind of helmet which allows the head to stay mobile
  speed: 500 Hz, accuracy: 0.5°

– **Dual Purkinje Image Eyetracker**
  individual bitebar to stabilize the head
  speed: 1000 Hz, accuracy: 0.1°
The use of eye movement equipment in experimental psycho-aesthetics

Two examples

1. Differences in viewing behavior between groups: on the left art novices, on the right art experts; the novices are more strongly driven by figure-background (clustering on the human figure); art experts scan more broadly

2. “regions of interest” in art: “golden ratio” with fixation cluster dominated by the global structure and not by the local image information
Our eye movement research in the framework of Parallellepipeda

“Kalligrafie” (15 drawings) by Anne-Mie Van Kerckhoven

- study by Peter De Graef, Karen De Ryck, & Johan Wagemans
- see room 1 for large dynamic display of the results (4 flat screens on the wall)
- scan paths, appreciation, and expertise

“Off the Record” (animation film) by Wendy Morris

- study by Peter De Graef, Line Denayer, & Johan Wagemans
- see room 4 for large dynamic display with the results (4 flat screens on the wall)
- scan paths, appreciation, and influence of knowledge
Now in **ROOM 1:**

**Eye movements and “Kalligrafie”**

AMVK herself: a lot of fixations (*continuous interchanges between looking centrally and peripherally*)

Novice: long fixations on the text

Art expert: in between both (*very complete scanpath, focused on the composition as a whole*)
Now in ROOM 4:

Eye movements and “Off the Record”

In a movie there is constant movement that is often followed by the eyes (“smooth pursuit”). Below you can see 3 quickly succeeding snapshots:

A slow viewer can only make one fixation per snapshot and has a more central view.

A fast viewer can fixate twice per snapshot and fixates on two striking objects.
5. Other examples of interactions between perception and art
Eye movements as art

Catherine Baker registers her fixations while drawing and uses the fixation contours as input for her graphic work.
Eye movements as art

An LCD display of Mirjam Netten’s *Infant* (left) is filtered by the cumulative viewing paths of the audience (right), registered with cameras (bottom left and top right in each panel)
The way in which scientists represent their data is very important for the communication of their research. The data-displays often are quite aesthetic. You can find some examples here.

Idea and selection: Jonas Kubilius.
An experimenter moved her hand up and down or left and right, while a participant had to either repeat her motion (left panel) or do an opposite motion (right panel). Here, the trajectory of a participant’s hand motion is drawn. The left panel has more consistent lines, so the task was easier when both the experimenter and the participant worked hand in hand.

Reproduced from Kilner et al., Current Biology (2003)
When presenting some stimuli in experiments, it is often useful to know where people are looking at. Scientists use eye-tracking machines that can record and display the position of where they were looking. The more yellow, the more one was staring there. Here, people were asked to look at the plus while some images were shown to the sides or above/below. You can see people sometimes peeking at those images: curiosity wins.

Reproduced from Dilks et al. (not published)
Images of various rooms have been superimposed on top of each other and painted red.

Reproduced from Dilks et al. (in preparation)
Mona Lisa, winking and smiling

Naoki Kogo studies figure-background organization and subjective contours by using variants of the Kanizsa square

On the left you can clearly see a square in the middle, on the right you cannot (although the corners within are locally identical)

When you enter these figures in the Mona Lisa you can sometimes discern distinct squares that are not present of course (thus: subjective or illusory figures)
AMVK is not an illusion

Here you can find the so-called “corridor illusion” which is a side-effect of the normal perception of depth based on perspective-cues and the unconscious correction of the perceived size in accordance with the retinal size and distance (the so-called size-constancy).

N.B. This is not only applicable to artists.

Idea and realization: Lee de Wit.
Point-light figure in good company

Point-light figures are often used in research on the perception of biological movement (see experiment on PC)

Here you can see one very well accompanied figure crossing Abbey Road (you can find the moving version on PC)

Idea and realization: Lee de Wit and Ervin Poljac
This is not conceptual art

Eef Ameel studies the mental representation of concepts and conceptual combinations. Here you can find some visual work in relation to her research topic.
For other amusing demonstrations: have a look on the computers and have a peak behind the small wall.

(Idea based on an existing illusion: Frank Amand)

(some days real experiments take place there)