The neuroscience of empathy and compassion

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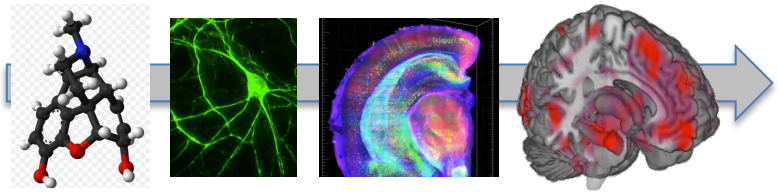
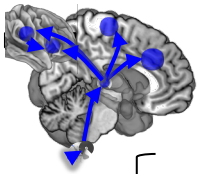
Papers: canlab.science

Data and code: canlab.github.io

@torwager

Understanding empathy and compassion across levels of analysis: A grand challenge



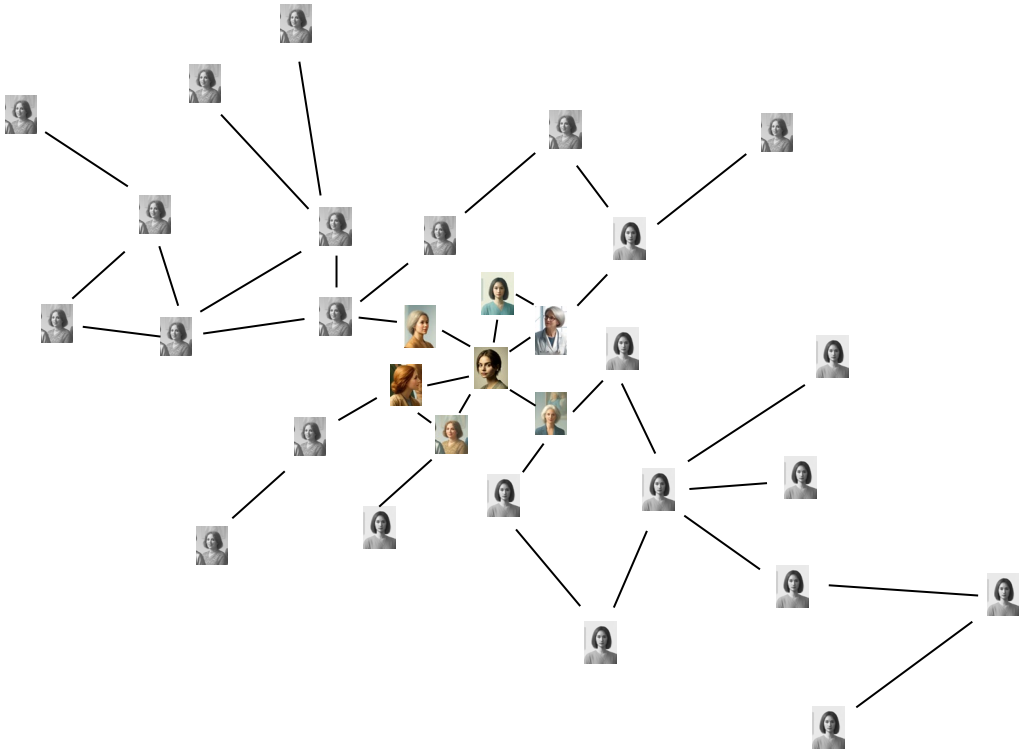


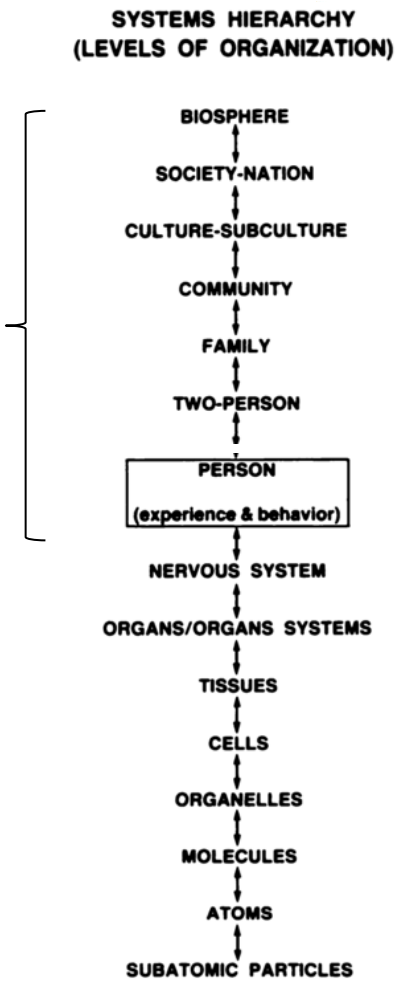
SYSTEMS HIERARCHY
(LEVELS OF ORGANIZATION)

BIOSPHERE
SOCIETY-NATION
CULTURE-SUBCULTURE
COMMUNITY
FAMILY
TWO-PERSON
PERSON
(experience & behavior)
NERVOUS SYSTEM
ORGANS/ORGANS SYSTEMS
TISSUES
CELLS
ORGANELLES
MOLECULES
ATOMS
SUBATOMIC PARTICLES

Engel, 1980

Interpersonal interactions: A key determinant of health





Bandura 1961; Christakis & Fowler 2010; Airoldi 2024 Science; Kramer 2014; Schechter 1991; Sieberg 2011

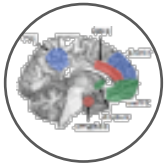
Roadmap

Consequences of provider empathy & alliance for health

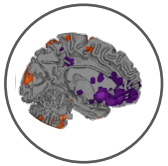
Empathy and therapeutic alliance are key

A little bit of connection goes a long way

Neural & psychological ingredients of compassion

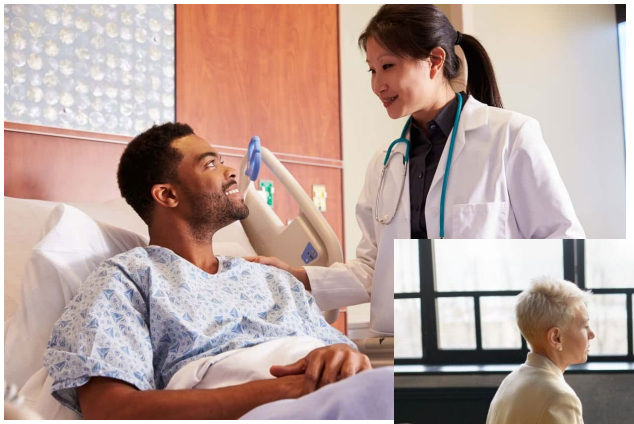


Multiple systems for compassionate action



A key role for medial prefrontal 'meaning making' systems

The patient-caregiver relationship

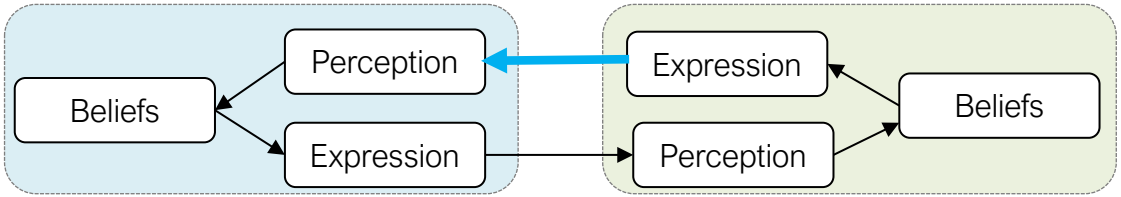


- Verbal communication
- Facial expression
- Eye gaze
- Posture and movements
- Implicit signals (what is unsaid)

Alone or supported?

Broken or resilient?

Hopeful or hopeless?



