



# Attachment, Bonding, and Neuroscience

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# Attachment

- John Bowlby and Mary Ainsworth formulated attachment theory as a way of describing what they believed was a **biological drive**
- Infants are born with proximity-promoting attachment behaviors: crying, sucking, rooting, smiling
- Through interaction with a primary caregiver the infant begins to organize these behaviors towards a specific caregiver
- Primary responsibility of a caregiver is to provide a **secure base** and encourage the child to explore from it
- In times of stress, a child needs a caregiver who is sensitive and attuned to their needs
- Attachment patterns are established early in development and tend to **persist over time** (attachment patterns create internal working models)



# Guess the Attachment Style



Secure

Anxious/Ambivalent

Avoidant

Disorganized



# Bonding

- Human bonds are **selective** (to a specific attachment target) and enduring
- Bonding behavior is triggered by person and culture specific behavior patterns
- Bond formation involves increased activity and tighter crosstalk among relevant systems (**reward, affiliation and stress management**)
- Human attachments promote homeostasis, health and well-being throughout life.



# Guess the Neurotransmitter



Dopamine

Oxytocin

Reward/pleasure

Indicator of safety

Nucleus accumbens

Motivational patterns

Increases salience

Functions in myoactivity



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# Guess the Neurotransmitter



## Dopamine

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Motivational patterns

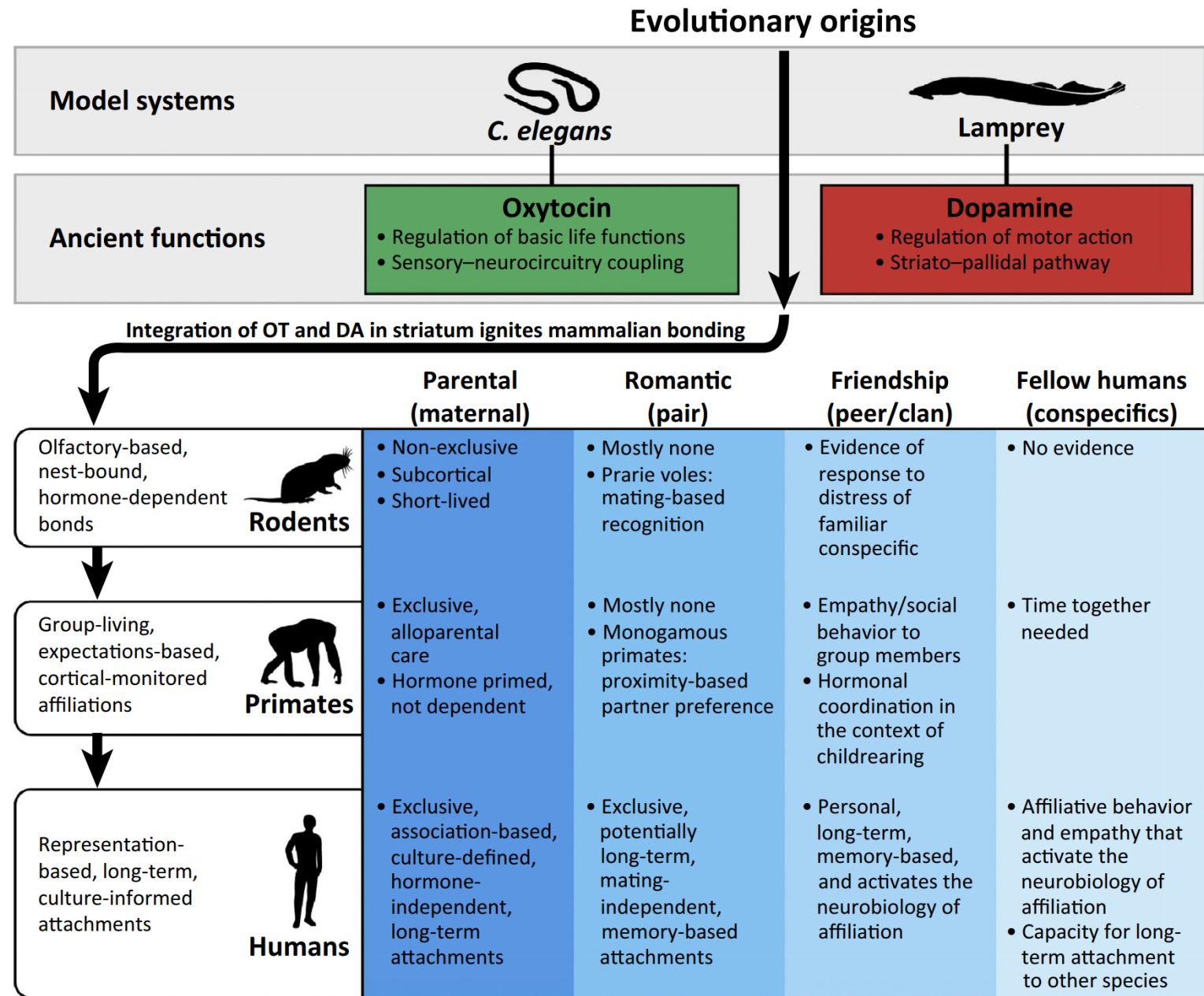
## Oxytocin

Indicator of safety

Increases salience

Functions in myoactivity

# Role of Dopamine and Oxytocin in Attachment





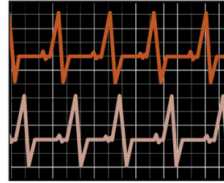
# Importance of the early environment

- The first environment an infant is born into is key in shaping its development
- Maternal heart rhythms, smell, touch, movement patterns, arousal dynamics, social cues, and stress response is the first environment the infant brain encounters.
- Ideal is to have a low stress environment for mom
- Humans' cortical complexity enables integration of the subcortical limbic network and OT and DA systems into love/attachment/connections built on representations of memory that adapt to cultural norms and carry bonds across generations. Love is grounded in meaning systems and incorporates empathy and trust to maintain long term affiliations. It extends the here and now so that love can be felt in its absence and can transcend to abstract ideas

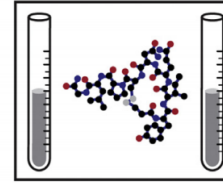
## Biobehavioral synchrony in human attachments



