

# Optimality Theory as a General Cognitive Architecture

**Tamás Biró (t.s.biro@uva.nl)**

Amsterdam Center for Language and Cognition,  
University of Amsterdam (UvA)  
Spuistraat 210, 1012 VT, Amsterdam, Netherlands

**Judit Gervain (judit.gervain@parisdescartes.fr)**

Laboratoire Psychologie de la Perception  
UMR 8158 CNRS-Paris Descartes  
45 rue des Saints-Pères, Paris, 75006, France

**Keywords:** Optimality Theory; Harmonic Grammar; cognitive architectures; connectionism; symbolic approaches.

## Optimality Theory and cognitive science

It was exactly 25 years ago that Paul Smolensky introduced *Harmony Theory* (Smolensky, 1986), a framework that would pursue an exciting, but certainly not straight path through linguistics (namely, *Optimality Theory*) and other cognitive domains. The goal of this workshop is not so much to look back to this path, but rather to discuss its potential continuation(s).

Soon after its publication, *Optimality Theory* (OT) (Prince & Smolensky, 1993/2004) became one of the most successful frameworks for linguistic research. The number of publications submitted to the *Rutgers Optimality Archive* (at <http://roa.rutgers.edu>) exceeded one thousand in November 2008, with a large number of OT-related publications never added to ROA. The older sister of OT, *Harmonic Grammar* (HG) (Smolensky, 1986) has also been the object of a recent raise in interest, especially since the publication of *The Harmonic Mind* (Smolensky & Legendre, 2006). The key idea shared by OT and HG is that the linguistic mapping between form and meaning, or between underlying form and surface form, is realized by optimizing an abstract function: a real-valued one in HG, and a vector-valued one in OT.

By developing the *Integrated Connectionist/Symbolic (ICS) Cognitive Architecture*, Smolensky and his colleagues worked out the connection between linguistics and a general theory of the mind/brain in a hardly precedented manner. Their approach is probably significantly closer to mainstream computational cognitive science than much of contemporary theoretical linguistics. General-purpose cognitive architectures (ACT-R) have also been combined with OT (Misker & Anderson, 2003; Rij, Rijn, & Hendriks, 2010). Learnability is addressed by, among others, Tesar, Boersma and Magri.

The authors of the *The Harmonic Mind* alluded to the possibility that ICS—that is, Optimality Theory and Harmonic Grammar—may prove a useful and adequate model of much of (higher) cognition, including domains beyond language. Simultaneously, and probably independently of their remark, simply as a consequence of OT's success in linguistics, a number of scholars have advanced Optimality Theoretic models for non-linguistic phenomena. The authors of these isolated attempts usually even did not know of each other.

Constraints applied to traffic rules (Boersma, 1998; Gilbers & Schreuder, 2000; Boersma, 2003) and to a Talmudic dilemma (Dresher, 1996) aim only at illustrating the OT formalism. Parker and Parker (2004) present an analysis of ethical *decision making* in a religious context, which is clearly a first step toward an OT-style account of a non-linguistic domain, despite potential criticism related to the cognitive grounding of their constraints. Although not elaborating on the connection with Optimality Theory, the “take the best” heuristics of the *ABC Research Group* can also be seen as an OT/HG-style approach (Gigerenzer, Todd, & the ABC Research Group, 1999). (Compare the *lexicographic decision rule* of Coenen and Marewski (2009) to strict domination in OT; see the comparison of OT and the ABC Research Group's heuristics in Smolensky and Legendre (2006, vol. 1, p. 41-42) and Biró (2006, p. 225f).)

Even more explicit is the wish to view OT as a general cognitive framework for (higher) cognition in the work of Douglas Jones on kinship terminology, as well as of Tamás Biró on religious rituals. Jones (2003, 2010) developed an Optimality Theoretic model for one of the classical topics in anthropology, the cross-cultural typology of kinship systems. Beside the connection to cognition in general, he also embedded his analysis in an evolutionary psychological account. His most recent article in BBS generated a vivid discussion on the applicability of OT beyond linguistics. Biró (in press) has employed Optimality Theory to account for food taboos and the dynamics of different types of rituals. By the latter, he attempted computationally to underpin current theories in the cognitive science of religion.

## Goals of the workshop

The workshop offers a meeting point to those applying OT (or HG) to non-linguistic domains, as well as an occasion to discuss the place of OT, HG and ICS within the cognitive sciences. Collocating it with CogSci makes it possible to non-OT'ers to join the discussion, and to OT'ers to get feedback and constructive criticism from external eyes.

By developing OT/HG-style analyses for various domains of (higher) cognition, we obtain descriptions of many functions of the human mind within a uniform paradigm, employing a shared language and shared standards. We also may get closer to understanding how these domains are processed in

the human brain, by translating symbols to connections using either Smolensky's ICS, or future alternatives to it.

We see a distinction between OT/HG-style models, on the one hand, and *utility function*-based models, on the other. A huge body of literature describe phenomena by optimizing a utility-like function external to the brain (for instance, energy needed to move one's arm during action planning), or even external to the human (for instance, monetary gain/loss). Unlike these approaches, an OT/HG-style model optimizes an abstract target function, a theoretical construct (which may or may not correspond to energy level of the network within the brain). A workshop at CogSci is a unique opportunity for those involved in the two research lines running in parallel to engage in a cross-fertilizing discourse.