Wager & Atlas 2015, Nat Rev Neuro

Trust and therapeutic alliance:
A gateway to effective treatment

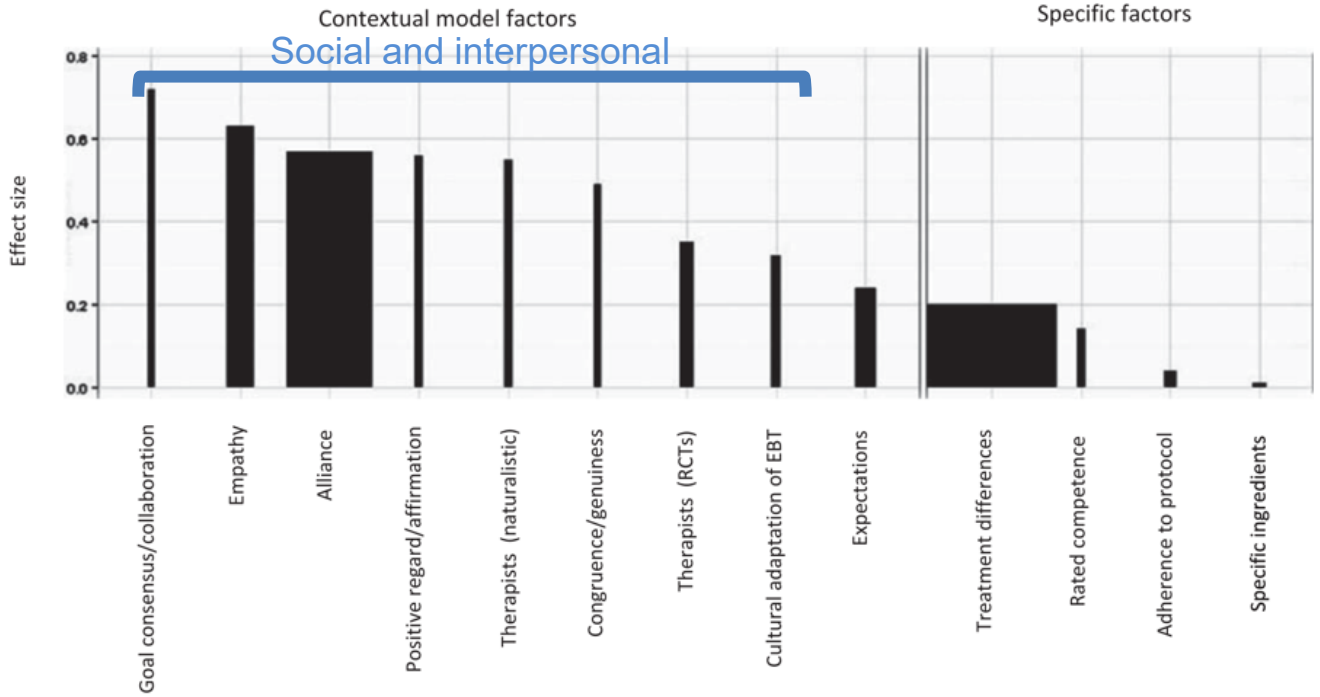


Figure 1 Effect sizes for common factors of the contextual model and specific factors. Width of bars is proportional to number of studies on which effect is based. RCTs – randomized controlled trials, EBT – evidence-based treatments

Wampold 2015

Pain as a window into the effects of empathy and trust

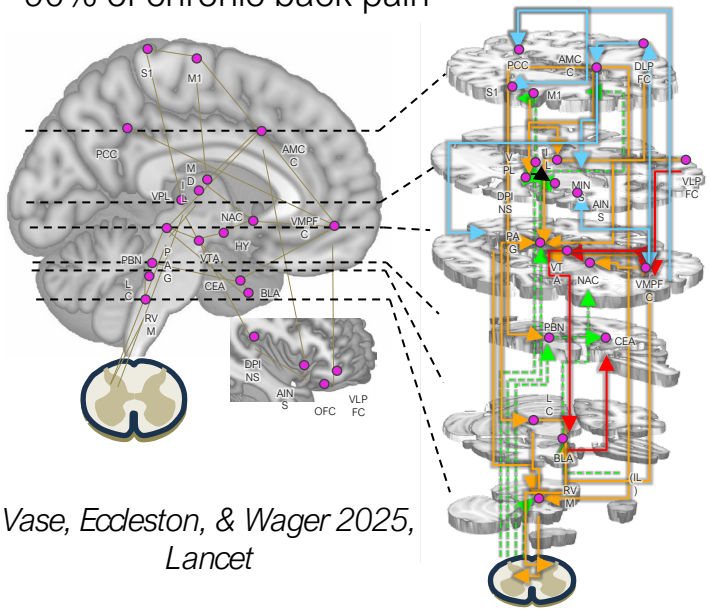
"There's nothing more horrific than a doctor looking you in the eye and saying there's nothing wrong with you when you're in debilitating pain"

- Ally Niemiec

Multiple kidney stones secondary to renal tubular acidosis type 1

Chronic pain in many cases is neuroplastic

- ”Safe”: Not a sign of tissue damage
- Alterations in brain pathways: pain, reward, fear, self
- Exposure & activity are keys to recovery
- ~90% of chronic back pain

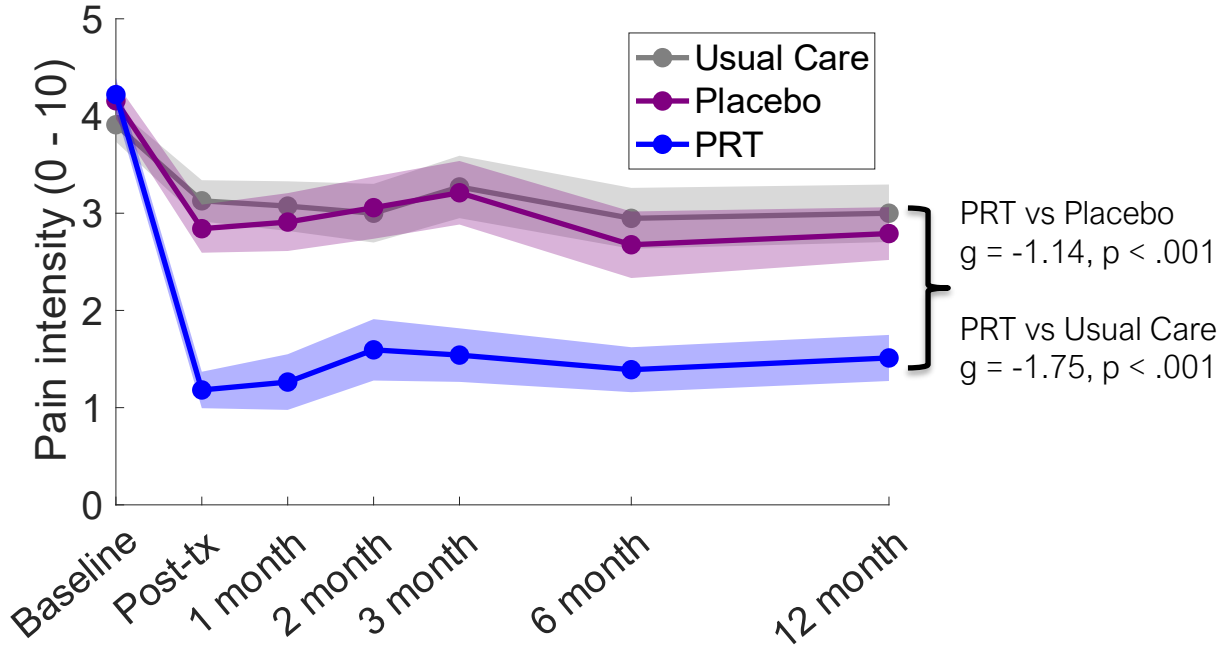


Vase, Eccleston, & Wager 2025, Lancet

Reviews: For 2006, Ji 2012, Navratilova 2015, Kuner & Flor 2018, Neugebauer 2021, Kuner & Kuner 2021

An example:
Improvement in chronic back pain with Pain Reprocessing Therapy

N = 150, Chronic back pain, 4/10+ for median of 10 years



- Therapeutic goal: Inform people that their pain is “safe pain” and engage in exposure


