Tightening the articulation between language and number

8 – 11 March @Oort

During this workshop, we brought together leading specialists from linguistics, neuroscience, and developmental pyschology to discuss the cognitive systems that have been proposed for the representation of number.

The relation between the cognitive and linguistic development of number, in particular with respect to counting and number word acquisition, as well as their relationship to language itself are poorly understood and hotly debated. In particular, there is no consensus on the aspects that must be ascribed to numerosity proper and those that can be attributed to more general processes, such as memory or perception.

This interdisciplinary workshop on the relationships between core and external systems of number and language and their interaction greatly enhanced our understanding of a number of the issues described above.

In order to prepare the workshop, we had asked the participants to provide an abstract of their presentation as well as some additional relevant publications. This allowed participants to better prepare for the workshop. The talks and discussions centered around the following 4 broad themes:

1. The acquisition of number

The presentations by **David Barner**, **Susan Carey**, **Rochel Gelman**, and **Charles Yang** focused on the mechanisms and factors that influence the acquition of numbers by young children. **Jeffrey Lidz** reviewed data from the acquisition and use of proportional and comparative quantifiers (*most* and *more*). Using a mix of psychophysical and behavioral techniques with children and adults, he showed that the extralinguistic systems that provide content for quantificational expressions can be used to probe the fine details of linguistic meaning.

2. The cognitive representation of number

Stanislas Dehaene presented recent research with Christophe Pallier using functional magnetic resonance imaging that shows that brain areas that play a central role in language syntax are not the same as those that are active in various aspects of mathematics. **Randy Gallistel** focused on the relation between the approximate number system and the exact number system, arguing that the brain represents and arithmetically manipulates discrete and continuous quantity. **Elizabeth Spelke** argued that natural number concepts emerge over the course of human development and depend on three innate, early emerging cognitive systems: a system for representing approximate numerical magnitudes, a system for representing up to three distinct objects and their mechanical interactions, and the system supporting learning of a natural language. **Stella Lourenco** argued that number is should be viewed as part of a 'general magnitude system', in which there is convergence of numerical and non-numerical magnitudes. Number and other magnitudes are not processed by fully differentiated systems.

3. Number and quantity in morphosyntax and semantics

Richard Kayne, Pierre Pica, and **Johan Rooryck** presented reserarch on the morphosyntactic analysis of number in various languages. **Richard Kayne** presented ongoing research on the underlying syntactic representation of the lower numbers. On the basis of data from Mundurucu, **Pierre Pica** developed an analysis of both approximate and exact number according to which a number is the result of the successor function mapping sets expressing numerical values into numbers. **Johan Rooryck** provided an analysis of the expression of paucity and abundance in Mundurucu comparing it to related

expressions in French and English. **Manfred Krifka** and **Lucas Champollion** presented an overview of approaches to number and quantification in formal semantics.

4. Number in nonhuman animals

Tetsuro Matsuzawa and **Justin Wood** focused on **number representation in animals**, **Tetsuro Matsuzawa** presented results from his research on the numerical cognition of chimpanzees, who outperformed human adults in memorizing briefly presented numerals in a masking task. These chimpanzees were less proficient at a variety of other cognitive tasks, suggesting that they do not possess human-like capabilities for the representation of number at an abstract level. On the basis of data from a high-throughput controlled-rearing approach, **Justin Wood** showed how advanced visual-cognitive abilities like object recognition and number representation emerge in the brain of newborn chicks.

The objectives of the workshop werre largely reached, and all participants were very satisfied about the the quality of the discussions and questions.

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