### Format of the workshop

The half-day workshop on July 20th consists of talks and a poster session:

- 9:00 Introduction (Judit Gervain and Tamás Biró)
- 9:10 Keynote address by Paul Smolensky (JHU): *Parallel Distributed Symbol Processing: Well-formedness optimization and discretization in cognition*
- 9:55 Giorgio Magri (Jean Nicod): *A comparison between OT and HG from a computational perspective*
- 10:20 Poster session followed by coffee break
- 10:50 Petra Hendriks (U. of Groningen): *Asymmetries between production and comprehension and the development of Theory of Mind*
- 11:15 Douglas M. Jones (U. of Utah): *Linguistic grammar and moral grammar: The case of kinship*
- 11:40 Lotte Hogeweg (RU Nijmegen): *Optimality Theory as a general linguistic theory*
- 12:05 Closing address by Géraldine Legendre (JHU)

A call-for-posters has been circulated seeking contributions by May 20th addressing, primarily, though not exclusively, the following issues:

- Optimality Theory and Harmonic Grammar as general models of the brain/mind, or of (higher) cognition.
- OT/HG-style analyses of phenomena belonging to (primarily, non-linguistic) domains that have not yet employed OT.
- The connection of linguistic OT/HG to the study of other (higher) cognitive functions.
- OT vs. HG, from theoretical-mathematical and cognitive-neuroscientific perspectives.
- OT/HG-style formalisms vs. utility function-based approaches from a mathematical-computational perspective.
- Relating connectionist and symbolic approaches: the ICS Architecture and its eventual alternatives.
- Ontogenetic aspects of OT/HG approaches (learnability).
- Phylogenetic aspects of OT/HG approaches (including historical change, evolutionary models, etc.).

More information, including the accepted posters, abstracts, a position paper and eventual changes in the program, is available on <http://www.biro.t.hu/events/OTGCA/>.

### Organizers of the Workshop

Tamás Biró is postdoc at the *Amsterdam Center for Language and Communication*, working on *Simulated Annealing for Optimality Theory*. Judit Gervain is CNRS researcher at the *Laboratoire Psychologie de la Perception* in Paris, working on neurolinguistic aspects of syntax and its early acquisition.

### References

- Biró, T. (2006). *Finding the right words*. Unpublished doctoral dissertation, University of Groningen. (ROA-896)
- Biró, T. (in press). Optimal religion: OT accounts for ritual dynamics. In I. Czachesz & T. Biró (Eds.), *Changing minds: Religion and cognition through the ages*. Peeters.
- Boersma, P. (1998). *Functional phonology* (Vol. 11). The Hague: Holland Academic Graphics.
- Boersma, P. (2003). Review of *B. Tesar & P. Smolensky (2000): Learnability in OT. Phonology, 20, 436–446*.
- Coenen, A., & Marewski, J. N. (2009). Predicting moral judgments of corporate responsibility with formal decision heuristics. In N. Taatgen & H. van Rijn (Eds.), *Proc. 31st annual conference of CSS* (pp. 1524–1528). Austin, TX.
- Dresher, E. (1996). The rise of optimality theory in first century Palestine. *GLOT Intern.*, 2. Available from <http://homes.chass.utoronto.ca/~dresher/col6.html>
- Gigerenzer, G., Todd, P. M., & the ABC Research Group. (1999). *Simple heuristics that make us smart*. Oxford: Oxford University Press.
- Gilbers, D., & Schreuder, M. (2000). *Language and music in Optimality Theory*. ROA-571.
- Jones, D. (2003). The generative psychology of kinship. Part 2. Generating variation from universal building blocks with OT. *Evolution and Human Behavior, 24, 320–350*.
- Jones, D. (2010). Human kinship, from conceptual structure to grammar. *Behavioral and Brain Sciences, 33, 367–416*.
- Misker, J. M., & Anderson, J. R. (2003). Combining Optimality Theory and a cognitive architecture. In F. Detje et al. (Ed.), *Proc. 5th International Conf. on Cognitive Modeling* (Vol. 5, p. 171–176). Universitäts-Verlag Bamberg.
- Parker, S., & Parker, M. (2004). Optimality Theory and ethical decision making. *Work Papers SIL*. Available from <http://www.und.edu/dept/linguistics/wp/2004ParkerParker.PDF>.
- Prince, A., & Smolensky, P. (1993/2004). *Optimality Theory: Constraint interaction in Generative Grammar*. Malden: Blackwell. Originally RuCCS-TR-2.
- Rij, J. van, Rijn, H. van, & Hendriks, P. (2010). Cognitive architectures and language comprehension. *Journal of Child Language, 37(3), 731–766*.
- Smolensky, P. (1986). Information processing in dynamical systems: Foundations of Harmony Theory. In *Rumelhart et al.: Parallel distributed processing* (Vol. 1, p. 194–281). Cambridge, MA, London, England: Bradford, MIT Press.
- Smolensky, P., & Legendre, G. (2006). *The Harmonic Mind: From neural computation to Optimality-Theoretic grammar*. Cambridge, MA – London, UK: MIT Press.