Howard Schubiner


Alan Gordon


Yoni Ashar

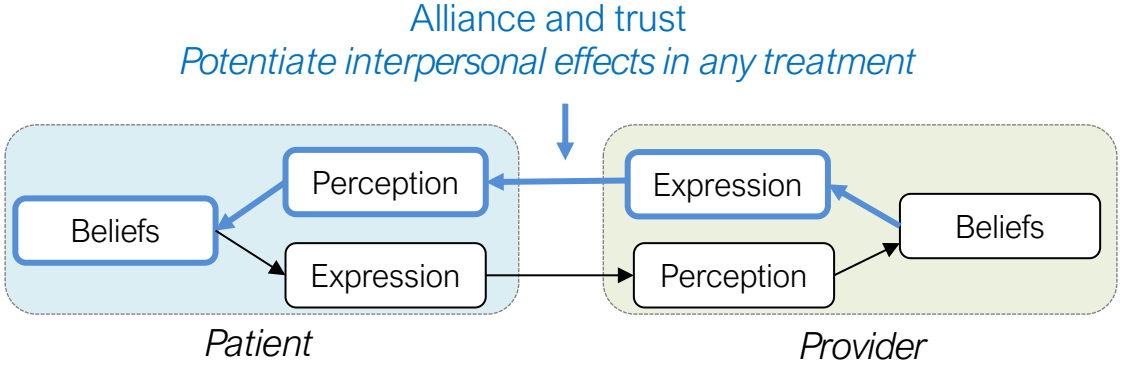
- Mediated by changes in pain beliefs (Ashar et al. 2024)
- Requires empathy, validation and alliance!

Ashar et al. 2022 JAMA Psych; 5-year follow-up Ashar 2025 JAMA Psych

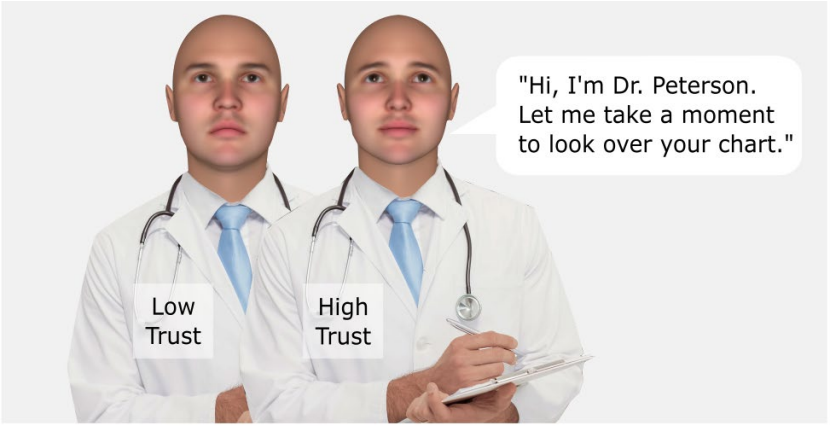
Roadmap

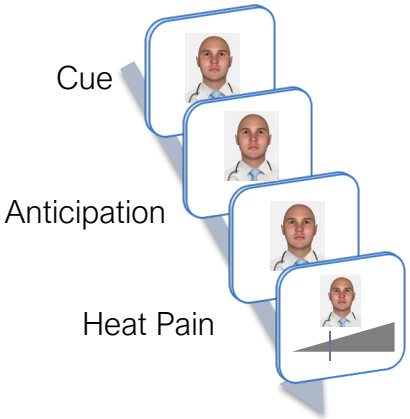
Consequences of provider empathy & alliance for health

Empathy and therapeutic alliance are a necessary starting point for successful treatment

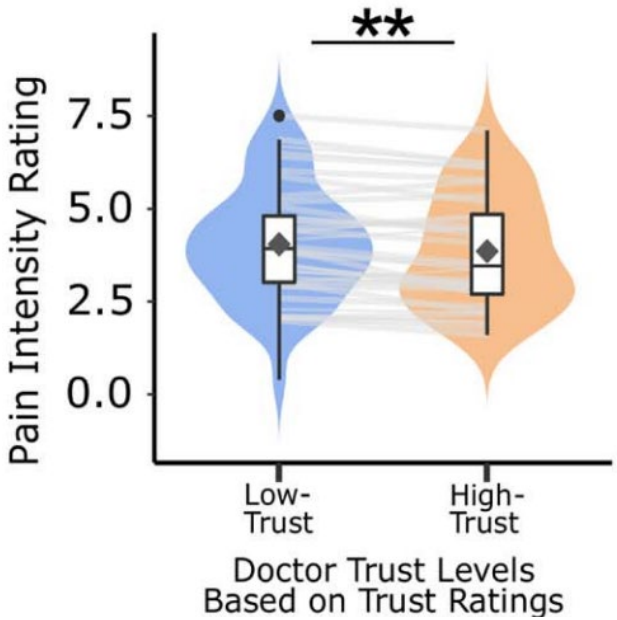


Trust in a clinician* reduces neuromarkers for nociceptive pain





** = simulated clinician; participants know it's not real*



- Trustworthy doctors: Increased trust, reduced pain intensity and unpleasantness

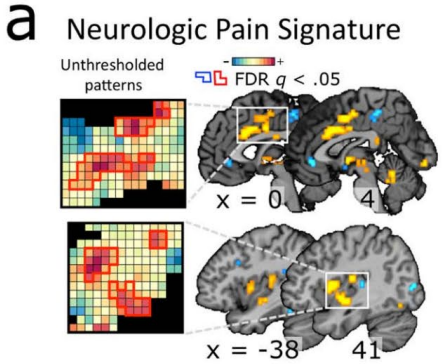
Anderson et al. (2022) *Cerebral Cortex*

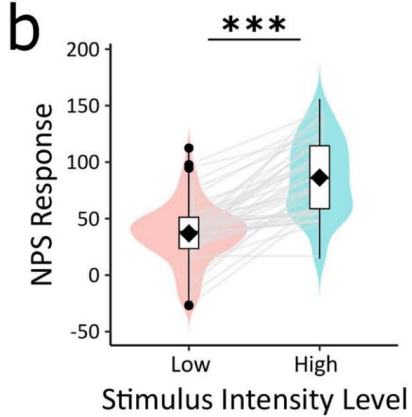
Trust in a clinician* reduces neuromarkers for nociceptive pain

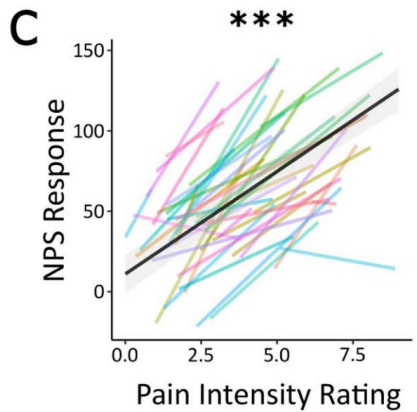
** = simulated clinician; participants know it's not real*

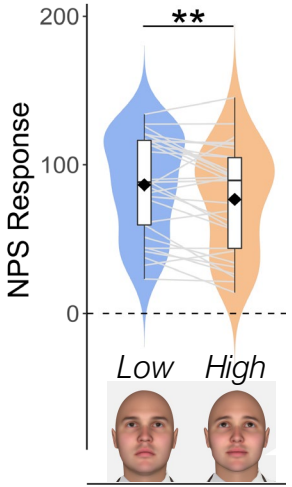
NPS responds to painful stimuli and tracks pain experience with high sensitivity and specificity

