

# Recombination Makes us Human

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Welcoming Address

First International Kyma Symposium

Barcelona 8-10 October 2009

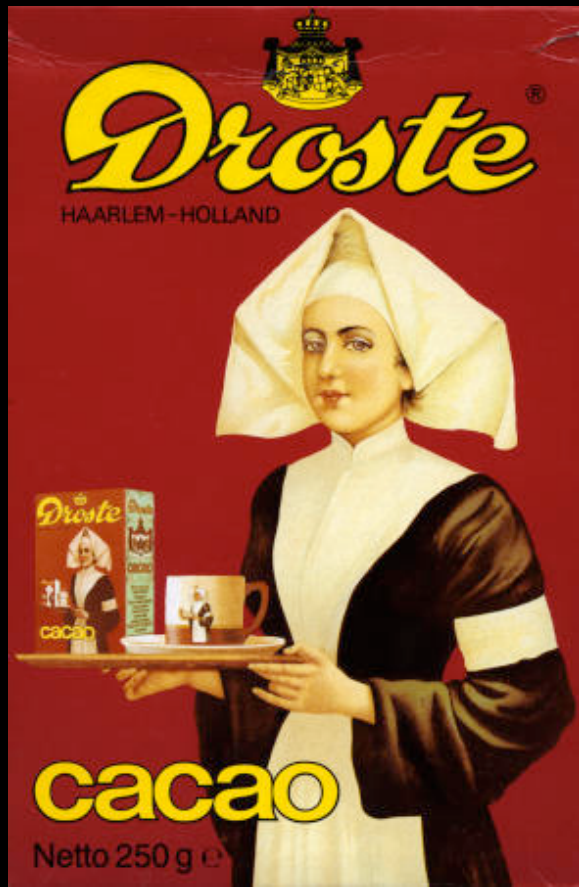
# Recombinance

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- Recursive
  - Applying a function to its previous output
- Combinatorial
  - Relating to combination & ordering of elements

# Droste Effect

Mise en abîme



# A recombinant process can:

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- Combine a finite number of elements
- In infinite variety of ways

# Language

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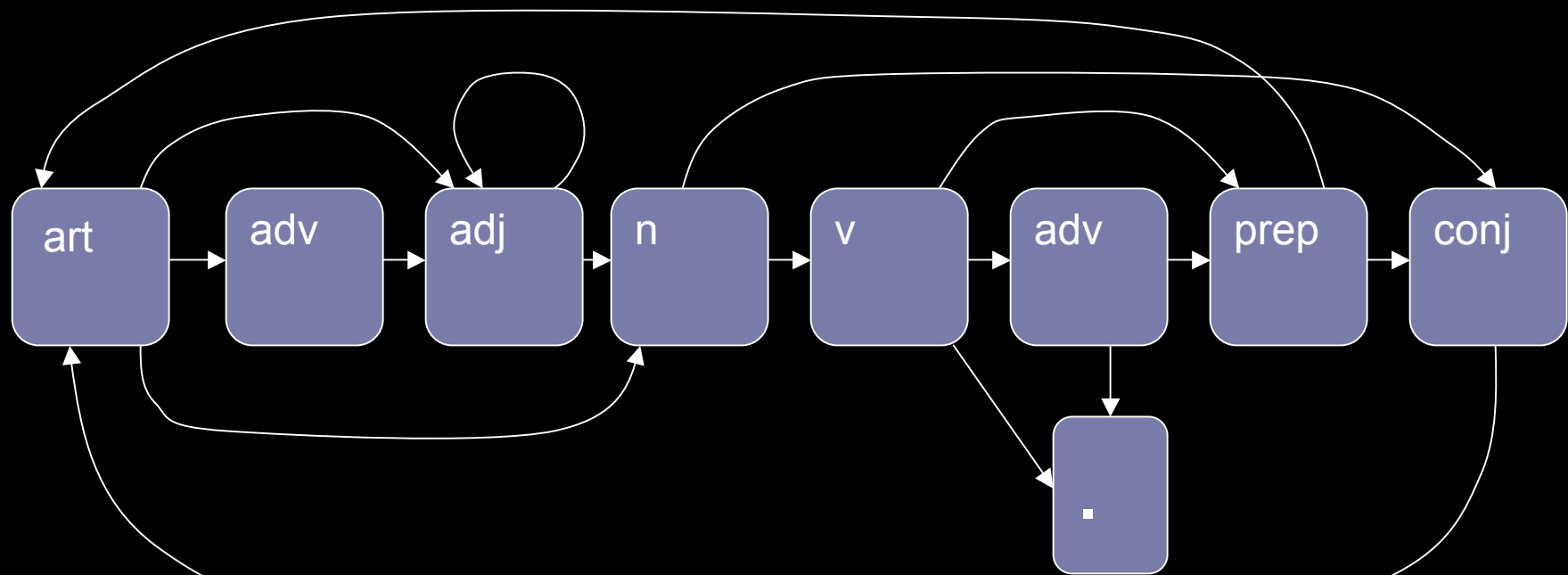
- Finite number of words in the dictionary
- Apply recursive grammar
- Generate infinite number of sentences

