Looks like a bad sign: EEG and behavioral data reveal a biased perception of correlation between the outcomes of choice options

Deborah Marciano-Romm[1, 2], Assaf Romm[4], Sacha Bourgeois-Gironde[5,6] , Shlomo Bentin[1,3] & Leon Y. Deouell[1,3]

1. Department of Psychology; 2. Federmann Center for the Study of Rationality; 3. Edmond and Lily Safra Center for Brain Sciences - The Hebrew University of Jerusalem; 4. Harvard University; 5. Department of Economics, LEMMA, Université Paris 2; 6. Institut Jean-Nicod, Ecole Normale Supérieure

Background

- Following a choice, we sometimes get feedback on both the outcome of the chosen option and the alternative outcome.
- Behavioral research has shown that in such cases people engage in outcomes comparison: the alternative outcome influences the way one evaluates his own outcome.
- In an EEG study, we tested whether the FRN (Feedback-Related Negativity) is sensitive to outcomes comparison.
- The FRN is an event-related potential associated with outcome evaluation. It distinguishes between losses and gains. Its amplitude correlates with subjective feelings of pleasantness.
- The surprising results we got led us to explore the possibility that people see an illusory negative correlation between the outcomes of choice options - an hypothesis confirmed by 3 behavioral experiments.

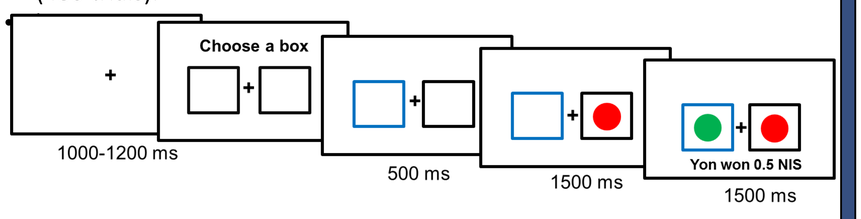
Exp. 1 – FRN and outcome comparison

Question

Is the FRN elicited by the received outcome influenced by the alternative outcome?

Method

- EEG was recorded from 64 electrodes.
- Subjects chose one of two boxes. Each box contained a green coin (gain) or a red coin (loss). The alternative outcome was always revealed first (480 trials).

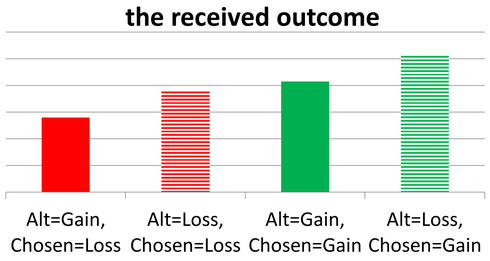


- Subjects were told that the outcomes of the two boxes were independent. They were NOT told that each box had a probability of 0.5 of containing a green coin.

Hypothesis

If the FRN elicited by the outcome of the chosen box is sensitive to outcomes comparison, its amplitude should reflect past behavioral findings.

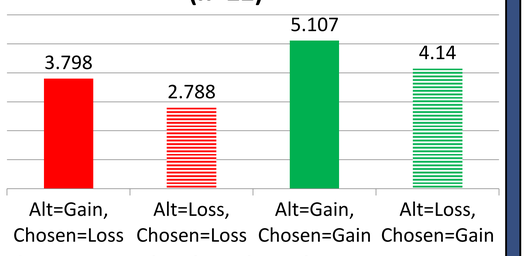
HYPOTHETICAL results- Mean amplitude of the FRN elicited by the received outcome



Results

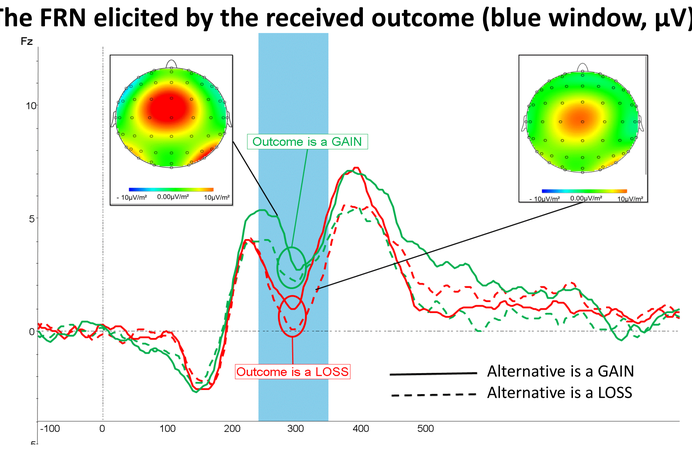
- The FRN elicited by the outcome of the chosen box was significantly modulated by the alternative outcome ($F=5.928$, $p=0.026$), but not in the expected way.

