Neural Processing of Risk

Peter N.C. Mohr
Guido Biele
Hauke R. Heekeren

Max-Planck-Institut für Bildungsforschung
Max Planck Institute for Human Development

Freie Universität Berlin

Risk

Traffic Risk

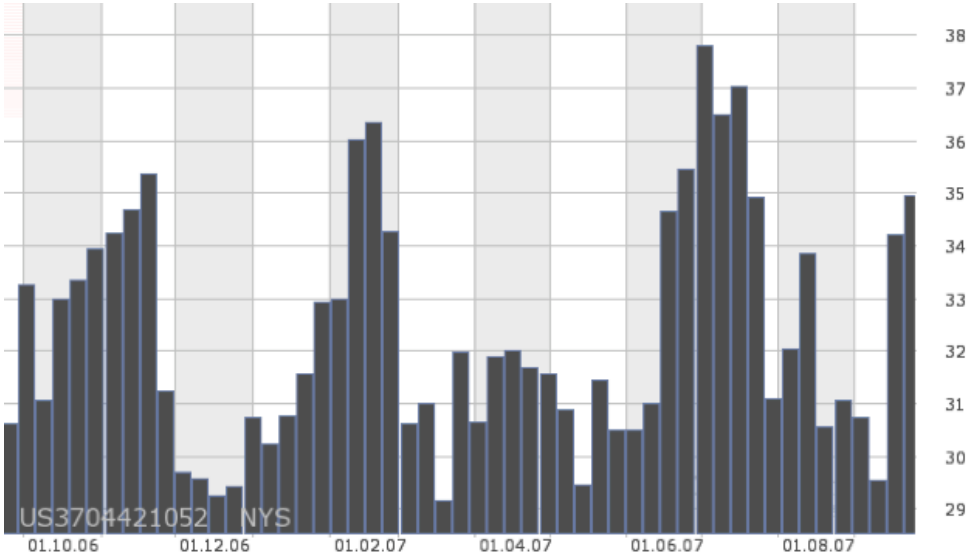
Terror Risk

Health Risk

Risk as the probability and/or amount of an unwanted outcome.

