

Keynote presentation

## **Neurocognitive approach to natural language understanding and creativity**

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**Abstract:** High-level brain functions involve thinking, reasoning, planning and language, all based on the use of symbols. How are these symbols represented in the brain, and how to model brain processes to reach high level of linguistic competence? A unified neurocognitive view of understanding the meaning of symbols may be based on spreading neural activation in the brain. This process is approximated by spreading activation in brain networks, providing enhanced representations that involve concepts that are not found directly in the text. Approximation of this process is of great practical and theoretical interest. Although activations of neural circuits involved in representation of words rapidly change in time snapshots of these activations spreading through associative networks may be captured in a semantic network or in a vector model. Concepts of similar type activate larger clusters of neurons, priming areas in the left and right hemisphere.

Analysis of recent brain imaging experiments shows the importance of the right hemisphere non-verbal clusterization. Medical ontologies enable development of a large-scale practical algorithm to re-create pathways of spreading neural activations. Short hospital discharge summaries are used to illustrate how this process works on a real, very noisy data. Expanded texts show significantly improved clustering and may be classified with much higher accuracy. Such knowledge representation may also be used in semantic search and in word games, for example in the 20 question game.

Creation and understanding of novel words, one of the simplest form of creative thinking, requires 3 factors: space for imagination provided by associative memory trained using statistical model of language; the process of imagination based on priming and chaotic activations; and competitive associative memory providing constraints and filtering the results. Analysis of the process of invention and understanding of novel words at different levels of brain's activity leads to practical algorithms that re-invented many names of products, companies and websites. Experimental evidence connecting creativity to processes of associative thinking is analyzed, including experiments with pairwise word association. Perspectives on computational approach to creativity and higher cognitive functions are outlined.

**Bio:** Włodzisław Duch heads the Department of Informatics, Nicolaus Copernicus University, Torun, Poland, and has been recently a Visiting Professor at Nanyang Technological University, Singapore (2003-07). Ph.D. in quantum chemistry (1980), postdoc at USC, Los Angeles (1980-82), D.Sc. in applied math

(1987); worked at University of Florida; Max-Planck-Institute, Munich, Germany, Kyushu Institute of Technology, Meiji and Rikkyo University in Japan, and several other institutions. He is on the editorial board of IEEE TNN, CPC, NIP-LR, Journal of Mind and Behavior, and 7 other journals; co-founder & scientific editor of the "Polish Cognitive Science" journal; president of the European Neural Networks Society (2006-2008), member of IEEE NNS Technical committee; expert of the European Union science programs; published over 380 scientific and popular articles, 4 books, edited many others, his DuchSoft company makes GhostMiner software package marketed by Fujitsu.

Expert in computational intelligence (CI), especially methods that facilitate understanding of data, and neurocognitive informatics, or algorithms inspired by models of brain functions at different levels. Among other topics he works on creation of general CI theory based on similarity evaluation, meta-learning schemes that automatically discover the best model for a given data, geometrical theories for modeling of mental events and relating such models to neurodynamics, computational creativity and intuition, tests and toys that facilitate mental development. With a wide background in many branches of science and understanding of different cultures he bridges various scientific communities. As a service to the international community he maintains many web pages related to CI, computational neuroscience, machine learning and statistics. To access these pages and his full CV type "W Duch" in Google.