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|  | Human | | | Monkey | Bird |
| Unintended action | Non-stereotypic action | Language |
| Level 1 system | Intended action:  Mirror neuron system | Stereotypic action:  Mirror neuron system | Simple Mirror Neuron System  Intended object oriented actions  Intended imitation | Homolog F5, only active if hand+object are visible  Allospecies activation  Grasping a visible object  Grasping | Candidate: HVCx neurons (songbird)  Learning by referential labeling, phoneme recognition  Vocalization: HVCx neurons show same activity in perception and production of same melody  (partly allospecies activation) |
| Level 2 system | Unintended action recognition  ToM or attention  rTPJ, l supramarginal gyrus  mesial prefrontal cortex | Non-stereotypic action recognition  Social network system (ToM)  TPJ, IPL, STS/MTG | Extended Mirror Neuron System  F5- evolved to Broca  Wernicke  DLPFC, AIP …  Connected to:  Theory of Mind-network,  Ontogeny of cortical inhibition | Minimal ToM vs. ToM  Limited domains  Limited to pointers  Asymmetry: Understanding > Production  Test expectation and reaction to pantomime | Attention vs. ToM  Is there anything that exclusively increases attention OR ToM activation? |

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| No ToM |  | No episodic WWW memory | Pigeon |
| Minimal ToM spatial | Field-related tasks, behavioral goals; pure bottom up | Episodic memory I, causal cognition, implicit planning | Maybe some macaque-like monkeys? Some birds? |
| Minimal ToM simple normative | Domain-related: Mistaken or inappropriate actions, behavioral goals  Top down combinatory normativity (“reasons”) | + simple level 1 system or homolog, enhanced causal cognition, teleological reasoning | Chimp (motor), scrub-jay (motor)  Parrot (vocal), infant (motor+vocal) |
| ToM | Discourse knowledge, norms, beliefs | + Level 2-system, episodic memory II | humans |

Hypothesis I: A *Minimal ToM spatial* in the sense of Butterfill and Apperly is suitable for all spatial/navigational tasks.

Hypothesis II: *Minimal ToM spatial* does not depend on a level 1 system.

Hypothesis III: *Minimal ToM simple normative* and ToM may not be easily distinguished purely functionally, because:

1. Individuality: the intraspecies-interindividual variance in ToM-capacities is in some domains bigger than interspecies-interindividual variance (for species with Minimal ToM)
2. Quantitative vs. qualitative differences: Think about number concepts – it is by no means the case that every human has a number concept that can be transferred to unlimited domains or is bigger than the set {1, 2, 3, many}. It is unlikely that “concept” really can be domain-independent, this is too idealistic. If a chimp or a parrot uses numbers in only some domains, this is no evidence for a qualitative difference between capacities.
3. Discourse knowledge: Many ToM-tasks like recognition of non-stereotypic or unintended action may be not useful to test universally for ToM. Think about dancing. It is even for most humans difficult to realize such failures in dances, e.g. if a Western-European looks at some Mongolian dancers. Specific knowledge is necessary, if it goes beyond causal cognition.

Research hypotheses:

1. One must care for ontogeny of mirror neuron systems and individuality. Maybe even in humans the mirror neuron system differs in its formation. If it differs, then the inhibitory effects of higher cortical systems (DLPFC) and mirror neuron system (level 2 system) may be different. In some cases there is a conflict between level 1 system and level 2 system.
2. A homolog mirror neuron system must exist in parrots, scrub-jays and other creatures with “practical rationality” and simple normativity. Especially, in brain *design top down control elements* are needed.
3. Apparently the main difference between full ToM and Minimal ToM is that every Minimal ToM-relation points to concrete objects. But it is known that in the primate hippocampus allocentric representations of hidden objects continue to exist. It would be interesting to test if e.g. chimps can combine/integrate properties of several hidden objects. The product of combinatory reasoning with hidden objects may resemble some properties of human concepts. (e.g. in arts there is the hypothesis that every creature in surreal or fantastic painting is only a recombination of singular known properties of existing creatures)