Risk

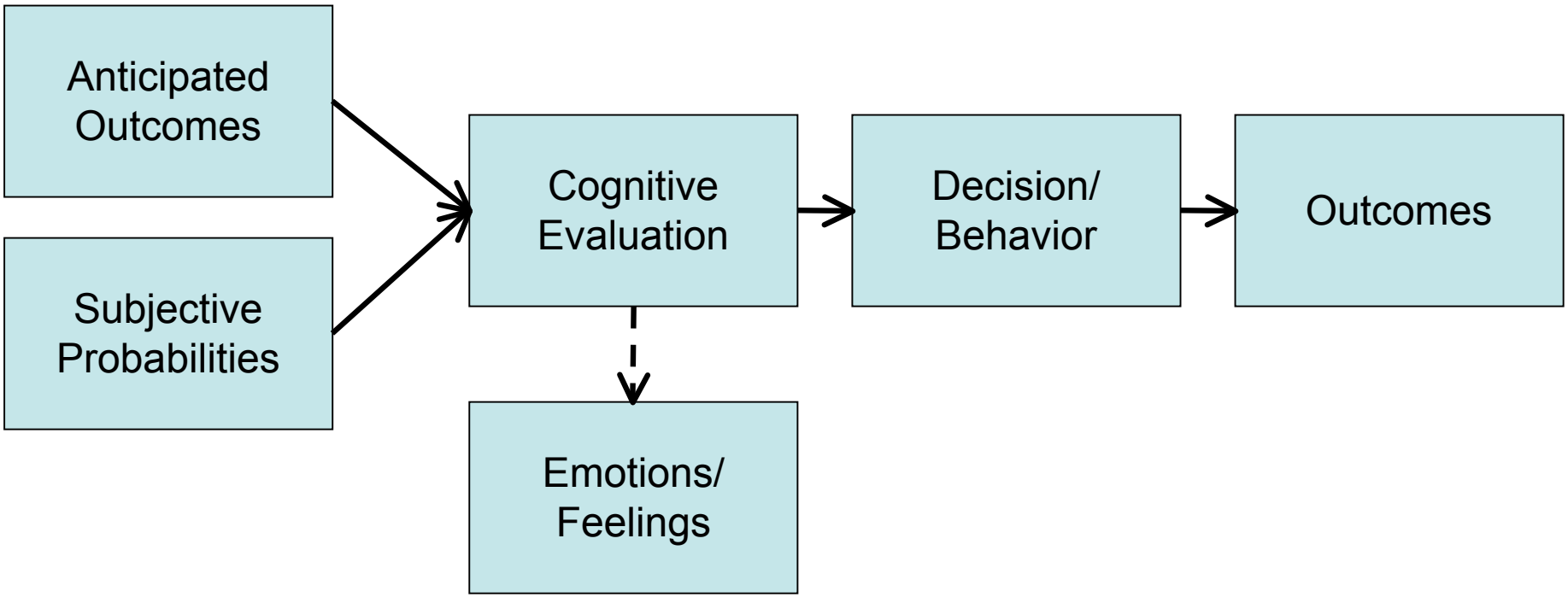
Roulette



Stocks

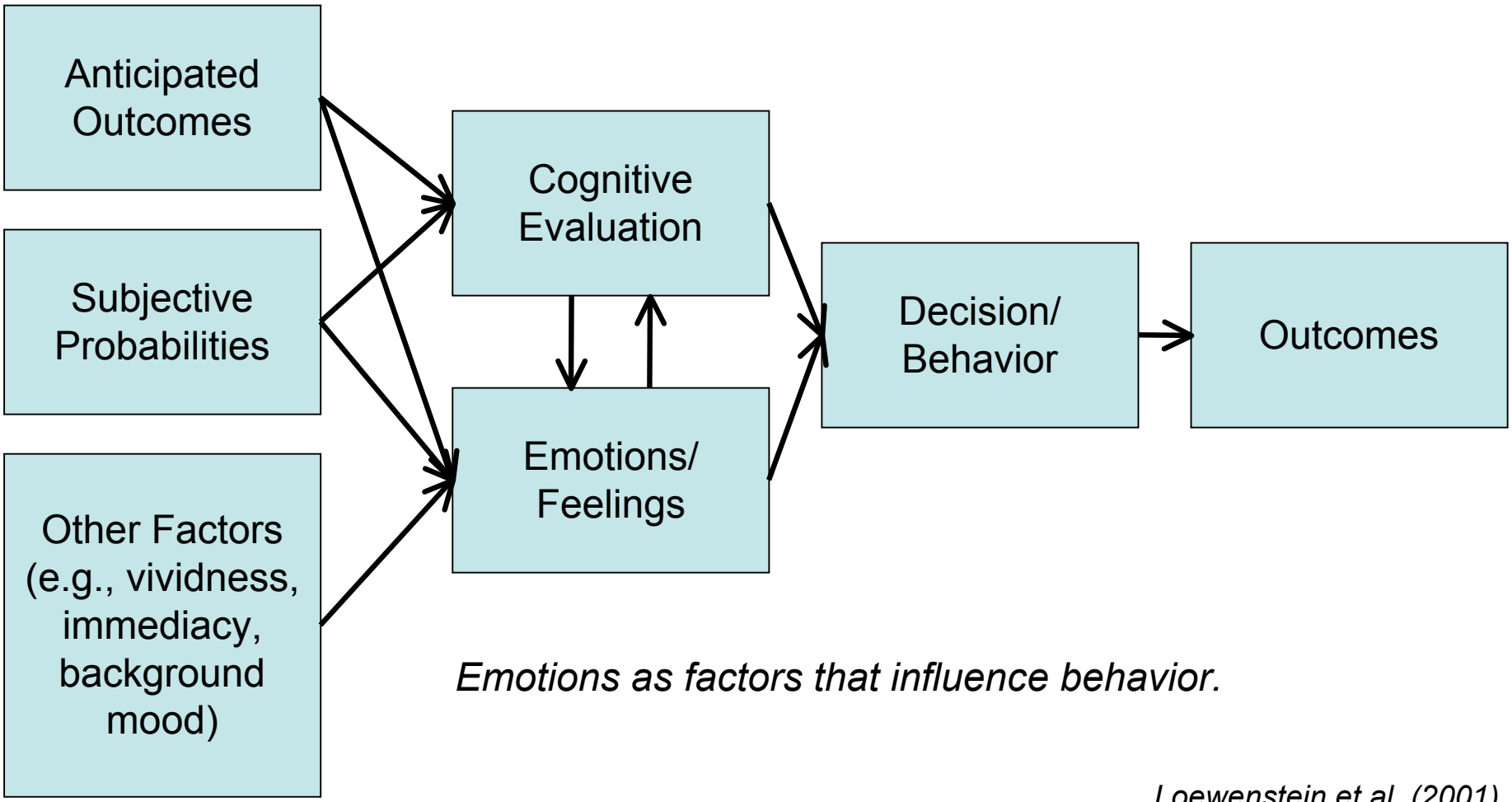
Risk as uncertainty of the outcome.

Consequentialist Perspective



Emotions as a byproducts of the cognitive evaluation that have no influence on decisions.

Risk-as-Feelings Hypothesis



Emotions as factors that influence behavior.

Loewenstein et al. (2001)

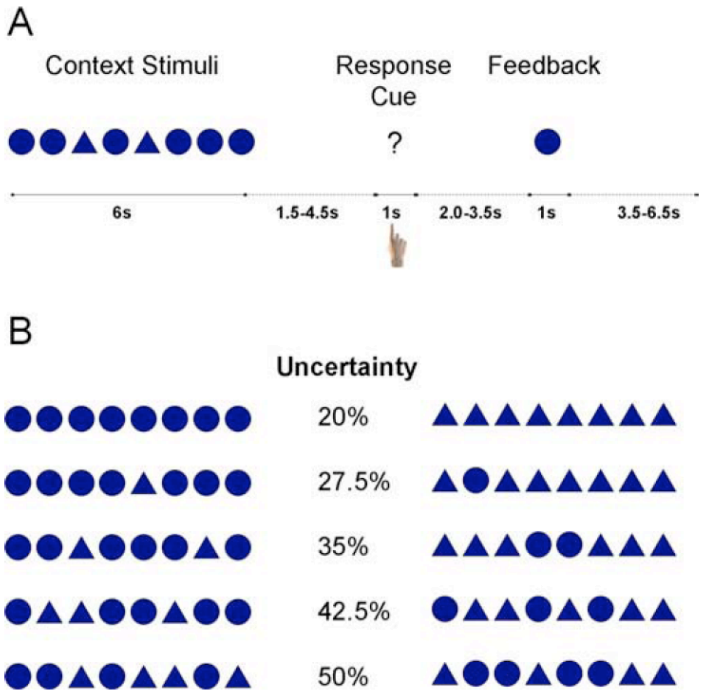
Question

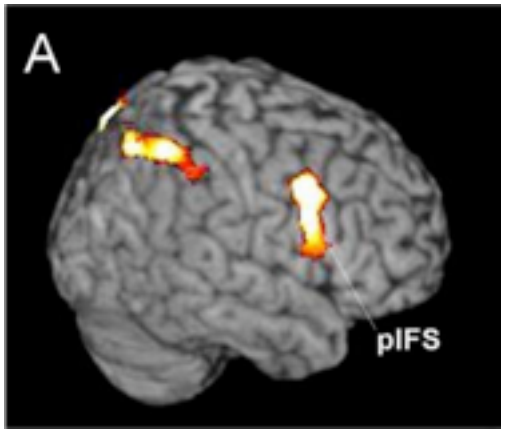
Is risk processing specifically influenced by emotions?

