Government of Russian Federation

Federal State Autonomous Educational Institution of High Professional Education

«National Research University Higher School of Economics»

Department of Psychology

Syllabus for the course
«Visual Perception and Attention»

37.04.01 «Cognitive sciences and technologies: from neuron to cognition», Master of Science

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Approved by:

Recommended by:

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1. Teachers

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2. Summary

Visual perception is an inference of a scene out there based on a sensory input from eyes. Visual attention is a process concentrating a computational force of the brain on a specific aspect of the perceived scene or of the sensory input. The processes of perception and attention interact with one another and the interaction is even indispensable for them. This course will review studies of them and of interactions between them. Theories behind perception and attention will be particularly emphasized. The first half of the course mostly covers perception: how the scene is represented in the brain, how the representation is computed in the brain, and how the perceptual process affects and is affected by attention. The second half of the course more emphasizes attention itself: types of attention, how attention affects cognitive performance, and its limitation. The first half of the course mostly covers perception: how the scene is perceived, how it is represented in the brain, and how the perceptual process affects and is affected by attention. The second half of the course more emphasizes attention itself: types of attention, how attention affects cognitive performance, how it makes us see what we see, how it is linked to memory and consciousness, and why it is limited.

3. Learning Objectives

3.1. Visual perception (Tadamasa Sawada)
   • Formalizing problems on vision
   • 2D perception
   • 3D perception
   • Colour perception
   • Perceptual representation

3.2. Visual attention (Igor S. Utochkin)
   • Varieties of attention and early attentional theories
   • Attention in light of the modern theory of vision
   • The deployment of attention over space and time
   • Feature-based and object-based attention
   • Visual representations beyond the focus of attention
   • Attention and consciousness

4. Learning outcomes

After completing the study of the discipline «Visual Perception and Attention» the student should:
   • Know the cutting edge of vision science.
   • Know the theories behind visual phenomena.
- Know the mathematical/computational methods to analyze results and to formulate theories in Psychology.
- Learn the inverse problem approach to study vision science (and also other research areas in Psychology).
- Learn the multidisciplinary approach to study vision science (and also other research areas in Psychology).
- Be able to work with scientific psychological articles and texts.

After completing the study of the discipline «Visual Perception and Attention» the student should have the following competences:

<table>
<thead>
<tr>
<th>Competence</th>
<th>Code</th>
<th>Code (UC)</th>
<th>Descriptors (indicators of achievement of the result)</th>
<th>Educativ forms and methods aimed at generation and development of the competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ability to reflect developed methods of activity.</td>
<td>SC-1</td>
<td>SC-M1</td>
<td>The student is able to reflect developed methods to discuss and think about problems in Psychology</td>
<td>Lectures, group discussions.</td>
</tr>
<tr>
<td>The ability to improve and develop intelligent and cultural level, to build track of professional development and career.</td>
<td>SC-4</td>
<td>SC-M4</td>
<td>The student is able to improve and develop intelligent and cultural level, to build track of professional development and career based on the critical/analytical thinking learnt via studying how the theories of vision have been developed.</td>
<td>Lectures, group discussions.</td>
</tr>
<tr>
<td>The ability to analyze, verify and assess the completeness of information during professional activity and work under ambiguity.</td>
<td>SC-6</td>
<td>SC-M6</td>
<td>The student is able to analyze, verify and assess the completeness of information during professional activity and work under ambiguity based on the concepts of the ill-posedness, the ill-conditionedness, and the inverse problem.</td>
<td>Lectures, group discussions, essays.</td>
</tr>
<tr>
<td>The ability to describe problems and situations of professional activity in terms of humanitarian, economic and social sciences to solve problems which occur across sciences, in allied</td>
<td>PC-5</td>
<td>IC-M5.3_5. 4_5.6_2. 4.1</td>
<td>The student is able to describe problems and situations of professional activity in terms of psychology by learning the multidisciplinary aspects of problems in psychology.</td>
<td>Lectures, group discussions, essays.</td>
</tr>
</tbody>
</table>
5. Place of the discipline in the Master’s program structure

The course «Visual Perception and Attention» is an attempt to give master course students multidisciplinary views to problems in Psychology and theoretical and analytical thinking of them via studying theories in vision science. Note that vision science is one of the most multidisciplinary areas in psychology (for example, Philosophy, Applied mathematics, Geometry, Photometry, Optics, Computer science, Physics, and Neuroscience). The course is offered to the first year of the Master’s program «Cognitive sciences and technologies» at HSE.

