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Monetary incentive provokes hazardous landing decision making by enhancing the activity of “emotional” neural pathways

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Introduction: In aeronautics accident analysis reveals that emotional concerns (economic pressure, passengers' anxiety...) lead some pilots to irrational decision making such as keeping landing on whereas all safety parameters are not respected. Moreover, the uncertainty of the landing situation is often a worsening factor as it generates psychological stress. Our assumption, based on existing fMRI studies on “emotional reasoning” (Goel & Dolan 2003), is that hazardous landing is due to an enhanced activation in ventromedial prefrontal cortex (VMPFC), linked to the limbic system, and a suppression of activation in lateral dorsolateral prefrontal cortex (L/DLPFC), one of the main centers of executive functions. Our goal is to uncover, in a simplified landing task, the neural and behavioral consequences of the emotional pressures that weight on the pilot's decision through a payoff matrix. The abstract presents our preliminary results.

Methods: The task (figure 1) is based on a simplified reproduction of an authentic ground-based instrument approach system that provides lateral and vertical guidance to adjust the trajectory of the aircraft to the runway according to the position of two rhombuses. The instruction is that the landing is safe when both rhombuses are close to the centre of their axes, the farthest from the centre the rhombuses are, the higher is the risk of crash. In each trial, the responses (accept landing or go-around) are given by pressing a response button during the stimulus presentation. We use a 2x2 factorial design crossing the monetary incentive (presence and absence) and the uncertainty (high, 50% chance of crash, or low, 100% or 0% chance of crash). Stimulus display and data acquisition are done with Cogent 2000 v125. Twelve subjects performed the behavioral task. One subject (age 28) was scanned in the fMRI. All the data were acquired in a single session on a 3 T Allegra scanner (Siemens Medical Solutions, Erlangen, Germany).

Results: The behavioral study showed a significant increase of landing acceptance under high uncertainty with monetary incentive vs. neutral ($p < 0.01$). We investigated which brain regions were differently involved in decision making under monetary incentive and neutral by performing overall contrasts including choice and delay (figure 2). The neutral reasoning showed an increased activity in right DLPFC and occipital cortex. On the contrary, the monetary incentive increased activity in bilateral VMPFC. An effect of the level of certainty was also found on neutral reasoning: low uncertainty increased activity of bilateral anterior cingulate cortices (ACC) whereas high uncertainty increased right DLPFC.

Conclusions: These results confirm the strong functional relationship between DLPFC and VMPFC, during reasoning under emotion. The modulation of occipital cortex activation gives clues on the possible top-down perturbing effect of monetary incentive on visual information processing. These observations are supported by behavioral results. The level of uncertainty also modulates activities in DLPFC and ACC, important centers of rational reasoning. fMRI sessions are currently performed and include a total of 16 subjects.

References: Goel, V., Dolan, R. (2003). Reciprocal neural response within lateral and ventral medial prefrontal cortex during hot and cold reasoning. *NeuroImage* (20), 2314–2321.

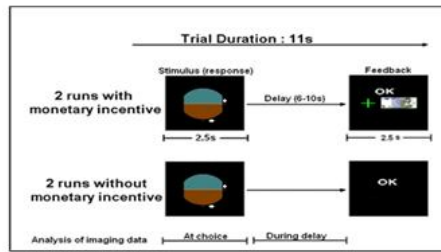


Figure 1. A total of 4 runs (2 neutrals, 2 with incentive) are performed. Each trial consists in a presentation of the stimulus (2.5 s), followed after a variable delay (6-10 s) by the feedback informing of the success or the failure, plus the outcome ($\{+5\text{€}\}$, $\{-5\text{€}\}$ or $\{-2\text{€}\}$ depending on the response) during incentive trials. Feedback and monetary reward are contingent upon the subject's response.

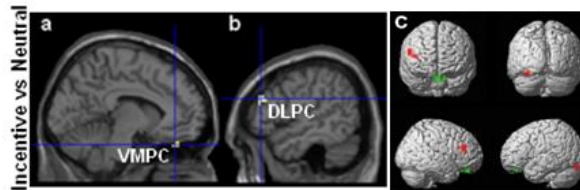


Figure 2. (A) Increased activation of the bilateral VMPFC (BA11) for monetary incentive vs. neutral. $P < 0.01$; $k > 15$. (B) Increased activation of the right DLPFC (BA46) for neutral vs. monetary incentive. $P < 0.01$; $k > 15$. (C) Global patterns for monetary incentive (in green) and neutral (in red) conditions. Left occipital cortex (BA18) activity was also increased during neutral vs. monetary incentive. $P < 0.01$; $K > 15$.