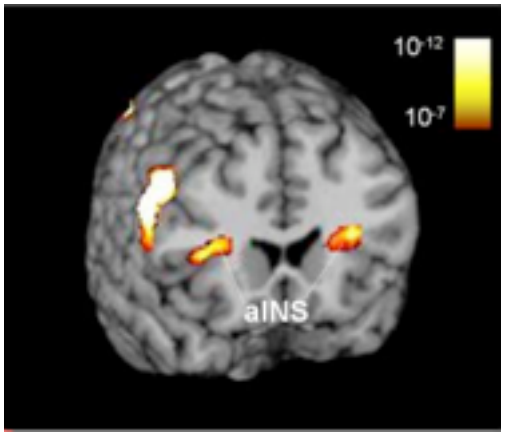
Behavioral evidence:

- Emotions influence judgements of perceived risk (e.g., Lerner/Keltner, 2000)

Neural Representations of Risk

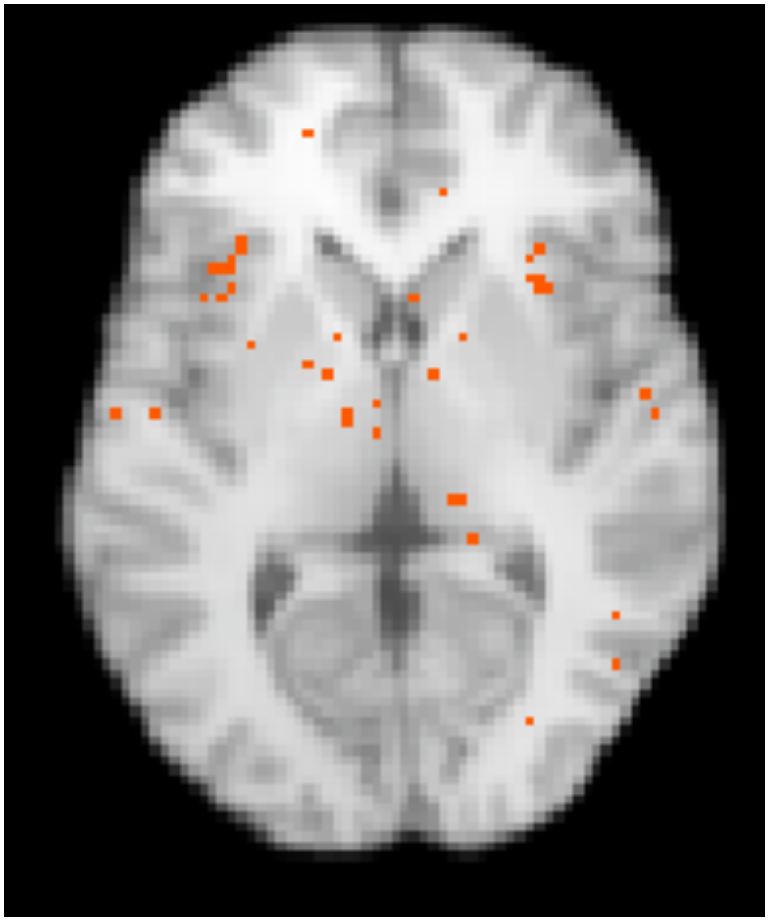