The following knowledge and competence are required to study the discipline:
- A good command of the English language.
- A basic knowledge of Mathematics.

6. Course Plan

<table>
<thead>
<tr>
<th>№</th>
<th>Topic</th>
<th>Total hours</th>
<th>Contact hours</th>
<th>Independent students’ work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lectures</td>
<td>Seminars</td>
</tr>
<tr>
<td>1.</td>
<td>Formalizing problems on vision</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>2D perception</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>3D perception</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Color perception</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Perceptual representation</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Varieties of attention and early attentional theories</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Attention in light of the modern theory of vision</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>The deployment of attention over space and time</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Feature-based and object-based attention</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Visual representations beyond the focus of attention</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Attention and consciousness</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total:</td>
<td>190</td>
<td>32</td>
<td>32</td>
</tr>
</tbody>
</table>

7. Requirements and Grading

<table>
<thead>
<tr>
<th>Type of grading</th>
<th>Type of work</th>
<th>1st year</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td>Homework</td>
<td>X</td>
<td>X Reading of materials for seminars.</td>
</tr>
<tr>
<td></td>
<td>Mid-term exam</td>
<td>X</td>
<td>Take home exam.</td>
</tr>
<tr>
<td>Final</td>
<td>Exam</td>
<td>X</td>
<td>Oral exam. Preparation</td>
</tr>
</tbody>
</table>
8. Course Grade Criteria

Continuous assessment: students have to demonstrate their understanding of theories in vision science. It is also expected that the students will be able to apply their knowledge in their independent work on topics, connected with the discipline.

All essays will be checked for plagiarism.

Final assessment: students have to demonstrate a knowledge of basic facts, their command of methodology of analysing problems, connected with vision science, and their ability to understand and interpret these problems. Students should be able to evaluate a practical situation easily and quickly, and to interpret studied issues.

9. The cumulative grade formulae:

Cumulative grade ($G_c$) for the student’s work during the semester consists of lecturer’s assessment of the student’s work at seminars and lectures (presence, participation, quality and quantity of answers, quality of presentations) ($G_p$) and the mid-term exam score ($G_t$).

$$G_c = G_p + G_t,$$

where $G_p = 0.6$ and $G_t = 0.4$.

The finale grade ($G_f$) is the sum of cumulative grade ($G_c$) and the final assessment (exam) mark ($G_{ex}$):

$$G_f = G_c + G_{ex}$$

where $G_c = 0.7$ and $G_{ex} = 0.3$.

The grades are rounded in favour of the student.

<table>
<thead>
<tr>
<th>Ten-point Grading Scale</th>
<th>Five-point Grading Scale</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - very bad</td>
<td>no pass – 2</td>
<td>FAIL</td>
</tr>
<tr>
<td>2 – bad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 – no pass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 – pass</td>
<td>pass – 3</td>
<td></td>
</tr>
<tr>
<td>5 – highly pass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 – good</td>
<td>good – 4</td>
<td>PASS</td>
</tr>
<tr>
<td>7 – very good</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 – almost excellent</td>
<td>excellent – 5</td>
<td></td>
</tr>
<tr>
<td>9 – excellent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 – perfect</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10. Course Description

10.1. Visual perception (Tadamasa Sawada)


- **2D perception**: Perceptual organization, Gabor stimulus (Fourier/Wavelet transforms), Group invariants, Model-based invariants, Gestalt laws as Model-based invariants.

- **3D perception**: Shape constancy and a priori constraints, Depth from multiple images, Pictorial depth cues, Oculomotor depth information.

- **Colour perception**: Colour constancy, Surface-colour and Apparent-colour, Trichromacy theory, Opponent colour theory, Colour spaces, Interaction between colour and 3D perception.

- **Perceptual representation**: Mental representation of a perceived 3D object and of a perceived 3D scene. Geon theory, 2.5D Sketch. Categorical colour perception.

