Alpine Brain Imaging Meeting, January 2007, Champéry, Switzerland.

Impulsive Decision Making

Findings from the modeling of 3 versions of the Iowa Gambling Task

Affective Sciences
SWISS NATIONAL CENTER OF COMPETENCE IN RESEARCH

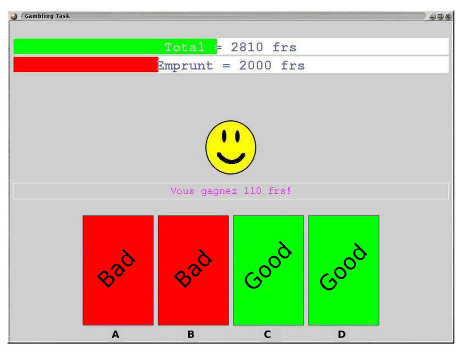
Mathieu d'Acremont	Swiss NCCR in Affective Sciences, University of Geneva
Manfred Gilli	Department of Econometrics, University of Geneva
Martial Van der Linden	Department of Psychology, University of Geneva
Antoine Bechara	Brain and Creativity Institute, University of Southern California

The Iowa Gambling Task (IGT)

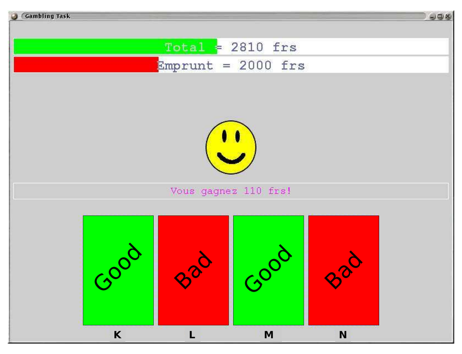
- The ABCD version of the IGT (Bechara et al., 1994) is frequently used in neuropsychology and psychopathology to assess decision-making;
- Participants have to select among 4 decks of cards, each selection is followed by a reward or a punishment (gain or loss of fictive money). Selections are repeated 100 times;
- Bad decks are disadvantageous (loss in the long run), good decks are advantageous (gain in the long run).

New versions of the IGT

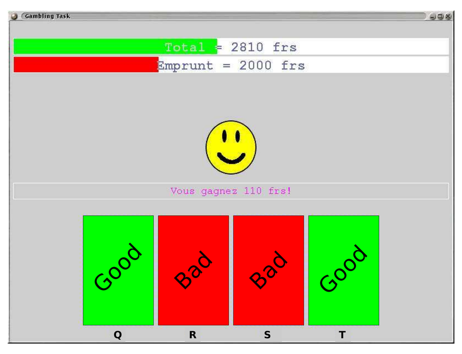
- Version KLMN and QRST were recently created to allow repeated assessments of decision making;
- Position of the good decks changes from one version to the other;
- Difficulty increases from one version to the other.



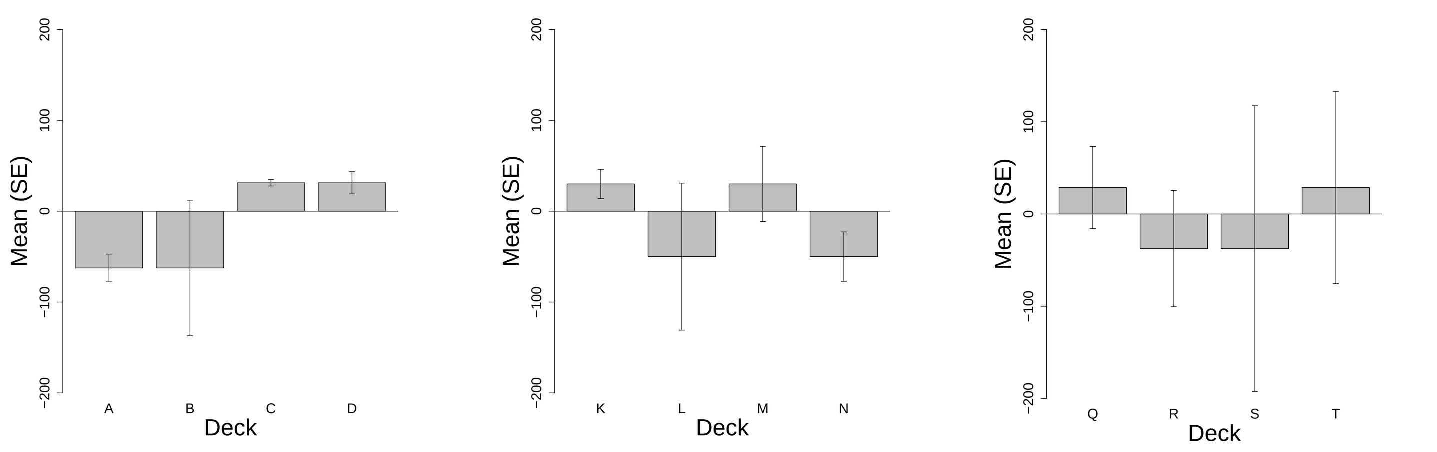
Version ABCD.



