The role of the opioid system in decision making and cognitive control
Henk van Steenbergen⁴,¹,², Marie Eikemo³,⁴, & Siri Leknes⁴

1) Cognitive Psychology Unit & 2) Leiden Institute for Brain and Cognition, Leiden University, The Netherlands
3) Department of Diagnostic Physics, Oslo University Hospital, Oslo, Norway 4) Department of Psychology, University of Oslo, Oslo, Norway

Why this review paper?
- Opioid peptides play an important modulatory role in neural signaling. Mu-opioid receptors are densely distributed in valuation and control regions. What is the current evidence that the opioid systems play a role in decision making and cognitive control?
- Animal studies have suggested that stimulating mu-opioid receptors shifts liking, but also wanting and learning. Do opioids also shift value-based decision making in humans?
- Acute and chronic opioid use has often been associated with impaired concentration. Which cognitive control components are exactly modulated by opioids?

This review summarizes what we currently know about acute effects of opioid drugs in healthy humans.

Opioids play a key role in pleasure and pain.
But how do they impact cognition?

Summary Cognitive Control
- Opioid agonists impair digit symbol substitution and logical reasoning, but high-dose effects could be due to sedation. No consistent effects of opioid drugs on working memory and attention.
- Some findings suggest that small dose of opioid agonists actually improves performance under stress.
- Working hypothesis: (endogenous) opioids dampen aversive arousal, which in turn can modulate cognitive control.

This field is in its infancy!
- Examples of future work:
  - What is the role of affective and motivational states?
  - How does the opioid system interact with other neurotransmitter systems?

Want to know more? Check out our review paper: van Steenbergen⁴, Eikemo³, & Leknes⁴ (2019). CABN

Summary Decision Making
- Initial evidence that opioid antagonists reduce outcome pleasantness.
- Stimulating opioid receptors enhances and blocking opioid receptors reduces the motivational value and learning of high-value outcomes.
- Impulsivity (delay discounting) not modulated by opioids.
- Proposal: opioid drugs shift the subjective value of reward. Similar modulation may occur for punishment but more research is necessary.

Highlight from Leiden lab
- Mu-opioid agonists versus antagonists might have opposite effects on value-based choice.
- Participants did a two-alternative decision-making task known to induce a bias towards the most frequently rewarded response option.
- Diffusion modelling results: 10 mg morphine (M) vs. placebo (P) increased preference for high-reward stimulus (starting point) and efficiency of evidence accumulation (drift rate). 50 mg naltrexone (N) produced opposite effect.

Eikemo et al. (2017), NPP

Highlight from Oslo lab
- Endogenous opioid tone might dampen the aversiveness of errors and conflict.
- Blocking the mu-opioid system using 50 mg naltrexone should increase the aversiveness of errors and conflict, which in turn should increase conflict-driven control.
- In line with predictions, naltrexone increased adaptations after errors (post-error slowing). Naltrexone did not increase conflict adaptation.

van Steenbergen et al. (2017), PNEC