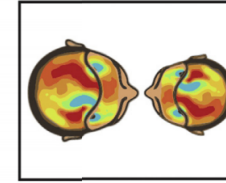
**Behavioral synchrony**



**Heart rate coupling**



**Endocrine fit**



**Brain-to-brain synchrony**



**Parents**



**Romantic partners**



**Friends**



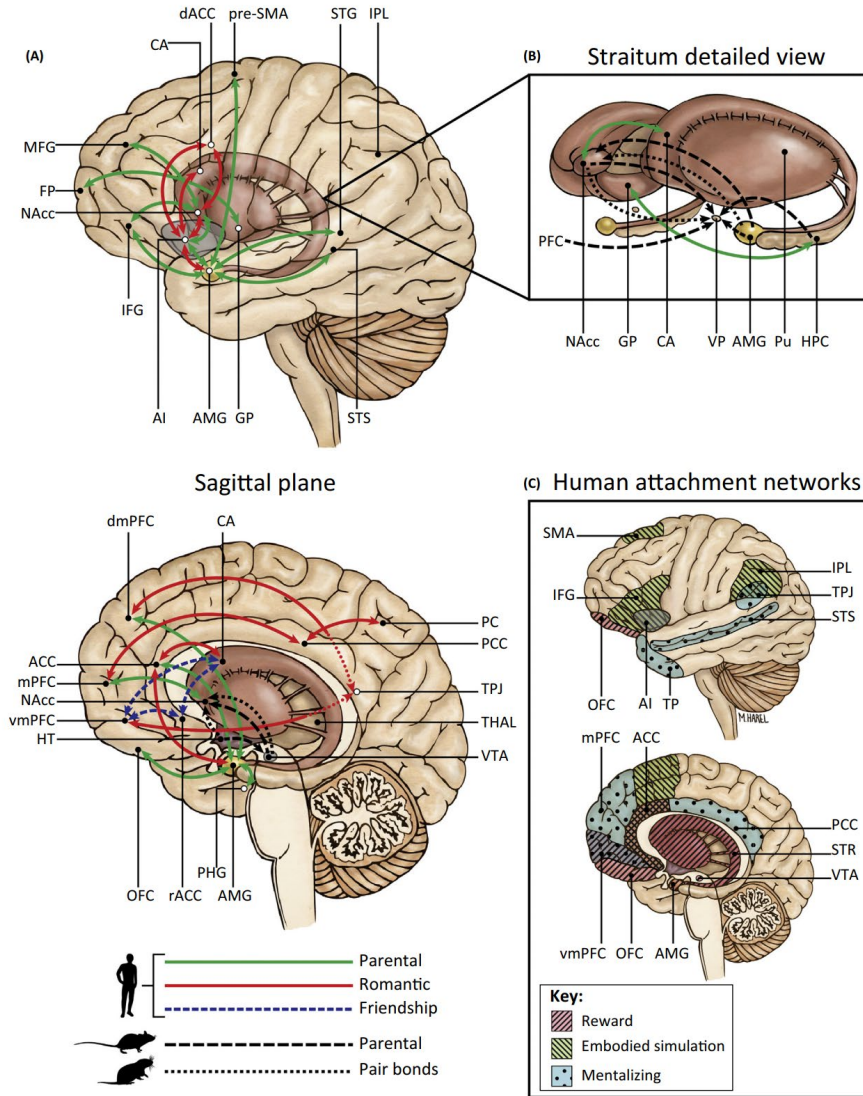
**Strangers**

<ul style="list-style-type: none"> <li>• Synchronized behavior in gaze, affect, vocal, and touch</li> <li>• Mother-specific father-specific</li> </ul>	<ul style="list-style-type: none"> <li>• Synchronized HR during synchronized interactions</li> </ul>	<ul style="list-style-type: none"> <li>• Coordinated OT response following contact</li> <li>• Coordinated cortisol response to stress</li> </ul>	<ul style="list-style-type: none"> <li>• Coordinated brain oscillations in alpha and gamma rhythms</li> </ul>
<ul style="list-style-type: none"> <li>• Synchronized nonverbal patterns</li> <li>• Coordinated self-disclosure + empathy</li> </ul>	<ul style="list-style-type: none"> <li>• HR coordination during or following interaction</li> </ul>	<ul style="list-style-type: none"> <li>• Coordination of OT and cortisol among parents</li> <li>• Coordination of OT among lovers</li> </ul>	<ul style="list-style-type: none"> <li>• Coordination of brain response in mentalizing network in parents</li> <li>• Coordination of gamma oscillations in temporal cortex in lovers</li> </ul>
<ul style="list-style-type: none"> <li>• Patterns of social reciprocity</li> </ul>	<ul style="list-style-type: none"> <li>• Teams coordinate heart rhythms during joint action</li> </ul>	<ul style="list-style-type: none"> <li>• OT is released during interactions with friends</li> <li>• No evidence for coupling</li> </ul>	<ul style="list-style-type: none"> <li>• Alpha response to behavioral synchrony among teams in social brain</li> <li>• Coordination among teams in mirror network</li> </ul>
<ul style="list-style-type: none"> <li>• Coordination of culture-specific display rules (e.g., eye gaze)</li> </ul>	<ul style="list-style-type: none"> <li>• Evidence for some coordination during joint action in close proximity</li> </ul>	<ul style="list-style-type: none"> <li>• OT is implicated in acts of empathy</li> <li>• No evidence for coupling</li> </ul>	<ul style="list-style-type: none"> <li>• Evidence for coordinated activation in mentalizing areas during interaction</li> </ul>