Version KLMN.



Version QRST.



Expected gain.

Modeling decision-making

- Decision-making in the IGT depends on several psychological processes;
- Authors (Busemeyer & Stout, 2002) have used a reinforcement learning model with 3 parameters to explain performance in the IGT:
  1. An updating rate ($0 < \beta < 1$);
  2. A sensitivity to reward ($0 < \sigma < 1$);
  3. An exploration tendency ($0 < \tau$).

Rational and aims

- The ABCD version has been used to model decision-making;
- This is problematic because it has been shown that model parameters are unreliable when estimated on only 100 trials (d'Acremont et al., 2006);
- Based on this limitation, our aims were twofolds:
  1. See if the model parameters are more reliable when estimated on the 3 versions of the IGT offering 300 trials (simulation);
  2. Estimate the model parameters on data collected with the 3 versions of the IGT and explore their relationships with impulsivity (application on real data).

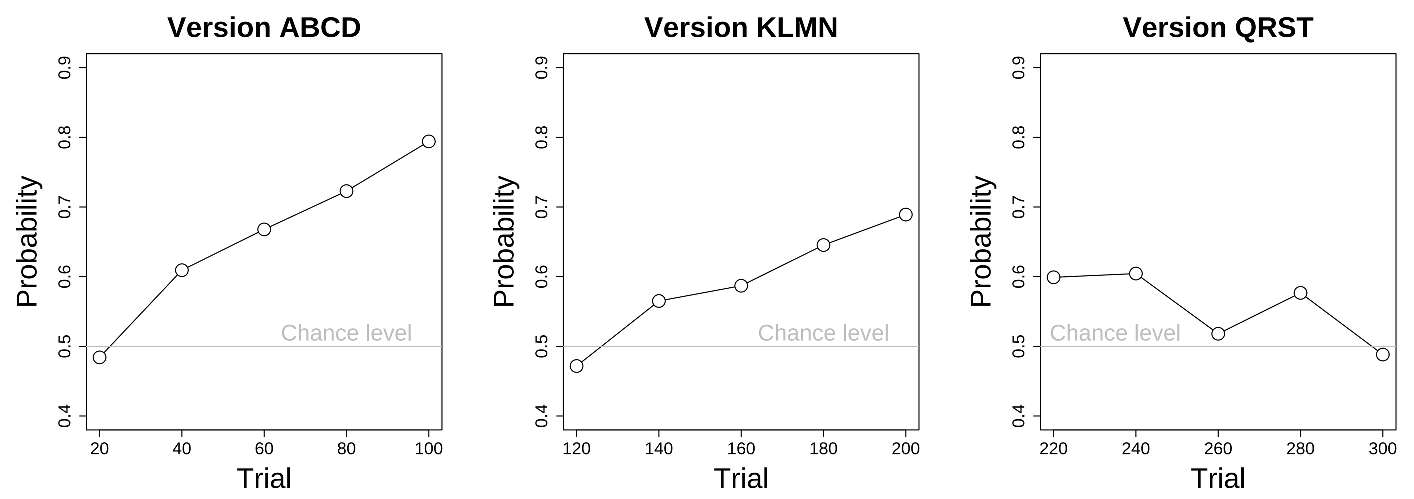
Simulated decisions

Reinforcement learning algorithm:

