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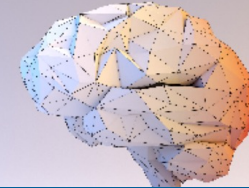


College of Liberal Arts
and Social Sciences

香港城市大學
City University of Hong Kong



Neuroimaging
Methods
Workshop



Incorporating mouse tracking in studies: From implementation to data modeling

Haiyan Wu (伍海燕)

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Dec 10, 2022

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and Department of Psychology
University of Macau



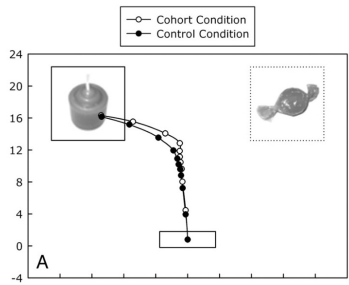
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Outline

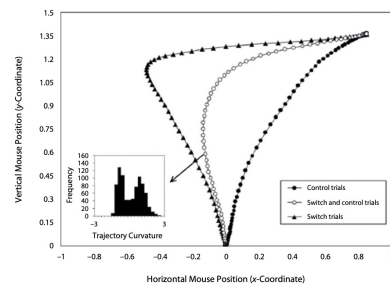
- **Introduction of mouse tracking (MT)**
- **Research examples**
 - Memory: aIAT with MT
 - Moral decisions with MT
 - Other decisions with MT
- **Implementations and data analysis**
 - Mouse tracker
 - Opensesame
 - Psychopy
 - Combine with EEG and fMRI

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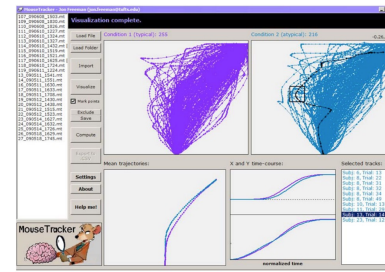
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Spivey, Grosjean, and Knoblich (2005)



Freeman et al. (2008)



MouseTracker: Software (2010)

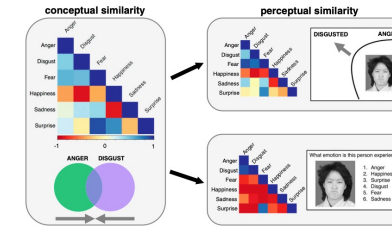
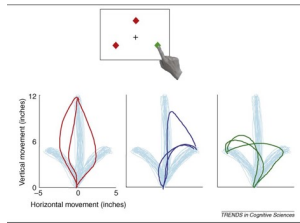


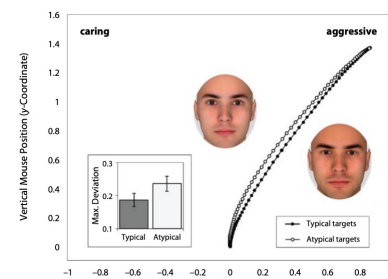
Fig. 2. Behavioral fMRI results. We measured each subject's conceptual similarity between each pairwise combination of the emotions Anger, Disgust, Fear, Happiness, Sadness, and Surprise through a conceptual ratings task. Perceptual similarity was measured via two tasks. One measure of perceptual similarity used computer mouse-tracking, which induced participants' response directed hand movements on mouse to an external category response in a facial emotion recognition task. Perceptual similarity was also assessed as participants' tendency to explicitly categorize faces as a "disgusted" response (that is, to select a certain category response (e.g., Disgust) instead of the intended category displayed by the image (e.g., Anger). Using each measure of perceptual similarity, we found face emotion categories that were perceptually more similar to the mouse to a given subject were predicted with a corresponding similarity, controlling for the visual similarity of the stimuli in each category. For illustrative purposes, the whole-sample average conceptual EMG, mouse-tracking perceptual DM, and explicit perceptual DMs are shown.

Brooks et al (2019)

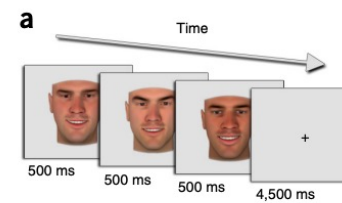
Song, and Nakayama (2006)



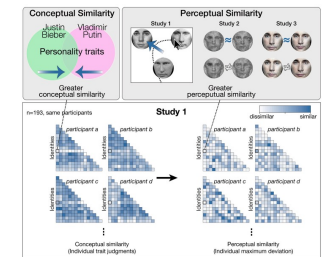
Freeman and Ambady (2009)



Stolier et al (2016)



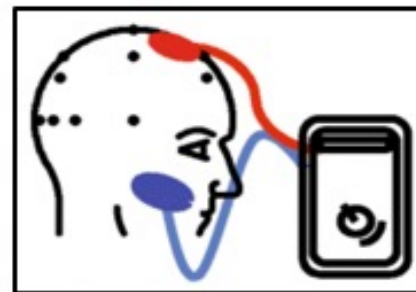
D. Oh et al. (2021)