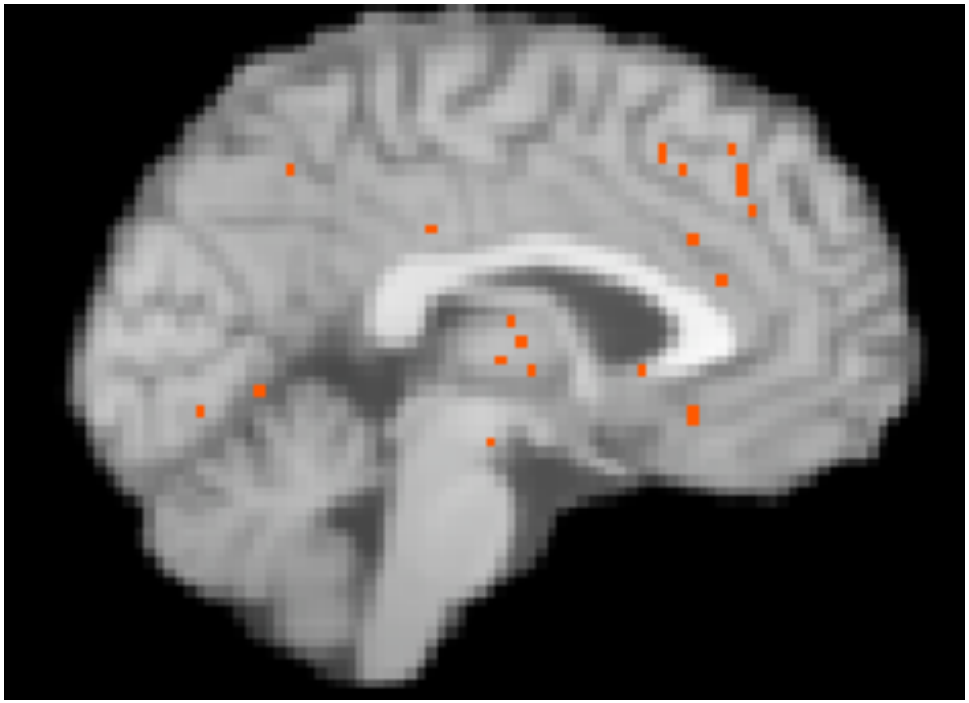




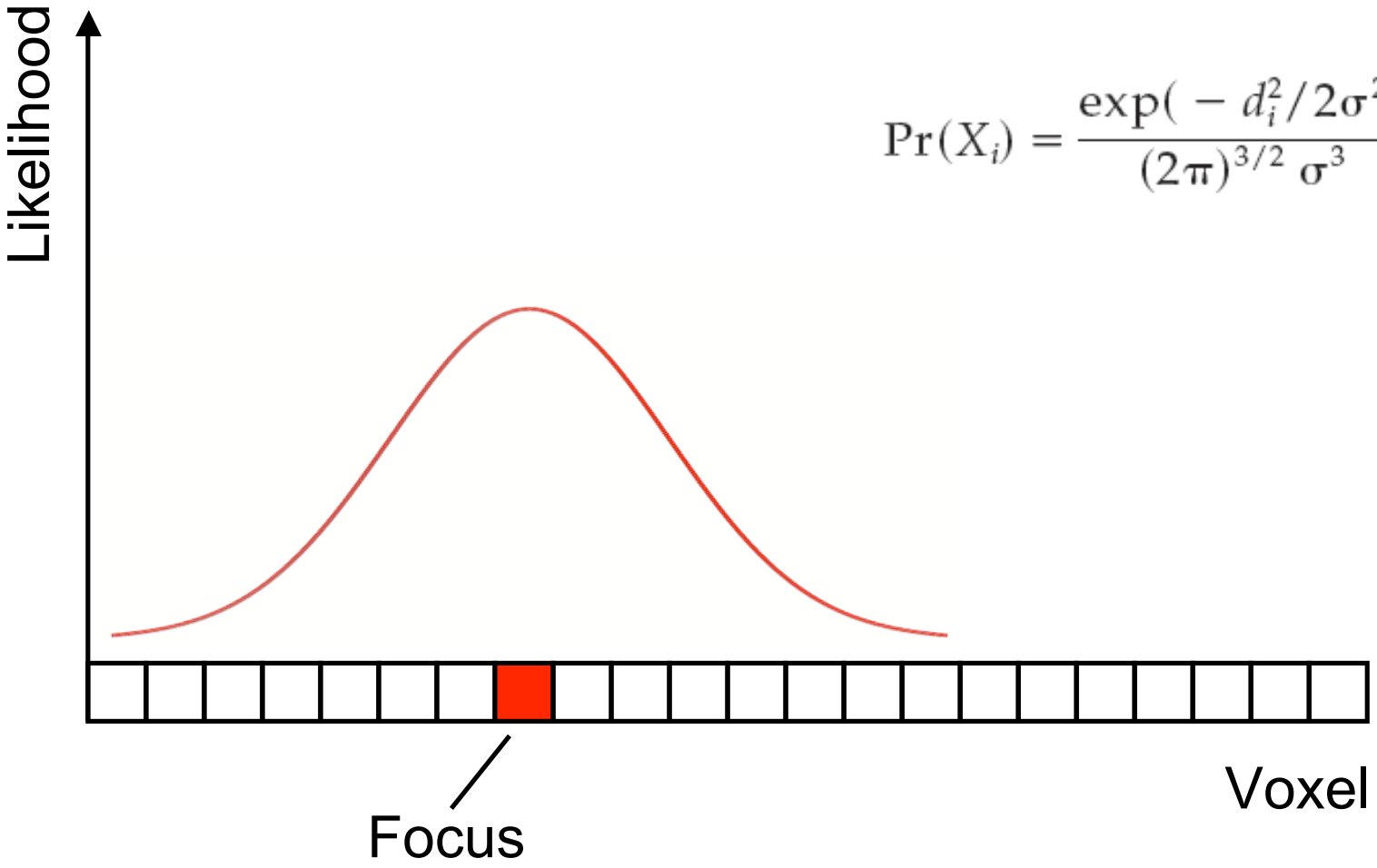
Huettel et al. 2005

Risk in the Brain





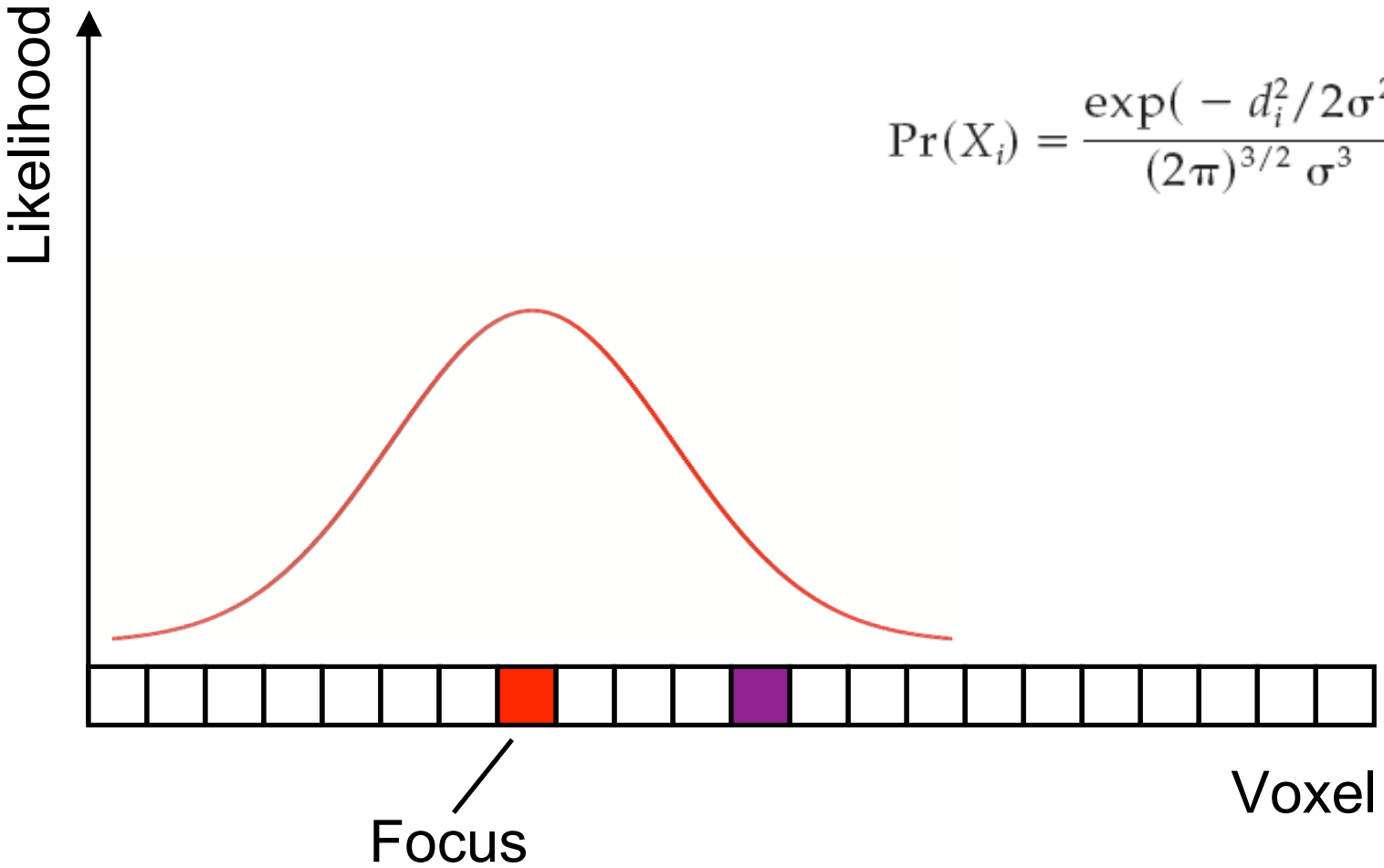
Activation Likelihood Estimation (ALE) Meta-Analysis