10.2. Visual attention (Igor Utochkin)

- **Varieties of attention and early attentional theories**: The omnipresence of attention. Attentional effects on perception, memory, behavior, and awareness. Modes of visual attention (focused, distributed, divided, sustained, etc.). Early attentional theories: Wundt, Titchener, James, filter models (early and late selection problem, Broadbent, Treisman, Deutche-Deutche, etc), resource models (Kahneman, etc).

- **Attention in light of the modern theory of vision**: Conceptual metaphors for studying attention (Fernandez-Duque & Jonston). Bottom-up and top-down processes in vision. Preattentive and attentive vision. The representational basis for attentional selection: space-based vs. object-based attention (Egly-Driver experiments).

- **The deployment of attention over space and time**: Spatial attention and spotlight theory of attention (Posner). The spatial cue paradigm. Overt and covert orienting of attention. Attention and eye movements ant premotor theory of attention (Rizzolatti). Time course of spatial attention (Posner, Jonides, etc). Spatial properties of the attentional spotlight (Eriksen) and its effect on the image resolution (Carrasco, Cavanagh). Crowding. Inhibitory effects of spatial attention: IOR, inhibitory surrounds and the dead zone of attention. Neural correlates of spatial selection (Posner, Duncan-Desimone, Tsotsos).

- **Feature-based and object-based attention**: Parallel and serial processing of objects and the nature of the "bottleneck" in vision (the binding problem, working memory, or FINSTs). Evidence from visual search, texture segregation, multiple-object tracking (MOT), numerical cognition, inattentional blindness (IB), change blindness (CB). Feature integration theory of attention (Treisman) and evidence. Treisman vs. Duncan-Humphreys debate. Guided search
model (Wolfe). The concept of feature/object saliency and its determinants. Popout, attentional capture, priming of popout, incentive-based saliency.

- **Visual representations beyond the focus of attention**: features, proto-objects, or statistics. Rapid gist perception (Potter, Thorpe, etc), global precedence (Navon), ensemble perception (Treisman, Rosenholtz, etc). The Grand Illusion of perception and consciousness. Classical preattention (Treisman) vs. distributed attention (Nakayama) frameworks in explaining parallel processing in vision.


### 11. Educational Technology

The following educational technologies are used in the study process:
- individual and group preparation of presentations on one of the chosen topics;
- discussion and analysis of the results of a home task in the group;
- group projects;
- demonstration of psychological effects and phenomena in a classroom;

### 12. Recommendations for course lecturer

Course lecturer is advised to use interactive learning methods, which allow participation of the students, such as discussions, case studies, role games, business games, analysis of psychological films. It is also expected that video materials and Power Point presentations will be used for the study process.

The course should be based on real-life psychological case studies, multimedia examples and current events.

### 13. Recommendations for Students

The course is interactive. Lectures are combined with classes. Students are invited to ask questions and actively participate in group discussions. There will be special office hours for students, which would like to get more precise understanding of each topic. All tutors are ready to answer your questions online by official e-mails that you can find in the “contacts” section.

### 14. Grading

#### 14.1. Provisional Topics for mid-term exam:

1. Formalizing problems on vision
2. 2D perception
3. 3D perception
4. Color perception
5. Perceptual representation
14.2. **Provisional questions for final assessment:**

1. Conceptual metaphors of attention
2. Early attentional theories
3. Attention in light of the modern theory of vision
4. Parallel and serial processes in vision. Preattention and attention
5. The deployment of attention over space. Posner’s cue task
6. The deployment of attention in space. RSVP. Attentional blink
7. Feature-based and object-based attention
8. Feature integration theory and derivatives
9. Visual representations beyond the focus of attention
10. Rapid scene and gist perception
12. Attention and consciousness

15. **Reading and Materials**

15.1. **Required Reading**


15.2. **Recommended Reading**


Additional readings will be suggested during the class

15.3. **Course telemaintenance**

All materials of the course are uploaded online and students are provided with their links during the course.

16. **Equipment**

The course requires a laptop, projector, and acoustic systems.
17. Office hour

Tadamasa Sawada: Wednesday, 10:00~12:00, 15:00~18:00
Room 110, Volgogradskiy Prospekt, 46B, Moscow