…and is reduced with high-trust cues









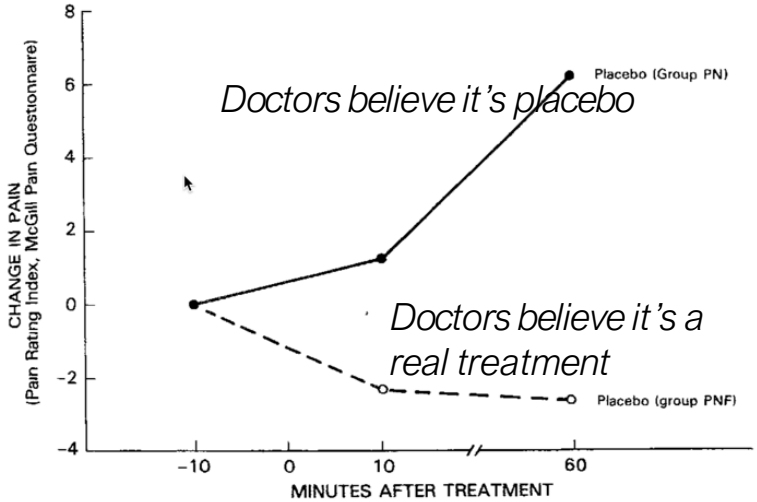
Low

Anderson et al. (2022) *Cerebral Cortex*

Socially transmitted placebo effects

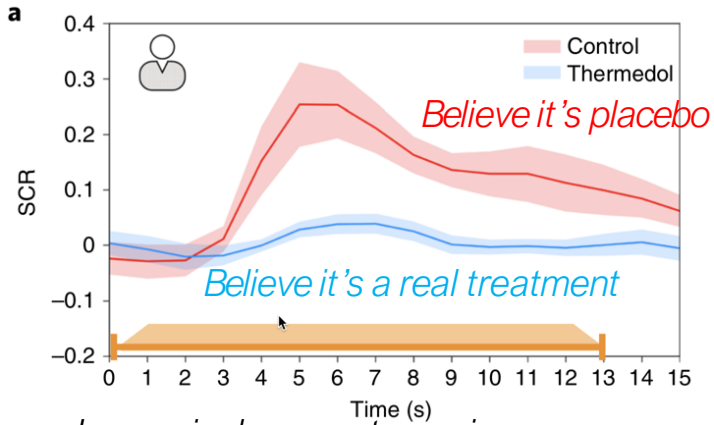
Doctors' beliefs in the treatments they administer influence patients' pain

Wisdom tooth extraction pain



Gracely et al. 1985, Lancet

Autonomic responses (electrodermal) to painful stimuli



Less pain, lower autonomic responses when doctor believes it's a real drug (3 experiments)

Chen et al. 2019, Nat Hum Beh

Roadmap

Consequences of provider empathy & alliance for health

Empathy and therapeutic alliance are a necessary starting point for successful treatment

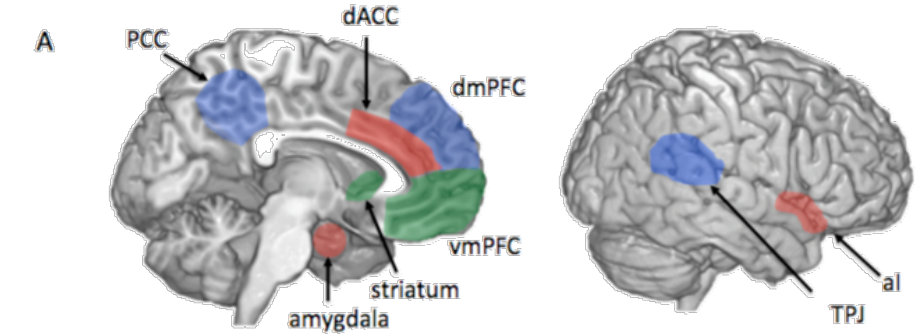
Even minimal signals of trust and care can affect pain (and brain/autonomic physiology)

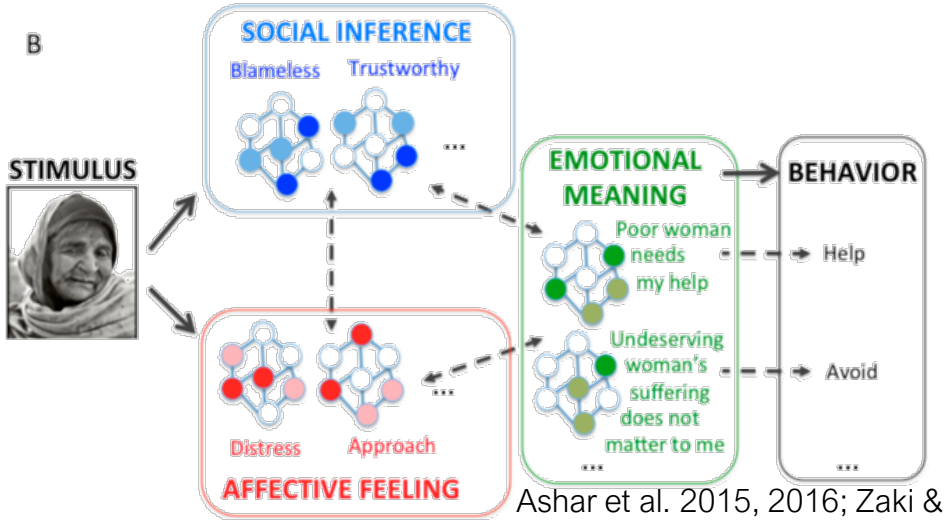
"Though our brother is upon the rack, as long as we ourselves are at our ease, our senses will never inform us of what he suffers…it is by the imagination only that we can form any conception of what are his sensations."

– Adam Smith (1759)

Cf. Zaki 2014; Cameron et al. 2019

The neuroscience of compassion:
Key processes and choices underlying helping decisions





Ashar et al. 2015, 2016; Zaki & Ochsner 2002

Recognizing:
Affective response

↓

Understanding:
Theory of mind

↓

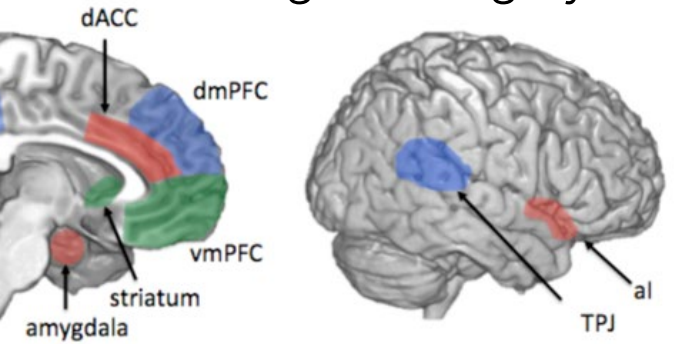
Caring:
Relation to self

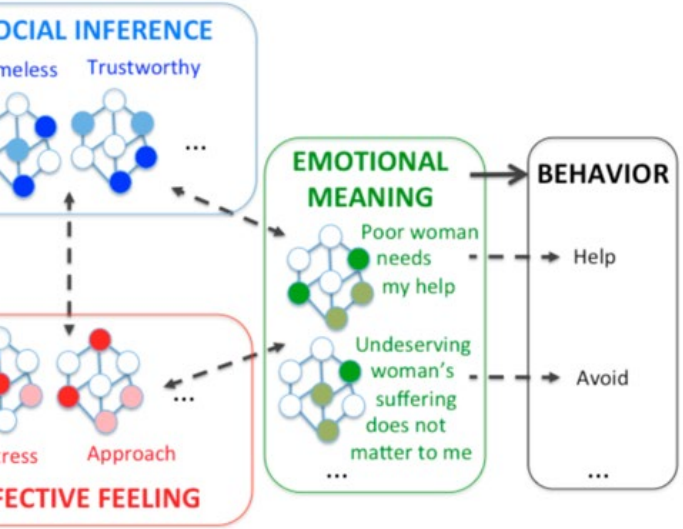
Batson: 'Walking in their shoes'

'Meaning' system:
- Cognitive maps of self in context
- Close to self -> "care"

