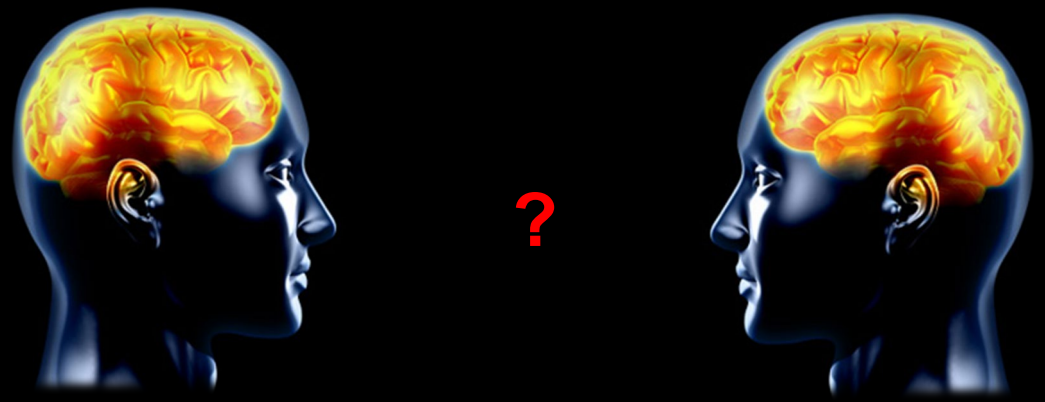

Shared, yet distinct - the neural bases of empathy and prosocial behavior

Claus Lamm, University of Vienna
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https://scan.psy.univie.ac.at

National Academy of Sciences – Neurobiology of Empathy
Keynote | May 19 2025

- Conflicts of interest declaration:

I have no conflicts of interest to disclose

SCAN Unit



SCAN Unit



SCAN Unit




MAGNETIC RESONANCE IMAGING (MRI)
Social cognition, emotions, and behavior
HORMONES
Psychological Science Accelerator
A Distributed Laboratory Network


PREREGISTERED
OPEN DATA
OPEN MATERIALS

Overview



- Part 1 – What 'is' empathy – concepts and key processes
- Part 2 – Empathy and affect sharing
- Part 3 – Empathy and self-other distinction
- Part 4 – Empathy and (pro)social behavior

Part 1- Let's talk definition(s)

In Social Neuroscience, we tend to define empathy like this:

- Empathy entails …
  - an affective state/response,
  - isomorphic to/sharing (in part) the one of the target (i.e., the person I show empathy for),
  - evoked by the observation or imagination of the target's affective state
  - with (some) awareness that the target is the source of my own affective (empathetic) state.

cf. Vignemont & Singer, Trends in Cognitive Sciences 2006; vgl. Singer & Lamm, Ann NY Acad Sci 2009

Empathy and related concepts



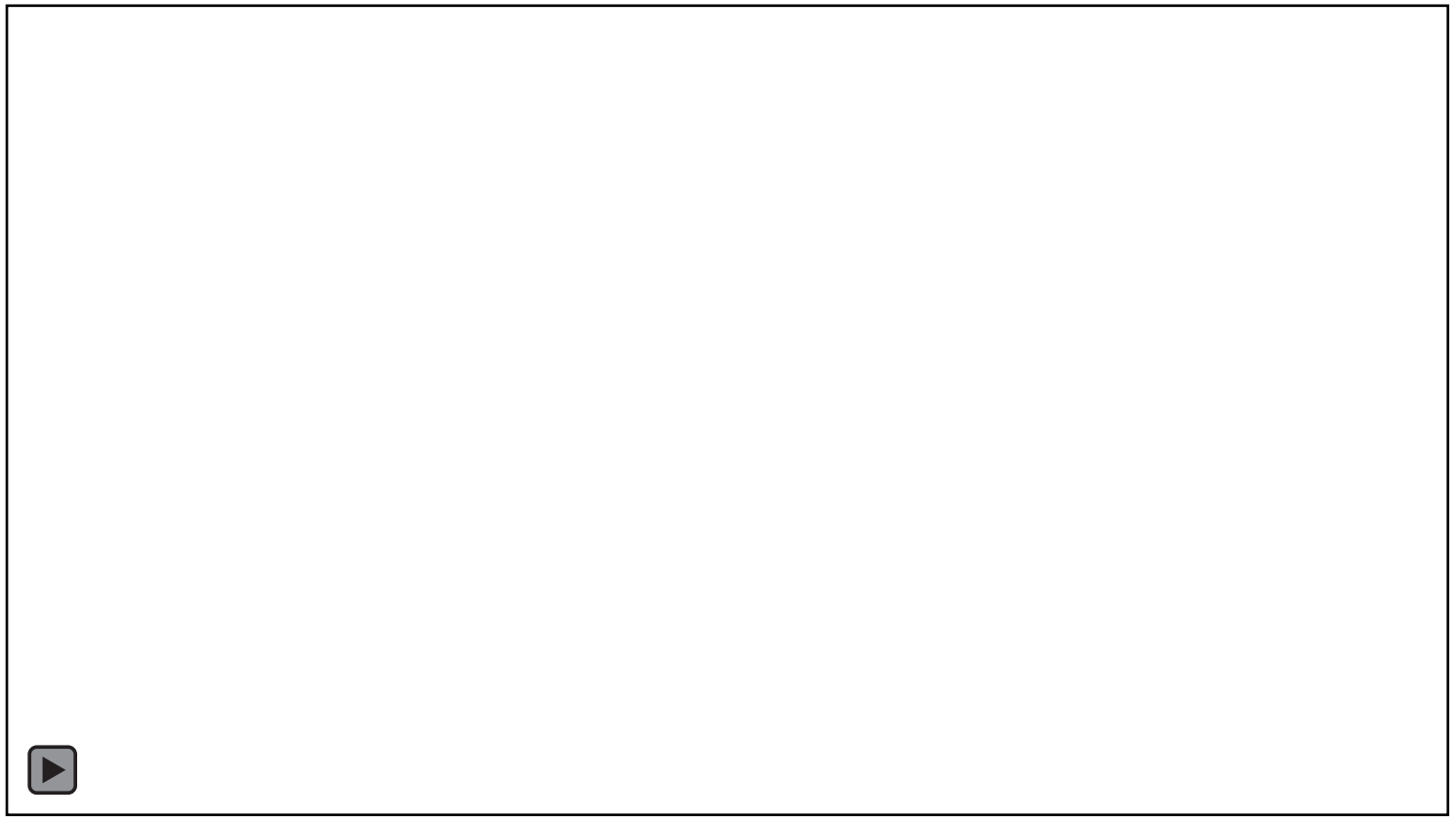


Mimicry
Motor contagion

Emotional Contagion
Affect contagion

https://www.slideshare.net/slideshow/ss-24541754/24541754
http://criandomultiples.blogspot.com/2010/11/los-bebes-no-son-soldados.html
https://slideplayer.es/slide/13746862/
https://www.humancondition.com/empathy-vs-sympathy/
https://ru.pinterest.com/pin/245094404696602987/

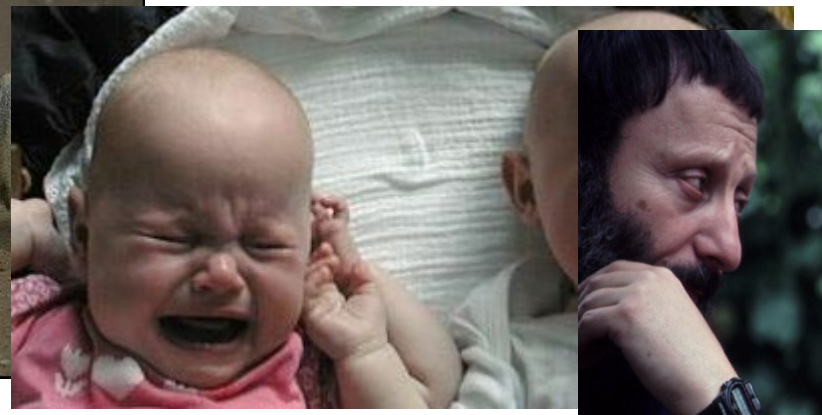
From mimicry and emotion contagion …



https://www.youtube.com/watch?v=qBay1HrK8WU

..to empathy, compassion, and (prosocial) behavior











Mimicry
Motor contagion

Emotional Contagion
Affect contagion

Empathy
Feeling **as** the other
affect sharing & self-other distinction

Compassion:
Feeling **for** another
+ concern and care

Altruism/Prosocial behavior
Costly acts of support to another
+ behavior

automatic *regulated*

hree key processes

Self-Other Distinction



Vicarious affect
Largely «bottom-up»
~automatic (perception & memory functions)

https://youtu.be/GpQVz7u0IYE?si=IkE0RLsx8BqudZTo

Perspective taking / cognitive regulation
Largely «top-down»
~regulated (executive functions)

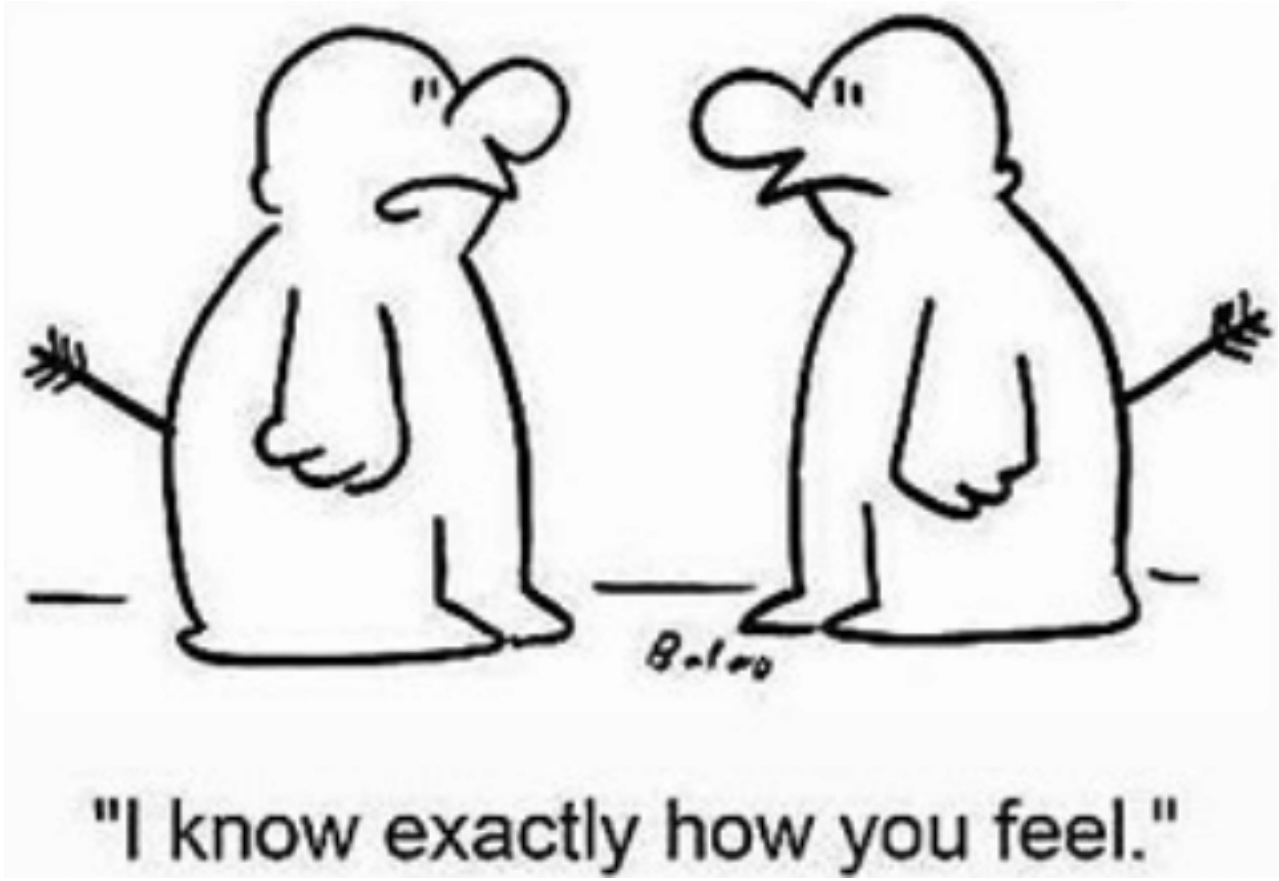
https://www.amnesty.hu/

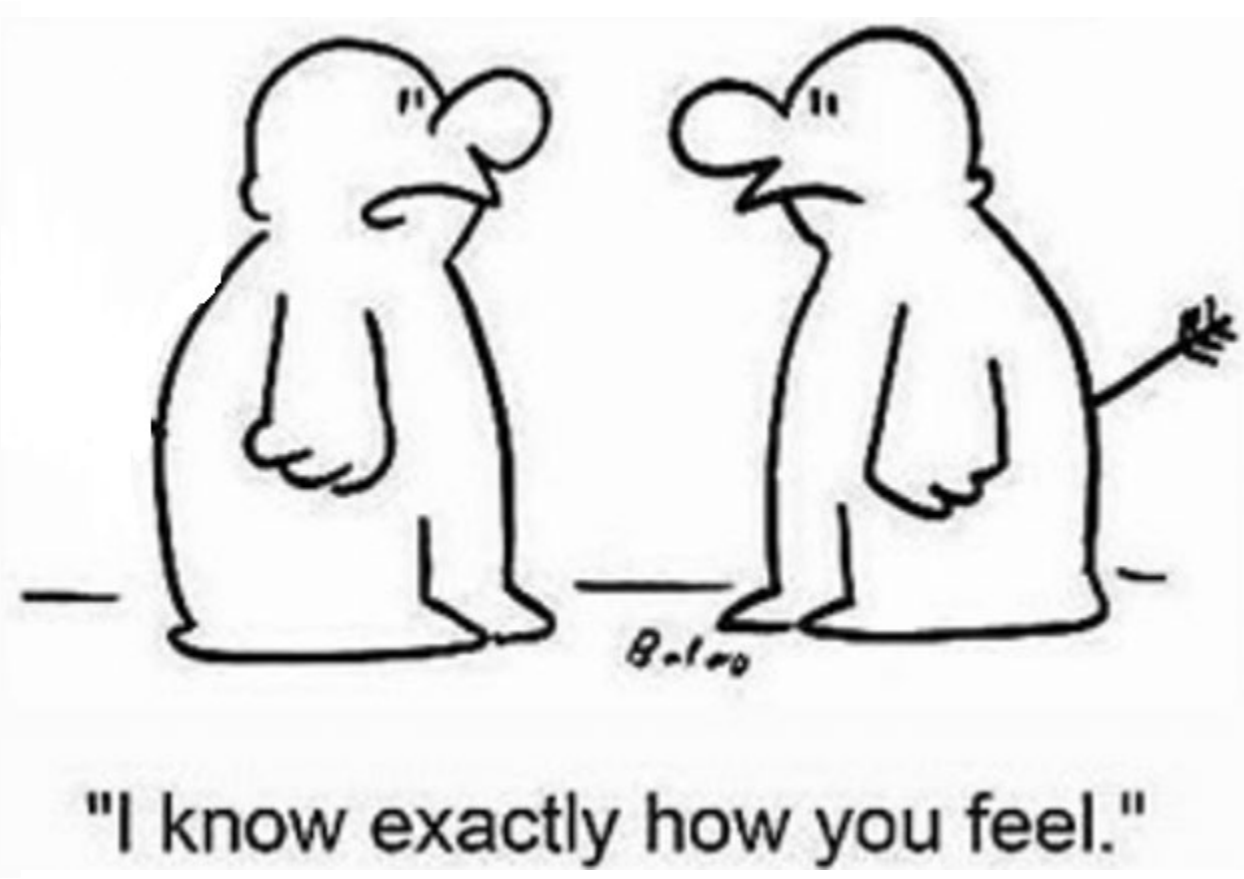
Part 2 – Empathy and affect sharing

- Empathy entails …
  - an affective state/response,
  - isomorphic to/sharing (in part) the one of the target (i.e., the person I show empathy for),
- But what do we share, and how do we share the affect of others?

