

Course syllabus

Course title	Information theory for cognitive sciences
Instructor(s)	prof. Joanna Rączaszek-Leonardi, prof. Marek Kuś, Szymon Talaga
Contact details	JRL: Tuesday 12-14; Thursday 13-15; e-mails: raczasze@psych.uw.edu.pl ; marek.kus@cft.edu.pl
Affiliation	JRL: University of Warsaw; MK: PAS Institute for the Theoretical Physics
Course format	seminar
Number of hours	30 hours
Number of ECTS credits	3 ECTS credits 1 ECTS stands for 25-30 hours of students work, and the 3 ECTS are distributed in the class workload as follows: <ul style="list-style-type: none">• 30 hours: class attendance, 2 unexcused absences are allowed; missing more than 2 classes (even if justified) requires completing an extra assignment• 15-20 hours: reading for classes, at least 1 paper before each class• 10-15 hours: preparation of a short presentation for the class• 25-30 hours: original project, which uses the notions taught in class and its presentation.
Brief course description	The course introduces the basic concepts and measures of the information theory. It provides an overview of the history of the information theory and its practical applications within cognitive sciences and other related fields such as biology, linguistics and social sciences. Limitations of the information theory as applied to cognitive sciences will also be addressed, basing on current discussions of the semantic aspects of information and the link between information-theoretical and thermodynamic entropy.
Full course description	The course introduces the basic concepts and measures of the information theory. It provides an overview of the history of the information theory and its practical applications within cognitive sciences and other related fields such as biology, linguistics and social sciences. The first part of the class will be devoted to a) presentation of the history of the theory of information (Hartley, Shannon); and b) most important concepts of the theory (entropy, information measures, coding and compression of information, capacity of informational channels. Next we will present the application of the measures designed within the theory of information in physics, biology, neuropsychology, linguistics). Finally, the limitations of the information theory as applied to cognitive sciences will also be addressed, basing on current discussions of the semantic or

pragmatic aspects of information and the link between information-theoretical and thermodynamic entropy.

Learning outcomes

Students after completing the course will be able to:

- Describe the history of the notion of the quantity of information and of the efforts to formalize it.
- Define the most important concepts of the theory (information quantity, entropy, mutual and joint information) and use mathematical formulas to compute them.
- Indicate the main areas of application for the measures of information within cognitive sciences and related disciplines.
- Use terminology pertaining to information theory and its application
- Discuss information-theoretic problems with specialists from other fields.
- Formulate questions within cognitive science, which can be answered using information-theoretic measures

Learning activities and teaching methods

The seminar will consist in:

- Presentation of information theory main concepts and measures; homework problems will be assigned to test students' understanding. Problems can be discussed in class.
- Students are expected to introduce 1 paper during the class (20 minutes) and initiate and guide the discussion of the paper.
- Students, individually or in pair will conduct a small research project: Students will formulate a research problem, gather simple datasets and use information theory measures to answer research questions.

List of topics/classes and bibliography

- 1. Introduction. Range of problems for information theory. Communication and Information.**
 - a. Gleick: Information: pp. 9-32 i 189-216 (r. 7); optional: Chapter 6.
 - b. Weaver, W. (1964). Recent contributions to the mathematical theory of communication. In: Shannon, C. & Weaver, In: The Mathematical Theory of Communication. The University of Illinois Press: Urbana
- 2. What is information theory NOT about. Gibson and the concept of a stimulus.**
 - a. Gibson, J. J. (1960). The concept of a stimulus in psychology.
- 3. Mathematical bases of information theory: entropy, conditional entropy, mutual information**
 - a. Brillouin, L. (1969). Nauka a Teoria Informacji. Rozdział 1.
 - b. Cover, T. M., Thomas, J. A. (1991). "Elements of Information Theory", New York: Wiley. Rozdział 2.

- c. Shannon, C. E. (1964). „The Mathematical Theory of Communication”. In: Shannon, C. & Weaver, W. The Mathematical Theory of Communication. The University of Illinois Press: Urbana.
- 4. Mathematical bases of information theory: mutual information, joint information**
- 5. Complexity measures**
- a. Kolmogorov, A. N. (1965). “Three approaches to the quantitative definition of information”, Probl. Inf. Transm., 1, p. 1–7. [1 osoba (Rysiek)]
- b. Deacon, T. & Koutroufinis, S. (2014). Complexity and Dynamical Depth. Information, 5, 404-423. [2 osoby]
- c. Cover, T. M., Thomas, J. A. (1991). “Elements of Information Theory”, Rozdz. 7.
- 6. Physical aspects of information**
- 7. Applications: neurobiology**
- 8. Applications: Language**
- 9. Information, energy & cognition**
- 10. Information: redefinition**
- 11. – 14. Project presentations**

Assessment methods and criteria	50% Project and its presentation 20% Homework 20% Short paper presentation and guiding the discussion 10% Class presence and active participation
Attendance rules	Attendance to the seminar is obligatory, 2 unexcused absences are allowed.
Prerequisites	CMP I, philosophy of mind course, basic skills in math, probability
Academic honesty	Students must respect the principles of academic integrity. Cheating and plagiarism (including copying work from other students, internet or other sources) are serious violations that are punishable and instructors are required to report all cases to the administration.
Remarks	The project presentations may take place within mini-conference organized towards the end of the semester