ウェブサイト公開用

（様式 10）
（海外特別研究員事業）

平成　31　年　　9月　10　日

海外特別研究員最終報告書

独立行政法人 日本学術振興会 理事長　殿

採 用 年 度　平成 29 年度
受 付 番 号　699
氏　　　名　飯谷 清仁

（氏名は必ず自署すること）

海外特別研究員としての派遣期間を終了しましたので、下記のとおり報告いたします。
なお、下記及び別紙記載の内容については相違ありません。

記

1. 用務地（派遣先国名）用務地：　カリフォルニア工科大学　（国名：　米国　）

2. 研究課題名（和文）※研究課題名は申請時のものと違わないように記載すること。
不確実な状況下での社会的意思決定の神経計算メカニズムの解明

3. 派遣期間：平成　29　年　9　月　5　日　～　平成　31　年　9　月　4　日

4. 受入機関名及び部局名
カリフォルニア工科大学人文社会学部

5. 所期の目的の遂行状況及び成果…書式任意　**書式任意（A4 判相当 3 ページ以上、英語で記入も可）**
（研究・調査実施状況及びその成果の発表・関係学会への参加状況等）
（注）「6. 研究発表」以降については様式 10－別紙 1～4 に記入の上、併せて提出すること。

5. 所期の目的の遂行状況及び成果

Neural and computational mechanism of social decision making under uncertainty

Summary of accomplishments:

1. Designed a novel decision-making experiment.
2. Performed fMRI experiments with healthy volunteers.
3. Built novel computational models.
4. Test computational models in behavioral data.
5. Analyzed fMRI data with our model.
6. Preregistered our analysis and results.
7. Performed a new set of fMRI experiments and analyzed data.

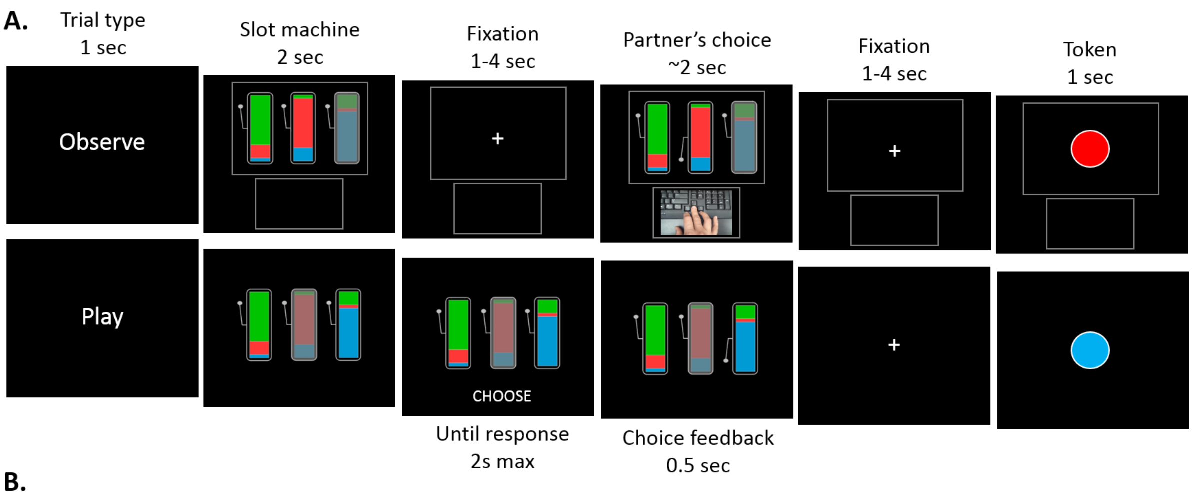
Remaining tasks:

1. Write up and submit our manuscript.

Details:

We designed and performed a novel experiment on social decision making in fMRI. This task consists of two types of trials: (1) In observing trials, the subject observes another agent’s choice about slot machines. Each slot machine is filled with three colors, the proportion of which predicts the chance of getting a token with the same color. One of the three colors can be exchanged with money, but the subject does not know the rewarding color. The agent has a full knowledge about this, so that the subject can learn, or infer, which token is valuable by observing the agent's decisions. (2) In choice trials, the subject needs to make his/her own decision about the slot machines. The subject can see which token was delivered but cannot see if the token was valuable or not.