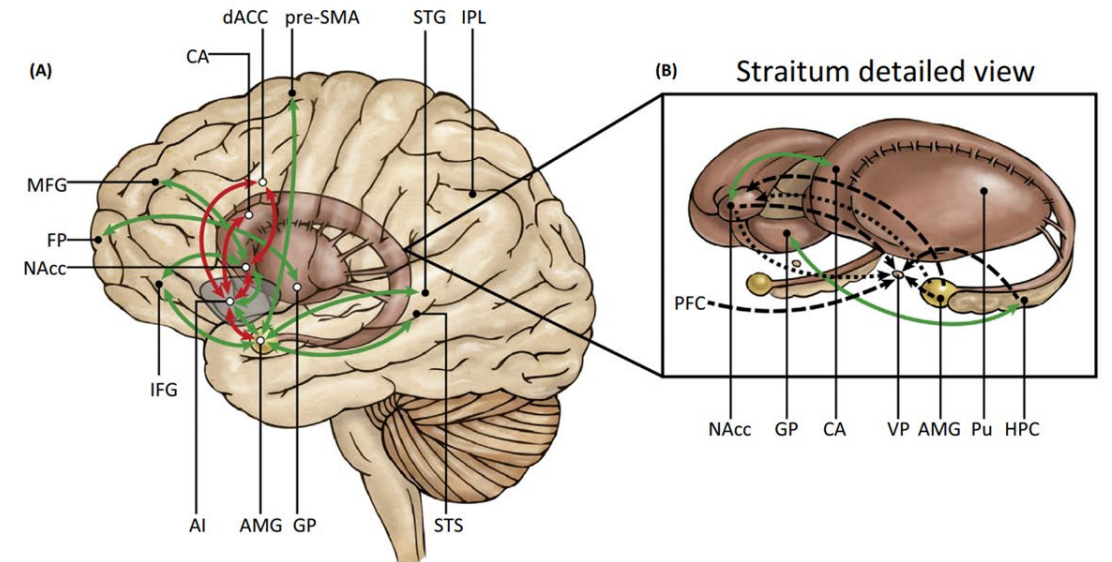
# Networks for Bonding

1. Reward-Motivation
2. Embodied Simulation/Empathy
3. Mentalizing

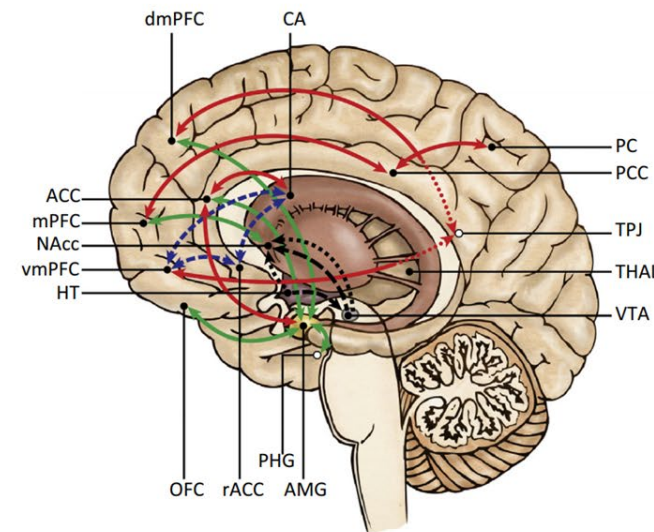


# 1. Reward-Motivation System

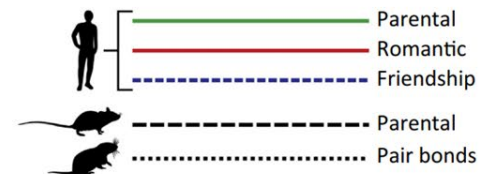
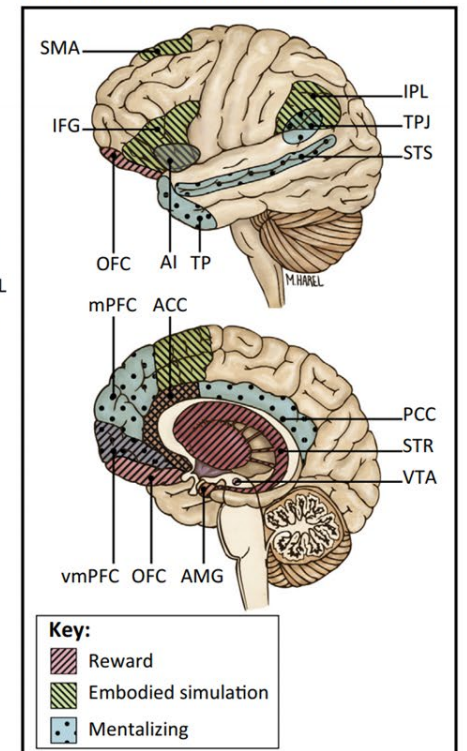
- Striatum (NA, caudate, putamen), amygdala, VTA, OFC, vmPFC, ACC
- DA and OT rich pathways supporting attachment related motivation patterns
- The **amygdala** plays a critical role in mothering and romantic attachment. It guides attention to biologically relevant stimuli, adjusts social orienting, codes the intensity of reward and computes the salience of social information
- **OFC** “pleasantness” and in effortful goal-directed actions to tend long term relationships
- **vmPFC** “love” “yearning” appraisal of safety, sense of self, inhibits limbic regions (reducing anxiety/avoidance in safe environments and long term attachments)