Mean amplitude (μV) of the FRN elicited by the received outcome* (n=22)



*100 ms around peak, at electrodes Fpz, Fz, Fcz, Cz, Pz.

The FRN elicited by the received outcome (blue window, μV)



- Gu et al. (2011) obtained similar results.

Searching for an explanation to our results

- In Exp. 1, it looks as if subjects used the alternative outcome as a cue regarding their outcome, even though the two outcomes were independent.
- **Hypothesis**: People see a good/bad alternative outcome as a bad/good sign regarding the outcome of the chosen option, when the two outcomes are in fact uncorrelated.

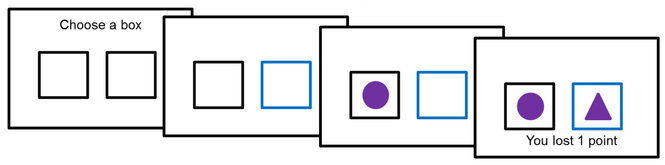
Exp. 2 – The Prediction Game

Method

Two types of trials were mixed:

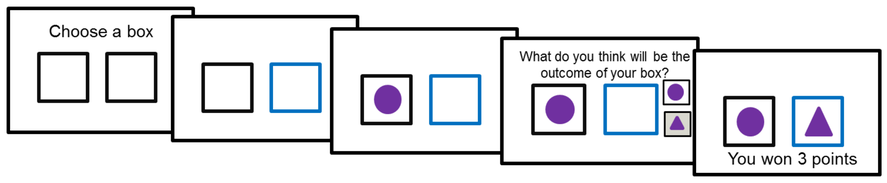
- **Regular Trials** (50):

As in Exp. 1, subjects chose one of two boxes. The unchosen box was opened first. The shape in the chosen box determined subjects' payoffs:



- **Prediction trials (30)**

After the unchosen box was opened, subjects were asked to predict what the chosen box contained. They won 3 points when their predictions were accurate.

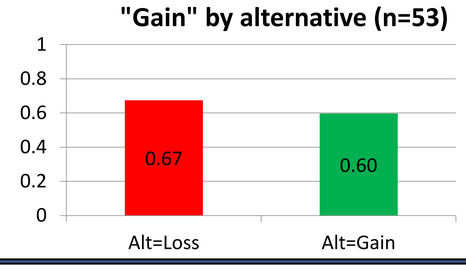


Subjects were NOT told tha the contents of the two boxes were independent.

Results

Subjects were significantly more likely to predict "Gain" when the alternative outcome was a loss ($p<0.001$).

Mean probability of predicting "Gain" by alternative (n=53)



Exp. 3 – Pass or Take?

Question

Does the bias found in Experiment 1 influence decision-making?

Method

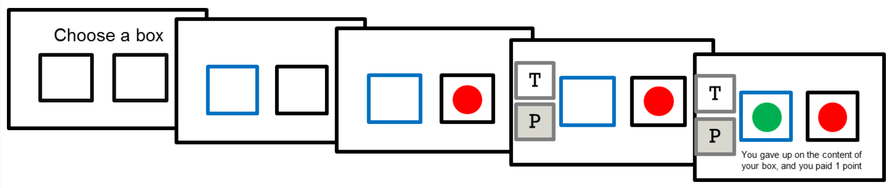
Two types of trials were mixed:

- **Regular Trials** (120):

Same as in Exp. 2, with green/red coins symbolizing gains/losses of 5 points.

- **Pass or Take Trials** (80):

After the unchosen box was opened, subjects were given the possibility to pay 1 point in order to give up the content of the chosen box ("Pass").