# Recursive Transition Network

Finite state automaton, Context-free Grammar

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■ Hofstadter: *Gödel Escher Bach*



# Human Immune system

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- Innate (shared with invertebrates, plants)
  - Specific to pathogens encountered in distant evolutionary past
- Adaptive (in vertebrates only)
  - Recombinant: infinite variety from small number of building blocks
  - Can generate millions of new antibodies by permuting just a few hundred genes
  - Tests and remember *new* sequences for antibodies to new pathogens that have never been encountered before
  - Adapts to pathogens (which evolve much faster than we do)

# Immunologist Susumo Ohno

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- Innate system == Epimetheus

- Backward-looking
- Result of natural selection
- *Reacting*



- Adaptive system == Prometheus

- Forward-looking
- Generative
- *Anticipating*



# Recombination makes us human

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- Power of recombination
  - Able to anticipate the unforeseen
  - Generate infinite variety
  - By recombining a finite number of building blocks
- What makes us human
  - How did we become human?
    - And why?

# Theory of origins ~ 800 BCE

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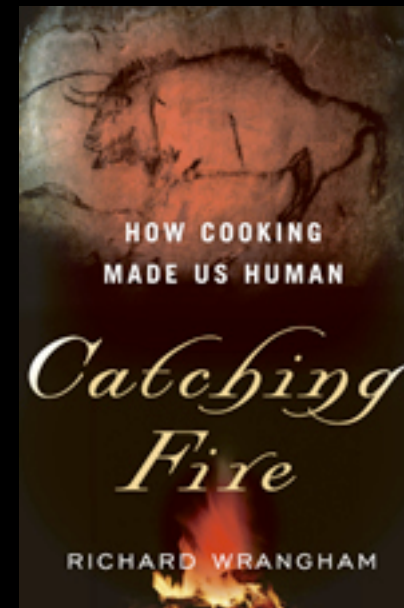
- Prometheus
  - Gave fire to humans
- Epimetheus
  - Opened Pandora's box
  - Evil, pain & disease



# Theory of origins 2009

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- **Frances D Burton** *Fire The Spark that Ignited Human Evolution*
- **Richard Wrangham** *Catching Fire: How Cooking Made Us Human*



# Not just size, but proportion

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## ■ Neocortex

- Outer shell or covering over the older parts of the brain
- First developed in primates 2-3 million years ago
- Highly connected (linking different parts of the older brain)
- Plastic, associative

## ■ Pre-frontal cortex

- Traditionally associated with planning, choice, anticipation
- ~ Same relative size as chimps, bonobos, gorillas, orangutans
- But with denser *interconnections* to other regions of brain

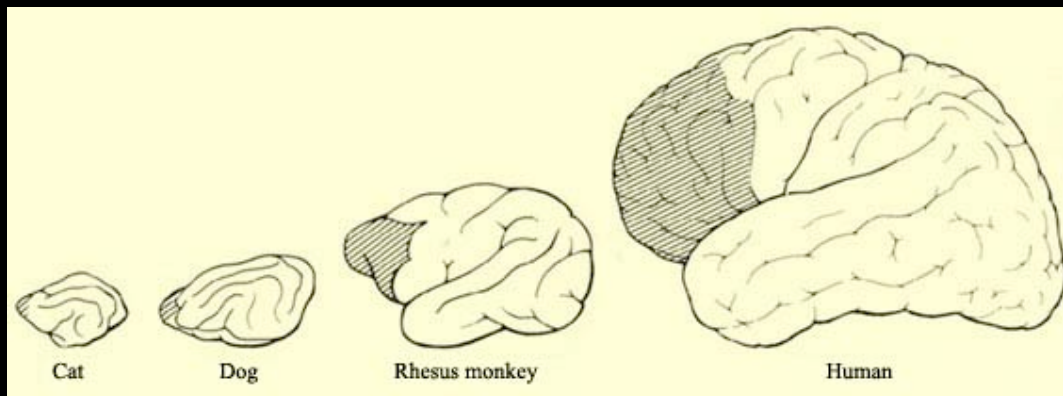
*The Brain from Top to Bottom*

- <http://thebrain.mcgill.ca>

# What a big brain you have!

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- The better to network with, my dear