Sagittal plane



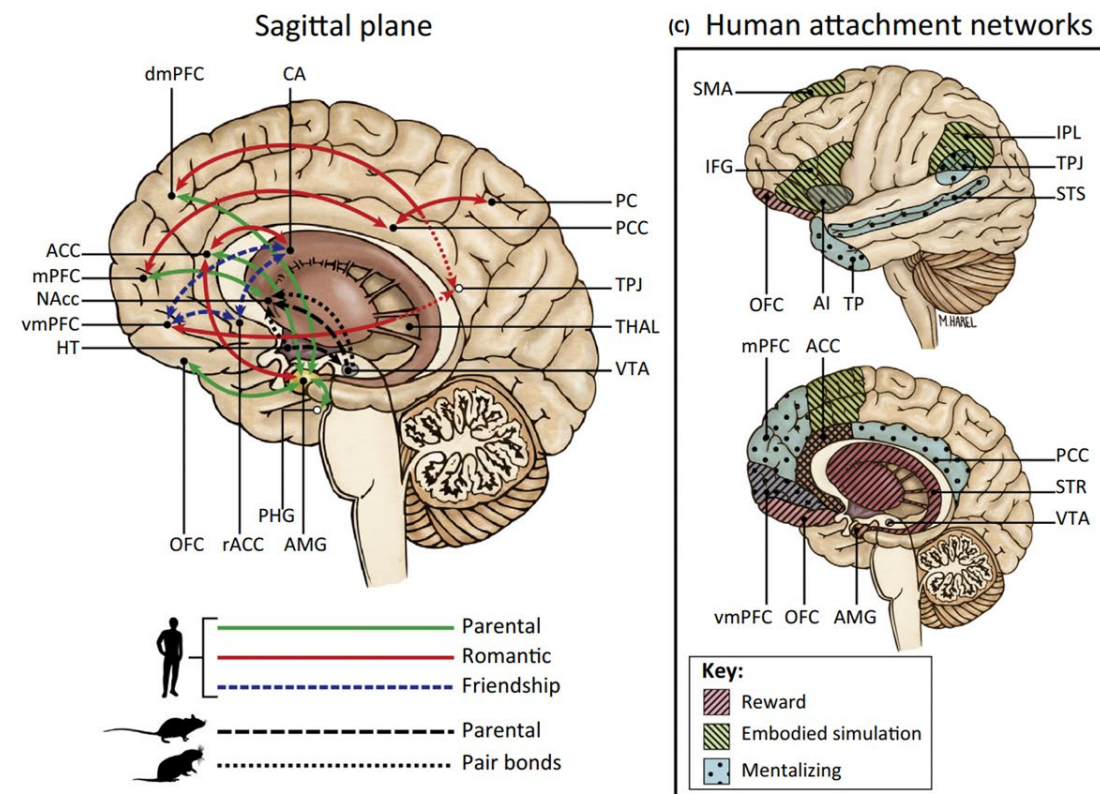
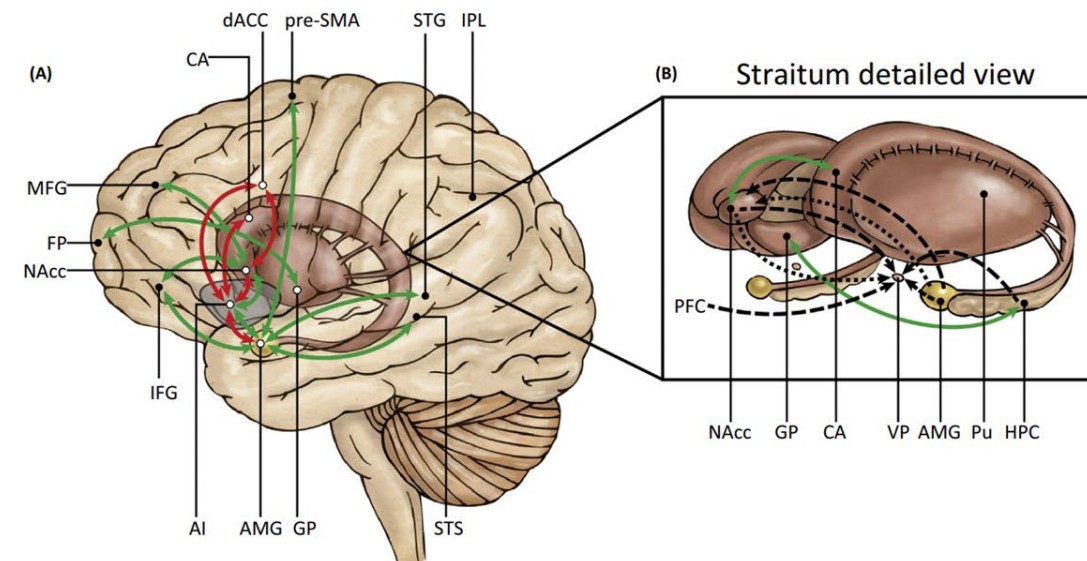
(c) Human attachment networks