Part 2 – Empathy and affect sharing

- Empathy entails …



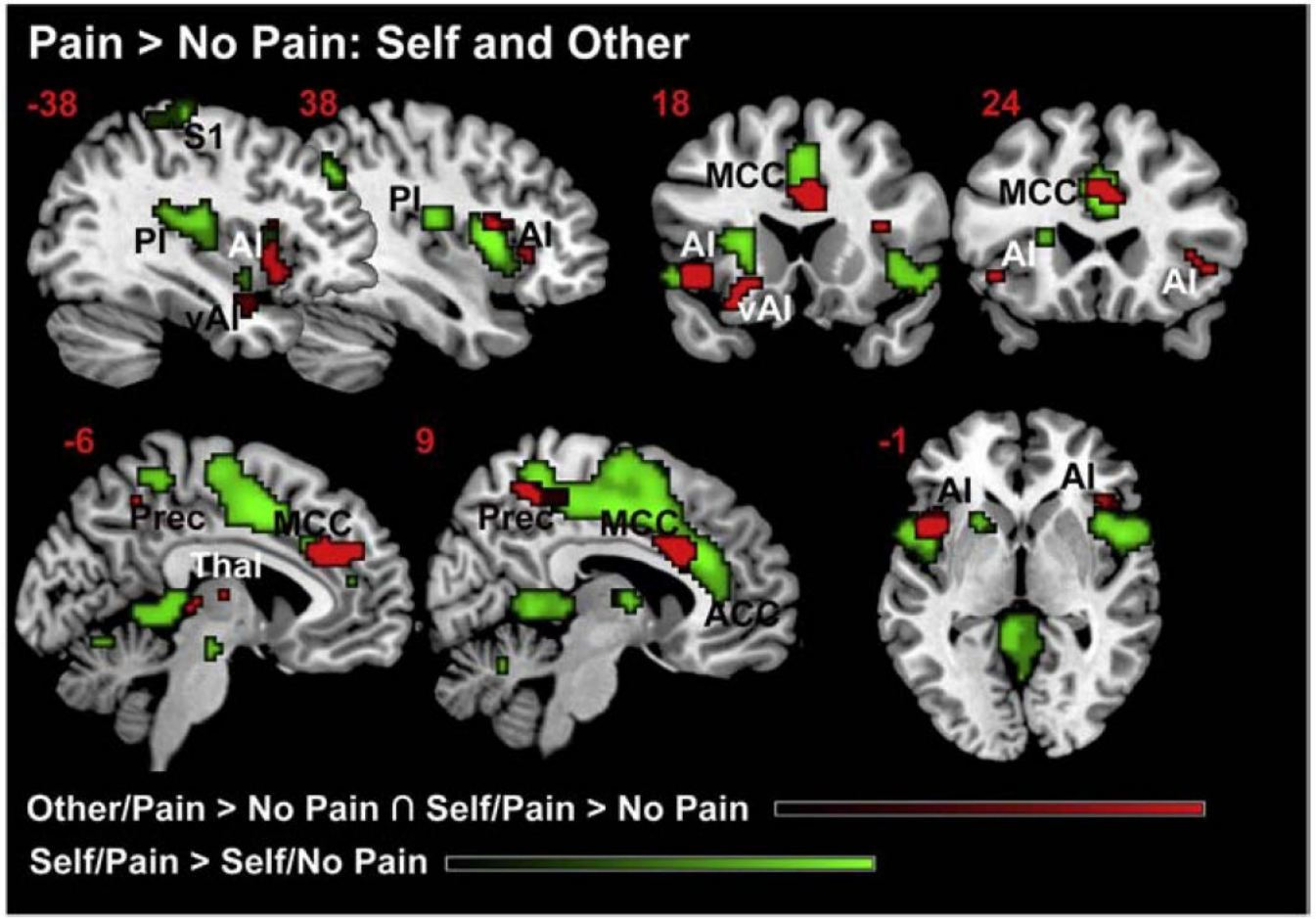


Part 2 – empathy and affect sharing

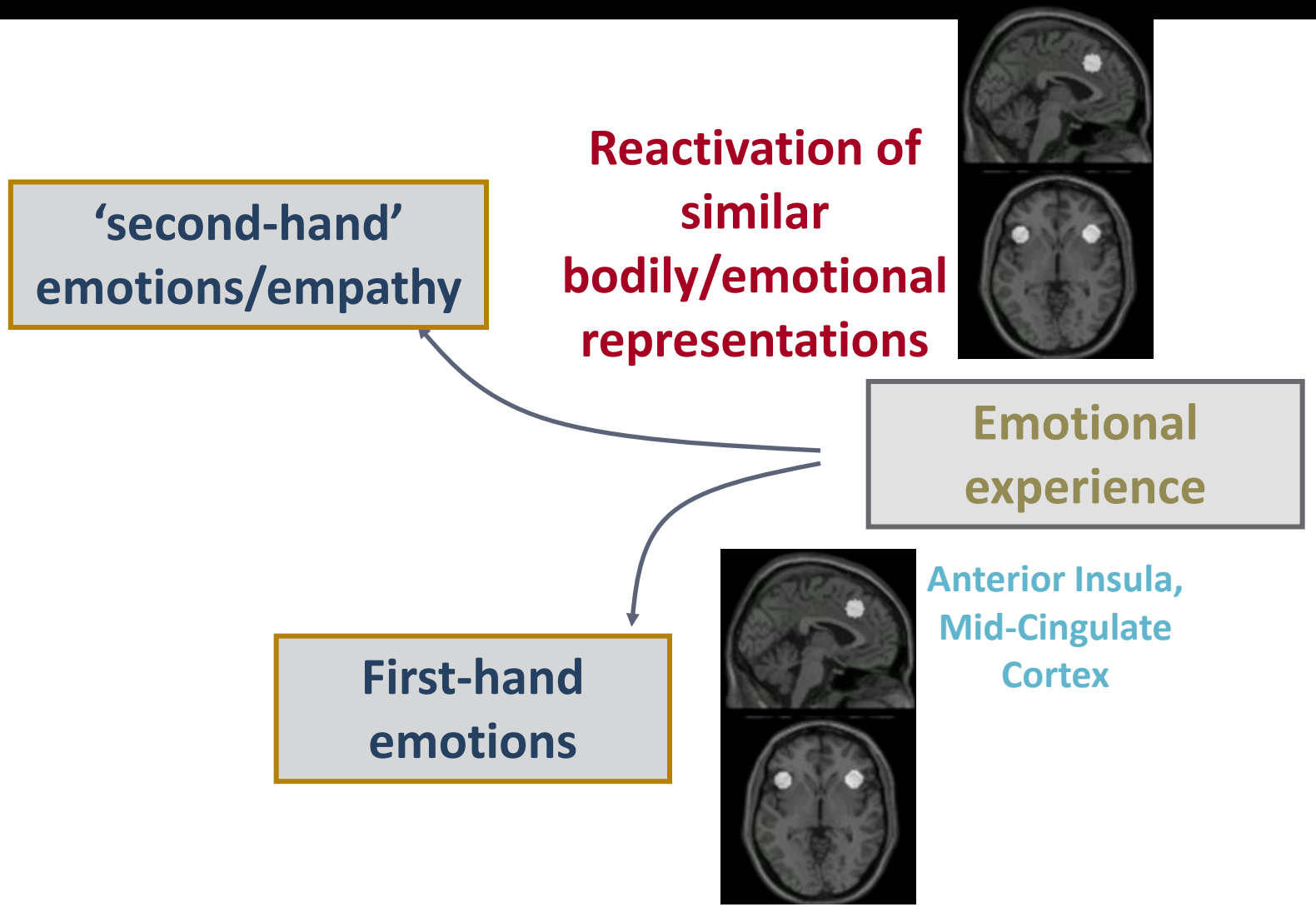
- Empathy for pain: shared activations in pain areas → shared affect?



C. Lamm et al. / NeuroImage 54 (2011) 2492–2502



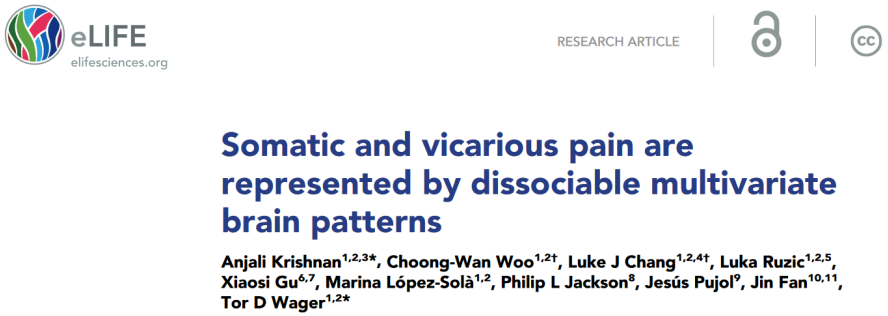
Affect sharing - shared neural representations?

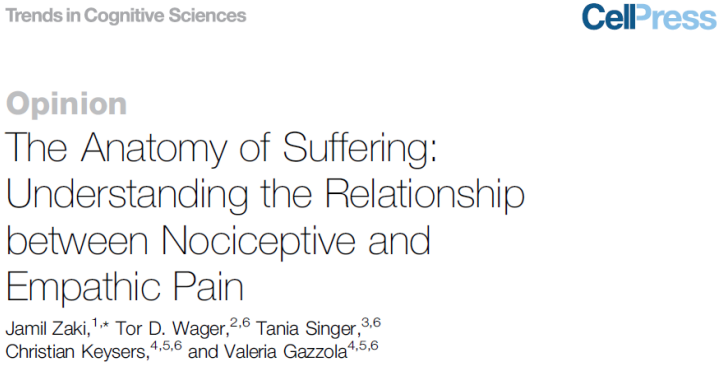


Affect sharing - shared neural representations?

However …

- Mere overlap of fMRI *activations* does not necessarily indicate engagement of equivalent *processes* or brain *functions („neural computations")*





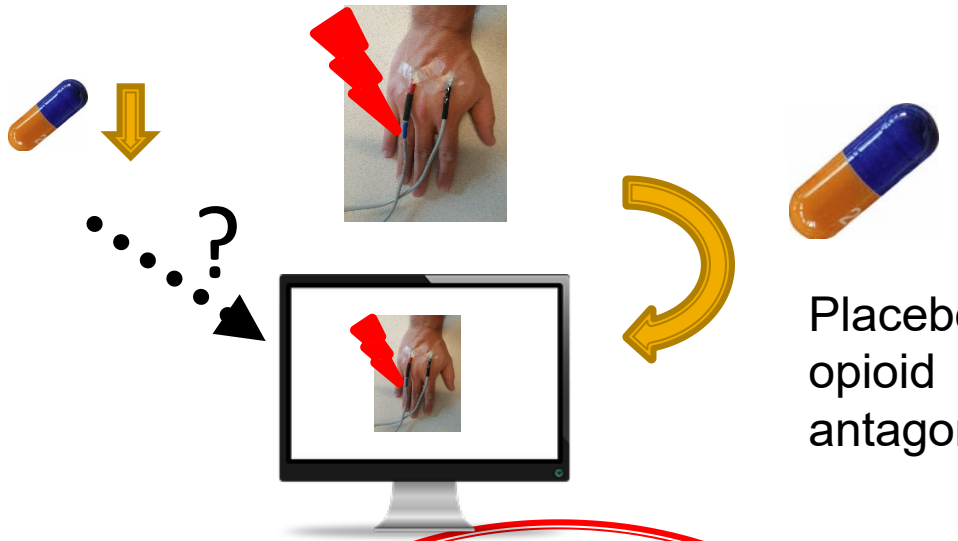
- fMRI is a neural correlate measure → no causality or „mechanistic" insights

From self to other in empathy for pain

How can we gain more mechanistic insights on the level of *functional correspondence* *between first-hand pain* and *empathy for pain*?