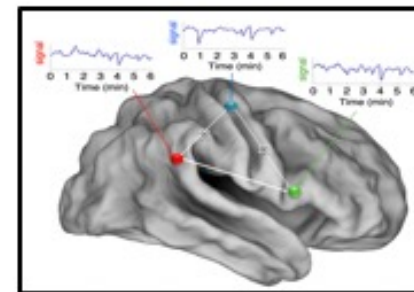
History



Mturk



Brain Stimulation



Brain Imaging data processing



EEG + fMRI

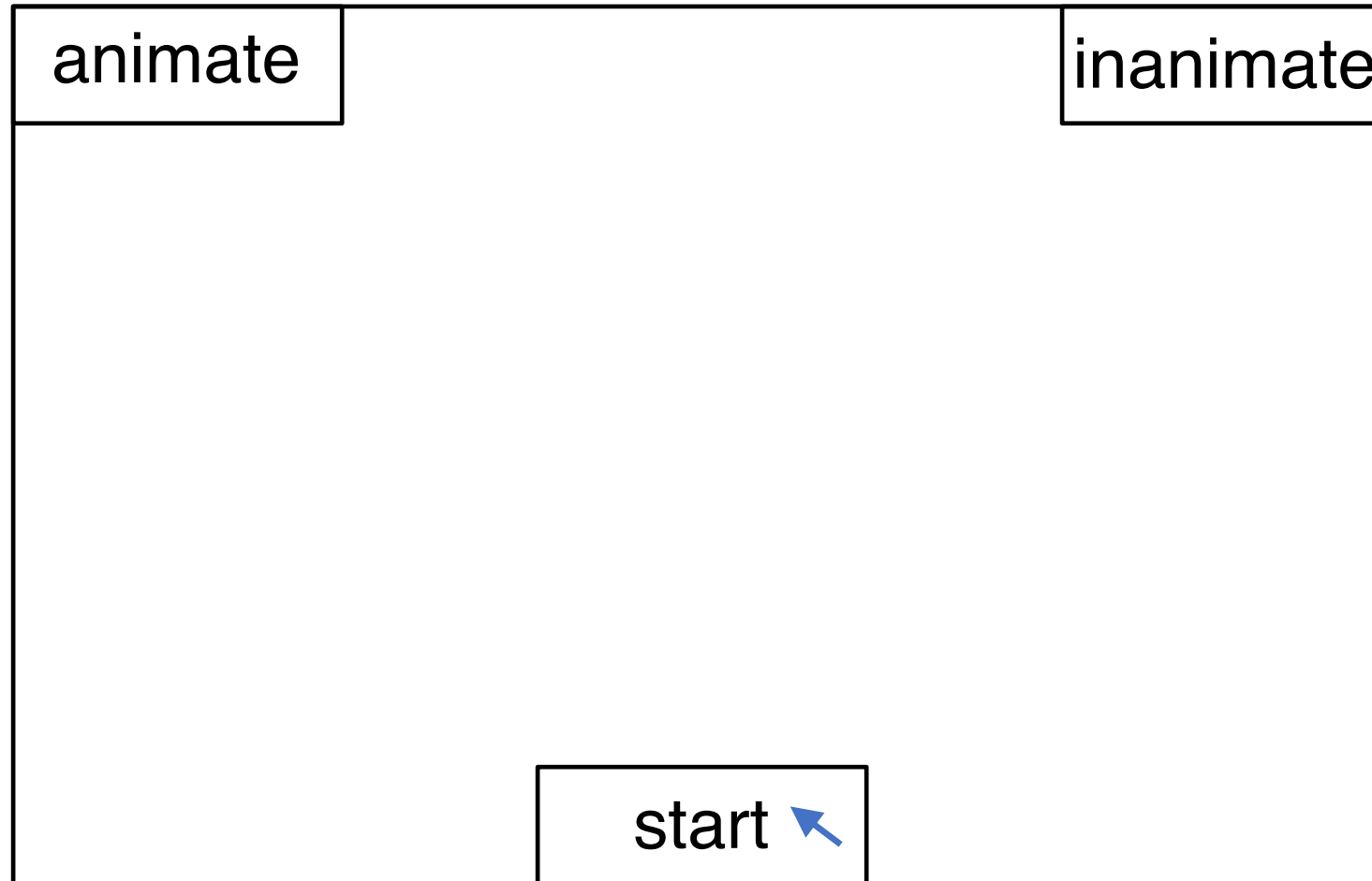
Compatibility with other methods

Introduction of mouse tracking (MT)