Initialize action probability $p_i = 0.25, \quad i = 1, \ldots, 4$
Initialize action value $\texttt{ActVal}_i = 0, \quad i = 1, \ldots, 4$
for $k = 1 : n$ **do**
  Select deck i according to p
  $\texttt{RewVal} = (\sigma\, \texttt{Reward}_i + (1 - \sigma)\, \texttt{Punish}_i)$
  $\texttt{PredErr} = \texttt{RewVal} - \texttt{ActVal}_i$
  $\texttt{ActVal}_i = \texttt{ActVal}_i + \beta\, \texttt{PredErr}$
  $x_i = \exp(\texttt{ActVal}_i / \tau), \quad i = 1, \ldots, 4$
  Update action probability $p_i = x_i / \sum_{j=1}^{4} x_j$
end for

Simulation on version ABCD, KLMN, and QRST:

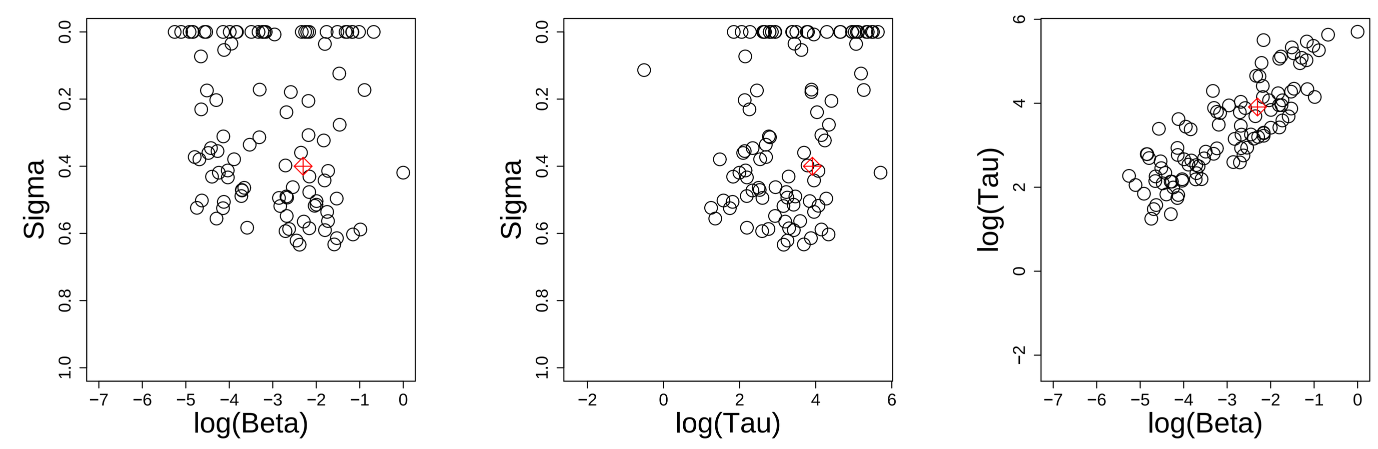
- Parameters in the learning algorithm are fixed to: a moderate updating rate ($\beta = .10$), a low sensitivity to reward ($\sigma = .40$), and a tendency to explore the environment ($\tau = 50$);
- The learning algorithm is used to simulate the decision of one "subject";
- Results indicate that the probability to select the good decks increases with trials in the ABCD and KLMN version ⇒ the algorithm learns to take advantageous decisions;
- There is no learning in the QRST version ⇒ this result reflects the difficulty of version QRST.



Probability to select the good decks.