First-hand pain

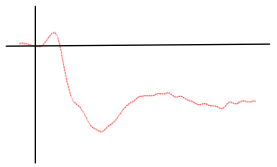
Empathy for pain



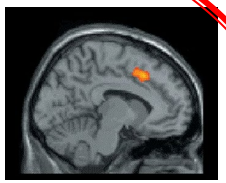
Self-report



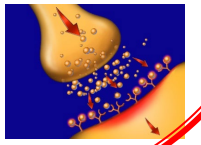
ERPs



fMRI



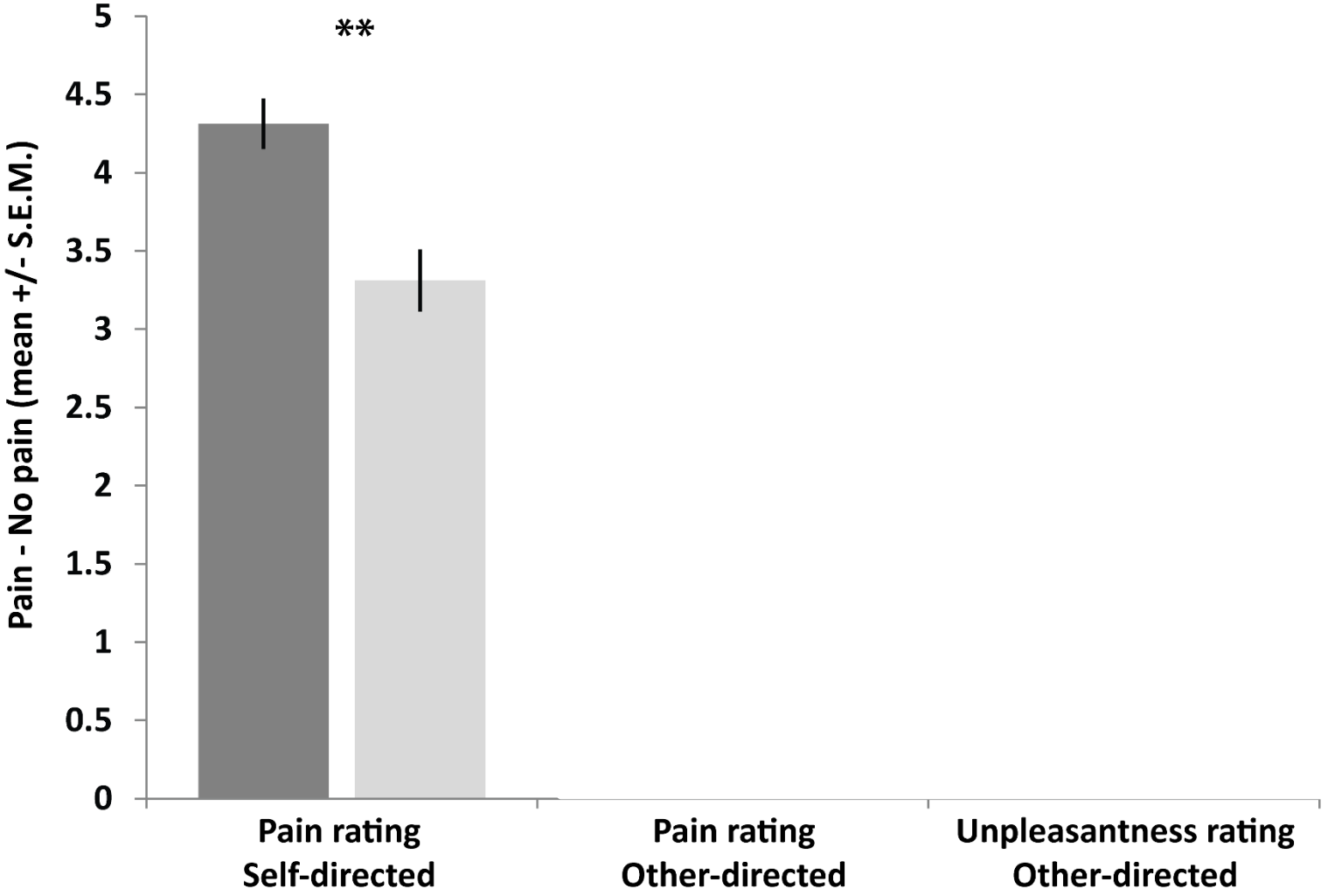
Psycho-pharmacology



Pain and pain empathy self-report

Markus Rütgen

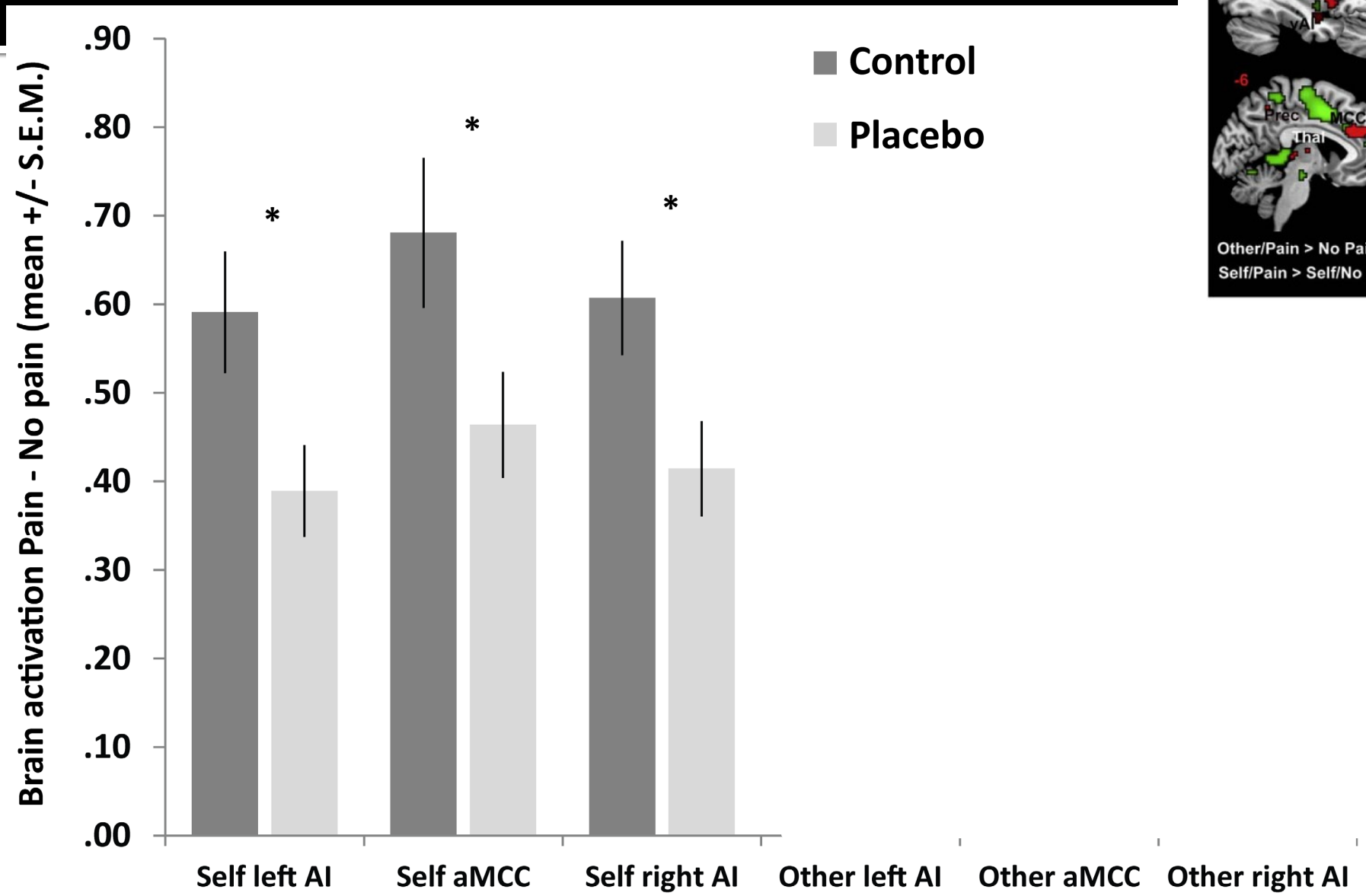


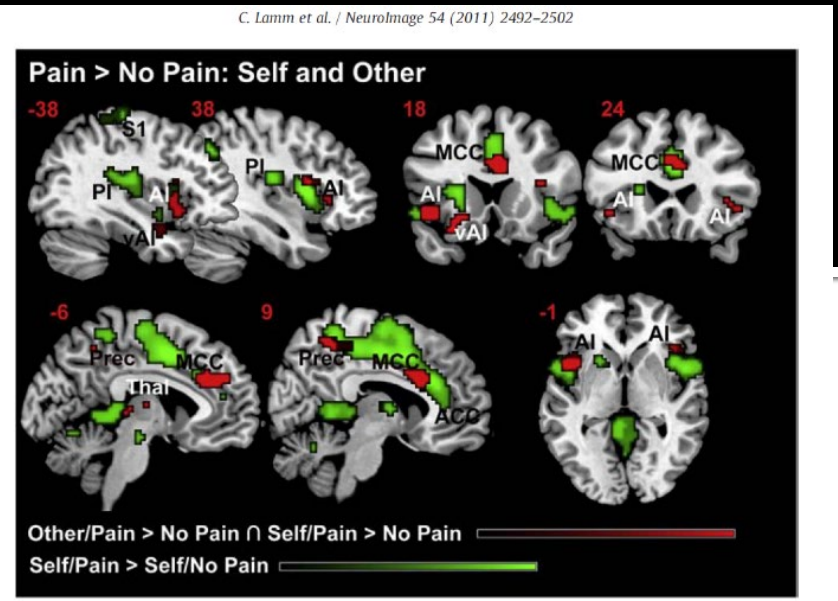


MAGNETIC RESONANCE IMAGING (MRI)

Rütgen et al., PNAS 2015
J Neurosci 2015; Cerebral Cortex 2021

Activation in aIns and aMCC





From correlates to an opiodergic mechanism?

fMRI results: lowered self pain → lowered empathy for pain

But: fMRI is a „neural correlate measure" – how can we relate effects more specifically to neurochemical processes?

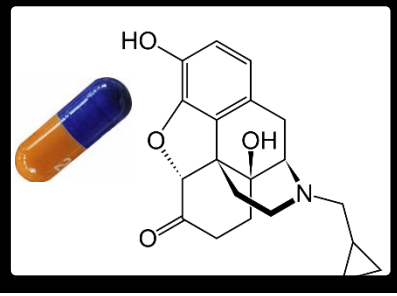


Block opioidergic transmission: opioid antagonist Naltrexone

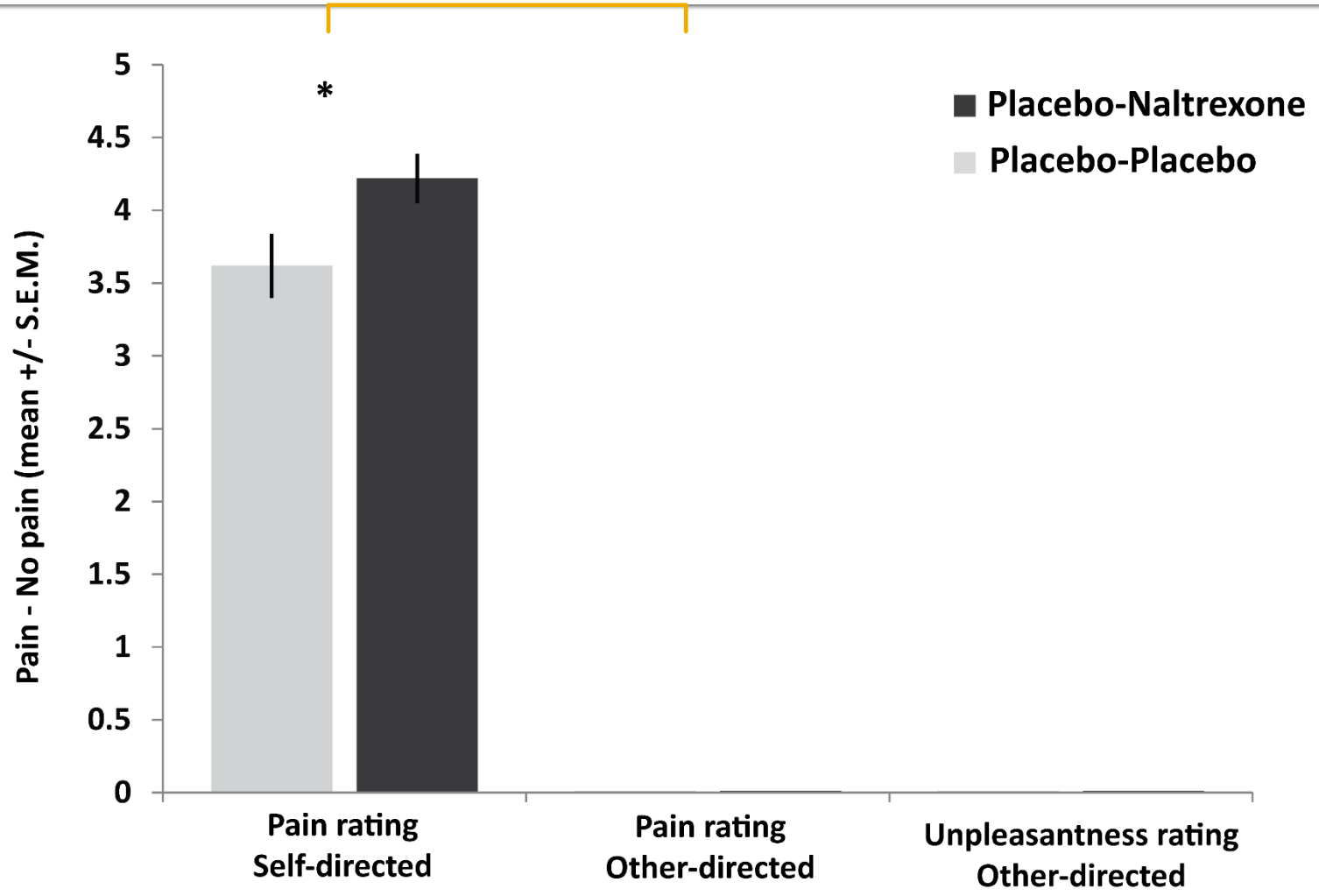
Hypothesis: if effects disappear with Naltrexone, they are related to opioidergic system

- Two groups:
  - Placebo induction – with Naltrexone (N = 25, 4 non-resp.)
  - Placebo induction – without Naltrexone (N = 25, 1 non-resp.)

Psychopharmacological study



n.s



Rütgen et al., PNAS 2015; replication: Neuropsychologia 2018

Converging evidence across methods and species

eLife RESEARCH ARTICLE

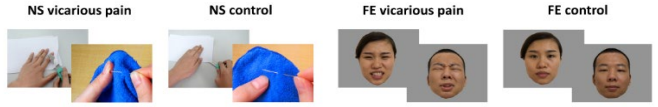
Empathic pain evoked by sensory and emotional-communicative cues share common and process-specific neural representations

Feng Zhou[1,2]*, Jialin Li[1], Weihua Zhao[1], Lei Xu[1], Xiaoxiao Zheng[1], Meina Fu[1], Shuxia Yao[1], Keith M Kendrick[1], Tor D Wager[2], Benjamin Becker[1]*

[1]Clinical Hospital of Chengdu Brain Science Institute, MOE Key Laboratory for Neuroinformation, University of Electronic Science and Technology of China, Chengdu, China; [2]Department of Psychological and Brain Sciences, Dartmouth College, Hanover, United States

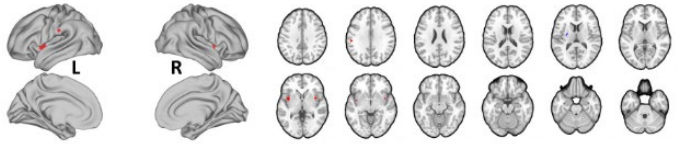
Zhou et al. eLife 2020;9:e56929. DOI: https://doi.org/10.7554/eLife.56929

A Examples of vicario

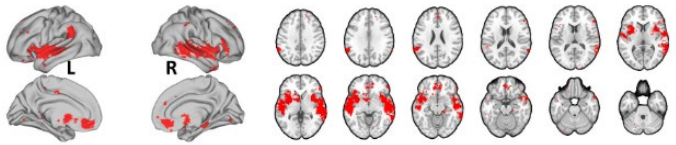


N > 200!

C Overlapping regions from whole-brain multivariate pattern analyses (FDR $q < 0.05$)



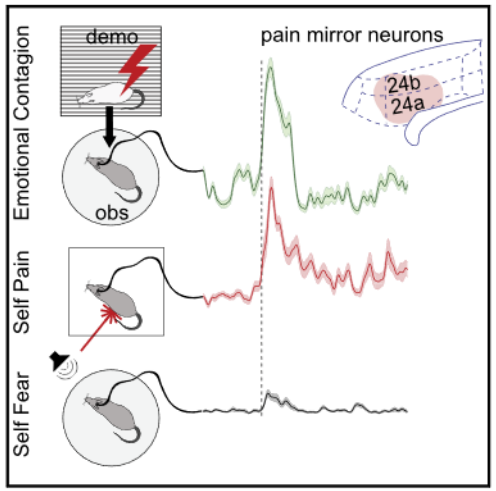
D Overlapping regions from the searchlight-based multivariate pattern analyses (FDR $q < 0.05$)



Current Biology

Emotional Mirror Neurons in the Rat's Anterior Cingulate Cortex

Graphical Abstract



Authors
Maria Carrillo, Yinging Han, Filippo Migliorati, Ming Liu, Valeria Gazzola, Christian Keysers

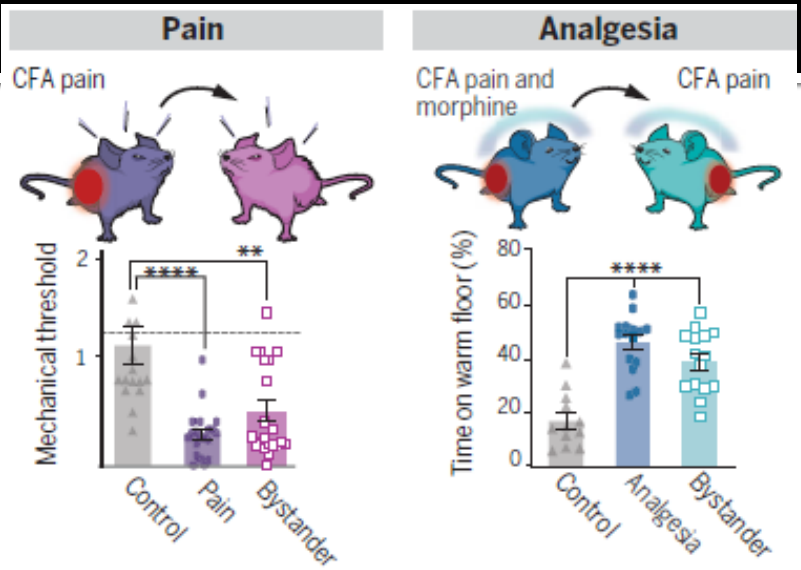
Correspondence
c.keysers@nin.knaw.nl

In Brief

Carrillo et al. show the rat anterior cingulate cortex contains emotional mirror neurons that respond when a rat experiences pain and witnesses another rat in pain but not while experiencing another salient emotion, fear. After cingulate deactivation, rats show reduced distress when witnessing another receive a shock.