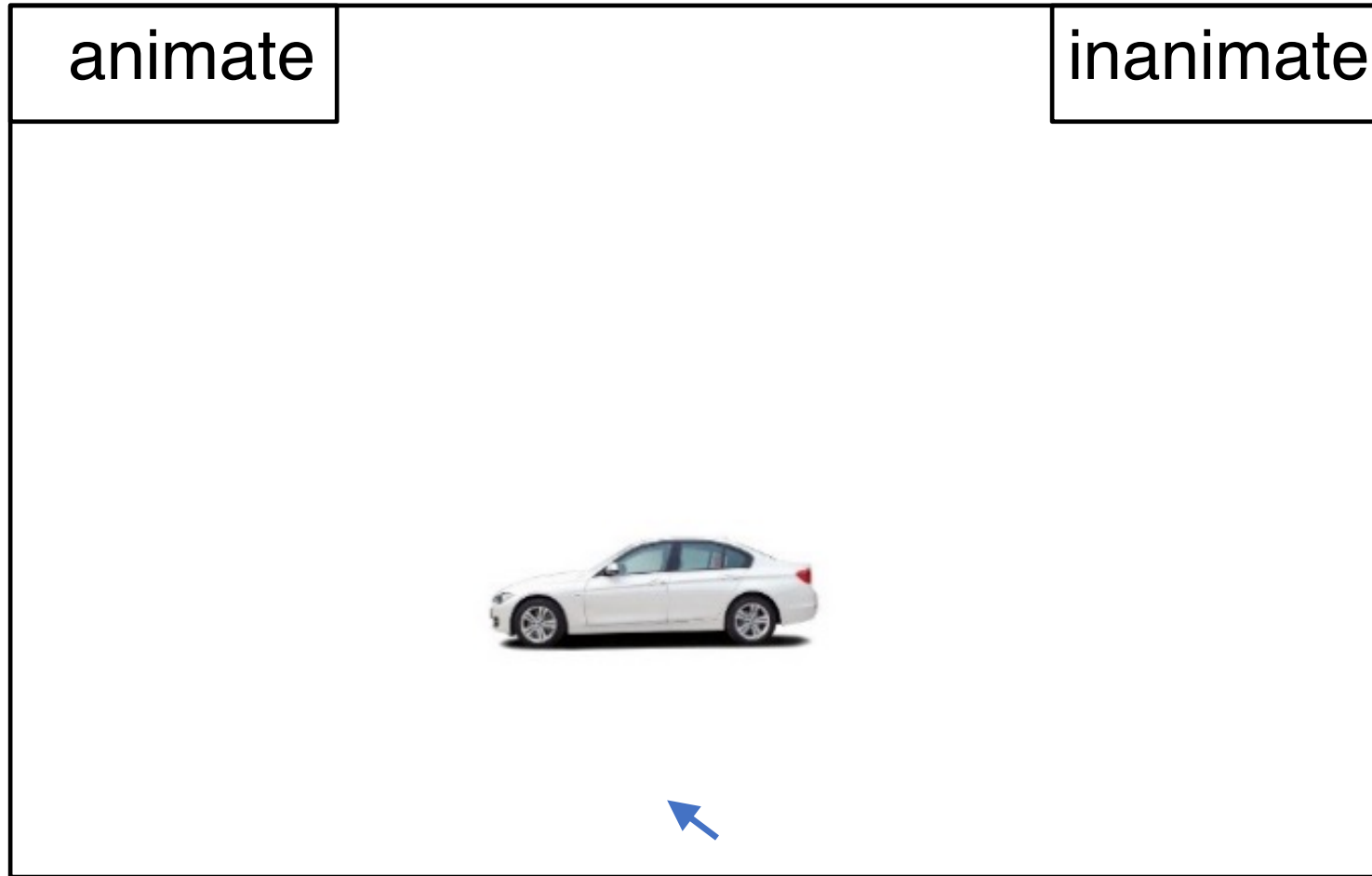
MALE

FEMALE

Paradigm 1



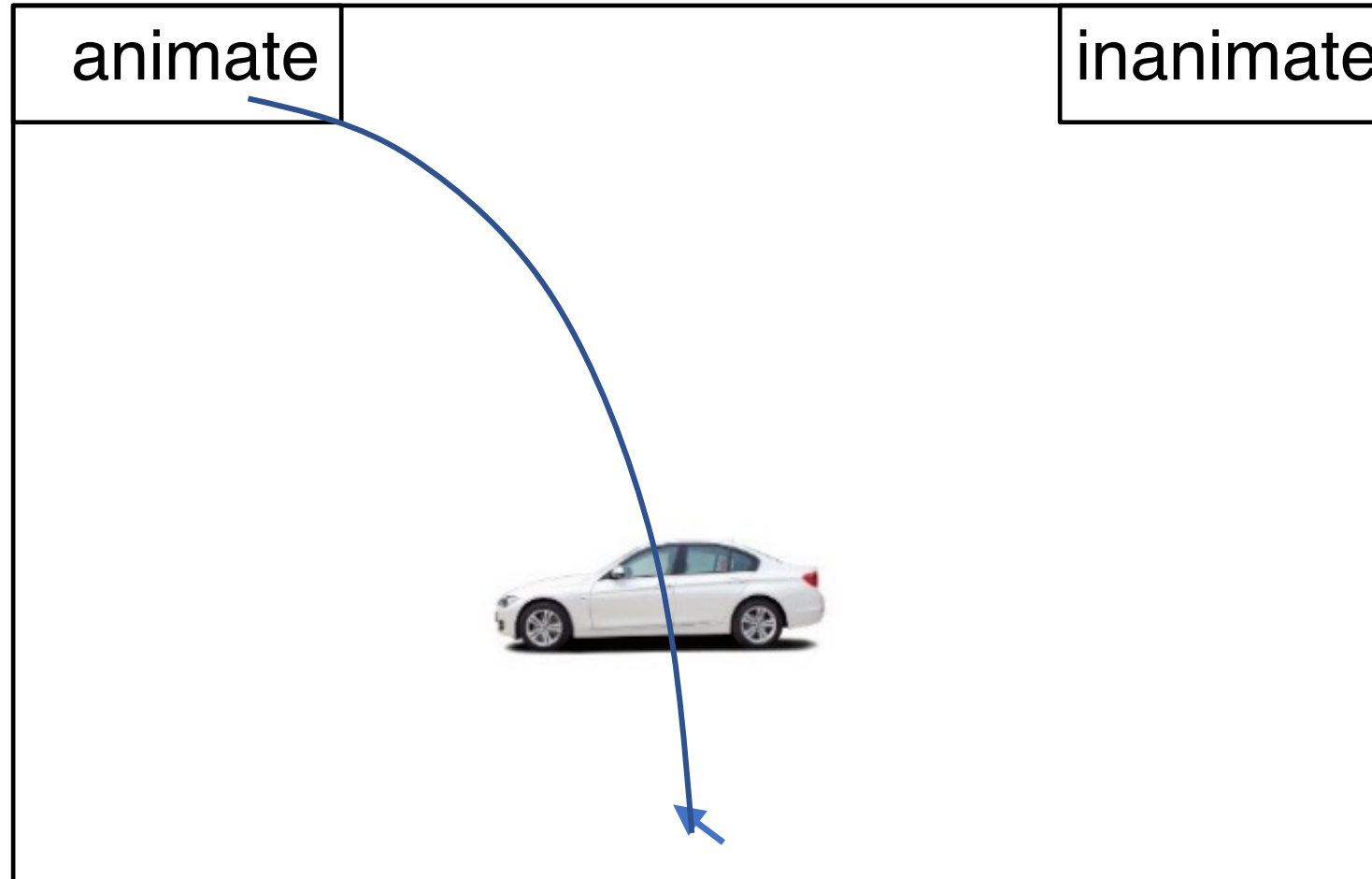
Paradigm 1





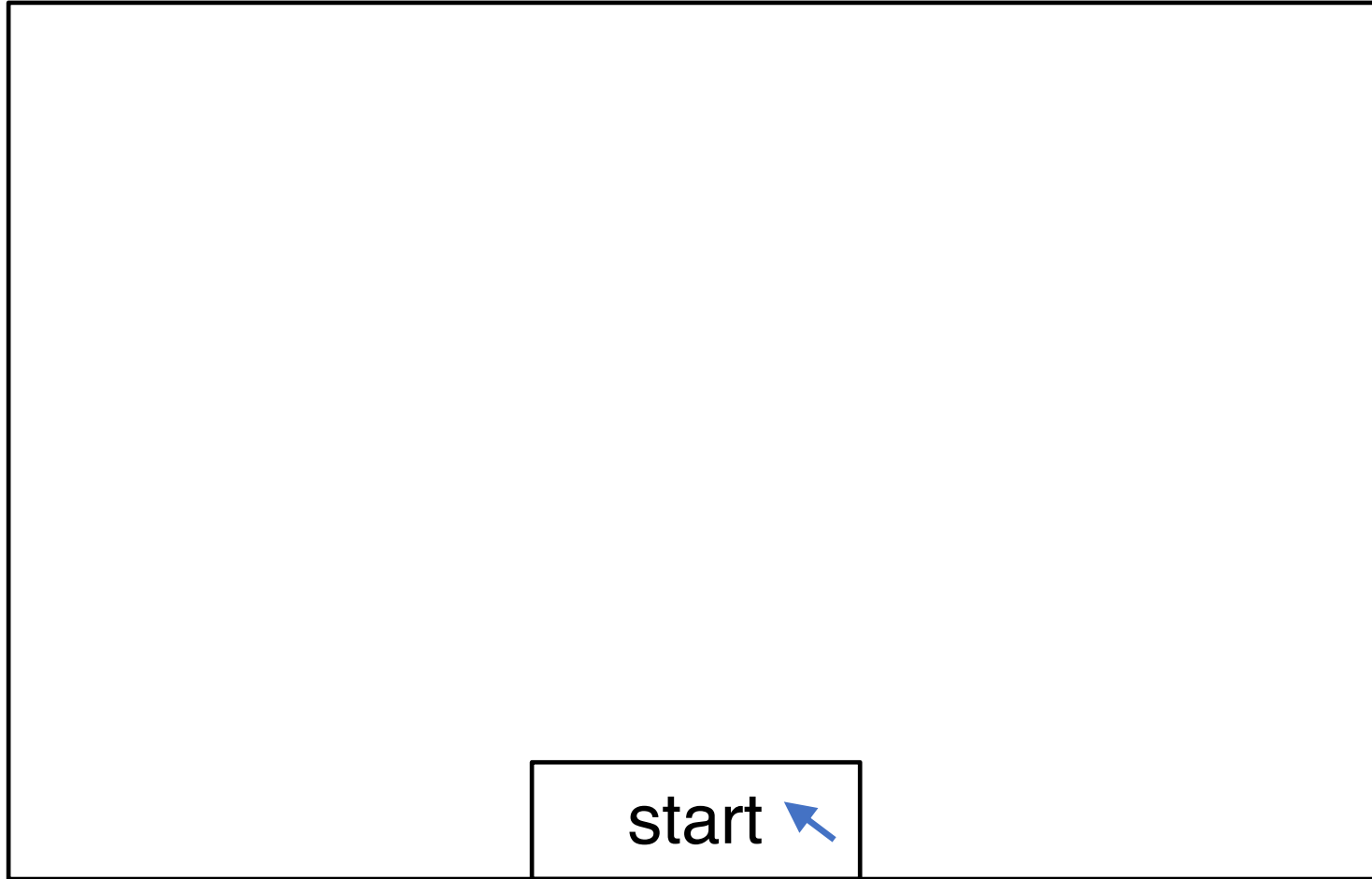
Kun Chen

Paradigm 1



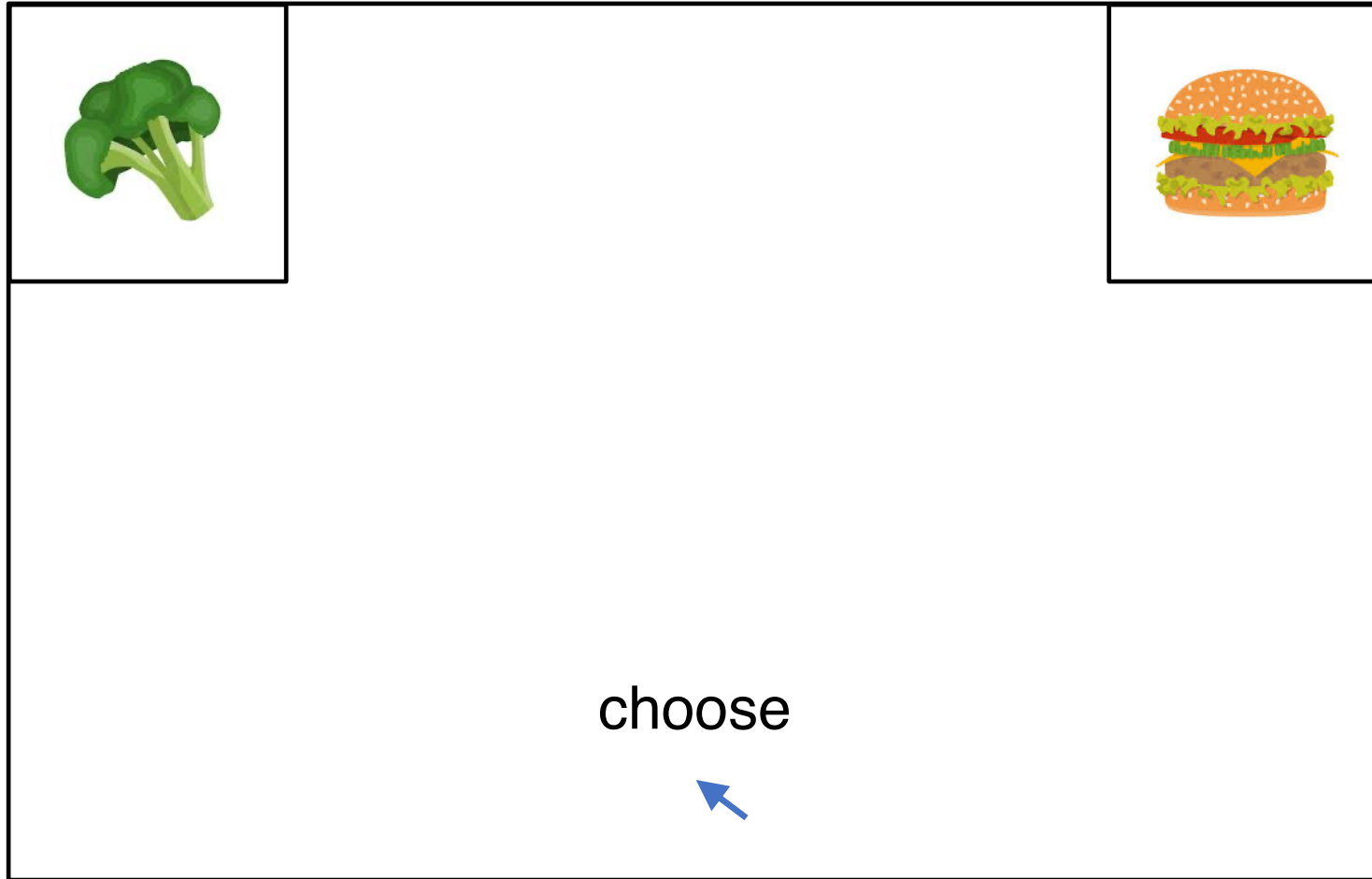
