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Abstract

Decision-making is strongly influenced by the counterfactual anticipation of personal regret and relief, through a learning process involving the ventromedial-prefrontal cortex. We previously reported that observing the regretful outcomes of another's choices reactivates the regret-network. Here we extend those findings by investigating whether this resonant mechanism also underpins interactive-learning from others' previous outcomes. In this functional-Magnetic-Resonance-Imaging study 24 subjects either played a gambling task or observed another player's risky/non-risky choices and resulting outcomes, thus experiencing personal or shared regret/relief for risky/non-risky decisions. Subjects' risk-aptitude in subsequent choices was significantly influenced by both their and the other's previous outcomes. This influence reflected in cerebral regions specifically coding the effect of previously experienced regret/relief, as indexed by the difference between factual and counterfactual outcomes in the last trial, when making a new choice. The subgenual cortex and caudate nucleus tracked the outcomes that increased risk-seeking (relief for a risky choice, and regret for a non-risky choice), while activity in the ventromedial-prefrontal cortex, amygdala and periaqueductal gray-matterreflected those reducing risk-seeking (relief for a non-risky choice, and regret for a risky choice). Crucially, a subset of the involved regions was also activated when subjects chose after observing the other player's outcomes, leading to the same behavioural change as in a first person experience. This resonant neural mechanism at choice may subserve interactive-learning in decision-making.

Crucially, there was a significant interaction between the *agent* of the preceding choice and the *gender* of the subject [$F(2,40) = 3.39$; $p = 0.043$]: although the gender of the subject was not significant *per se* [$F(1,20) = 1.46$; $p = 0.24$], female subjects were more prone than males to an influence from the other player's outcomes. This difference may be related to the higher empathic aptitude observed in females than males, as assessed with the Balanced-Emotional-Empathy-Scale (BEES). Mean scores were 53.83 (s.d. = 11.67) for females and 23.08 (s.d. = 27.11) for males, and revealed a significant difference, females being more empathic than males (Kolmogorov–Smirnov test for normality: $d = 0.19$, $p > 0.2$; two-sample *t*-test, $N = 24$, $t(22) = 3.62$, $p = 0.007$).