$$\Pr(X_i) = \frac{\exp(-d_i^2/2\sigma^2)}{(2\pi)^{3/2}\,\sigma^3} \cdot \Delta V$$

Turkeltaub et al. 2002; Laird et al. 2005

ALE Meta-Analysis



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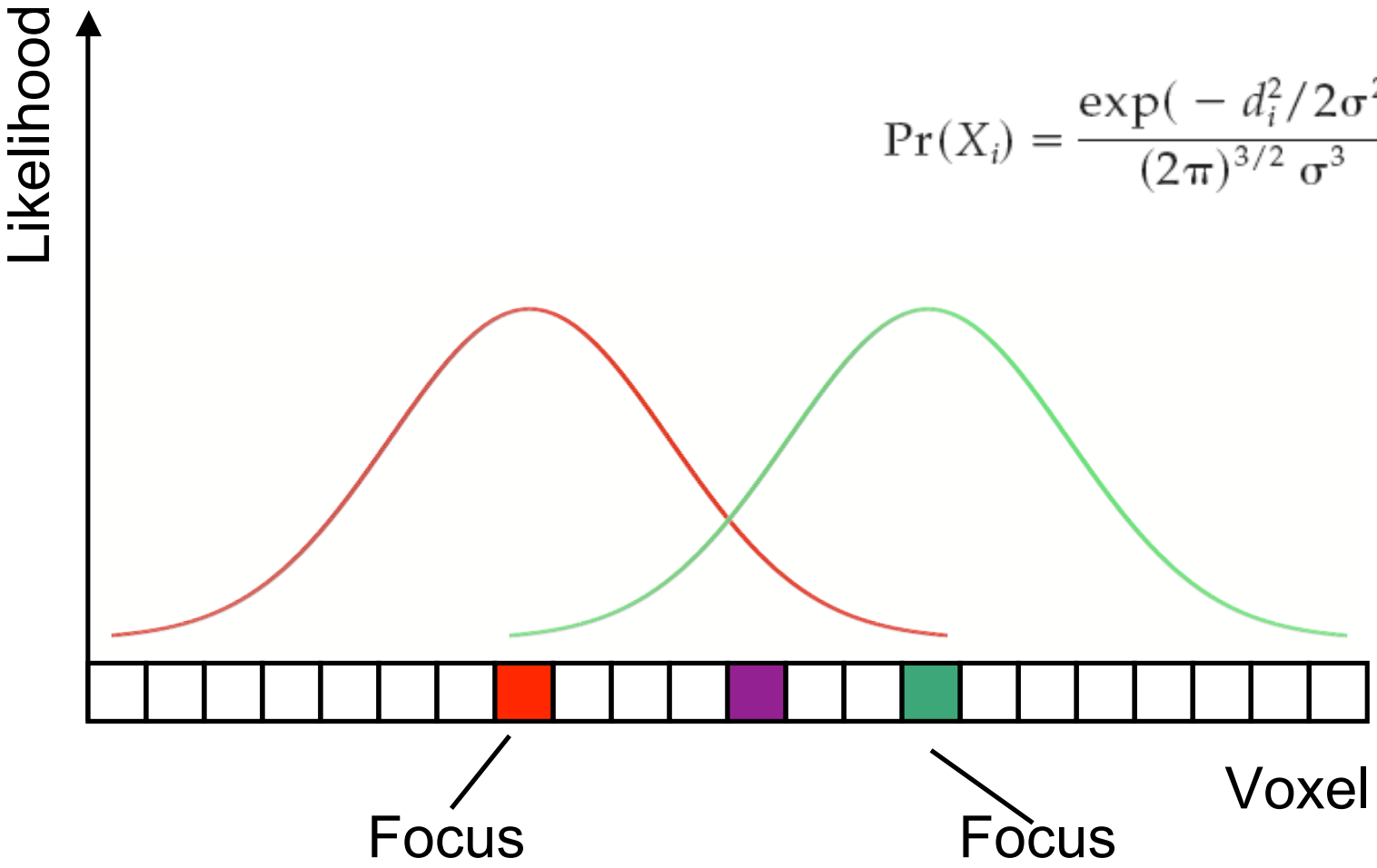