Chen, K., Wang, R., Huang, J., Gao, F., Yuan, Z., Qi, Y., & Wu, H. (2022). A resource for assessing dynamic binary choices in the adult brain using EEG and mouse-tracking. *Scientific data*, 9(1), 1-10.

Paradigm 2



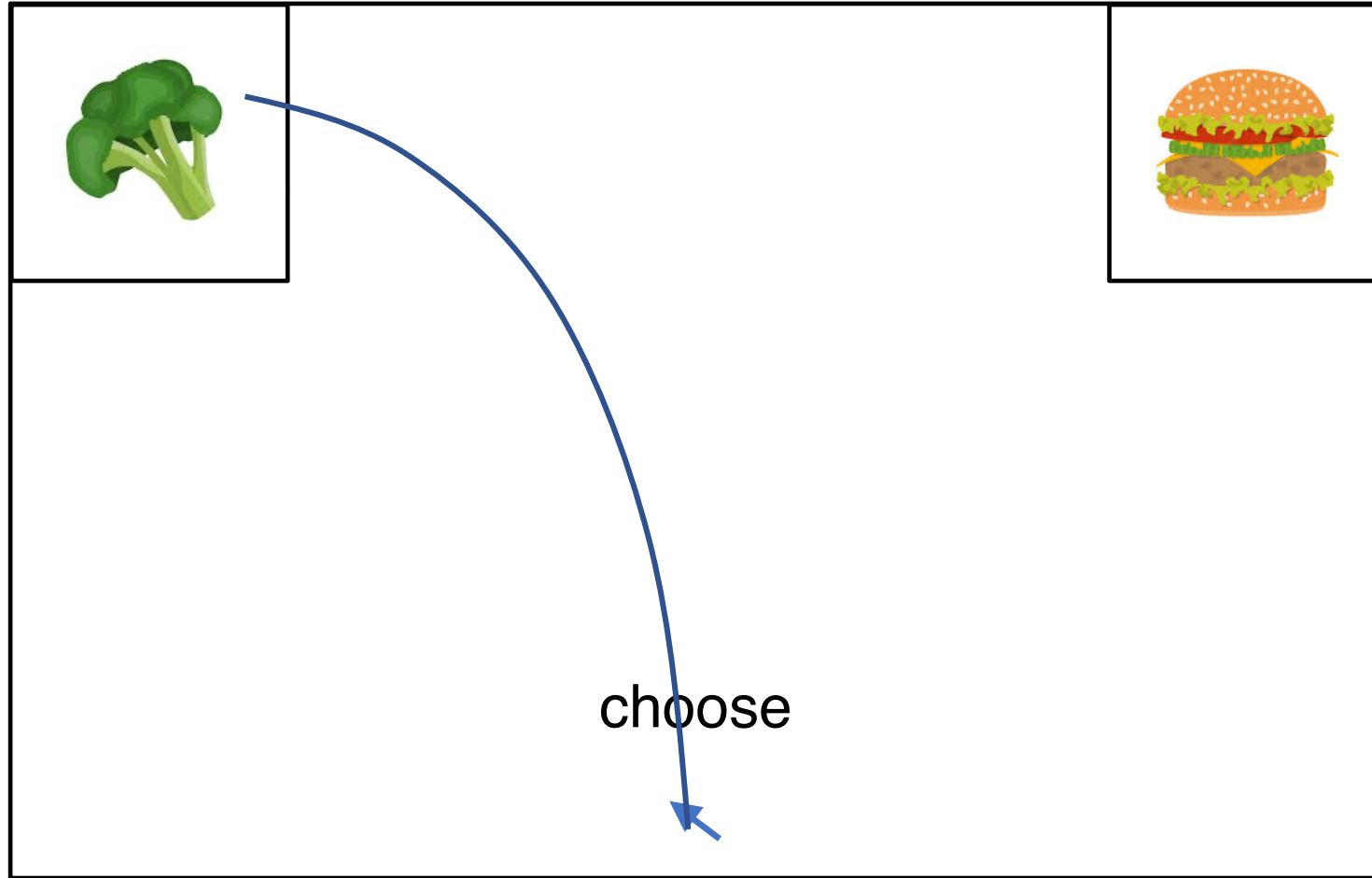
Stillman et al. (2018)

