Both physical pain and negative emotion activate periaqueductal gray, but with different cortical-brainstem connectivity

Jason Buhle1, Hedy Kober2, Kevin N. Ochsner1, Peter Mende-Siedlecki2, Jochen Weber1, Brent Hughes4, Ethan Kross5, Tor D. Wager1,6.

1Columbia University, Department of Psychology; 2Yale University, Department of Psychology; 3Princeton University, Department of Psychology; 4University of Texas, Austin, Department of Psychology; 5University of Michigan, Department of Psychology; 6University of Colorado, Boulder, Department of Psychology and Neuroscience

Reprints available at: www.columbia.edu/cu/psychology/tor/

What is the relationship between physical and emotional pain?
- Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage8.
- Negative emotion is often described using the language of physical pain “emotional pain”, “heartache”, etc.

1. Do physical pain and negative emotion rely on shared mechanisms?

2. How are neural and physiological responses to an aversive event coordinated?

Periaqueductal gray (PAG)

Animal research

- Columnar organization associated with distinct modes of coordinated behavior and physiology8.

- Rostrolateral
  - Defensive aggression
  - Heart races
  - Blood flow to face
  - Pain is blocked

- Ventrolateral
  - Aversive images
  - Heart races
  - Blood pressure up
  - Blood flow to limbs
  - Pain is blocked

- Caudolateral
  - Aversive event coordinated?

Human research

- PAG is central to neural models of human pain processing
- PAG is nearly absent from neural models of emotion
- However, PAG is reliably reported in brain imaging studies

Design of current study

- Two trial types:
  - Aversive images
  - Neutral images

- Duration: 6 s each
- 16 participants included in analysis

Results

1. Robust regression group contrasts

2. PAG connectivity

3. Relative PAG Connectivity

4. Network connectivity with PAG

Conclusions

Neural models of human emotion should incorporate PAG

PAG may coordinate neural, behavioral and physiological components of the response to aversive events.

Combining modality-specific brain networks and networks common to negative emotion in general may underlie the brain’s ability to adaptively respond to an infinite diversity of possible aversive experiences.

References

1. International Association for the Study of Pain
2. Bandler & Shipley, 1994
3. Atlas & Wager, unpublished data
4. Kober et al., 2008