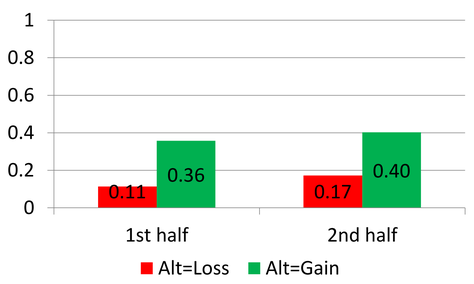
Hypothesis

If subjects see a good alternative as a bad sign regarding their outcome, they should be more likely to choose "Pass" when the alternative outcome is a gain.

Results

- Subjects were significantly more likely to choose "Pass" when the alternative outcome was a gain ($p<0.001$).
- The influence of the alternative decreased in the 2nd half of the experiment but it was significant in both halves ($p<0.001$; $p<0.001$; Alternative x Half Interaction: $p=0.046$).

Mean probability of choosing "Pass" by alternative and by half (n=40)



Exp. 4 – The Inverse Prediction Game

Question

Do subjects present the same bias when the outcome of the chosen option is shown first?

Method

- We replicated Exp. 2 with 2 between-subjects conditions:

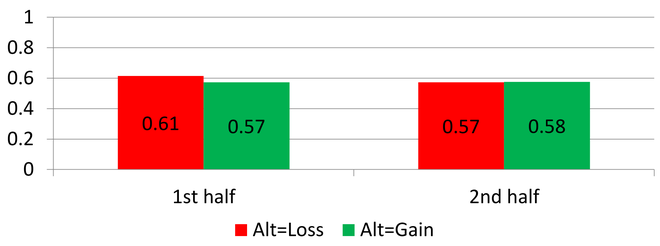
- "Alternative first": Subjects saw first the outcome of the alternative.
- "Chosen first": Subjects saw first the outcome of the chosen box.

- There were 120 Regular trials and 80 Prediction trials.

Results

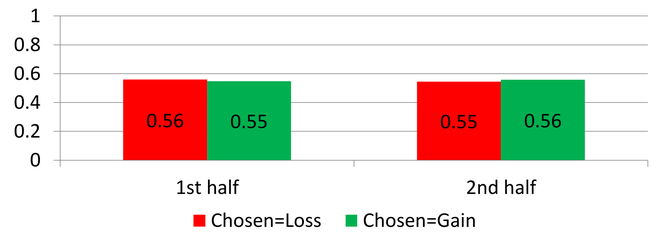
- We found a Condition x First_Outcome_Displayed x Half Interaction ($p=0.037$).
- In the Alternative First condition, subjects' predictions were biased in the 1st half of the experiment ($p=0.043$), but not in the 2nd half ($p=0.546$, Alternative x Half Interaction: $p=0.04$, one tailed).

Mean probability of predicting "Gain" in the Alternative First condition (n=40)



- No bias was found in the Chosen First condition (1st half: $p=0.263$; 2nd half: $p=0.499$, Chosen_outcome x Half Interaction: $p=0.223$)

Mean probability of predicting "Gain" in the Chosen First condition (n=40)



Conclusions

People are biased

- Exp.1 raised the question of whether people perceive an illusory negative correlation between the uncorrelated outcomes of choice options.
- In 3 behavioral experiments we found that subjects indeed viewed a good/bad alternative as a bad/good sign regarding their outcome.

Some caracteristics of this bias

- This illusory correlation influences decision making processes:

1) It can affect choice behavior (Exp.3).
2) By creating expectations, it is likely to impact subjects' satisfaction with their own outcome (Exp.1; Oliver, 1980).

- People can get "debiased" after being exposed to a high number of trials (Exp. 3 and 4).
- This bias differs whether you "care" or not: no bias was found when the outcome of the chosen box was presented first (Exp.4).

Future research

- In future EEG studies, we aim to disentangle the two effects of the alternative outcome – its influence through the creation of expectations, and its role as a reference point in outcome comparison.

References

- Gu, R., Wu, T., Jiang, Luo, Y-J. (2011). Woulda, coulda, shoulda: The evaluation and the impact of the alternative outcome. *Psychophysiology, 48*, 1354–1360
- Oliver, R. L. (1980). A cognitive model of the antecedents and consequences of satisfaction decisions. *Journal of marketing research*, 460-469.

For further information, please contact: dvorah.marciano@gmail.com