Rodriguez, A.; Granger, R.
The grammar of mammalian brain capacity. (English) Zbl 1342.92050

Summary: Uniquely human abilities may arise from special-purpose brain circuitry, or from concerted general capacity increases due to our outsized brains. We forward a novel hypothesis of the relation between computational capacity and brain size, linking mathematical formalisms of grammars with the allometric increases in cortical-subcortical ratios that arise in large brains. In sum, (i) thalamocortical loops compute formal grammars; (ii) successive cortical regions describe grammar rewrite rules of increasing size; (iii) cortical-subcortical ratios determine the quantity of stacks in single-stack pushdown grammars; (iv) quantitative increase of stacks yields grammars with qualitatively increased computational power. We arrive at the specific conjecture that human brain capacity is equivalent to that of indexed grammars – far short of full Turing-computable (recursively enumerable) systems. The work provides a candidate explanatory account of a range of existing human and animal data, addressing longstanding questions of how repeated similar brain algorithms can be successfully applied to apparently dissimilar computational tasks (e.g., perceptual versus cognitive, phonological versus syntactic); and how quantitative increases to brains can confer qualitative changes to their computational repertoire.

MSC:
92C20 Neural biology
68Q42 Grammars and rewriting systems
68Q45 Formal languages and automata

Keywords:
brain allometry; grammars; high-order pushdown automata; thalamocortical circuits

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