Assignments | Perception: Psychophysics and Modeling

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In this bachelor lecture course on *Perception: Psychophysics and Modeling* you are expected not only to attend the lectures themselves, but do a number of assignments in your own time. Some as a preparation for classes, some to consolidate the material of the lecture. None of them will be graded but it is nonetheless strongly recommended that you do them—in case of the quizzes it is in fact mandatory.

Most of the lectures will be classic frontal teaching—I will do most of the talking. However, I will try and intersperse this classic lecture format with periods using the *inverted classroom method*.[1] For you as students the inverted classroom implies more reading to do *before* the lecture.[2]

1 *Asynchronous videos*

There are a number of asynchronous videos I recommend you to watch—this is not compulsory but for most of you I believe it will be helpful. Furthermore, I suggest you watch the videos in the order listed in the handout `00b-CourseOutline.pdf` on ILIAS and repeated below. For your own benefit it is recommended to watch the videos before certain of my lectures; the temporal constraints are again to be found in the handout `00b-CourseOutline.pdf`.

For this course I ask you to watch in total eight video lectures by Prof. Karl Gegenfurtner from the University of Gießen; Karl Gegenfurtner is one of Germany's most well-known vision scientists and his introductory lecture course on *Wahrnehmungspsychologie*[3] is really comprehensive and often excellent. Those of you who study Cognitive Science may find that some of the material in the Gegenfurtner videos is already familiar from the module *Neurobiologie und Sinnesphysiologie*. If yes, simply increase the Playback speed on YouTube ….

1. Karl Gegenfurtner, Folge 1, *Einführung*. [60 mins]
2. Karl Gegenfurtner, Folge 2, *Neuronale Verarbeitung*. Relevant is only the second half, starting at 47:48 mins as well as the first one or two minutes of background information. [81 mins but only 37 mins are relevant]
3. Nancy Kanwisher, *Marr's Levels of Analysis*. Well-known professor at MIT, mainly known herself for her fMRI work. Very US-style in presentation, but nonetheless clear on why David Marr's levels are so important. [24 mins]
4. Donald Hoffman, *Computational Theory Mind*. Well-known professor at UC Irvine, known for theoretical and computational approaches to vision

[1] For a somewhat detailed explanation of the essentials of the inverted classroom method see the handout `00a-Admin.pdf` on ILIAS. Furthermore, there exist plenty of literature on the inverted classroom—or flipped classroom as it is sometimes called. The inverted classroom is related to what Eric Mazur calls *Peer Instruction*. I recommend you watch Eric Mazur: `https://www.youtube.com/watch?v=WwslBPj8GgI`. There exist many other, shorter, Eric Mazur videos on YouTube. But I strongly recommend the first 30 or so minutes of the linked video. Very instructive, very entertaining, and at the same time very sad in a way (with respect to much of school or University teaching).

[2] Typically you will only have to read a single article or book chapter before a "normal" or "traditional" lecture where I do most of the talking.

[3] The asynchronous video lectures are all in German, I'm afraid.

and the mind. Short video of which only the first 90 seconds (!) are really relevant. [7 mins but only 90 secs are relevant]

5. Noam Chomsky, *Mind, Brain, Neuroscience and David Marr*. Interview with one of the most prominent living intellectual giants of our time. [7 mins]
6. Karl Gegenfurtner, Folge 3, *Auge*. [89 mins]
7. Karl Gegenfurtner, Folge 4, *Retina*. [79 mins]
8. Karl Gegenfurtner, Folge 9, *Objekte*. [87 mins]
9. Karl Gegenfurtner, Folge 10, *Aufmerksamkeit*. [76 mins]
10. Karl Gegenfurtner, Folge 6, *Farbe*. [82 mins]
11. Karl Gegenfurnter, Folge 12, *Hören*. [79 mins]

If watched at normal speed, the ten videos amount to about ten and a half hours.

2 *Quizzes*

As part of the mandotory course requisites you have to do twelve quizzes; quizzes are helpful and important, as explained in the handout `00a-Admin.pdf` on ILIAS. Detailed information about which quiz you have to do exactly when can be found in the handout `00b-CourseOutline.pdf`.[4] Please note that all quizzes can only be done once, and you can only see the correct solutions to the questions if you have done the quiz! Quizzes are typically short with around ten questions. For those typical quizzes you have 60 minutes to complete the quiz after you have started it. A few of the quizzes are longer, however, and then you have 90 minutes to complete them.