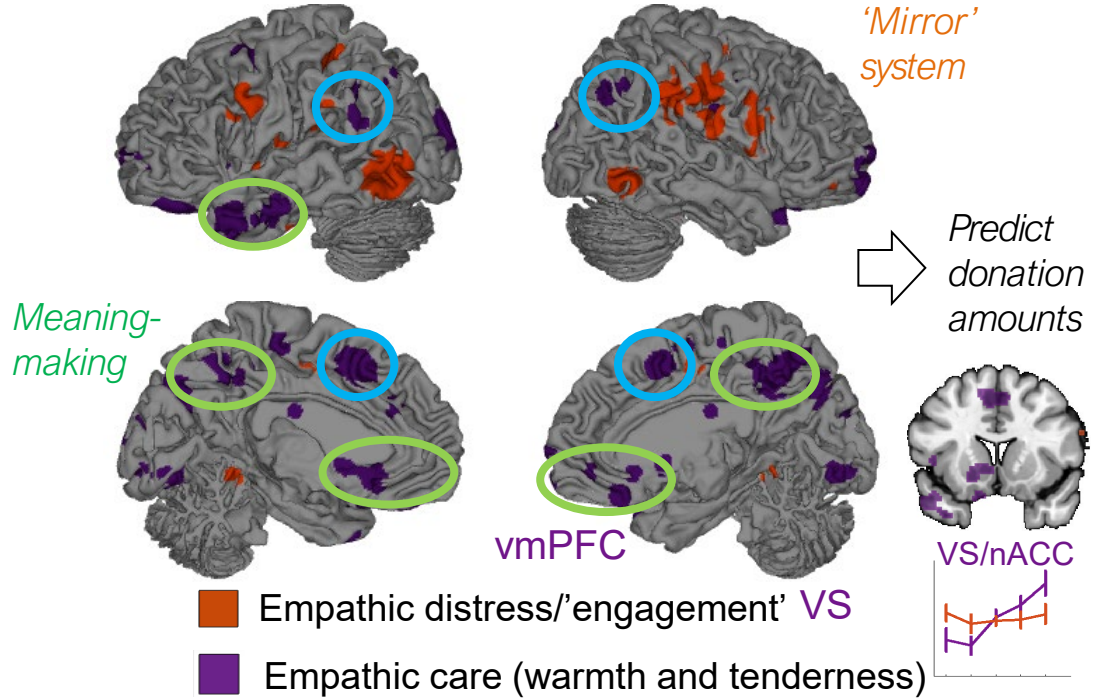
Roy et al. 2012; Koban et al. 2021

The neuroscience of compassion:
Meaning-making systems are central for compassionate choices



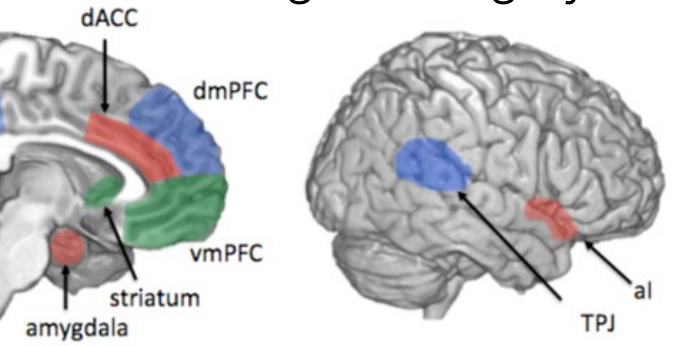


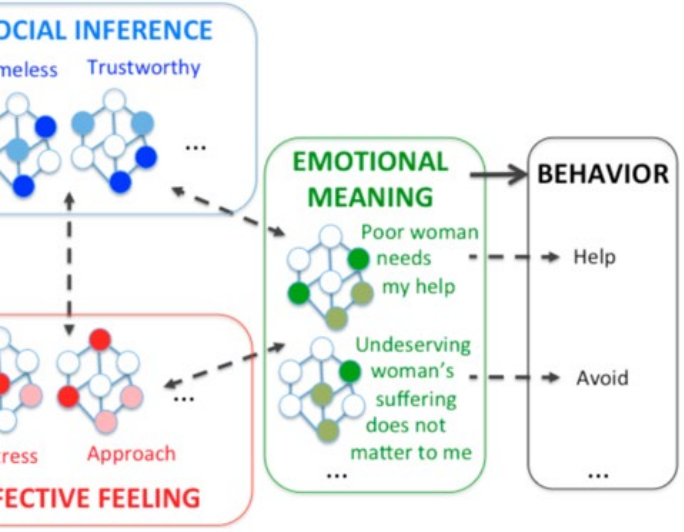
Separable neural predictors of moment-by-moment empathic distress and care



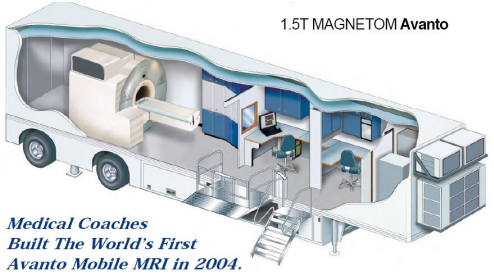
Ashar et al. 2017, Neuron

The neuroscience of compassion:
Meaning-making systems are central for compassionate choices



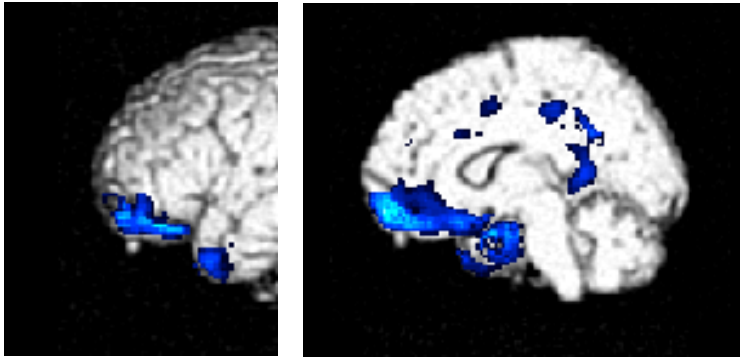


Psychopathy: Lack of empathy, guilt, remorse



Structural brain correlates of psychopathy
(gray matter reductions)

Male & female cohorts
N > 500 each



Ermer et al 2012, 2013; Courtesy Prof. Kent Kiehl.
Cf. Shamay Tsoory 2009; Koenigs 2012

Ingredients of ‘compassionate action’: Predicting helping behavior from feelings and social cognition

Samantha has HIV. She contracted the disease from a dirty needle in a doctor's office abroad. She attends peace rallies once a month. She did well in high school.