Highlights

- Rat ACC contains mirror-like neurons responding to pain experience and observation
- Most do not respond to another salient negative emotion: fear
- One can decode pain intensity in the self from a pattern decoding pain in others
- Deactivating this region (area 24) impairs the social transmission of distress

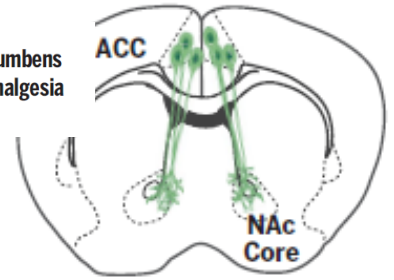


NEUROSCIENCE

Anterior cingulate inputs to nucleus accumbens control the social transfer of pain and analgesia

Monique L. Smith, Naoyuki Asada, Robert C. Malenka*

Smith et al., Science 371, eabe3040 (2021)

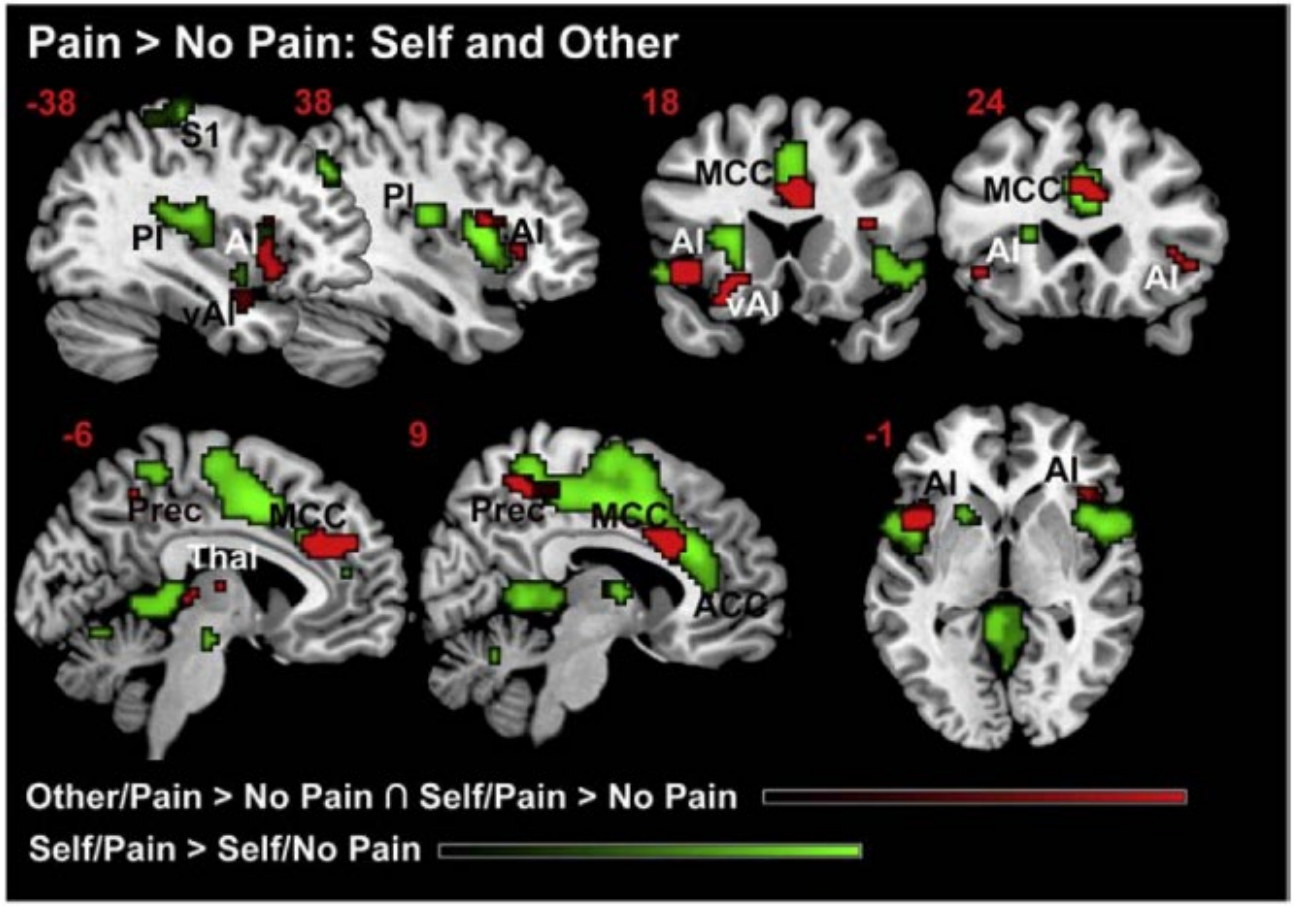


Dependent on ACC-NAc projections

talks today and tomorrow by Valeria (Gazzola), Monique (Smith), and Tor (Wager)

Part 2 - Summary

C. Lamm et al. / NeuroImage 54 (2011) 2492–2502



ıan animal studies suggest

agion) entails neural sharing of

notivational component of pain –

- Pain empathy and pain are maybe isomorphic, but certainly not identical experiences!

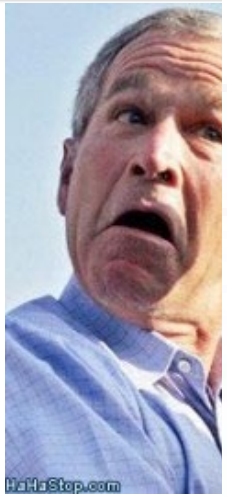
Part 3 – empathy and self-other distinction

In Social Neuroscience, we tend to define empathy like this:

- Empathy entails …
  - an affective state/response,
  - isomorphic to/sharing (in part) the one of the target (i.e., the person I show empathy for),
  - evoked by the observation or imagination of the target's affective state
  - **with (some) awareness that the target is the source of my own affective (empathetic) state.**

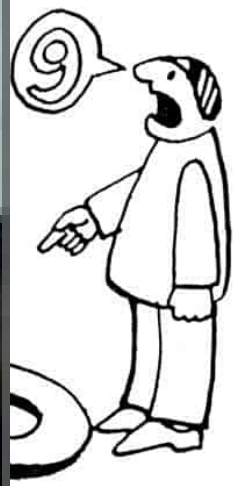
cf. Vignemont & Singer, Trends in Cognitive Sciences 2006; vgl. Singer & Lamm, Ann NY Acad Sci 2009

Wh









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https://www.shutterstc

https://begrip.be/perception/
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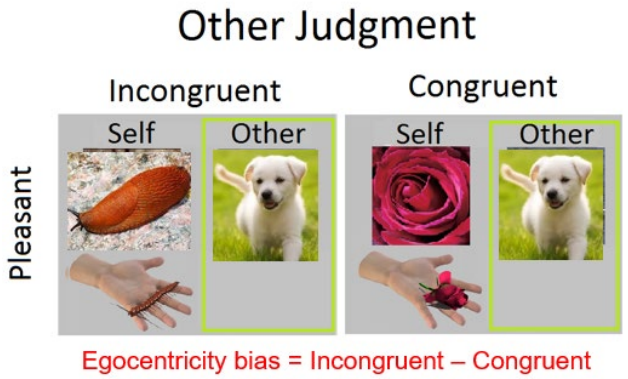
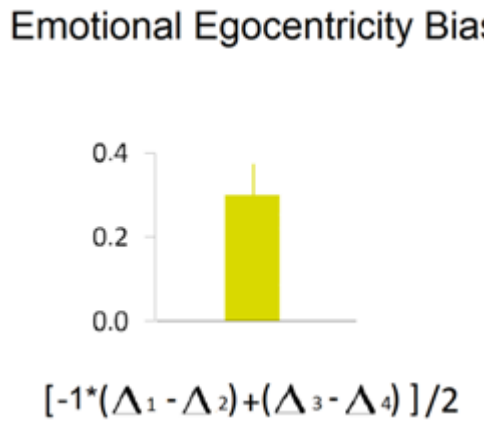
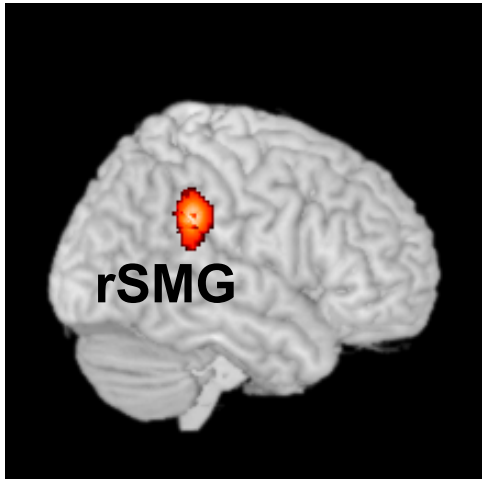
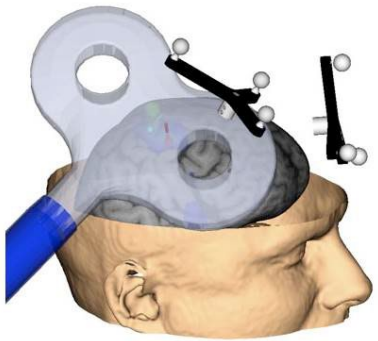
rSMG/raTPJ as a mechanism of self/other distinction

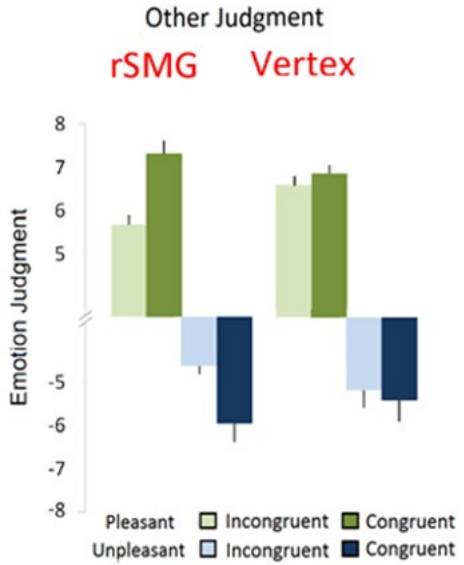












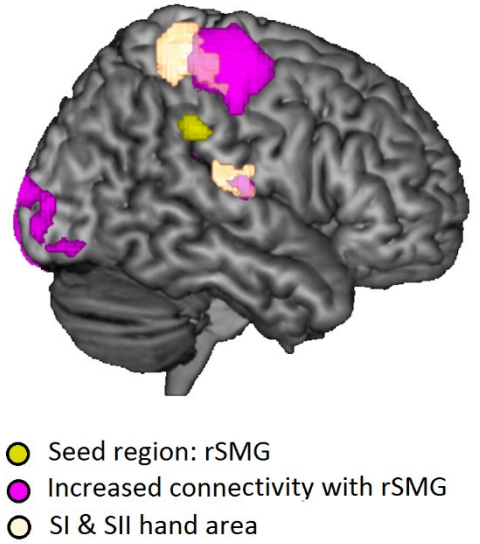
rSMG is involved in

overcoming

emotional egocentricity

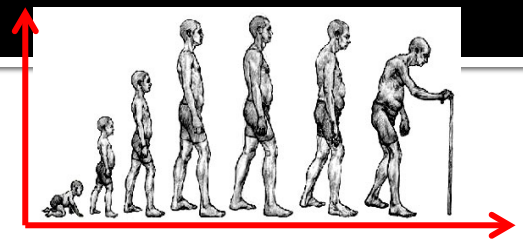
…

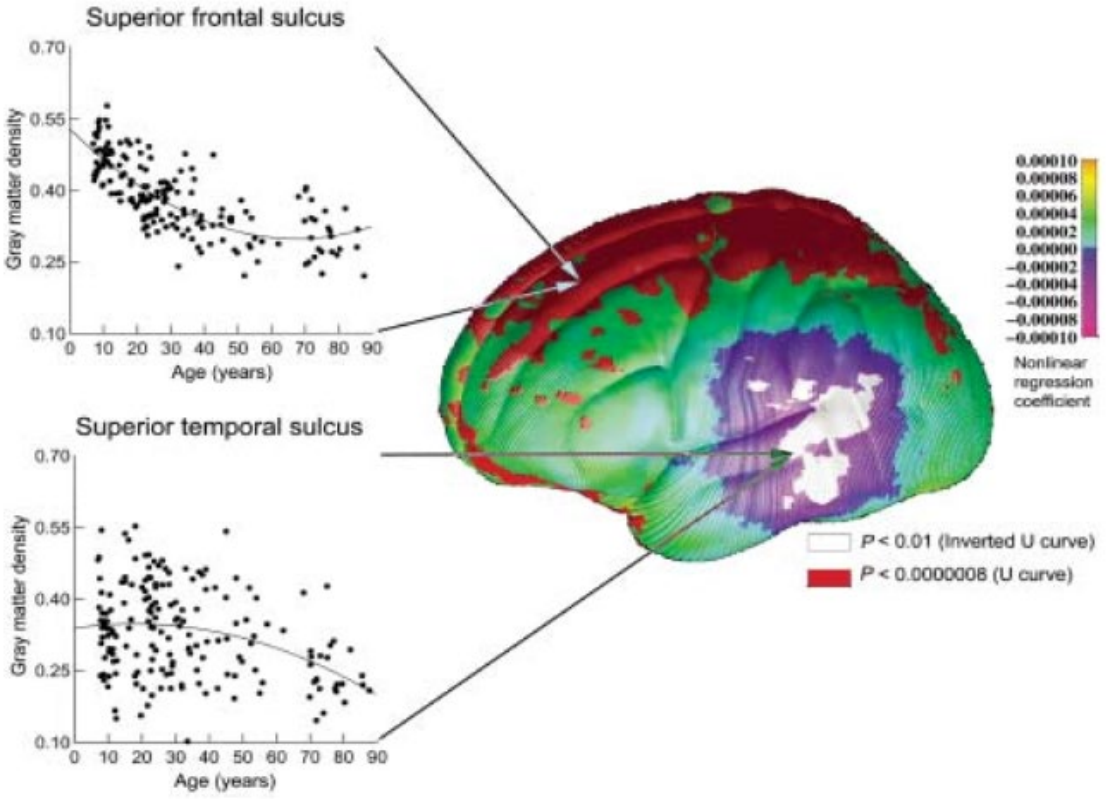
by increasing connectivity of somatosensory and visual areas)



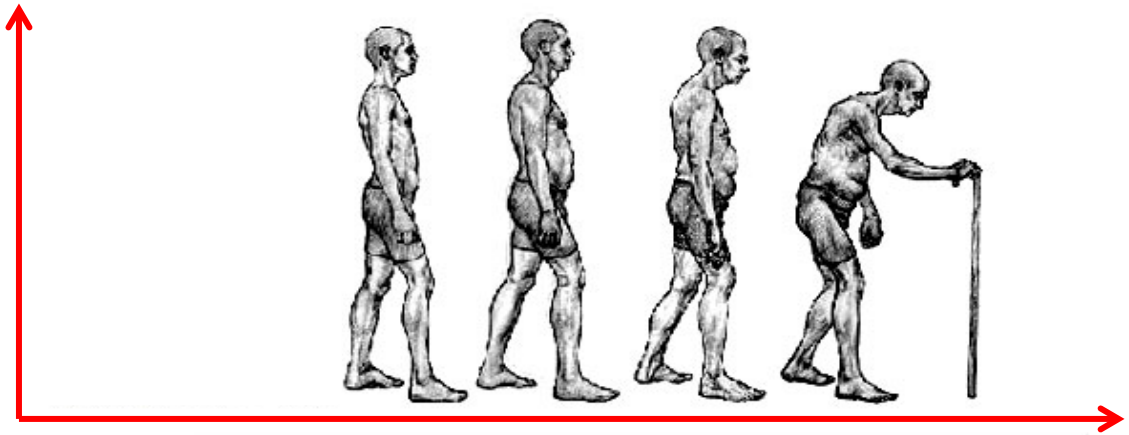
Self/other distinction across the lifespan?