At least one quiz is unusual as it (only) contains free-text fields, that is, you should answer it in a few sentences ("mini-essay"). After you've completed the quiz, you can compare your "mini-essays" to those I wrote. Some quizzes contain questions which are a bit longer and of the more difficult *cloze test* variety ("Lückentext")—they require detailed knowledge of the original articles you have had to read!

[4] Often there are only a few days within which you can do a quiz, after one particular lecture finished until the evening prior to the following lecture. Note that there are neither exceptions nor mercy: the quiz is automatically disabled at that time and there will be no other chance to do it (or see the solutions afterwards!).

3 *MATLAB tutorials*

There are a number of MATLAB tutorials[5] I recommend you to explore and play around with—this is not compulsory but for most of you I believe it will be helpful. For your own benefit it is recommended to complete the tutorials before particular lectures; the temporal constraints are again to be found in the handout `00b-CourseOutline.pdf`.

[5] All students of the University of Tübingen can download a copy of MATLAB from the ZDV for free: `https://uni-tuebingen.de/en/einrichtungen/zentrum-fuer-datenverarbeitung/dienstleistungen/clientdienste/software/matlab-einzelplatzlizenz/`

4 *VL 1 | How to study vision*

The amount of work you have to do before the lecture *VL 1 | How to study vision* may initially appear a lot—perhaps even too much. Please remember, however, that you have several weeks to complete the asynchronous video watching, reading and the online quiz—in that order, I suggest.

ESSENTIAL READING for the second lecture are the following three book chapters: First, please read chapter 1 entitled *How to study vision* in Wandell (1995)—only eight pages long.[6] Thereafter please read two chapters in the seminal book *Vision* by David Marr (1982): *General Introduction* and *The Philosophy and Approach*, together 35 pages.

[6] You find PDFs of the relevant chapters of the Wandell book on ILIAS; however, the entire book is also available online: `https://foundationsofvision.stanford.edu`. Please note that online the first chapter is simply titled Preface.

QUESTIONS TO THINK ABOUT while reading—these are likely questions we will be discussing together during inverted classroom periods:

- Wandell stresses encoding, representation and interpretation—make sure you know what he means by the three terms.
- Marr distinguishes understanding computers from understanding computations—what is this distinction? Is one more important than the other?
- Marr, too, talks about the importance of representation—what is a representation for Marr?
- What are the three levels of analysis or explanation Marr distinguishes? Make sure you can define all three of them in one or two sentences each.

5 *VL 2 | Linear systems, Fourier transform and optics*

ESSENTIAL READING for the second lecture are the following two book chapters: First, please read chapter 1 entitled *Linear Systems Analysis*, pp. 3–22 in De Valois and De Valois (1988). Thereafter please read chapter 2 entitled *Image Formation*, pp. 13–41 in Wandell (1995).

QUESTIONS TO THINK ABOUT while reading:

- Why are linear systems so important?
- If optical systems were not linear—what would the implication be for glasses and contact lenses?

6 *VL 4 | Psychophysics and Experimental Design*

The amount of work I expect you to have done before this lecture is a little more extensive: one book chapter as well as large parts of a review article.

ESSENTIAL READING for the fourth lecture is the following: First, please read parts of chapter 1 entitled *Introduction* in Wolfe et al. (2015); stop on p. 18: no need to read *Sensory Neuroscience and the Biology of Perception*. After this introductory book chapter please read parts of a book chapter with the title *Methods in Psychophysics* by yours truly: Wichmann and Jäkel (2018). Again you do not need to read the entire chapter, only the first nineteen pages till the section *Data Analysis* (pp. 1–19) as well as the *Conclusion* section (pp. 35–36).

QUESTIONS TO THINK ABOUT while reading:

- Assume that sensation, perception and cognition could be clearly separated from another—what would this imply for the way our mind (or brain) works?
- You often hear and read that the human threshold to see or hear something has this or that value—signal detection theory states, however, that there are no thresholds. How can this state of affairs be reconciled?
- Why are forced-choice procedures accussed of "taking perception out of perception research"?