The experiment has two by two design --- we manipulated the volatility and ambiguity in the experiment. The volatility was manipulated by changing the rate of un-signaled changes in valuable tokens. If the changes are frequent, then the agent's choice appears to be more volatile. In this case we predict that the subject tends to rely on emulation strategy, in which the subject infers which token is valuable, by integrating information about chosen slot machine. Another condition was ambiguity. Under a high uncertainty condition, the relative proportion of colors filling each slot machine is very close, so that the subject cannot easily compute the value of slot machine by colors. Under such a condition, we predict that the subject tend to use imitation strategy, in which the subject simply repeat the agent's most frequently repeated actions in recent trials.



B.

Stable, Low Uncertainty	14 trials			16 trials		
	17 trials			13 trials		
Stable, High Uncertainty	15 trials			15 trials		
	13 trials			17 trials		
Volatile, Low Uncertainty	5 tr.	5 tr.	4 tr.	4 tr.	6 tr.	6 tr.
	6 tr.	4 tr.	5 tr.	4 tr.	6 tr.	5 tr.
Volatile, High Uncertainty	5 tr.	4 tr.	6 tr.	6 tr.	4 tr.	5 tr.
	6 tr.	5 tr.	4 tr.	5 tr.	4 tr.	6 tr.

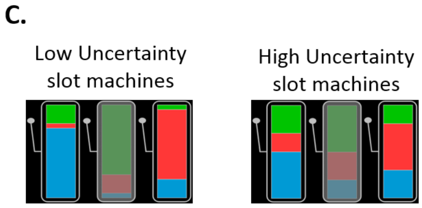


Figure 1. Observational Learning task design. (**A**) Illustration of two example trials (**B**) Outline of the task structure. (**C**) Illustration of low vs high token uncertainty conditions.

We preformed this task with healthy volunteers in fMRI scanner, and we found that subjects indeed changed their strategy according to the experimental conditions. In order to probe this more dynamically, we constructed novel computational models that arbitrate two strategies: emulation and imitation. We found that this model can account for the behavior better than other existing models (out-of-sample predictions).

Then we performed a model-based fMRI analysis. We fit our computational model to behavior, and generated predictions about fMRI signals. By this way, we identified a neural regions that are responsible for computing imitation and emulation strategies.

In response to recent criticism about reproducibility of fMRI experiments, we preregistered our results and analysis. Then we performed the same experiments and the same analysis for another set of 20 subjects. We found that our results were mostly reproducible.

Some of the results were presented at international conferences (please see below).

Other accomplishments

I have published a research article on the role of serotonin in learning and decision making (Iigaya et al. Nature Communications, 2018). In this paper we discovered that optogenetic stimulation of serotonin-, a neuro-modulator that is crucial in treating psychiatry disorders, neurons can speed up learning. This is particularly important for treatment of psychiatric disorders, because it is known that medications by antidepressant (selective serotonin reuptake inhibitors: SSRI) can be more effective if combined what is often referred to as cognitive behavioral therapy (CBT). The goal of CBT is in fact to encourage the patients to re-learn the old habit that underlies disorders. This is consistent with our finding that serotonin can make us neural system more plastic and (re)learn faster old habit.

I also published an article on the role of multiple timescales of learning (Iigaya et al. Nature Communications, 2019). In this paper we report evidence that animals integrate reward history over multiple timescales, and they use this to solve the so-called bias-variance tradeoff. Our study suggests multiple timescales of reward integrations as biologically plausible strategy for optimizing decision making under uncertainty.