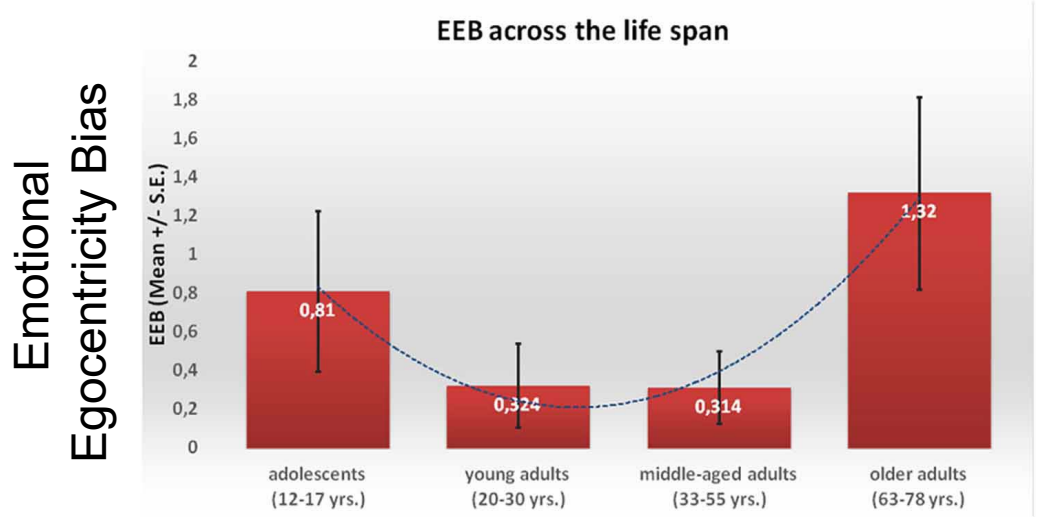






Sowell et al., J Neurosci 2003

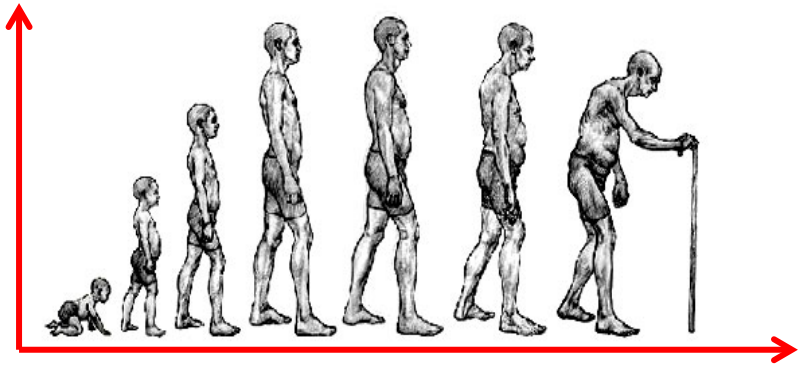




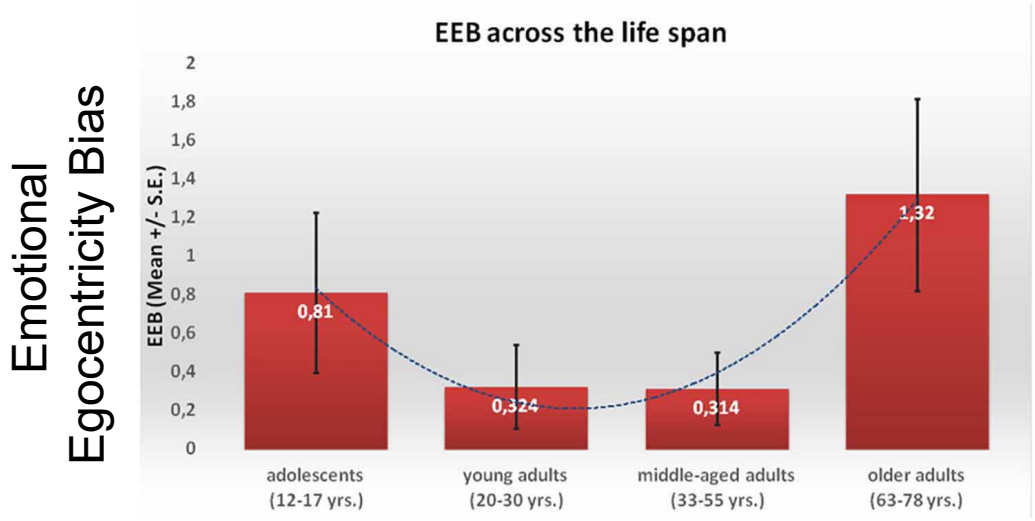
Riva et al., Front Aging Neurosci 2016;
Neurobiology of Aging 2022

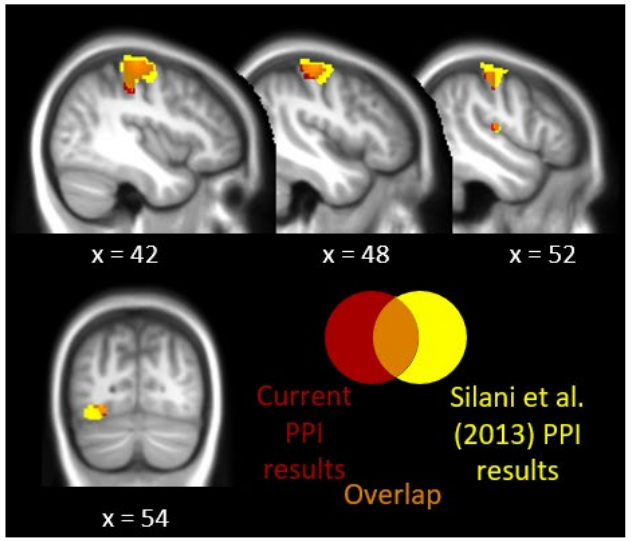
Self/other distinction across the lifespan?

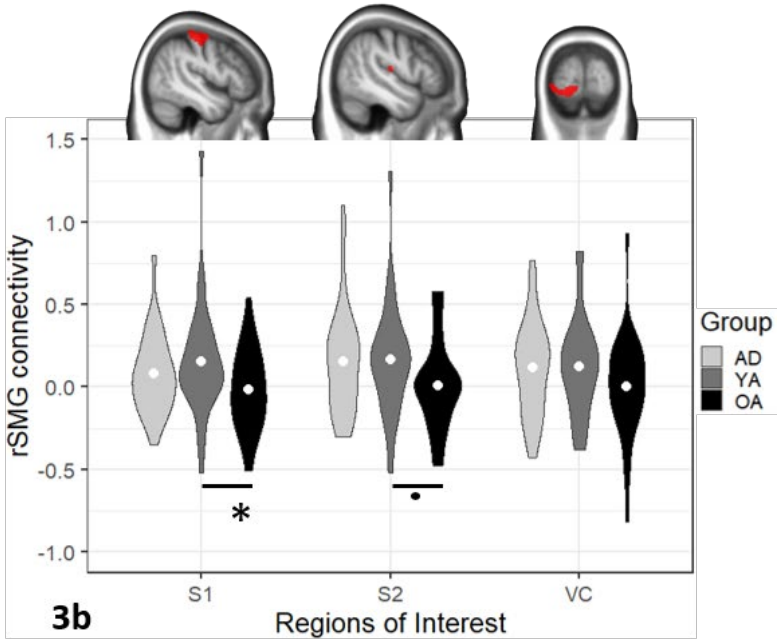




No activation differences, but differences in connectivity … between somatosensory („private“) and visual („public“) areas

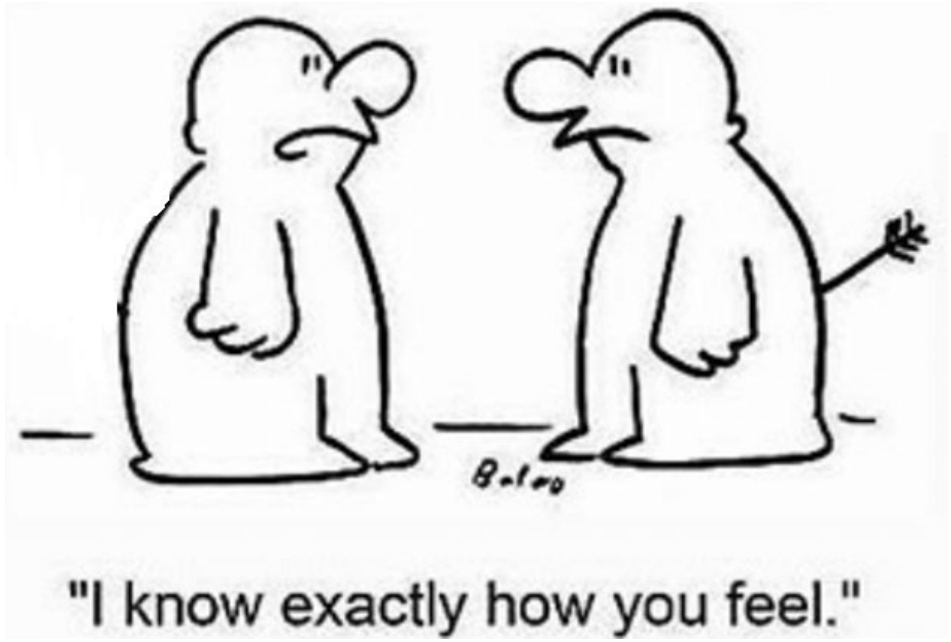






Riva et al., Front Aging Neurosci 2016;
Neurobiology of Aging 2022

Part 4: From affect sharing to prosocial behavior





Part 4: From affect sharing to prosocial behavior

Prosocial behavior:
„… Across mammalian species, animals display various forms of prosocial behaviors –comforting, helping, and resource sharing – to support others' emotions, goals, and/or material needs."

Trends in
Neurosciences

Review

Neural basis of prosocial behavior

Ye Emily Wu[1] and Weizhe Hong[1,*]

Empathy and related concepts are only one possible driver of prosocial behavior

Empathy-Altruism hypothesis (cf. Dan Batson's work)

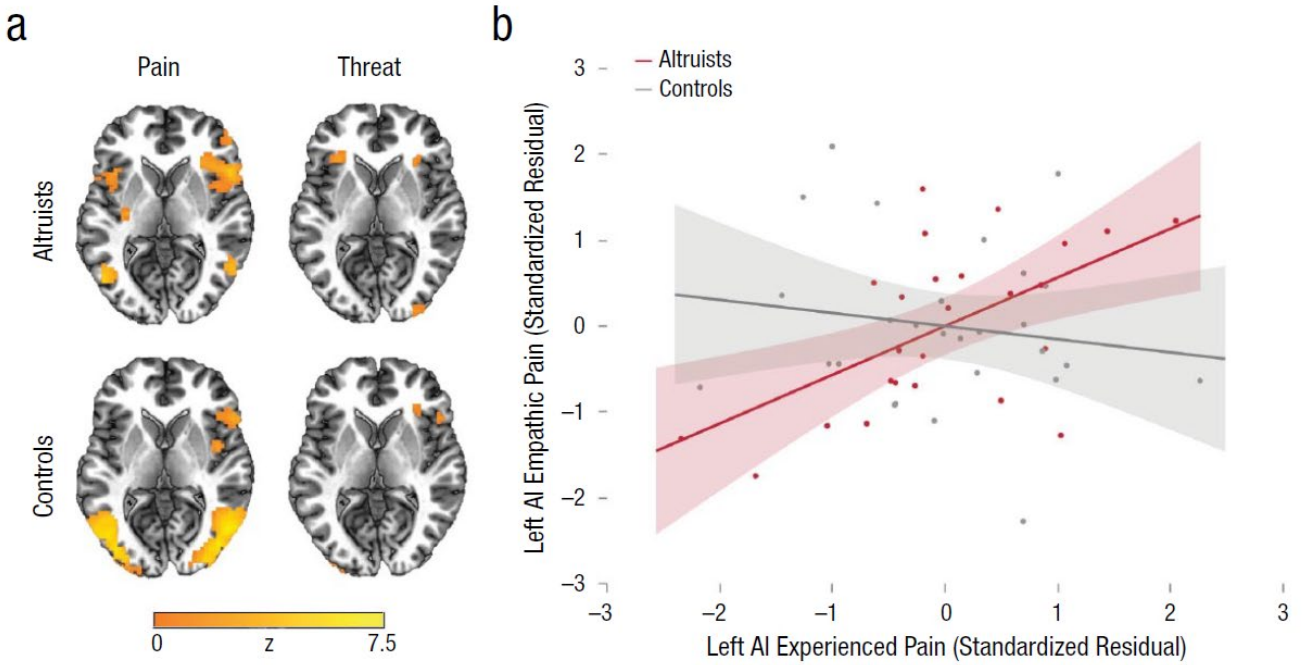


→ talk today by Weizhe Hong

Part 4: From affect sharing to prosocial behavior

Individual differences in altruism/prosocial behavior
Extraordinary altruists: donated a kidney to a stranger

Do they differ in terms of affect sharing/self-other overlap in an empathy for pain paradigm?