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ALE Meta-Analysis

- voxel-wise meta-analysis
- ALE statistic

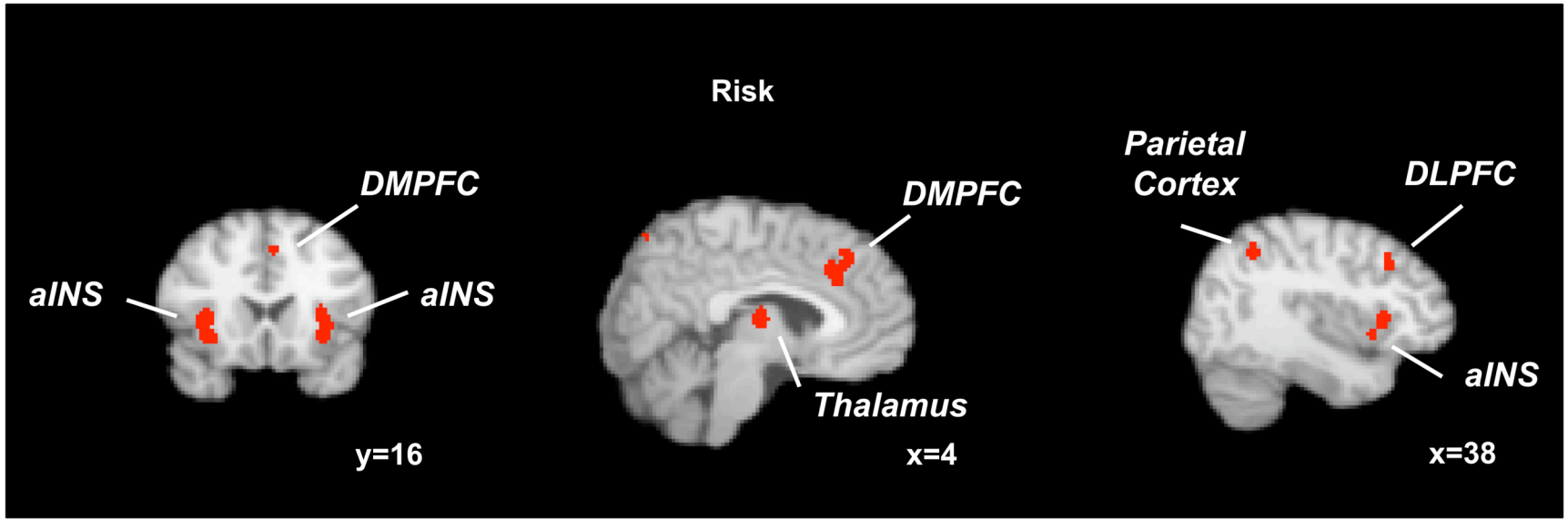
$$\Pr(X_i) = \frac{\exp(-d_i^2/2\sigma^2)}{(2\pi)^{3/2}\,\sigma^3} \cdot \Delta V$$

- statistical test based on null distribution generated via permutations
- frequently applied in neuroscience (e.g. Di Martino et al., 2008; Witt et al., 2008; Spreng et al., 2008; Buchsbaum et al., 2005; etc.)

Risk Meta-Analysis

- ALE Meta-Analysis
- 30 studies
- 232 foci
- explicitly examined risk or uncertainty
- published from 2001 to 2009
- including contrasts (risky vs. riskless; high risk vs. low risk) and correlations with risk

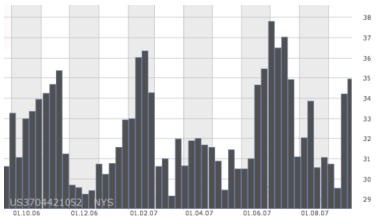
Risk Meta-Analysis



Mohr et al. (2010)

Decision vs. Anticipation Risk

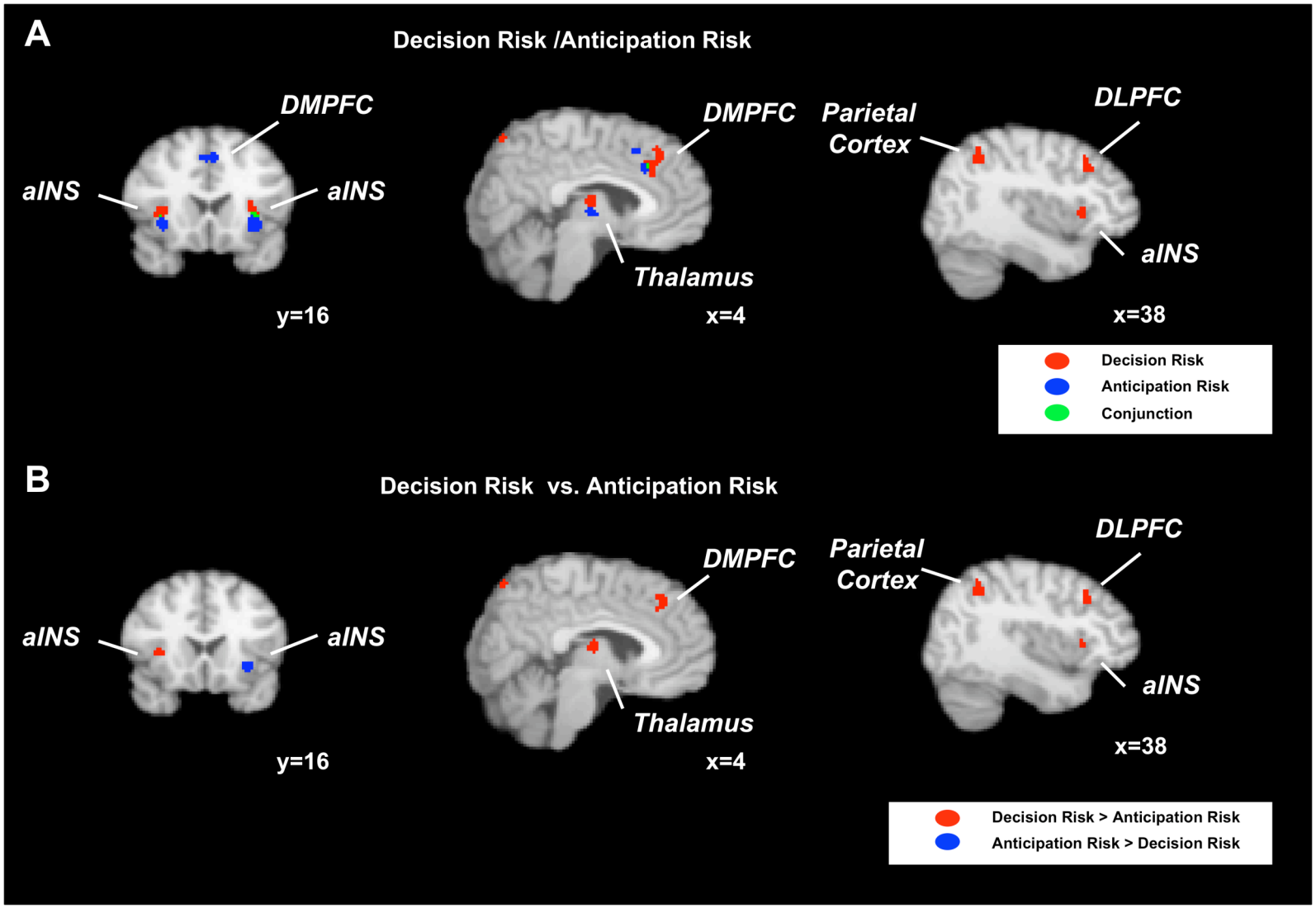
- Decision Risk:
  - Risk of a gamble in a choice situation (need for action)
  - Example: Choosing between stocks