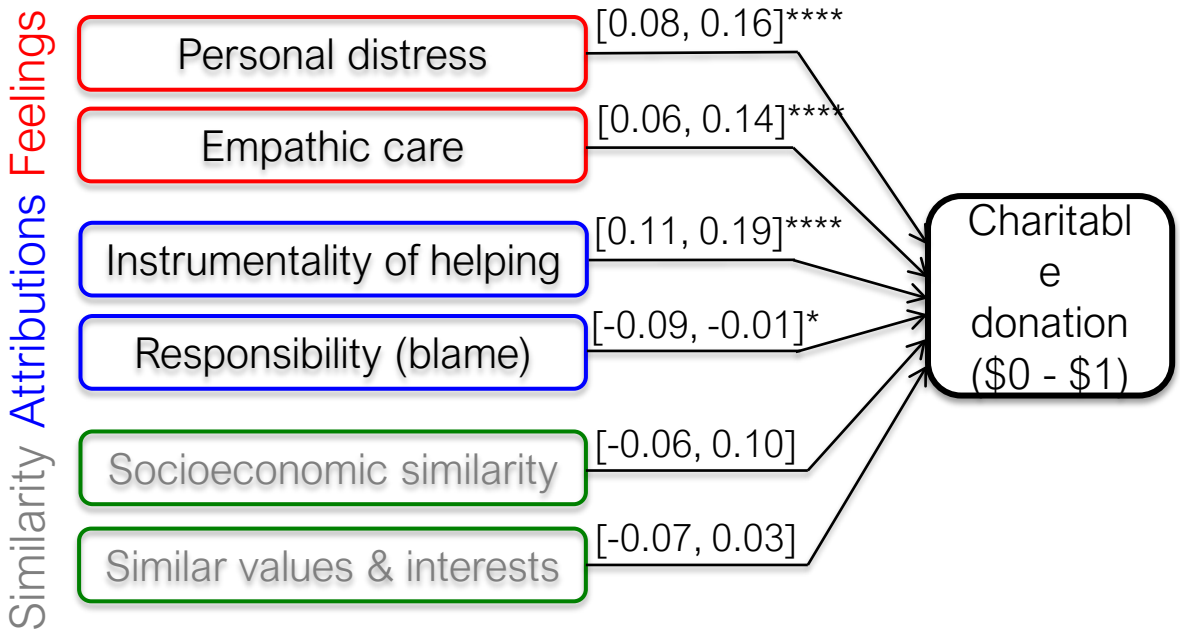
N = 200

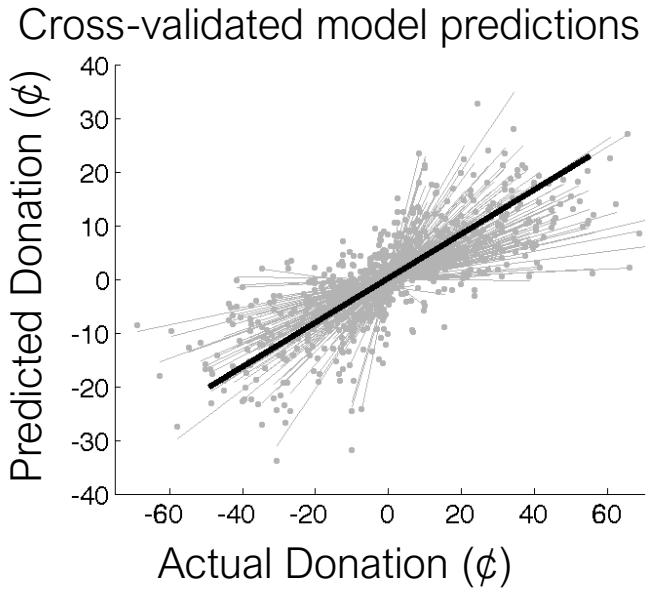
- Over 4,000 unique vignettes
- Systematically vary:
  - Age
  - Race
  - Sex
  - Similarity to perceiver
  - Responsibility for hardship
  - Instrumental value of money to help
- *Measured feelings, social cognition, similarity, donations to charity related to each case*

Ashar et al. 2016

Ingredients of 'compassionate action': Predicting helping behavior from feelings and social cognition

"Feelings & Attribution Scale" (FAS):
Predicting donations requires empathic care, distress, and social cognition (attributions)





Ashar et al. 2016

cf. Batson et al 2005, 2011; Zaki et al. 2012; Fan et al 2010; Shamay-Tsoory et al. 2009; Raz et al. 2013

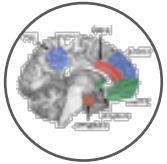
Roadmap

Consequences of provider empathy & alliance for health

Empathy and therapeutic alliance are a necessary starting point for successful treatment

Even minimal signals of trust and care can affect pain (and brain/autonomic physiology)

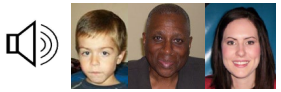
Neural & psychological ingredients of compassion



Compassionate behavior involves interactions between affective, social cognitive, and personal meaning-making systems

Towards a neuroscience of compassionate action: Randomized controlled trial of compassion meditation (CM) with fMRI

Pre-intervention



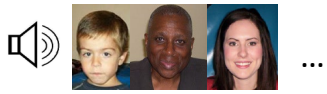
... x 24 true stories

Compassion Meditation (*N*=20)

Placebo (sham oxytocin) (*N*=17)

Familiarity training (*N*=18)

Post-intervention



...

CM smartphone app:
20min daily for 4 weeks

Develop empathic care and equanimity for suffering others

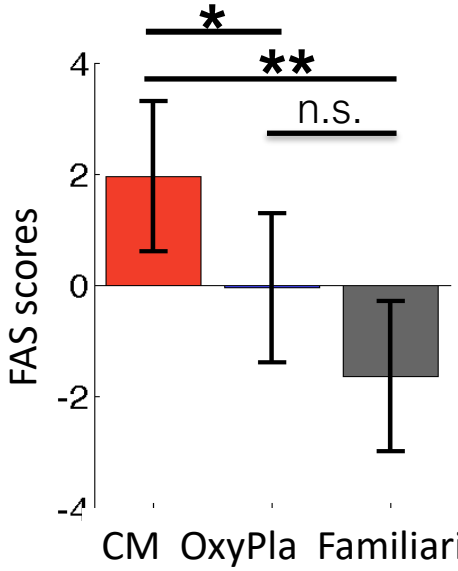
"Strong back

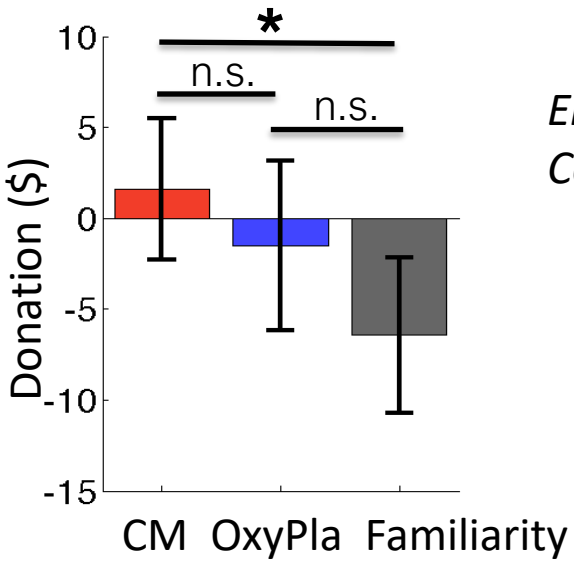
Soft front"

Roshi Joan Halifax

Ashar et al. 2016, 2021

Towards a neuroscience of compassionate action: Randomized controlled trial of compassion meditation (CM)