*The Brain from Top to Bottom*

- <http://thebrain.mcgill.ca>

# The Social Mind

## Machiavellian Intelligence Hypothesis

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- Neocortex evolved in response to
  - Complexity of maintaining social networks
  - Predicting intentions & actions of other individuals
- Using “theory of mind”
  - Robin Dunbar (2003): "The Social Brain: Mind, language and society in evolutionary perspective"
  - [http://www.lifesci.sussex.ac.uk/teaching/C1021/TBCE\\_social\\_brain\\_2009.pdf](http://www.lifesci.sussex.ac.uk/teaching/C1021/TBCE_social_brain_2009.pdf)

# Theory of Mind

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- Theory that another individual has a mind like yours
  - Ability to infer another's mental state, knowledge, beliefs
  - Predict another individual's actions
  - Also understand how your behavior affects others
- Mind-reading
- Several animals have Theory of Mind
  - Humans practice several levels of recursion



# Level $\rightarrow$ Size of Frontal Lobe

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- Level 1
  - *I think that Kurt has some food*
    - C (f)
- Level 2 (children ~4 years, some primates?)
  - *I think that Kurt thinks there is some food over there*
  - *I think that you understood what I just said*
    - C ( K ( f ) )
- Level 3 (10-11 year old children)
  - *I think that Kurt thinks that I don't know where the food is*
    - C ( K ( C ( f ) not ) )



# Level 3 Theory of Mind

## C ( K ( C ( food ) not ) )

- *Journal of Cultural and Evolutionary Psychology*, 4(2006)3–4, 231–246 DOI: 10.1556/JCEP.4.2006.3–4.3  
**HIGHER-ORDER THEORY OF MIND AND SOCIAL COMPETENCE IN SCHOOL-AGE CHILDREN** BETHANY LIDDLE AND DANIEL NETTLE



# Consenting Adults Only

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## ■ Level 4

- I think Kurt doesn't know that I don't know where Mr Javelina thinks the food is

## ■ Level 5

- Shakespeare intends that the audience believes that Iago intends that Othello supposes that Desdemona loves Cassio, who in fact loves Bianca

## ■ Level 6++

- Chess? (if future mental states add to the recursion)

# False Belief Task

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- Show child a toothpaste box
- What do you think is inside?
  - Toothpaste
- Reveal that there are pencils inside
- Child's mom enters the room
- What will your mom think is inside the toothpaste box?

# Primate Social Networks

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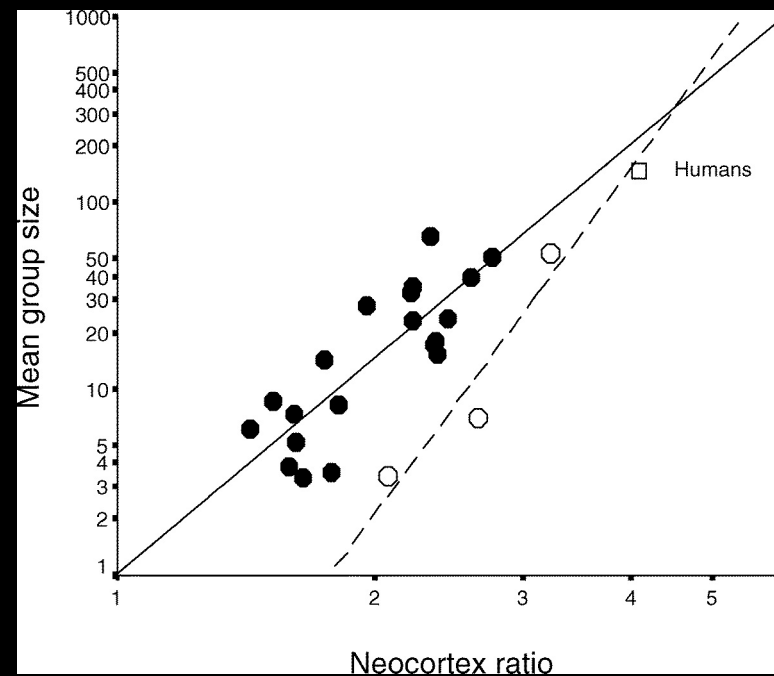
- Maintained through mutual grooming
- Larger network->more time grooming



[http://en.wikipedia.org/wiki/Social\\_grooming](http://en.wikipedia.org/wiki/Social_grooming)

# Neocortex to Group Size

- Barrett et al (2002) *Human Evolutionary Psychology*
- Figure 9.3 NeocortexToMeanGroupSize



# Human Core Group Size

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- Core group size 150
- 42% of the day spent in grooming activities
- How many in your Facebook group?
  - How much time do you spend grooming it?