Paradigm 2



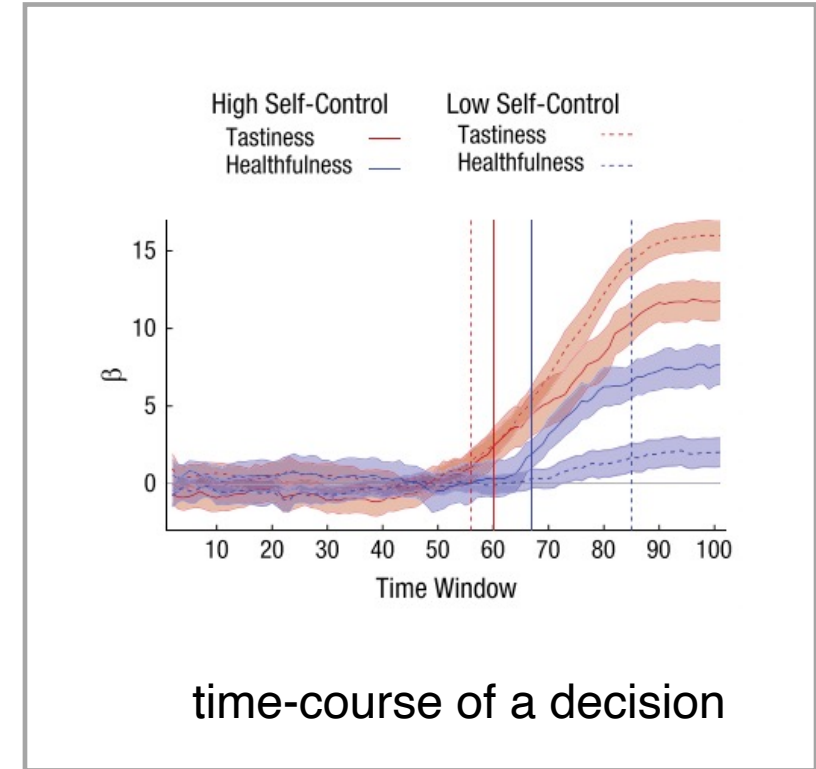
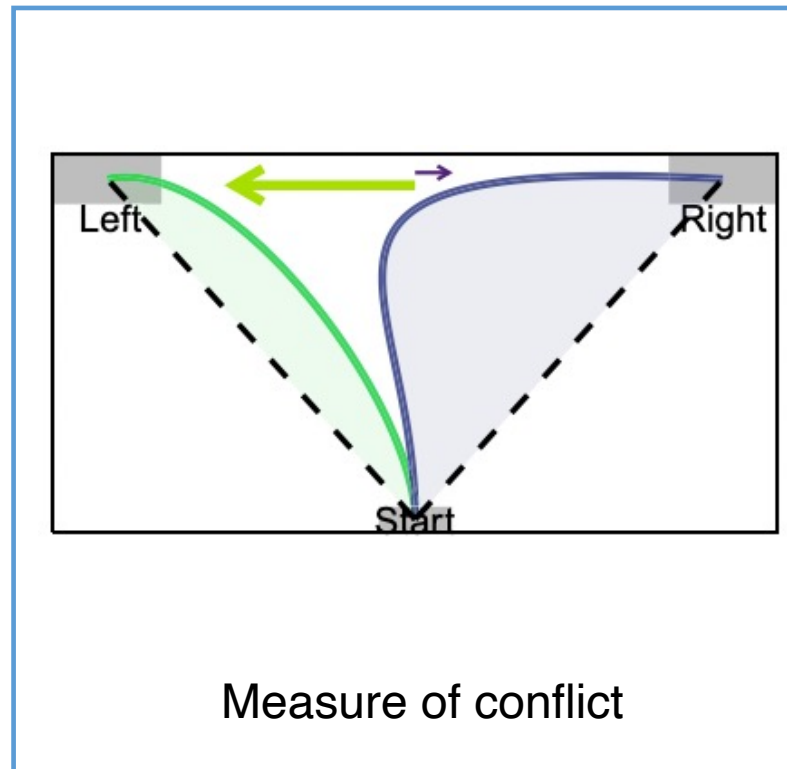
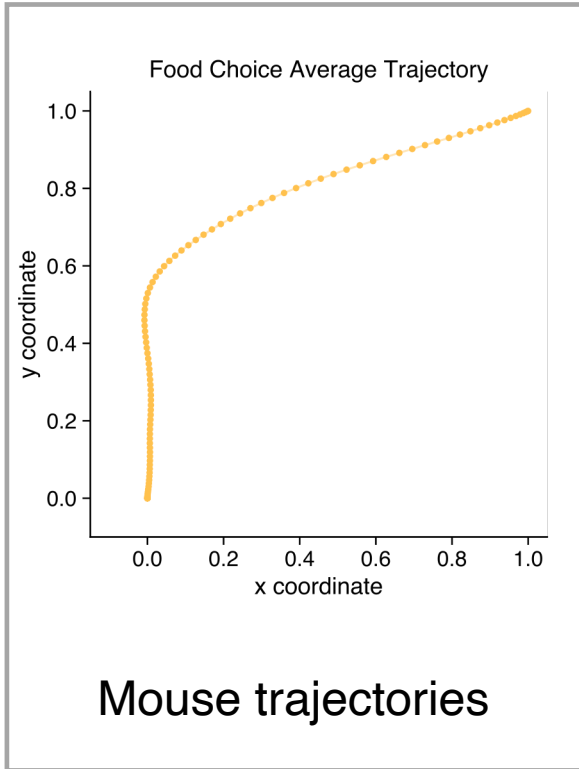
Sullivan et al. (2015)