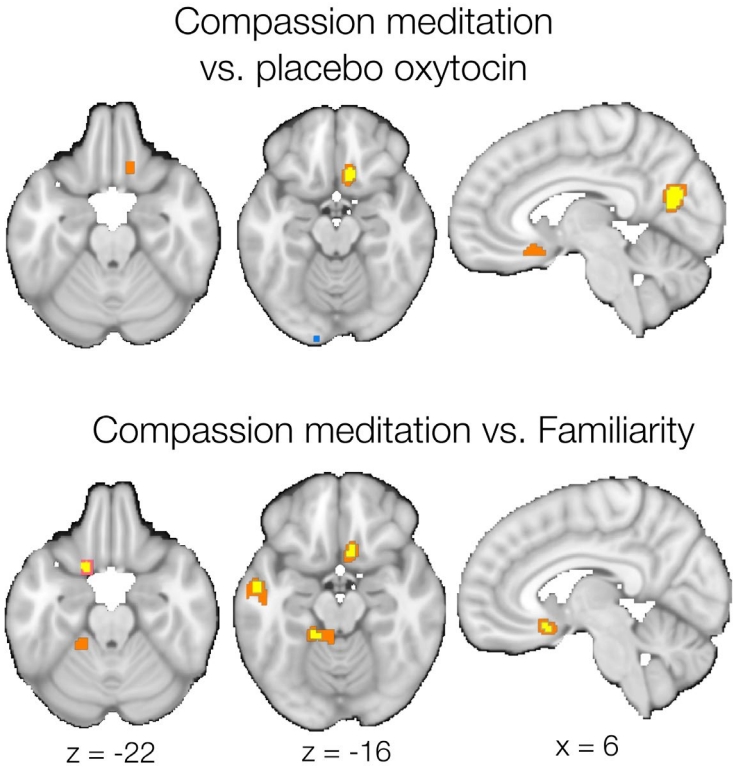


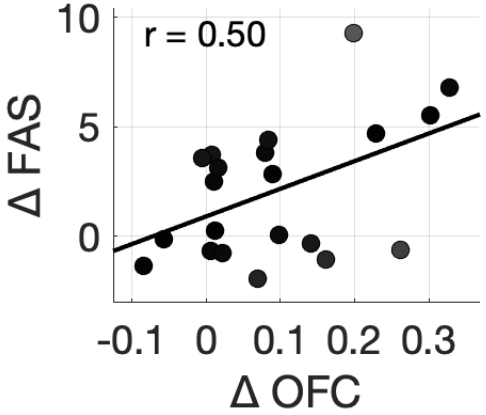


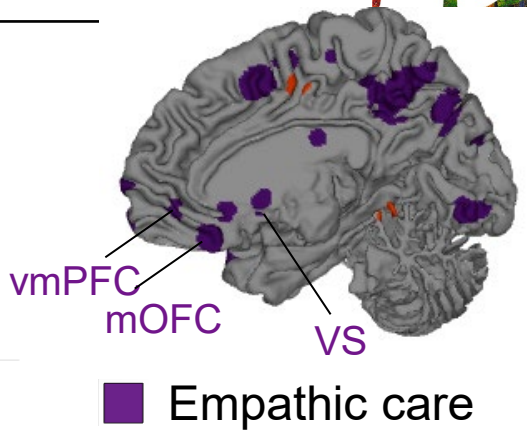
Error bars: 95% Cis
Complete mediation

Ashar et al. 2016

Brain changes with Compassion Meditation: Ventromedial ‘care’ system







Ashar et al. 2021; N = 55

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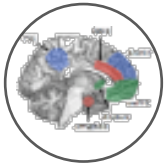
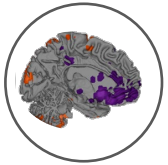
Neural & psychological ingredients of compassion



Compassionate behavior involves interactions between affective, social cognitive, and personal meaning-making systems



Meaning-making systems are critical for generating empathic care and action

Cognitive and Affective Neuroscience Lab Members - 2025

Postdocs


Rotem Botvinik-Nezer


Michael Sun


Ke Bo


Katerina Zorina-Lichtenwalter


Amin Deghani

Affiliated faculty


Marta Čeko


Lukas Van Oudenhove


Martin Lindquist

Graduate students


Mijin Kwon


Bogdan Petre


Heejung Jung


Byeol Kim


Ben Graul


Zizhuang Miao

Staff


Sydney Shohan


David Gantz

Funding Sources

Catalan government
Mind, Brain, Body and Health Network

Code: shared on https://github.com/canlab . *Papers, etc.* : http://canlab.science

CANlab studies

Minimal social influence
- Koban et al. 2016 Emotion
- Koban, Kusko et al. 2018
- Koban et al. 2019 Nat Comms
- Botvinik-Nezer et al. in prep
- Jung et al. in prep

Interpersonal influences on pain
- Losin et al. 2017 J of Pain
- Lopez-Sola 2018 Psychosom Med
- Goldstein et al. 2020 J of Pain
- Chen et al. 2019 Nat Hum Beh
- Losin 2020 Nat Hum Beh
- Landa 2020 J Psychosom Res
- Anderson et al. 2023 Cer Ctx
- Dehghani 2024 Pain

Social touch and support
- Lopez-Sola et al. 2019a Pain
- Reddan et al. 2020, SCAN
- Reddan et al. 2022

Dyadic psychotherapy for pain
- Ashar et al. 2021, JAMA Psych
- Ashar et al. 2023, JAMA Netw Open
- Tankha et al. 2023, J of Pain

Plus many placebo studies!!

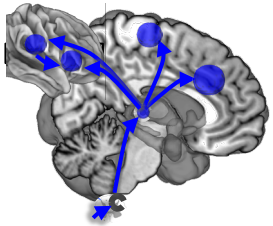
Expression → Perception → Pain

Interpersonal influences on pain

←

Perceiving & responding to pain in others

→



Vicarious pain
- Krishnan et al. 2016 eLife
- Zakl et al. 2016 TICS
- Lopez-Sola et al. 2017 Neuropsychologia
- Ashar et al. 2017 Neuron
- Zhou et al. 2020 eLife

Social influences on vicarious pain
- Zhang et al. 2021 J of Pain
- Zhang et al. 2024 Eur J Pain

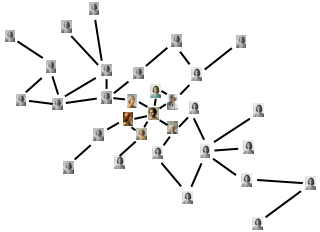
Training to enhance empathy and compassion
- Ashar et al. 2016, Handbook of Positive Neuro
- Ashar et al. 2016, Emotion
- Ashar et al. 2021, SCAN

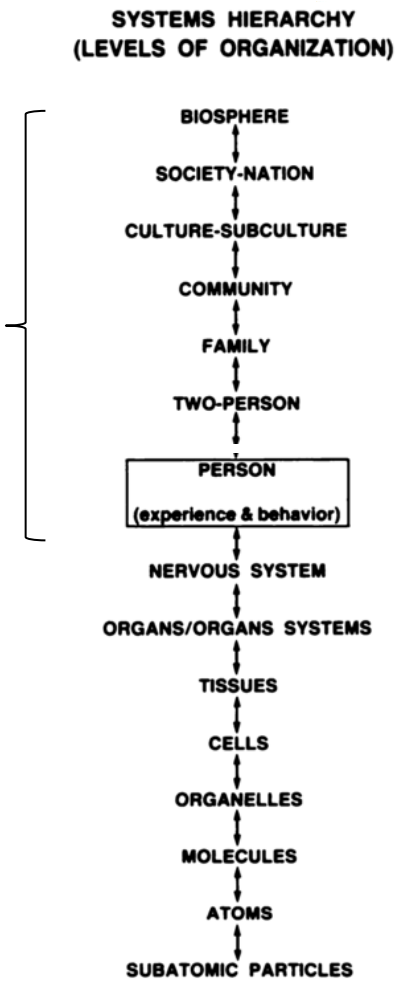
Social influences on anxiety and self-perception
- Koban et al. 2023 Trans Psychiatry
- Koban et al. 2017 Emotion

Empathy and compassion:
Hidden, ubiquitous determinants of health

Disorders:
Frequently studied, funded

Ongoing processes supporting health:
Rarely studied or funded





Empathy gaps in pain

- Infants

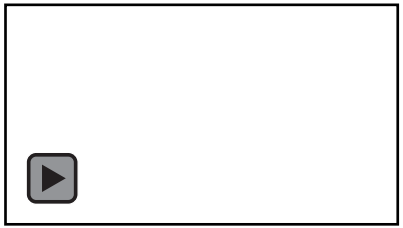
  Fitzgerald 2005
  Beggs et al. 2012

- Women

  Hamberg et al. 2002
  Robinson 2003

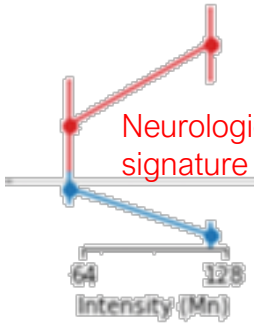
- African descent

  Cruz-Almeida et al. 2014
  Hoffman et al. 2016



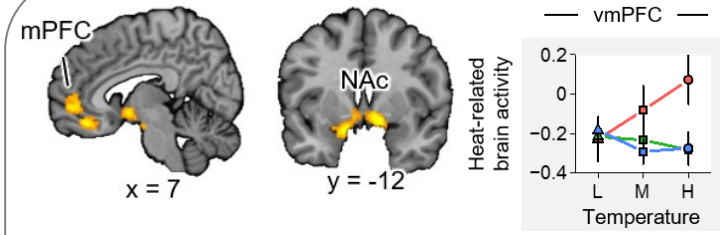
Infants show responses in cortical systems and neuromarkers for pain.