- Anticipation Risk:
  - Risk of a gamble in anticipation of an outcome (no need for action)
  - Example: Observing a Roulette wheel

- Difference:
  - Preferences are based on Decision Risk

Decision vs. Anticipation Risk



Mohr et al. (2010)

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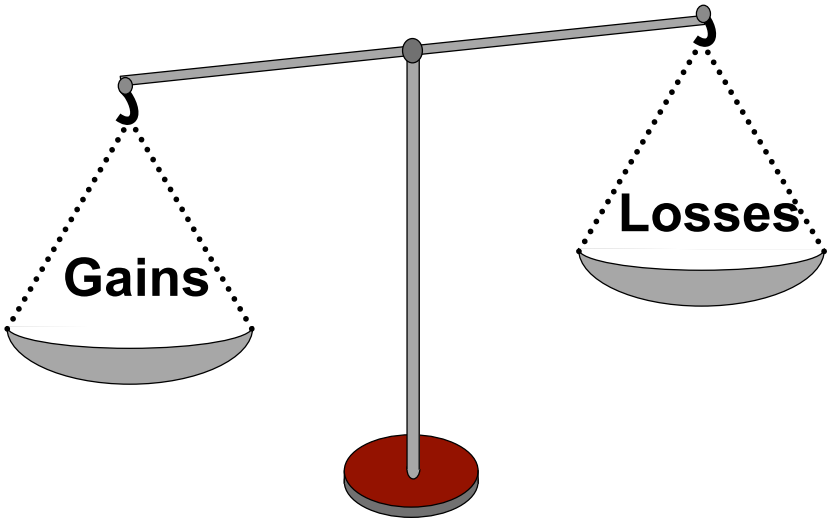
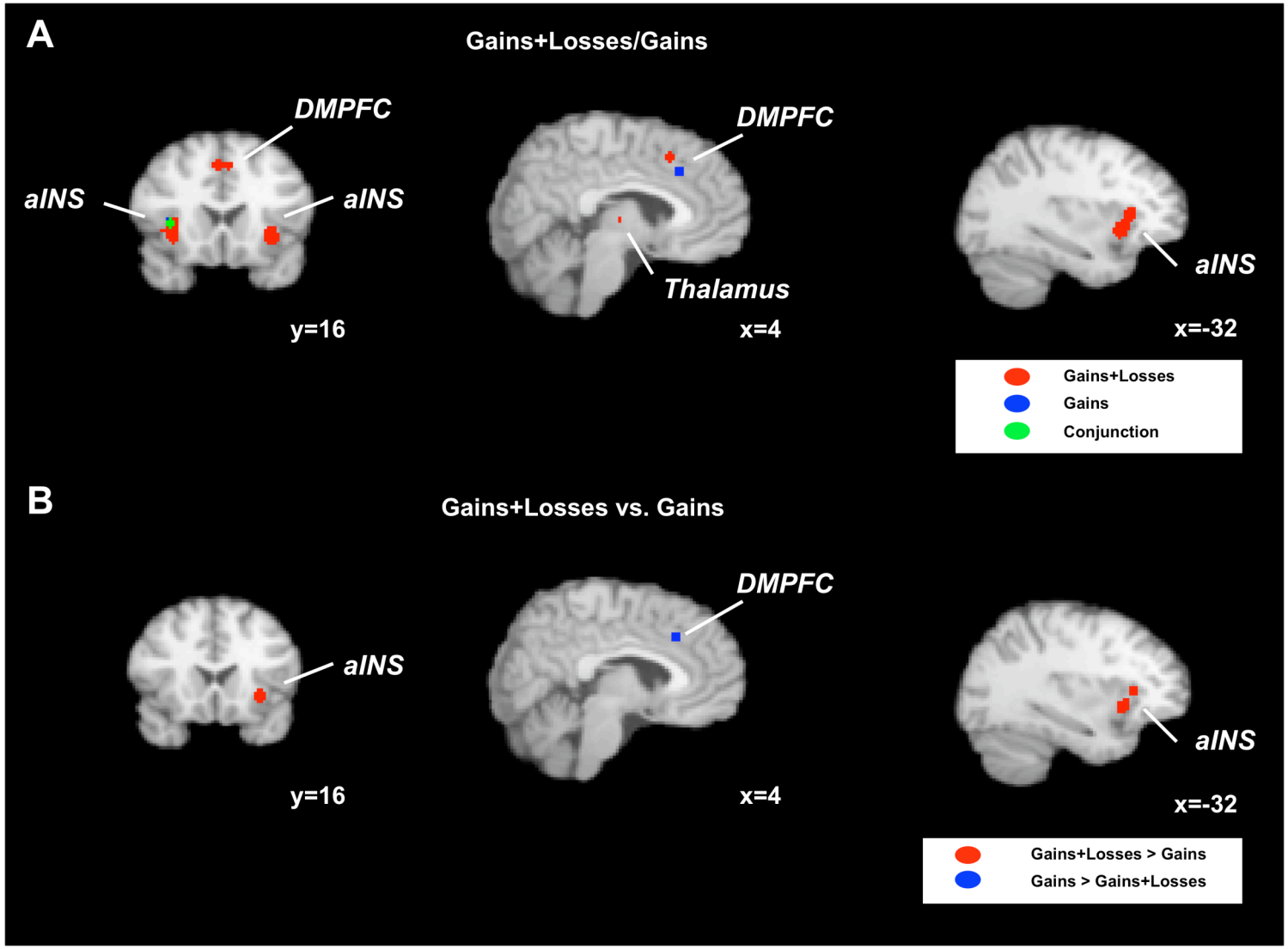
Gain vs. Loss Domain