Research Article

aps ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Psychological Science
2018, Vol. 29(10) 1631–1641
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DOI: 10.1177/0956797618779500
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Extraordinary Altruists Exhibit Enhanced Self–Other Overlap in Neural Responses to Distress

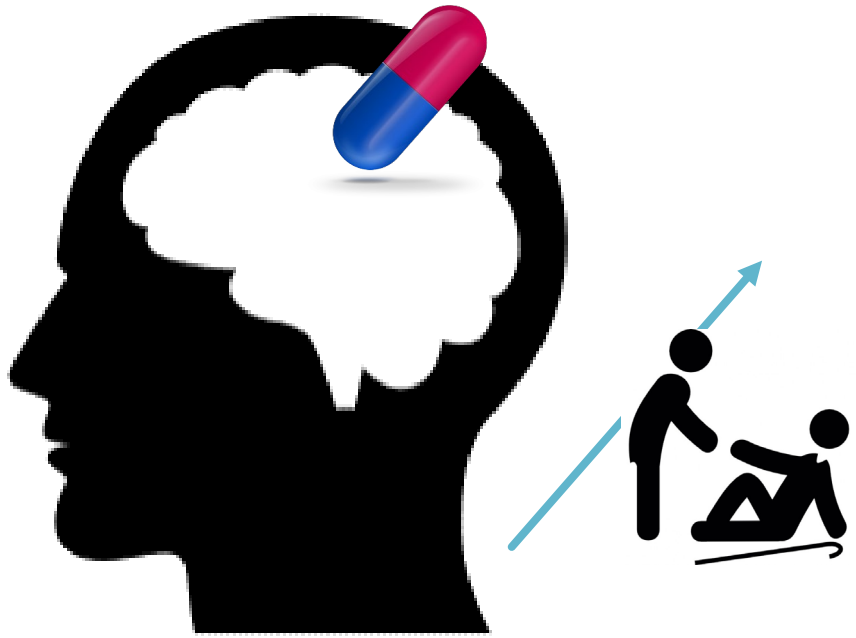
Kristin M. Brethel-Haurwitz[1], Elise M. Cardinale[2], Kruti M. Vekaria[2], Emily L. Robertson[3], Brian Walitt[4], John W. VanMeter[5], and Abigail A. Marsh[2]

[1]Department of Psychology, University of Pennsylvania; [2]Department of Psychology, Georgetown University; [3]Department of Psychology, Louisiana State University; [4]National Institute of Nursing Research, National Institutes of Health, Bethesda, Maryland; and [5]Department of Neurology, Georgetown University Medical Center

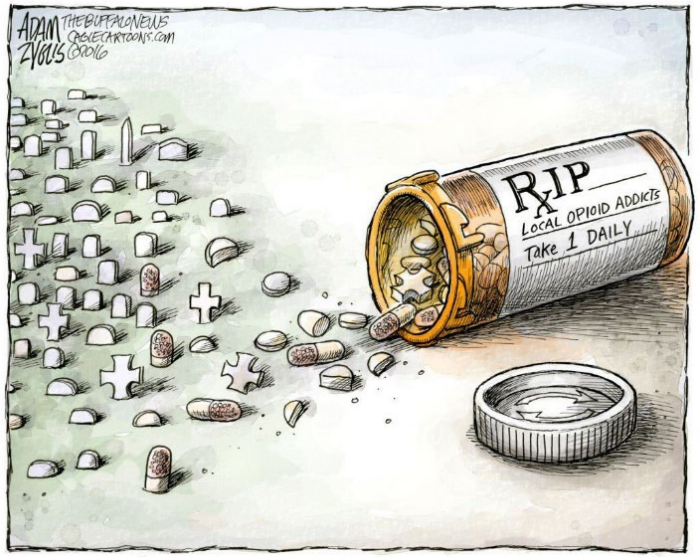
Abigail (Marsh) later today

Affect sharing and prosocial behavior

But: individual differences only allow correlative evidence/conclusions,
no causal-mechanistic insights as to the role of affect sharing



Does lowering pain sensitivity by painkillers also influence actual (pro)social behavior, and social interactions, and not ‚just' empathy?



Helena Hartmann



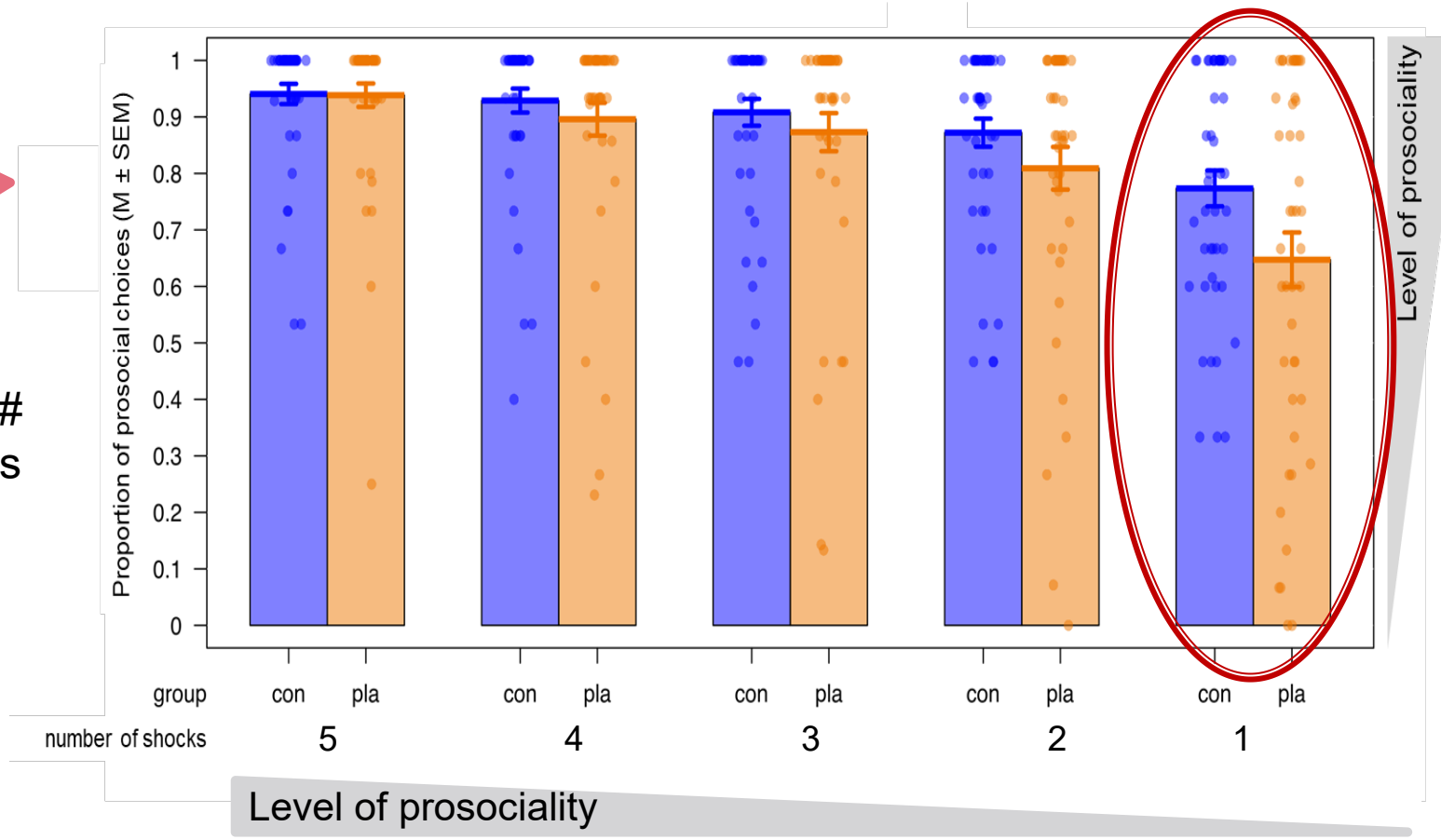
Prosocial effort is reduced by lower empathy

Prosocial Effort Task



Reduce # of shocks

Pat (Lockwood) later today



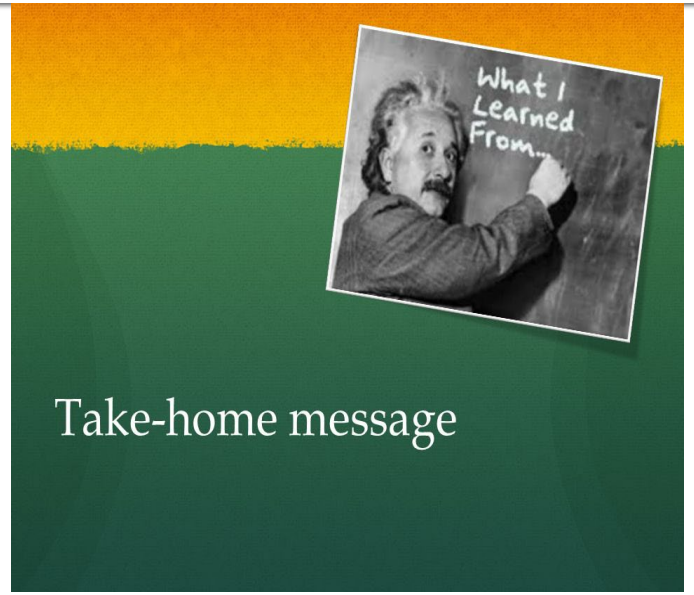
→ **Reducing empathy by (placebo) painkiller also reduces helping behavior**

Hartmann et al., Psychol Sci 2022

Wrapping things up



Wrapping things up



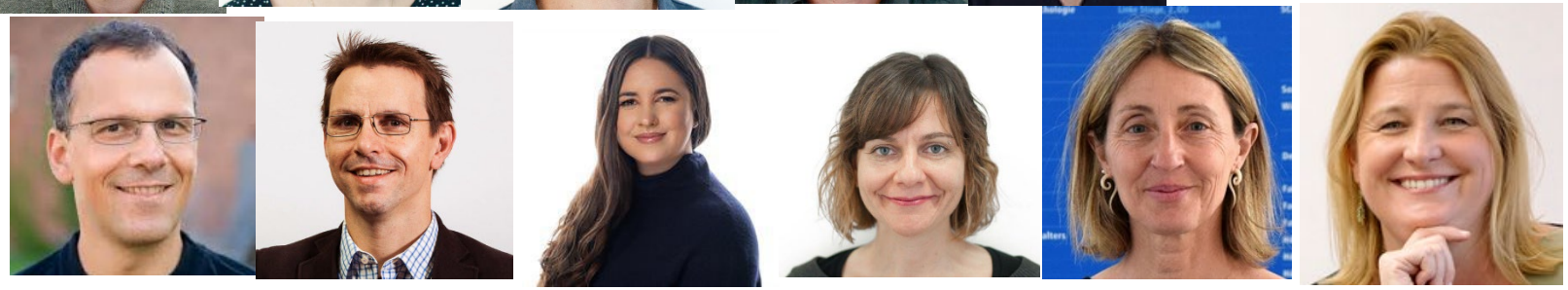
- Empathy is a complex and multi-faceted phenomenon
- ….in which multiple automatic and regulated processes are orchestrated
- Entails self-other affect sharing, but also self-other distinction
- Empathy is not synonymous to compassion or prosociality, nor morality
- A neuroscientific lens provides mechanistic insights that may help us better understand how we (mis)understand each other

https://slideplayer.com/slide/9525438/, 24.6.24

Acknowledgments







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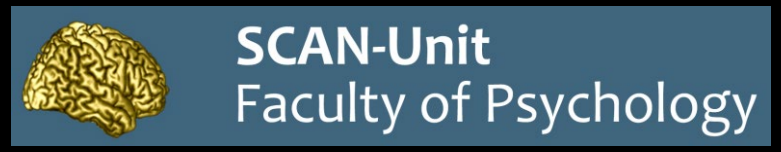
Special thanks to you, for your attention, and to the grant agencies



















Claus Lamm

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Further reading

PNAS

Placebo analgesia and its opioidergic regulation suggest that empathy for pain is grounded in self pain

Markus Rütgen[a], Eva-Maria Seidel[a], Giorgia Silani[b,c], Igor Riečanský[a,d], Allan Hummer[e,f], Christian Windischberger[e,f], Predrag Petrovic[g], and Claus Lamm[a,1]

[a]Social, Cognitive and Affective Neuroscience Unit, Department of Basic Psychological Research and Research Methods, Faculty of Psychology, University of Vienna, Vienna 1010, Austria; [b]Cognitive Neuroscience Sector, International School for Advanced Studies, Trieste 34136, Italy; [c]Department of Applied Psychology: Health, Development, Enhancement and Intervention, Faculty of Psychology, University of Vienna, Vienna 1010, Austria; [d]Laboratory of Cognitive Neuroscience, Institute of Normal and Pathological Physiology, Centre of Excellence for Examination of Regulatory Role of Nitric Oxide in Civilization diseases, Slovak Academy of Sciences, Bratislava 813 71, Slovakia; [e]Medical Research (MR) Center of Excellence, Medical University of Vienna, Vienna 1090, Austria; [f]Center for Medical Physics and Biomedical Engineering, Medical University of Vienna, Vienna 1090, Austria; and [g]Cognitive Neurophysiology Research Group, Department of Clinical Neuroscience, Karolinska Institute, Stockholm 171 76, Sweden

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Dissecting shared pain representations to understand their behavioral and clinical relevance

Markus Rütgen [a,*], Claus Lamm [b,c,**]

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Psychological Science
2018, Vol. 29(10) 1631–1641
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DOI: 10.1177/0956797618779590
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Extraordinary Altruists Exhibit Enhanced Self–Other Overlap in Neural Responses to Distress

Kristin M. Brethel-Haurwitz[1], Elise M. Cardinale[2], Kruti M. Vekaria[2], Emily L. Robertson[3], Brian Walitt[4], John W. VanMeter[5], and Abigail A. Marsh[2]

[1]Department of Psychology, University of Pennsylvania; [2]Department of Psychology, Georgetown University; [3]Department of Psychology, Louisiana State University; [4]National Institute of Nursing Research, National Institutes of Health, Bethesda, Maryland; and [5]Department of Neurology, Georgetown University Medical Center

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https://doi.org/10.1177/09567976221119727

SAGE journals

Trends in Cognitive Sciences

CellPress

Opinion

The Anatomy of Suffering: Understanding the Relationship between Nociceptive and Empathic Pain

Jamil Zaki,[1,*] Tor D. Wager,[2,6] Tania Singer,[3,6] Christian Keysers,[4,5,6] and Valeria Gazzola[4,5,6]

Empathic pain evoked by sensory and emotional-communicative cues share common and process-specific neural representations

Feng Zhou[1,2*], Jialin Li[1], Weihua Zhao[1], Lei Xu[1], Xiaoxiao Zheng[1], Meina Fu[1], Shuxia Yao[1], Keith M Kendrick[1], Tor D Wager[2], Benjamin Becker[1*]

[1]Clinical Hospital of Chengdu Brain Science Institute, MOE Key Laboratory for Neuroinformation, University of Electronic Science and Technology of China, Chengdu, China; [2]Department of Psychological and Brain Sciences, Dartmouth College, Hanover, United States

Zhou et al. eLife 2020;9:e56929. DOI: https://doi.org/10.7554/eLife.56929

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Opinion piece

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Cite this article: Lamm C, Bukowski H, Silani G. 2016 From shared to distinct self–other representations in empathy: evidence from neurotypical function and socio-cognitive disorders. *Phil. Trans. R. Soc. B* **371**: 20150083. http://dx.doi.org/10.1098/rstb.2015.0083

From shared to distinct self–other representations in empathy: evidence from neurotypical function and socio-cognitive disorders

C. Lamm[1], H. Bukowski[1] and G. Silani[2]

[1]Social, Cognitive and Affective Neuroscience Unit, Department of Basic Psychological Research and Research Methods, and [2]Department of Applied Psychology: Health, Development, Enhancement and Intervention, University of Vienna, Vienna, Austria