Paradigm 2

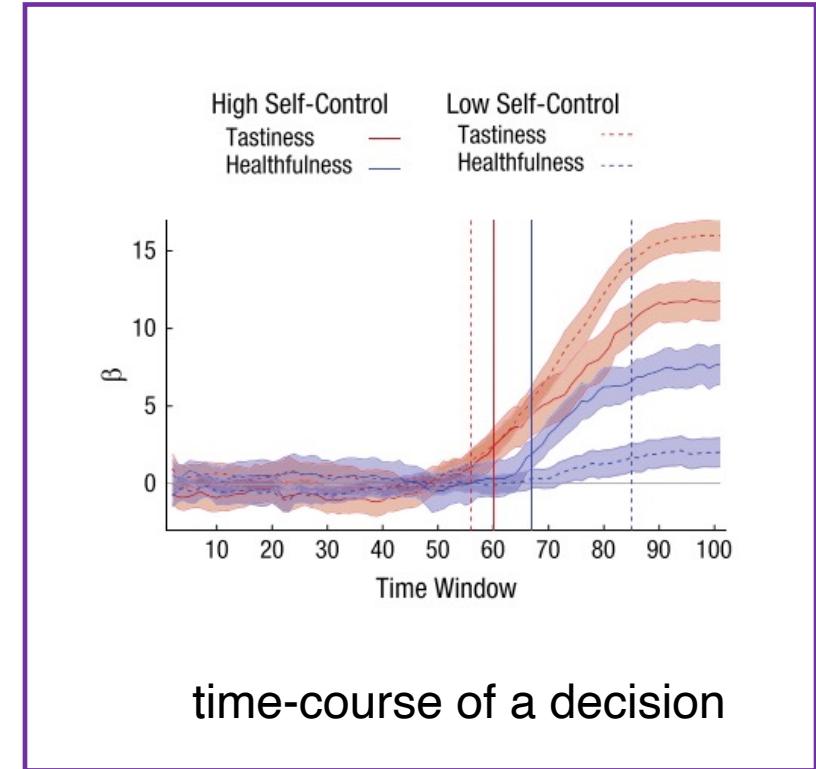
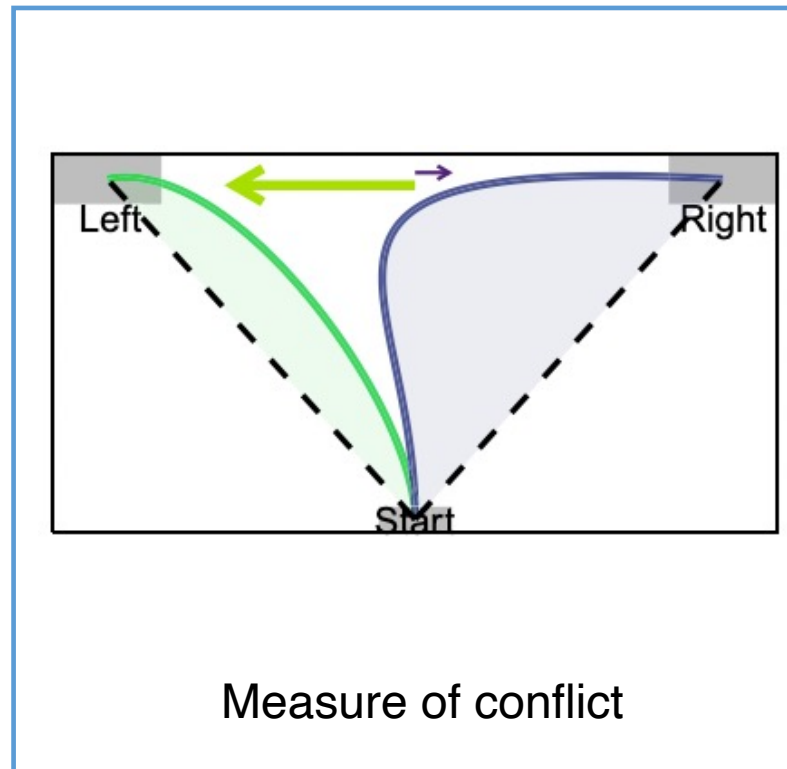
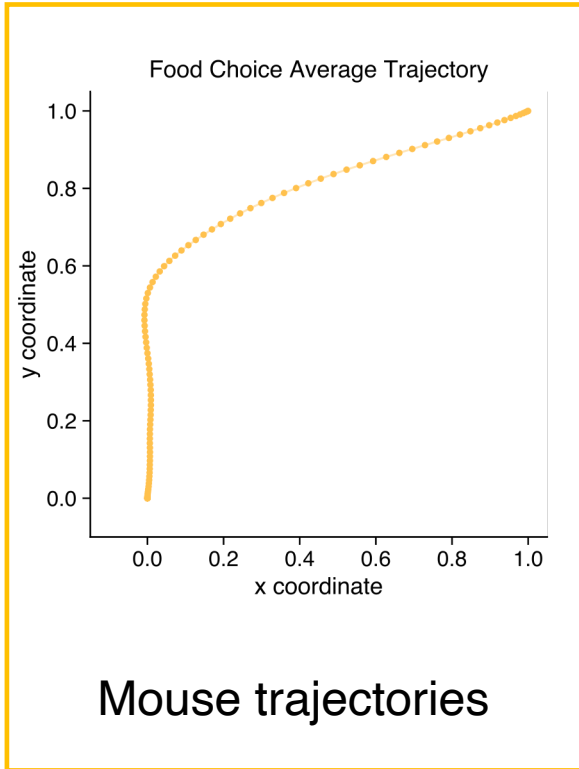


Sullivan et al. (2015)