Gains+Losses vs. Gains

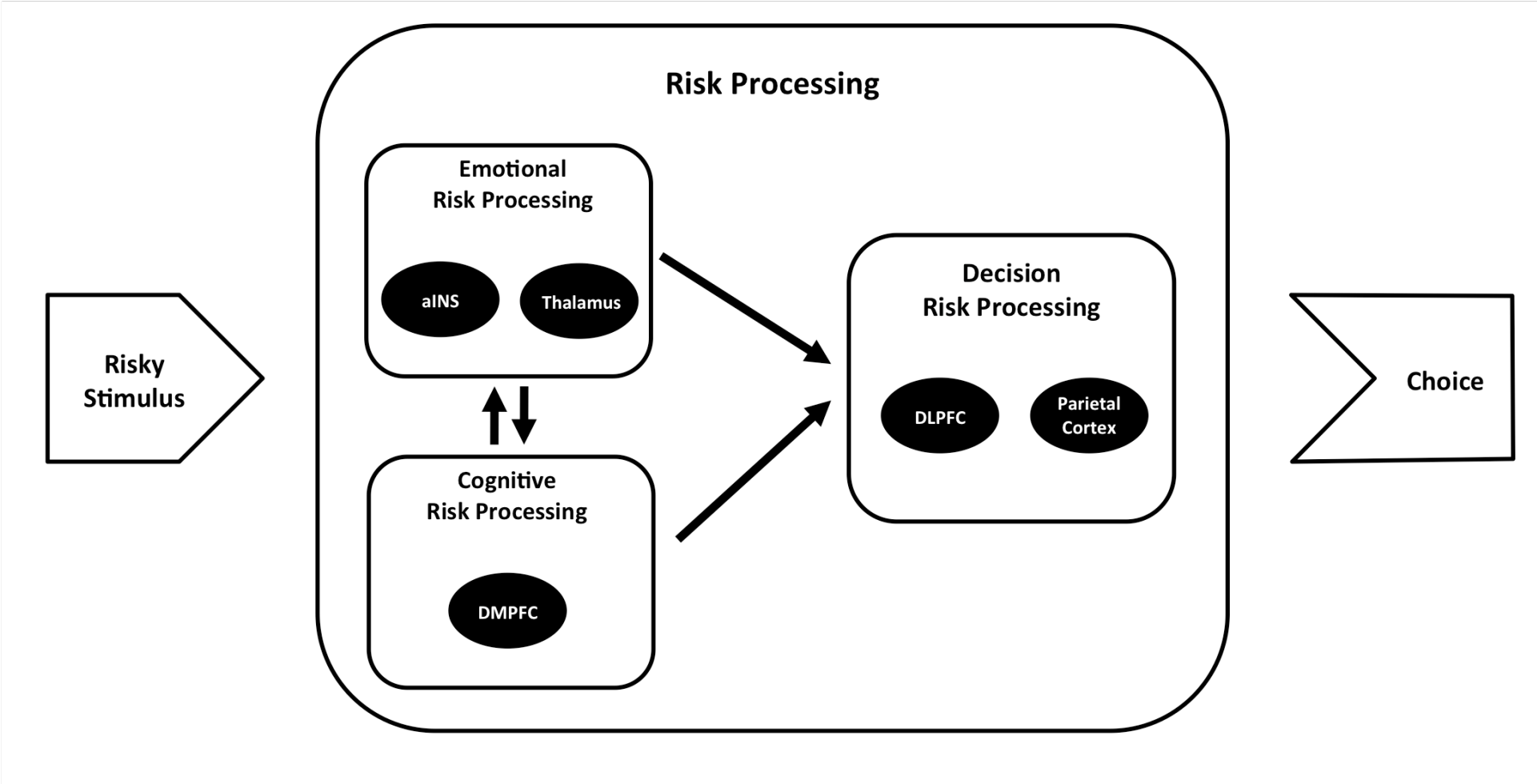


Mohr et al. (2010)

Conclusion

- Activitions in the aINS and the Thalamus suggests that risk processing is performed on an emotional level.
- Activations in the DMPFC suggests that risk processing is also performed on a cognitive level.
- Exclusive activations in DLPFC and parietal cortex for decision risk but not for anticipation risk suggest that these brain regions integrate the risk information into the decision making process.
- Stronger activation in the aINS when faced with potential losses indicate that losses modulate risk processing and that the emotional influence on risk processing is especially pronounced when losses are possible.

Risk Processing



Thanks to

Hauke Heekeren

Guido Biele

Backup

ALE statistic

$$\Pr(X) = \Pr(X_1 \cup X_2 \cup \cdots \cup X_n) = \Pr(\cup_i X_i)$$

$$\Pr(X) = 1 - \Pr(\overline{\cup_i X_i}).$$

$$\overline{A \cup B} = \overline{A} \cap \overline{B}.$$

$$1 - \Pr(\overline{\cup_i X_i}) = 1 - \Pr(\cap_i \overline{X_i}).$$

$$\Pr(\cap_i \overline{X_i}) = \Pr(\overline{X_1}) * \Pr(\overline{X_2}) * \cdots * \Pr(\overline{X_n})$$

$$\Pr(X) = 1 - [\Pr(\overline{X_1}) * \Pr(\overline{X_2}) * \cdots * \Pr(\overline{X_n})]$$

$$\Pr(X) = 1 - [(1 - \Pr(X_1)) * (1 - \Pr(X_2)) * \cdots * (1 - \Pr(X_n))]$$