Estimation on version ABCD:

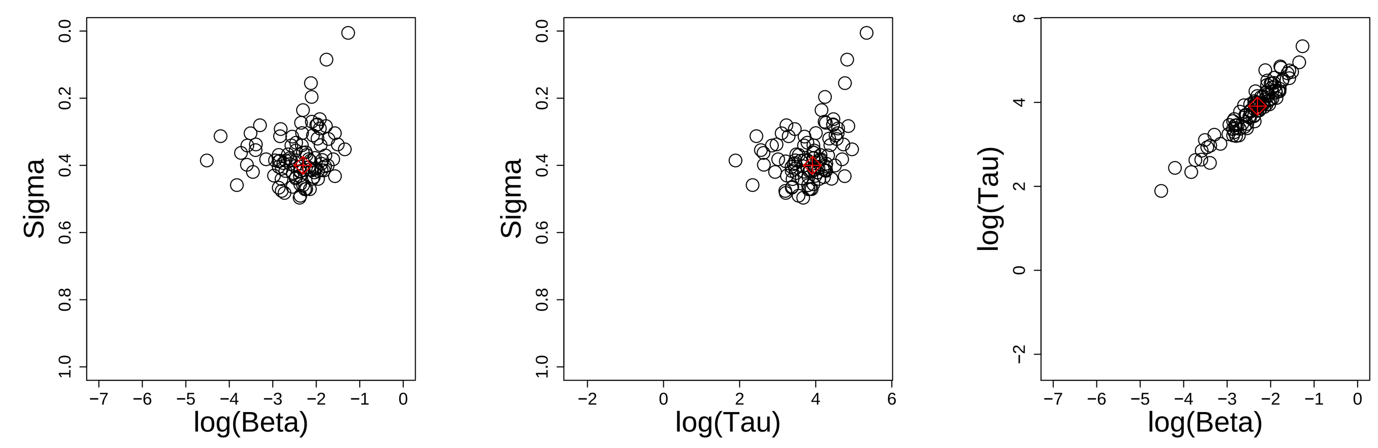
- Parameters in the learning algorithm are fixed to the same values: ($\beta = .10$, $\sigma = .40$, $\tau = 50$);
- Decisions for 100 "subjects" are simulated with the learning algorithm on version ABCD;
- For each "subject", the models parameters are estimated by mean of maximum likelihood;
- Results show a high variability of the estimated parameters around the fixed parameters.



The red point = fixed parameters. Small points = estimated parameters for 100 "subjects".

Estimation on version ABCD, KLMN, and QRST:

- The same strategy is used, but decisions for the 100 "subjects" are simulated on the 3 versions;
- Results show a reduced variability of the estimated parameters around the fixed parameters ⇒ the reliability of the estimated parameters increased with the use of the 3 versions;



The red point = fixed parameters. Small points = estimated parameters for 100 "subjects".

Parameter estimation from real data

- 61 adults completed successively the 3 versions of IGT and the UPPS Impulsive Behavior Scale (Whiteside & Lynam, 2001);
- The model parameters (β, σ, τ) were estimated for each subject on the 300 trials;
- A significant correlation was found between lack of Premeditation (one aspect of impulsivity) and sensitivity to reward, r = .34*, 95% CI = (.09, .55);
- This results corroborate the hypothesis of a higher sensitivity to reward in impulsive subjects (Corr et al., 1995);

Conclusions

- Simulation revealed that the use of 3 versions of the IGT gives a more accurate estimation of the parameters;
- An application on real data showed a meaningfull relationship between one aspect of impulsivity and decision-making.

References

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, *50*, 7–15.

Busemeyer, J. R., & Stout, J. C. (2002). A contribution of cognitive decision models to clinical assessment: Decomposing performance on the Bechara gambling task. *Psychological Assessment*, *14*, 253–262.

Corr, J., P., Pickering, D., A., & Gray, A., J. (1995). Personality and reinforcement in associative and instrumental learning. *Personality and Individual Differences*, *19*(1), 47–71.

d'Acremont, M., Gilli, M., & Van der Linden, M. (2006, January). *Modeling decision making in the Iowa Gambling Task.* Poster session presented at the Alpin Brain Imaging Meeting, Champéry, Switzerland.

Whiteside, P., S., & Lynam, R., D. (2001). The five factor model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and Individual Differences*, *30*(4), 669–689.