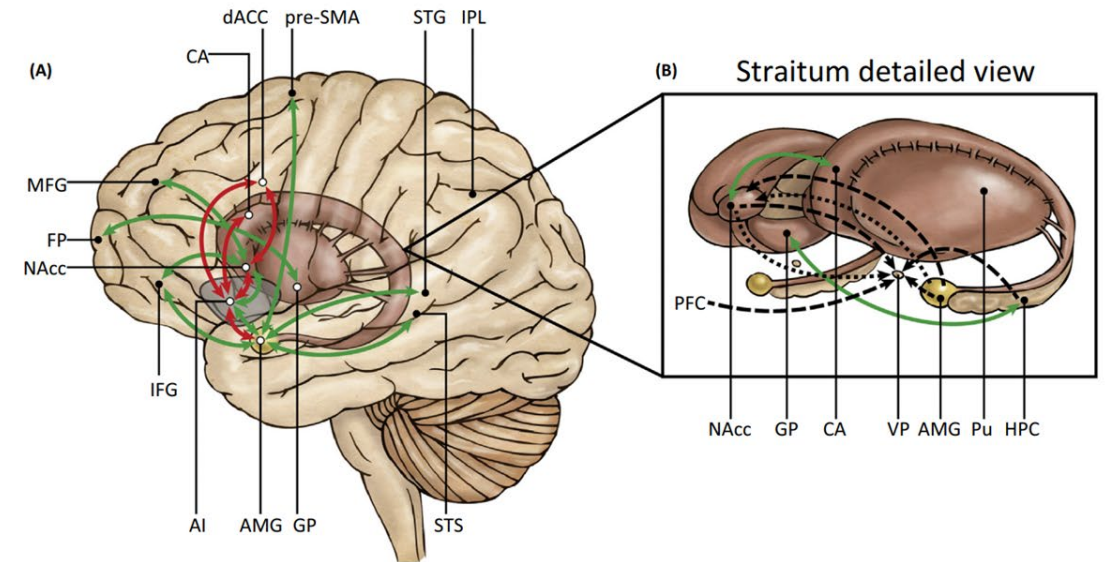
## 2. Embodied Simulation/Empathy Network