Duff 2020 Lancet Dig Hlth



Men and women systematically under-value women's pain

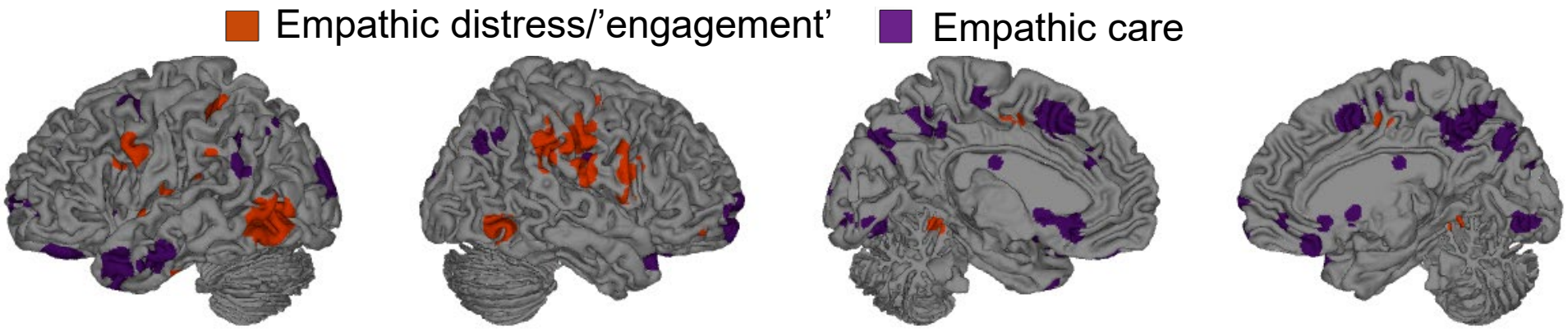
Zhang et al. 2021



African-Americans show stronger pain-related in fronto-striatal pathways than White / non-White Hispanic individuals. *Losin 2020 Nat Hum Beh*

Differential fMRI neuromarkers for empathic care and distress

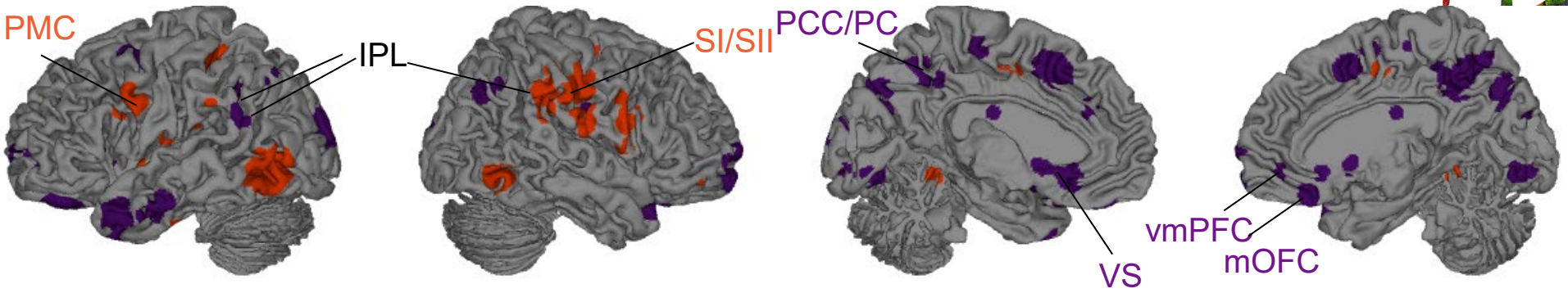
- Predict within-person variations in the degree of care and distress over time



Ashar et al. 2017, Neuron

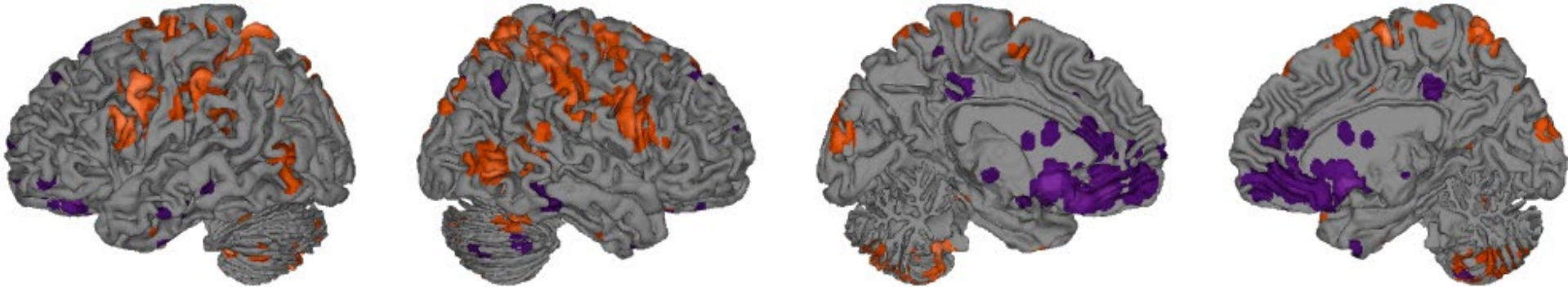
Regions preferentially related to:

Empathic distress/'engagement' Empathic care



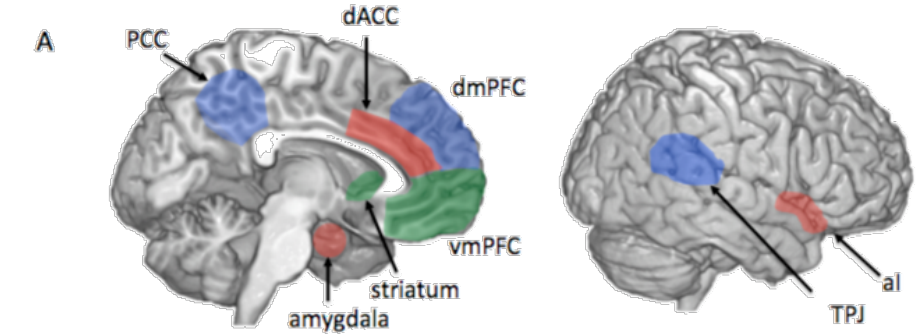
Neurosynth meta-analyses:

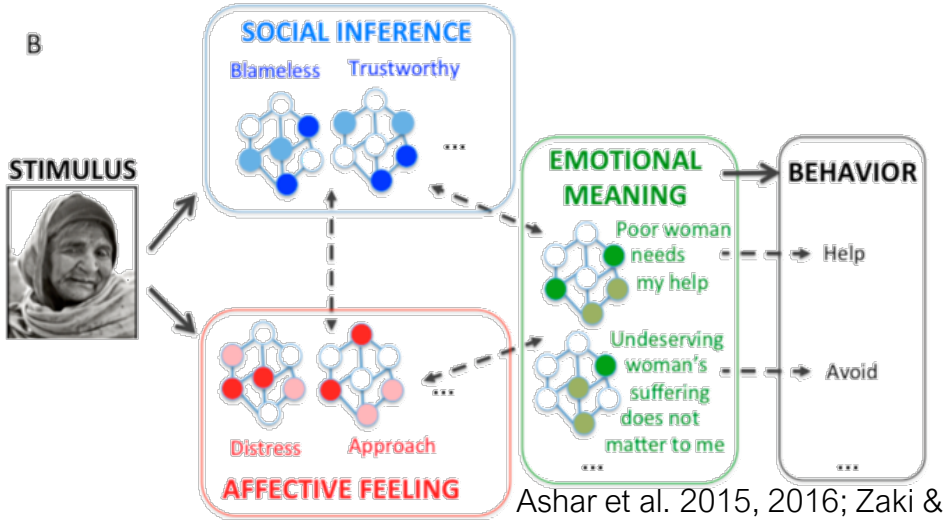
"mirror" "value"



Ashar et al. 2017

The neuroscience of compassion:
Key processes and choices underlying helping decisions





Samantha has HIV. She contracted the disease from a dirty needle in a doctor's office abroad. She attends peace rallies once a month. She did well in high school.

Donate up to $100
(of your real earnings)
to charity to support people like Samantha?

Ashar et al. 2015, 2016; Zaki & Ochsner 2002