# Auditory Grooming

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- RIM Dunbar *Language, Music and Laughter in Evolutionary Perspective* chapter in **Evolution of communication systems: a comparative approach, Page 90** By D. Kimbrough Oller, Ulrike Griebel The MIT Press; (September 1, 2004)

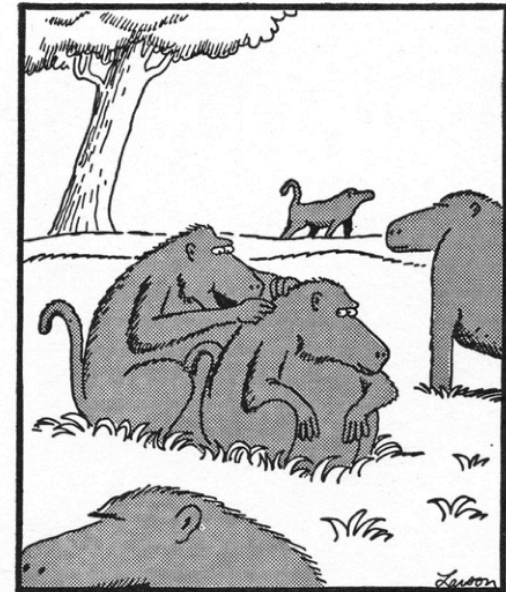


[www.gibbons.de](http://www.gibbons.de)

# Language as Grooming

- Language as efficient form of grooming
  - Social cohesion while working
  - Social cohesion at a distance
- Expanded size of core group
  - Recursive groups of groups
- Distributed cognition

- Gary Larson: The Far Side



"So then Sheila says to Betty that Arnold told her what Harry was up to, but Betty told me she already heard it from Blanche, don't you know ..."



# Trading Brains

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- Epimethean brain
  - Innate abilities from evolutionary past (“instinct”)
  - Reactive
- Promethean brain
  - Recursive recombinations
  - Knowledge distributed in social networks
  - Anticipatory
- Steven Mithin (2006) *The Singing Neanderthals*
  - Domain specific knowledge
  - Cognitive fluidity

# Innate vs Adaptive Ability

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- Oliver Sacks describes Stephen Wiltshire
- Prodigious drawing ability @ age 5
- Disinterested in
  - People
  - Language
  - Play

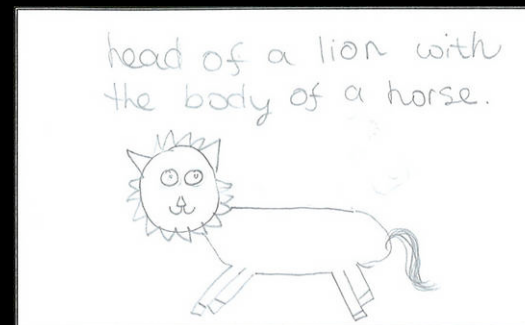


<http://www.stephenwiltshire.co.uk/>

# The Price of Prometheus' Gift

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- ...suddenly appearing, full-blown, 'unchildlike'
- VS incrementally developing over many years



# Recombination in Music

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## ■ Traditional music

- Finite scales & durations (or ragas + talas)
  - An infinite variety of novel melodies
- Recursive structures at different timescales
  - Interval, motive, phrase, movement, sonata etc

## ■ Electro-acoustic music

- Continuous functions recursively combined @ different timescales and scale factors
- Voltage-control: Modulate the modulator

# Mathematics

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- Innate: Subitizing up to 4
  - Infants, animals
- Recursion gives us Counting
  - $2 + 1 + 1, 3 = 2 + 1$ , etc
  - or Clustering, Grouping: “4 groups of 4”
- Observe indefinitely repeating processes
  - Bouncing ball
    - $y(n) = y(n-1) * 0.5$
  - Counting
- Then add “in the limit” to that repeating process



# Infinity makes us human?

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- Infinity + self-awareness of finitude
- Key to happiness: ignore your neocortex?



120.1 *Kaukasian Eagle & Prometheus*



[thenewheretics.wordpress.com](http://thenewheretics.wordpress.com)

# Recombination in Language

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- Finite set of words in the dictionary
  - Combined using a recursive grammar
  - Generates millions of novel expressions & ideas

# Recombinant Culture

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- Language as efficient form of grooming
  - Social cohesion while working
  - Social cohesion at a distance
- Written language
- Electronic communication



# Power of Social Networks

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- To know things we have not experienced
- Exponential expansion of what we can know, remember & learn

# Welcome to the Symposium!

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- Let the distributed social recombination begin!