Hand in motion reveals mind in motion



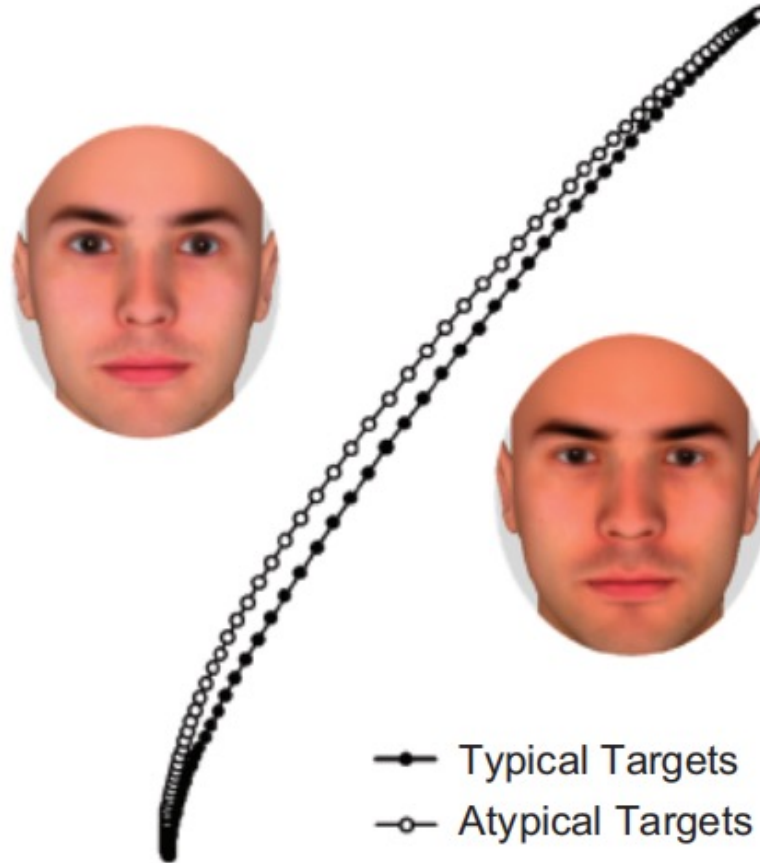
Hand in motion reveals mind in motion



Mouse trajectories – different stimuli

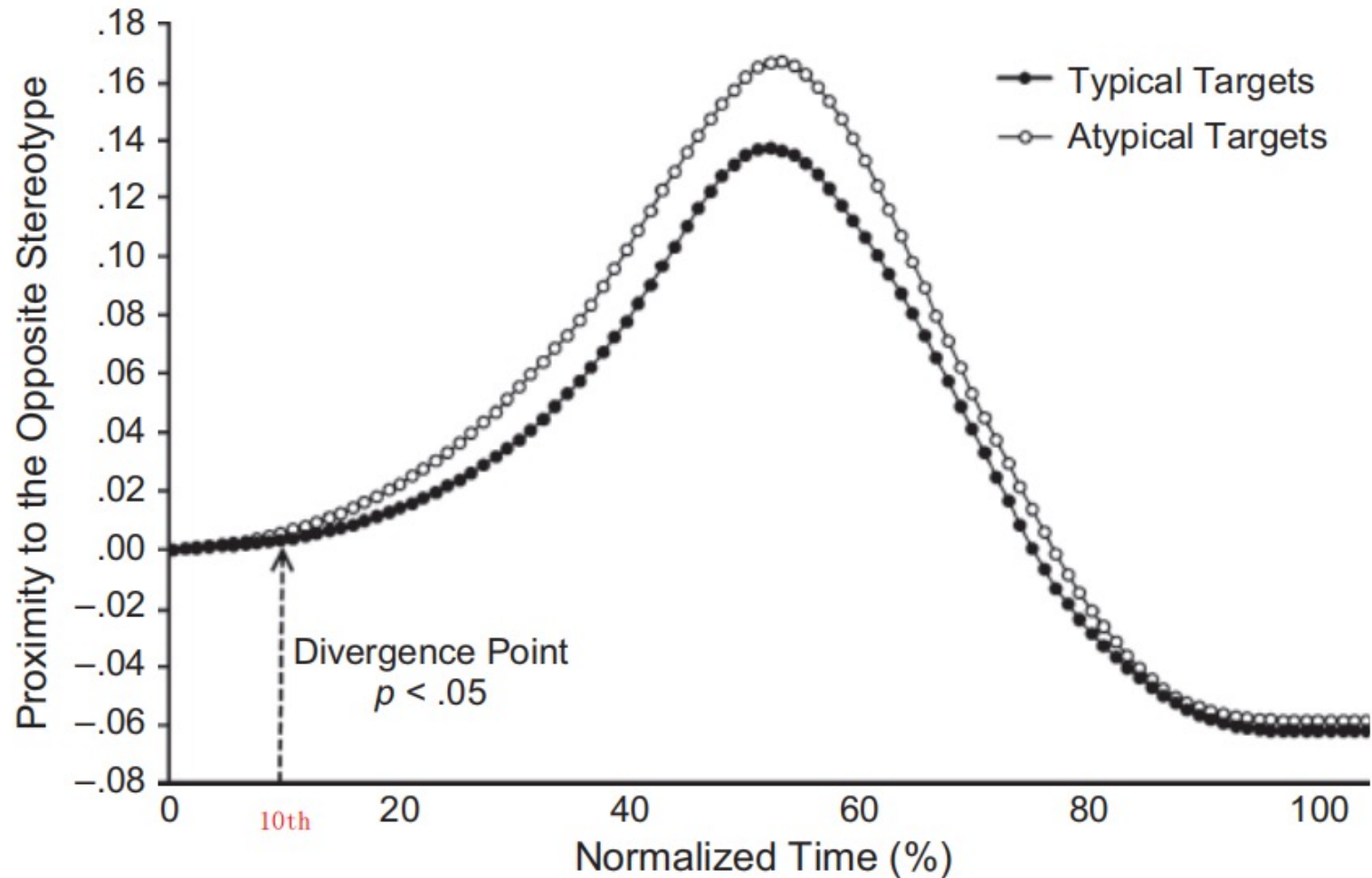
Caring

Aggressive



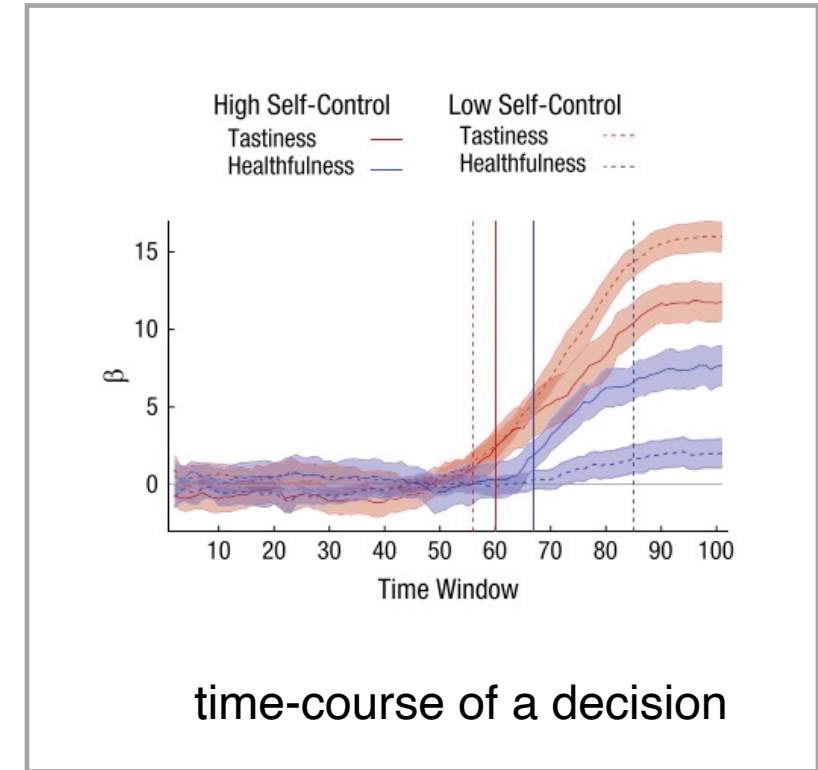
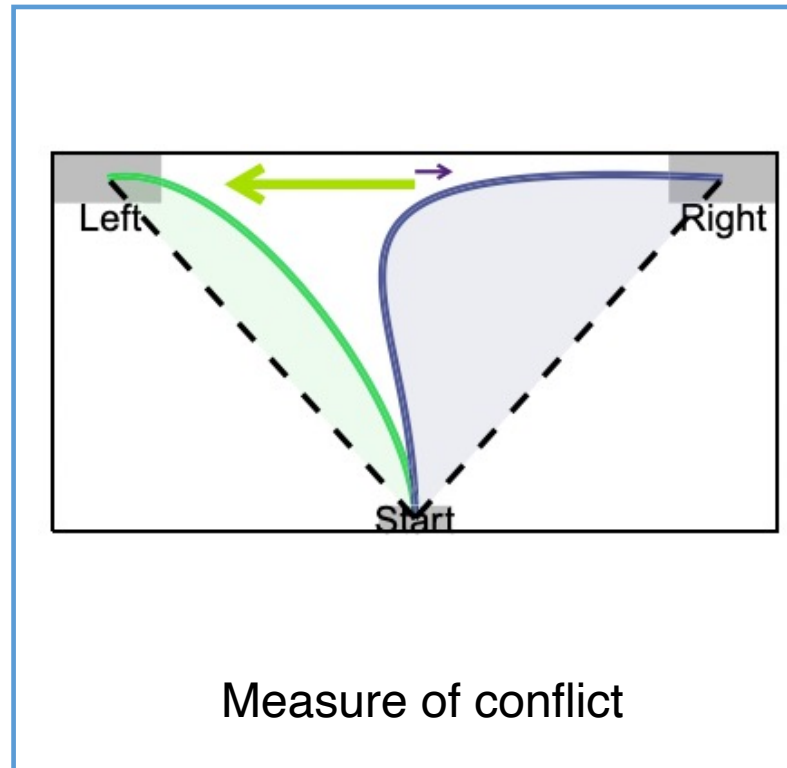
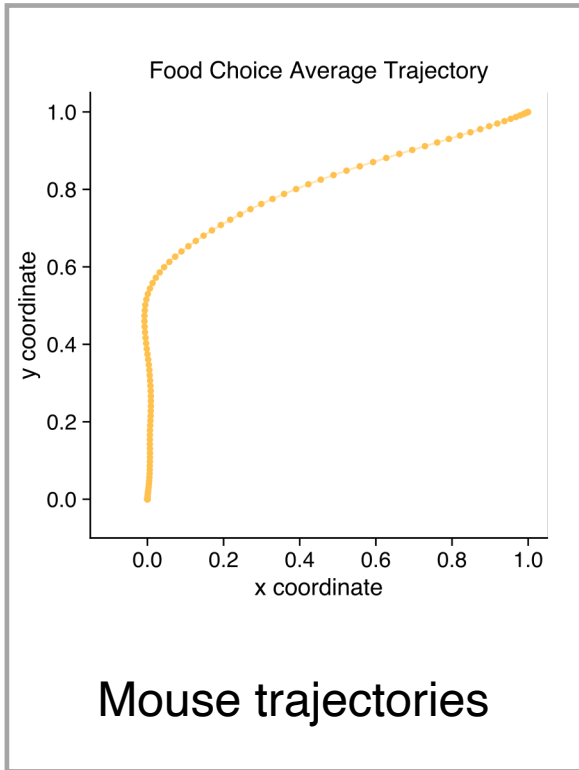
*Freeman and Ambady
(2009)*