CL, 0000-0002-5422-0653; HB, 0000-0001-9412-1855; GS, 0000-0002-4284-3618

Neuroscientific research has identified two fundamental components of empathy: shared emotional representations between self and other, and self–other distinction. The concept of shared representations suggests that during empa-

Current Biology

Article

Emotional Mirror Neurons in the Rat's Anterior Cingulate Cortex

Maria Carrillo,[1,3] Yinging Han,[1,3] Filippo Migliorati,[1,4] Ming Liu,[1,5] Valeria Gazzola,[1,2] and Christian Keysers[1,2,6,*]

[1]Social Brain Lab, Netherlands Institute for Neuroscience, Royal Netherlands Academy of Arts and Sciences, Meibergdreef 47, 1105 BA Amsterdam, the Netherlands
[2]Department of Psychology, University of Amsterdam, Nieuwe Achtergracht 166, 1018 WV Amsterdam, the Netherlands
[3]These authors contributed equally
[4]Deceased
[5]Present address: Cognitive Psychology Unit, Institute of Psychology, Leiden University, Wassenaarseweg 52, 2333 AK Leiden, the Netherlands
[6]Lead Contact
*Correspondence: c.keysers@nin.knaw.nl
https://doi.org/10.1016/j.cub.2019.03.024

General Article - Research Article

Placebo Analgesia Reduces Costly Prosocial Helping to Lower Another Person's Pain

Helena Hartmann [1,2], Paul A. G. Forbes [1], Markus Rütgen [1], and Claus Lamm [1]

Trends in Neurosciences

Review

Neural basis of prosocial behavior

Ye Emily Wu[1] and Weizhe Hong [1,*]

Further reading

- Rütgen, M., Wirth, E. M., Riecansky, I., Hummer, A., Windischberger, C., Petrovic, P., Silani, G., & Lamm, C. (2020). Beyond sharing unpleasant affect – evidence for pain-specific opioidergic modulation of empathy for pain. *bioRxiv*. https://doi.org/10.1101/2020.06.10.143495
- Lengersdorff, L. L., Wagner, I. C., Lockwood, P. L., & Lamm, C. (2020). When Implicit Prosociality Trumps Selfishness: The Neural Valuation System Underpins More Optimal Choices When Learning to Avoid Harm to Others Than to Oneself. *The Journal of Neuroscience*, *40*(38), 7286–7299. https://doi.org/10.1523/JNEUROSCI.0842-20.2020

- Rütgen, M., Seidel, E. M., Pletti, C., Riecansky, I., Gartus, A., Eisenegger, C., & Lamm, C. (2017). Psychopharmacological modulation of event-related potentials suggests that first-hand pain and empathy for pain rely on similar opioidergic processes. *Neuropsychologia*, *116*, 5-14. http://doi.org/10.1016/j.neuropsychologia.2017.04.023
- Rütgen, M., Seidel, E. A., Silani, G., Riecansky, G., Hummer, A., Windischberger, C., Petrovic, P., & Lamm, C. (2015). Placebo analgesia and its opioidergic regulation suggest that empathy for pain is grounded in self pain. *Proceedings of the National Academy of Sciences*, *112*(41), E5638–E5646. https://doi.org/10.1073/pnas.1511269112
- Rütgen, M., Seidel, E.M., Riecansky, I., & Lamm, C. (2015). Reduction of empathy for pain by placebo analgesia suggests functional equivalence of empathy and first-hand emotion experience. *Journal of Neuroscience*, *35*(23), 8938–8947. https://doi.org/10.1523/JNEUROSCI.3936-14.2015

7286 • The Journal of Neuroscience, September 16, 2020 • 40(38):7286–7299

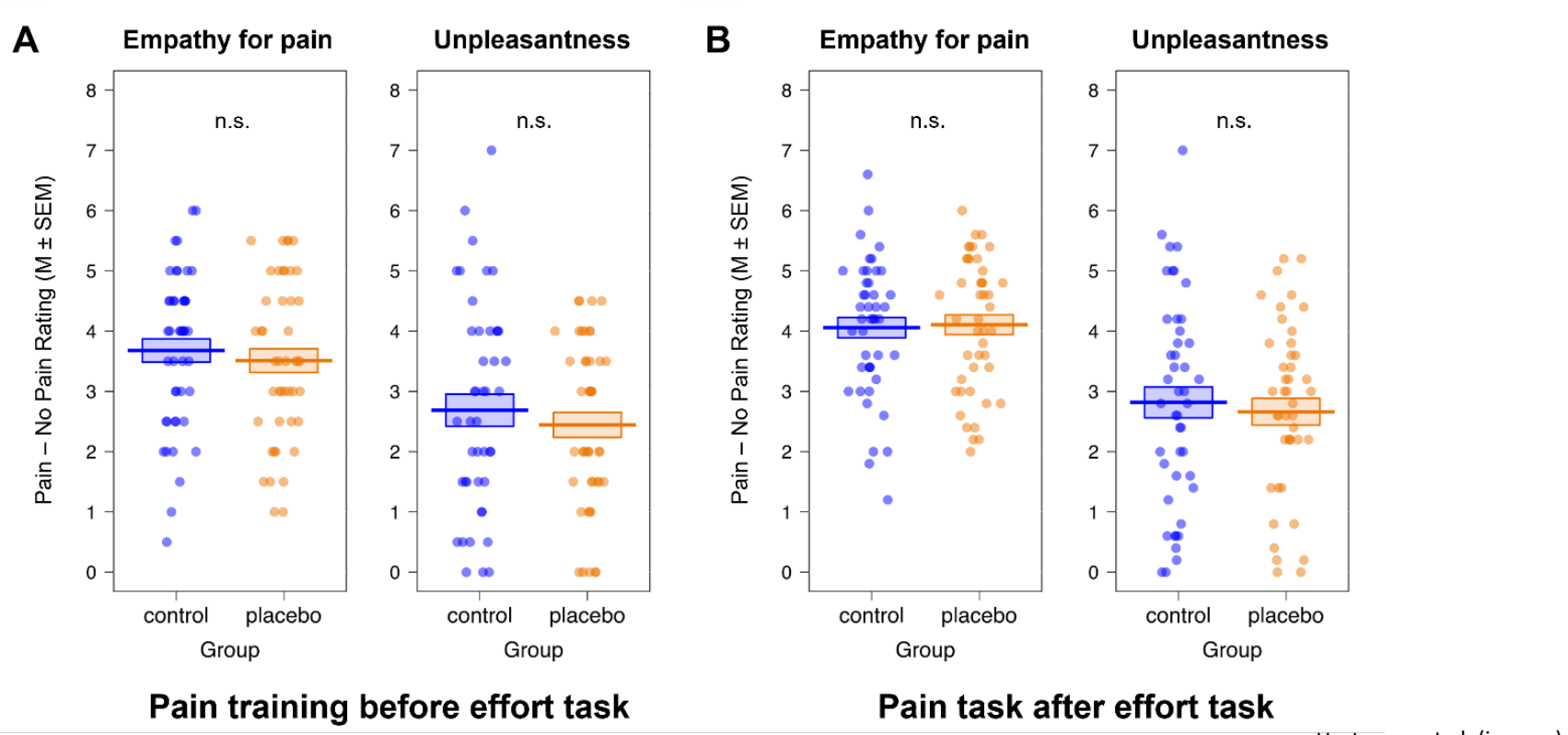
Behavioral/Cognitive

When Implicit Prosociality Trumps Selfishness: The Neural Valuation System Underpins More Optimal Choices When Learning to Avoid Harm to Others Than to Oneself

Lukas L. Lengersdorff,[1] Isabella C. Wagner,[1] Patricia L. Lockwood,[2,3] and Claus Lamm[1]

Results

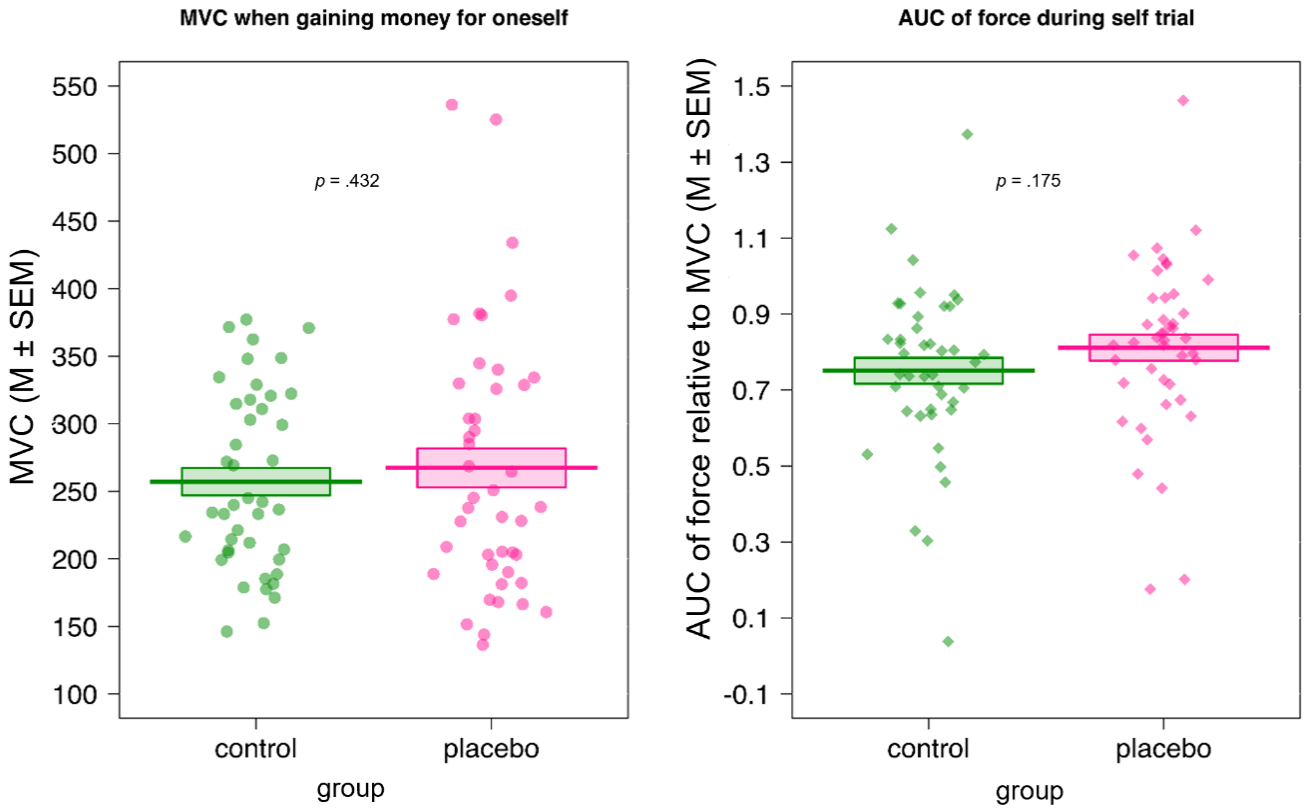
- No replication of previous transfer of placebo analgesia to empathy behavior …



Hartmann et al. (in prep)

Results

- No effects of placebo analgesia on self-related motivation in a one-shot task



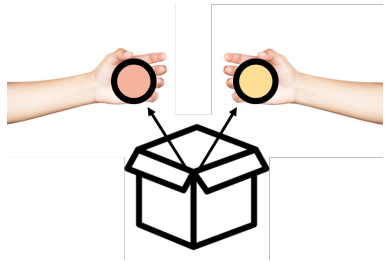
MVC = maximum voluntary contraction; AUC = area under the curve; Hartmann et al. (in prep)

Session overview

Placebo Analgesia Manipulation



Participant & same-sex confederate (arrive separately)

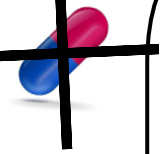


Anonymous role assignment: Decider and Receiver of pain

Group 1
Placebo induction + conditioning procedure („analgetic“ pill)



Group 2
Control (no pill + waiting time)



Prosocial Effort Task



First-hand and Empathy for Pain Task



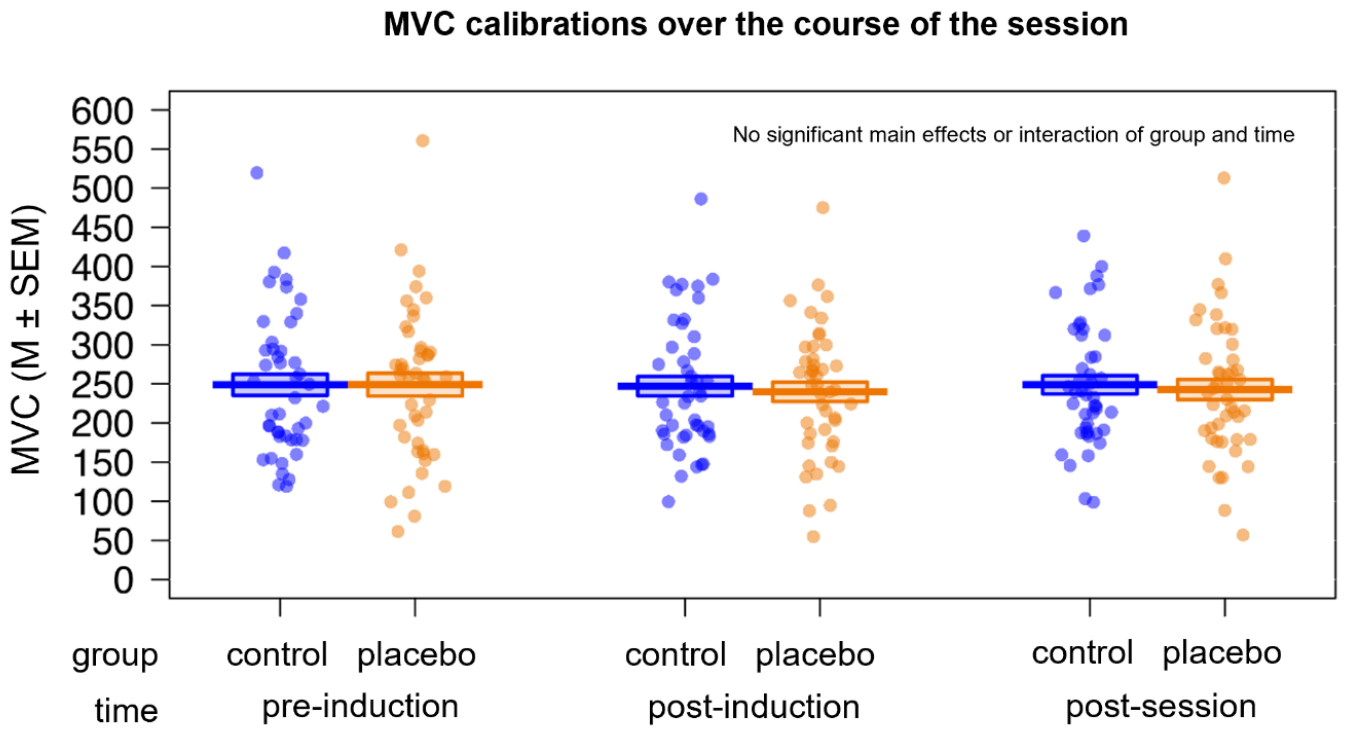
90 right-handed subjects (45 per group, balanced gender ratio)

Time

Hartmann et al. (in prep)