- Insula, ACC, IFG, IPL, SMA
- Recreates other's state in one's brain. Grounds a "shared world" in the brain
- Enables the parent/partner to integrate interoceptive and affective information, resonate with mental states and emotions and ground experience in the present moment giving it color, immediacy and situatedness

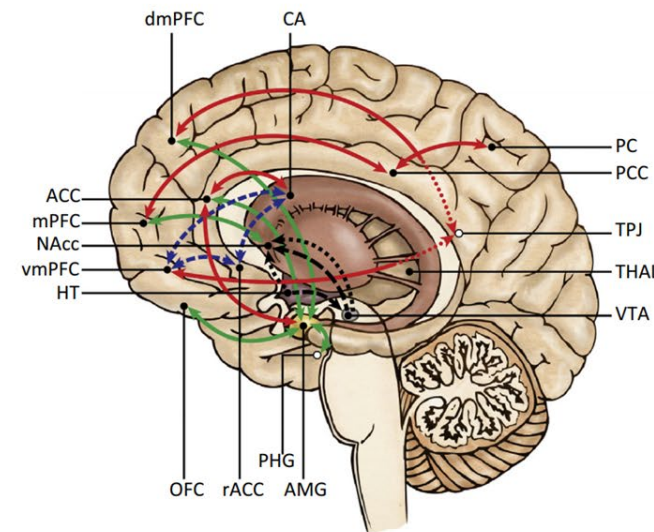


# 3. Mentalizing System

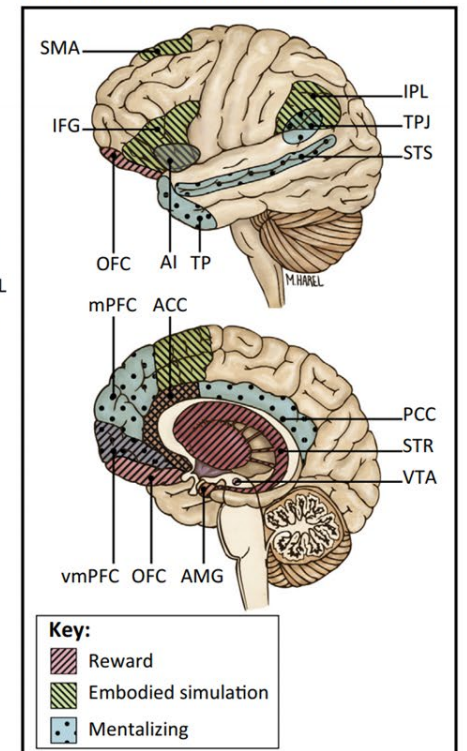
- Frontotemporal-parietal structures (STS, PCC, TPJ, temporal pole, mPFC)
- Higher order processes that allow us to infer other's mental states
- Helps attachment by allowing us to appreciate multiple perspectives, understand partner's goals and motives and keep in mind our values and concerns
- STS and TPJ play vital role in social cognition.



Sagittal plane



(c) Human attachment networks



# Summary

- Attachment is a **biological drive** that starts from birth
- **Attunement** between caregiver and infant or pair bonds is key in attachment
- The **early environment** has a significant impact on attachments
- For humans, bonds and attachment are formed early on and tend to be **enduring**
- **DA and OT** are key hormones involved in bonding and attachment
- Key neural affiliative networks involve **reward and motivation** systems, **simulation and empathy** systems, and **mentalizing systems**

# References

- Ainsworth, M. D. S., & Bell, S. M. (1970). Attachment, exploration, and separation: Illustrated by the behavior of one-year-olds in a strange situation. *Child Development*, 41(1), 49–67. <https://doi.org/10.2307/1127388>
- Bowlby, J. (1973). *Attachment and loss, vol. 2: Separation: Anxiety and anger*. New York: Basic Books
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- Patterson, D., Pollock, D., Carter, S., & Chambers, J. (2021). Treating opioid use disorder in peripartum mothers: A look at the psychodynamics, neurobiology, and potential role of oxytocin. *Psychodynamic Psychiatry* 49 (1), 48-72