7 VL 5 | Spatial Vision I

For the next two lectures on *Spatial Vision* you have to read two book chapters and an original research paper. The workload for spatial vision is a bit higher than usual, as the reading is, I believe, on the more difficult side.

ESSENTIAL READING for the two lectures is the following: First, please read chapter 7 *Pattern Sensitivity*, pp. 195–244, in Wandell (1995). Then in De Valois and De Valois (1988) read ch. 6 with the title *Multiple Spatial Frequency Channels* (pp. 176–211). De Valois and De Valois (1988) repeats some of the material of Wandell (1995) but in different words—thus I think it is worthwhile reading both chapters on "the same topic." After the two book chapters please read the original paper by Campbell and Robson (1968)—one of the most influential papers in vision science of all times! The paper is certainly rather dense and written for researchers rather than Bachelor students; still, I think you should give it a go: Perhaps you enjoy the challenge.

QUESTIONS TO THINK ABOUT while reading:

- What is the relation between the modulation transfer function (MTF) in optics and the contrast sensitivity function (CSF) in visual perception?
- Is the definition of Michelson contrast the only possible way to specify "contrast"?

8 *VL 7 | Object Recognition I*

ESSENTIAL READING for the first lecture on object recognition is a chapter in Wolfe et al. (2015), ch. 4 (pp. 89–120), with the title *Perceiving and Recognizing Objects*.

9 *VL 9 | Object Recognition III*

For the third of the four lectures on *Object Recognition* there are two original papers to be read. However, both of the papers are comparatively time intensive: One is long (Biederman, 1987), the other dense (DiCarlo et al., 2012).

ESSENTIAL READING for the third lecture on object recognition are two original research papers mentioned above. First one of the most influential papers on human object recognition by Biederman (1987). He argues that the human visual system represents objects in terms of a "visual language" consisting of three-dimensional visual primitives (a.k.a. *phonemes* in speech) and rules how they are combined (a.k.a. a *grammar* in speech). DiCarlo et al. (2012), on the other hand, conceptualise object recognition as multiple non-linear transformation of the two-dimensional image on our retinae without explicit "syntactic" internal representations.

10 *Object Recognition IV*

ESSENTIAL READING for the final lecture on object recognition are the two papers by Yamins et al. (2014) and Geirhos et al. (2018). The first explores similarities between the response properties of units in deep neural networks and neural responses in monkey cortex. The second explores similarities (and differences) between the behaviour of deep neural networks and human observers during object recognition.

11 *Scene Perception*

ESSENTIAL READING is a highly influential paper by Thorpe et al. (1996)—they showed that complex decisions about an image ("a scene") can be made in less than 150 ms. Torralba and Oliva (2003) offer a potential solution to this surprising finding in terms of natural image statistics and a biologically plausible model which could implement their statistical ideas in the human brain. Wichmann et al. (2010), finally, argue that humans do not use the algorithm suggested by Torralba and Oliva (2003) to perform the rapid detection described by Thorpe et al. (1996); in fact, they argue that the statistical differences are only found in images, not the real world.

12 *Visual Attention*

ESSENTIAL READING this week is only a single, rather "chatty" book chapter from Goldstein (2007): chapter 6 entitled *Visual Attention*, pp. 133–152). Much of the material is covered in the asynchronous video by Karl Gegenfurtner; I suggest you watch the video first and then read the book chapter somewhat quickly, concentrating on the aspects not covered in the video.

13 *Colour Vision I*

For the two Colour Vision lectures you have to read two book chapters. Note that this is the entire preparation for both colour vision lectures.

ESSENTIAL READING this week are two book chapters from Wandell (1995): chapter 4 entitled *Wavelength Encoding*, pp. 69–101, and chapter 9, *Color*, pp. 287–338.[7] The material is covered in a less mathematical style in the asynchronous video by Karl Gegenfurtner; I suggest you watch the video first and then read the book chapters.

[7] Note: You find a PDF of chapter 4 on ILIAS, however, chapter 9 is only available online: `https://foundationsofvision.stanford.edu`.

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