Results

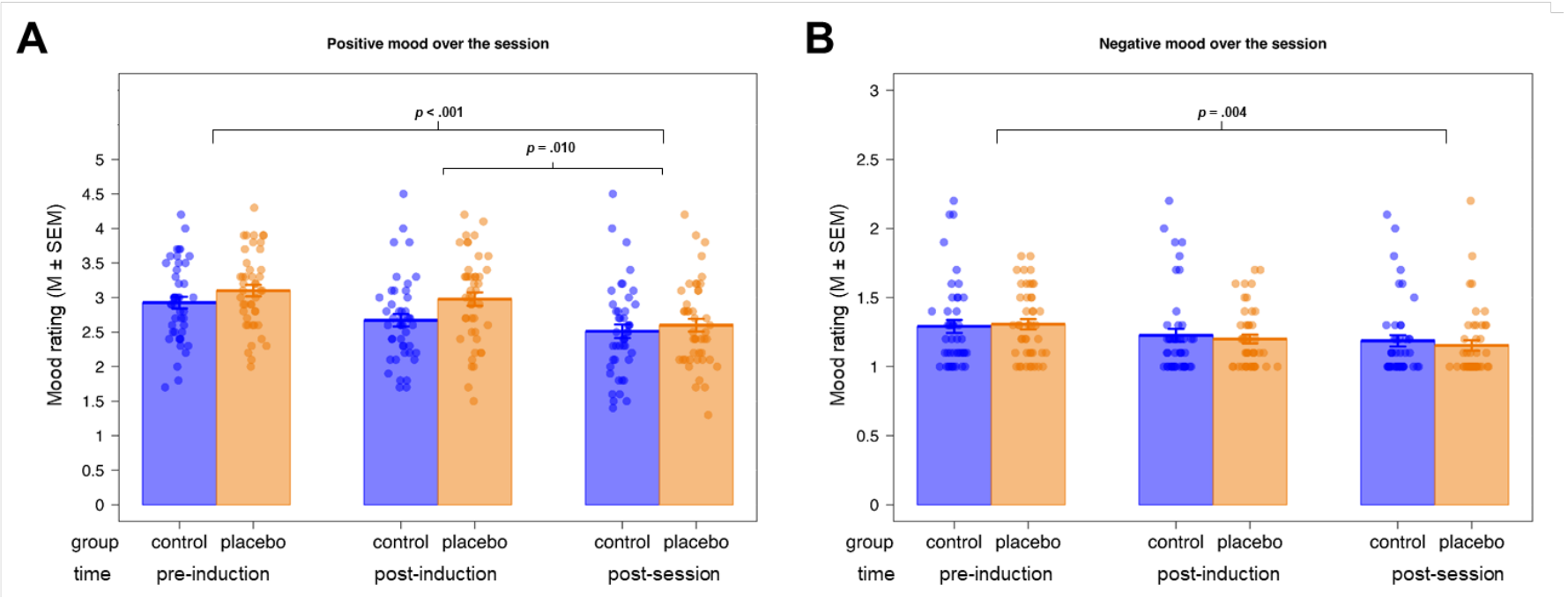
- No effects of placebo analgesia on general strength over the session



MVC = maximum voluntary contraction; Hartmann et al. (in prep)

Results

- No effects of placebo analgesia on mood over the course of the session



Hartmann et al. (in prep)

Empathy and prosocial behavior

Lukas Lengersdorff

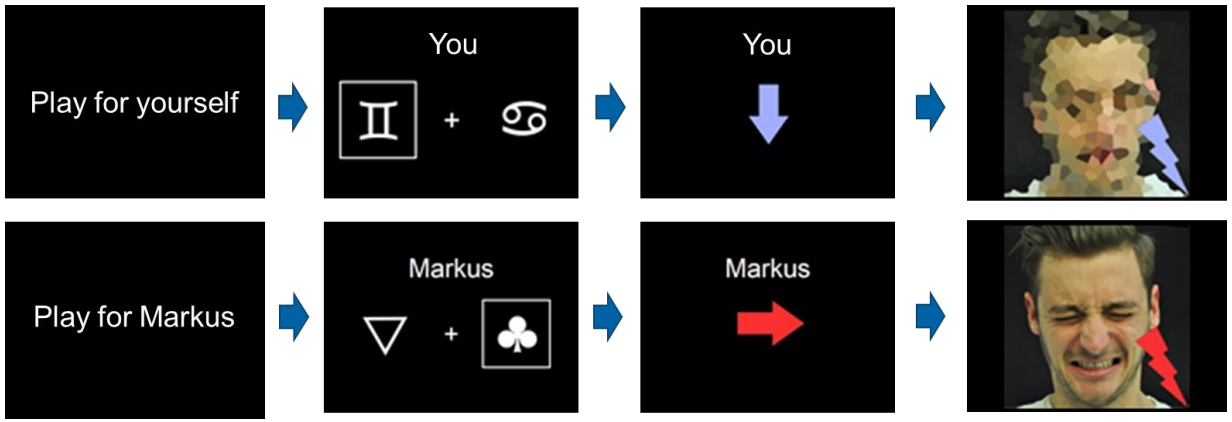


- Empathy and prosocial behavior – a neurocomputational account



Empathy and prosocial behavior

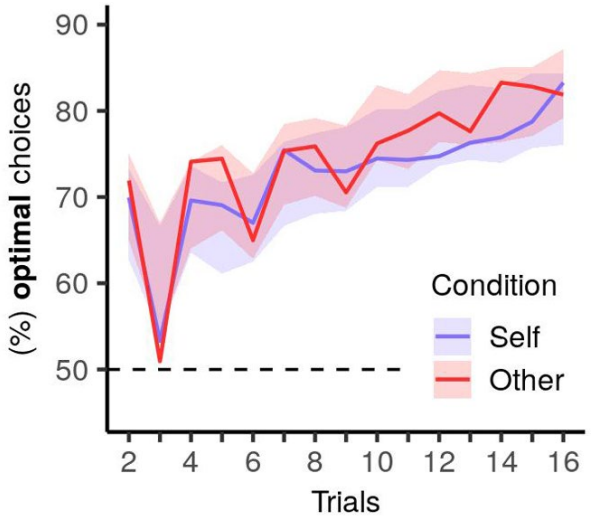
- Prosocial learning of harm-avoidance:
  Learning to avoid actions that would cause other people harm
- fMRI study (N = 96)
- Forced-choice task
  - „Bad" symbol:
    70% chance of pain
  - „Good" symbol:
    30% chance of pain
- Pain delivered to
  self or **other**



Lengersdorff et al., J Neurosci 2020

Empathy and prosocial behavior

- Participants made **more optimal choices** for the other person than for themselves



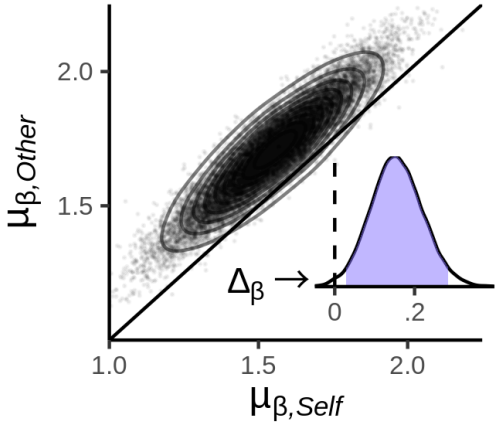
- Why? ⇨ computational modeling
  - Reinforcement learning models
  - Possibly different learning rates **α** and inverse temperature **β** for prosocial and self-oriented learning

$$P(\text{choice}_t = A | V_{A,t}, V_{B,t}) = \frac{1}{1+e^{-\beta(V_{A,t}-V_{B,t})}} \qquad V_{A,t+1} = V_{A,t} + \alpha(R_t - V_{A,t})$$

Lengersdorff et al., J Neurosci 2020

Empathy and prosocial behavior

- Modeling results:
  - Higher inverse temperature **β** for prosocial learning
  - No differences in learning rate **α**



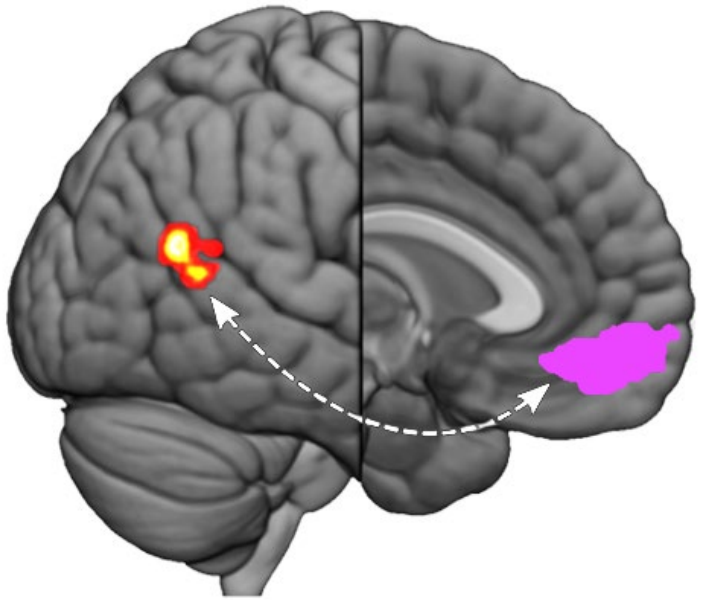
- ⇨ Higher sensitivity to values of possible actions that could cause others harm

- Correlation between **affective empathy** and $\beta_{Other} - \beta_{Self}$:
  The more participants share emotions, the more sensitive they are to other-related values

Lengersdorff et al., J Neurosci 2020

Empathy and prosocial behavior

- During prosocial choices: Increased connectivity between ventromedial PFC and rTPJ
- Interplay of the value network and the „social brain“:
  - Optimal decisions for other require perspective taking?
  - Increased need for self-other distinction?



Lengersdorff et al., J Neurosci 2020

Summary:
Empathy and prosocial behavior

- Humans are particularly adept at learning to protect others from harm ⇨ „Intuitive prosociality“?

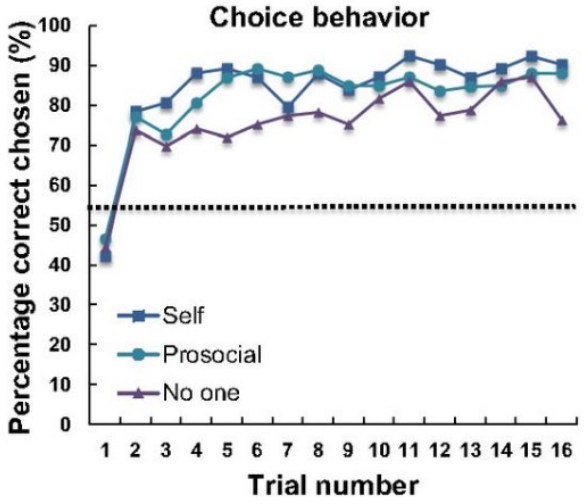
- They are more sensitive to the relative values of different actions when these might affect others…
  … and this sensitivity increases with affective empathy

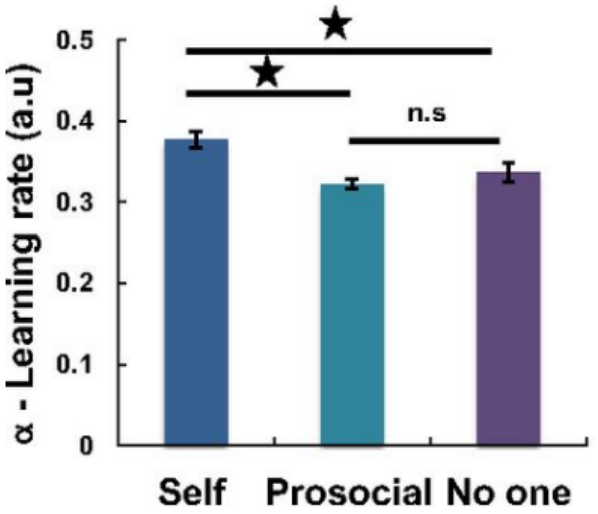
- Prosocial learning ⇨ increased communication between brain areas for value processing and social cognition

Intuitive prosociality or selfishness?

- However: People are „selfish learners“ when they can **gain money** for self vs. others
  - Lower learning rate α for prosocial learning
    - ⇨ Quicker change of behavior



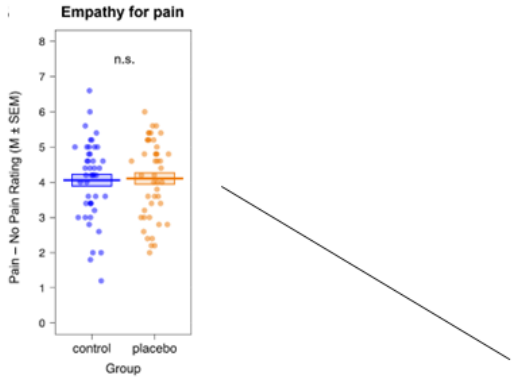


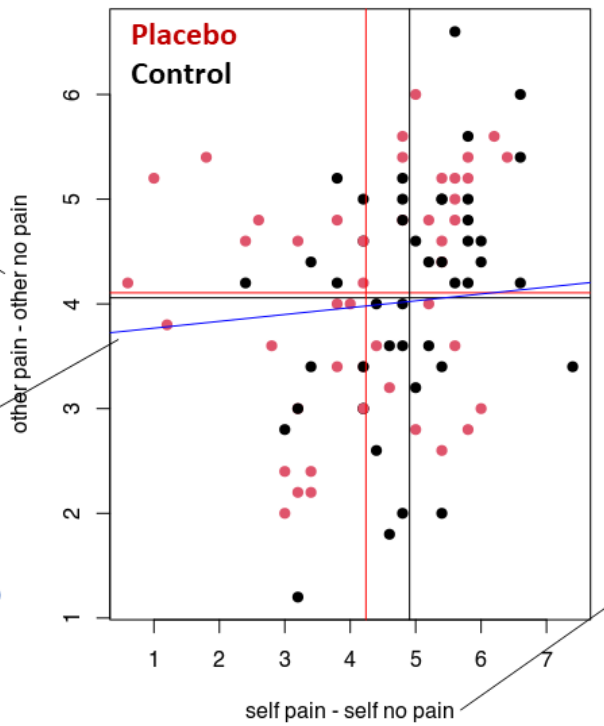


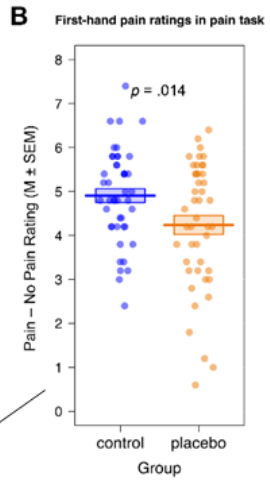
Lockwood et al., PNAS 2016

Intuitive prosociality or selfishness?

- Importance of outcome modality: „wealth vs. health“
  - *Hyperaltruistic learning* when other‘s physical integrity is at stake
  - *Selfish learning* when financial outcomes are at stake
- Implications for research on prosocial behavior: Investigate different outcomes and contexts!
- Social Cognitive Neuroscience and computational modeling can provide important insights into the cognitive, affective and motivational antecedents („proximate mechanisms“) of prosocial behavior







BLUE LINE ON FIGURE SHOWS CORRELATION SLOPE

```
# t = 2.5875, df = 88, p-value = 0.01131
# alternative hypothesis: true correlation is not equal to 0
# 95 percent confidence interval:
#  0.06223804 0.44830665
# sample estimates:
#  cor
# 0.265902
```

Empathy – concepts and processes

The age of empathy?