Mouse trajectories – different stimuli

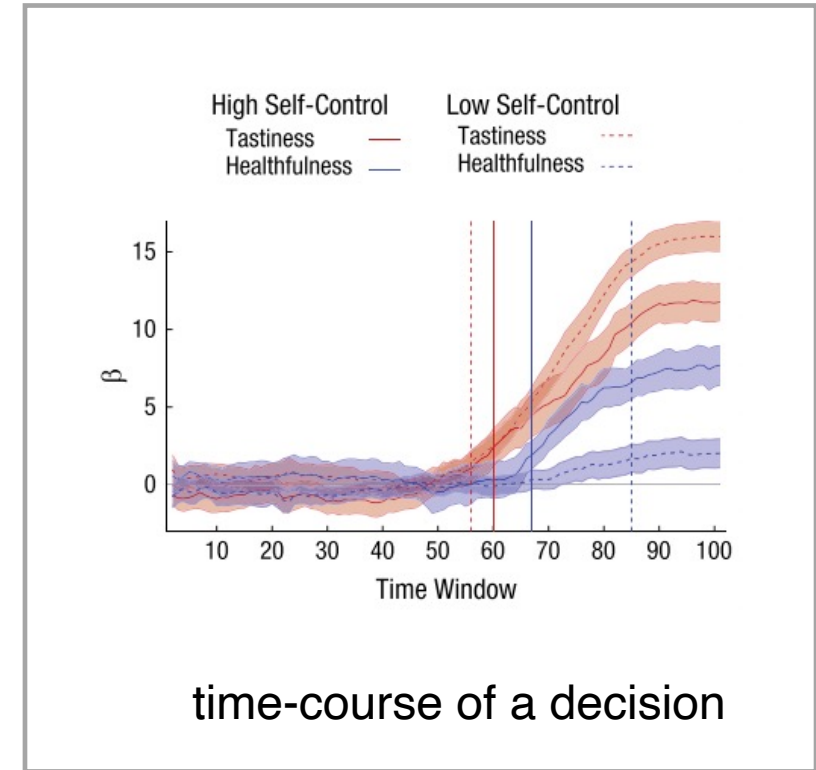
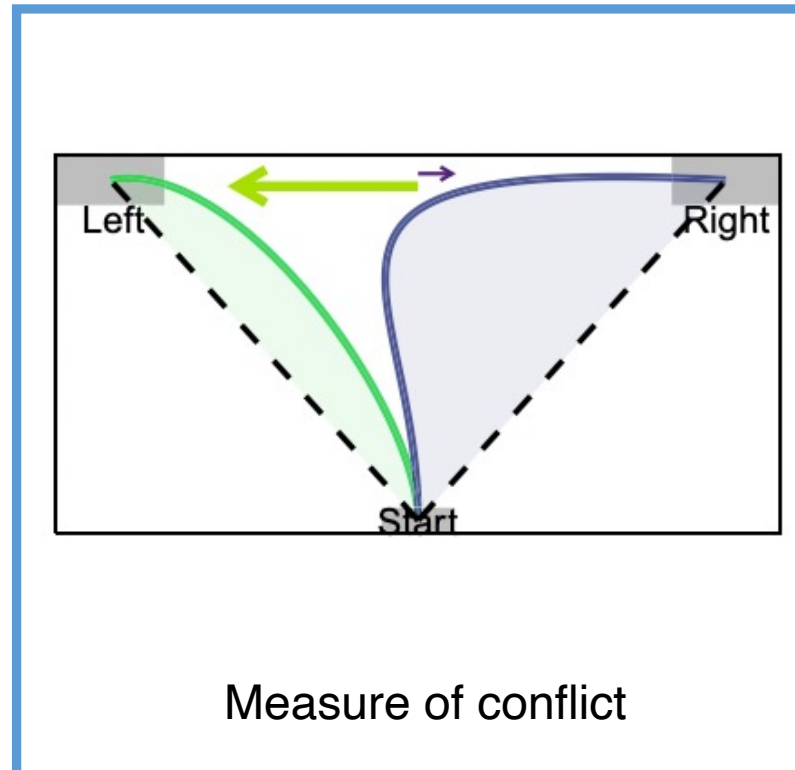
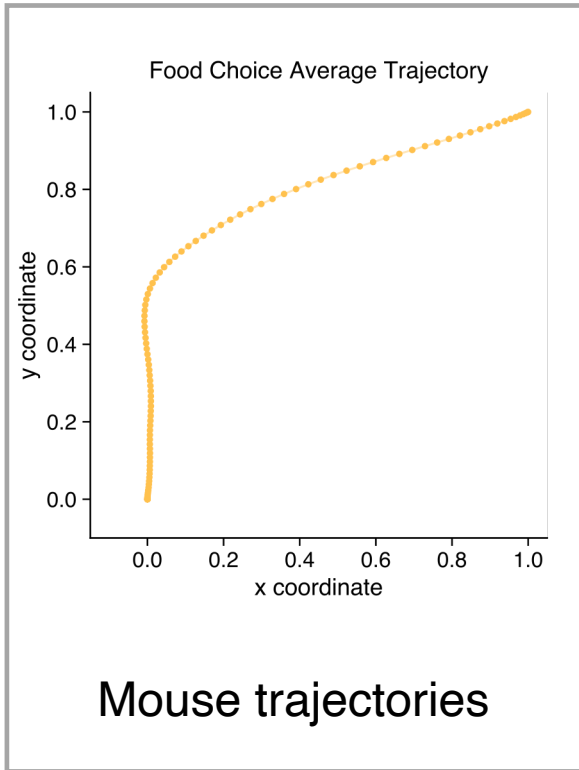


*Freeman and Ambady
(2009)*

Hand in motion reveals mind in motion

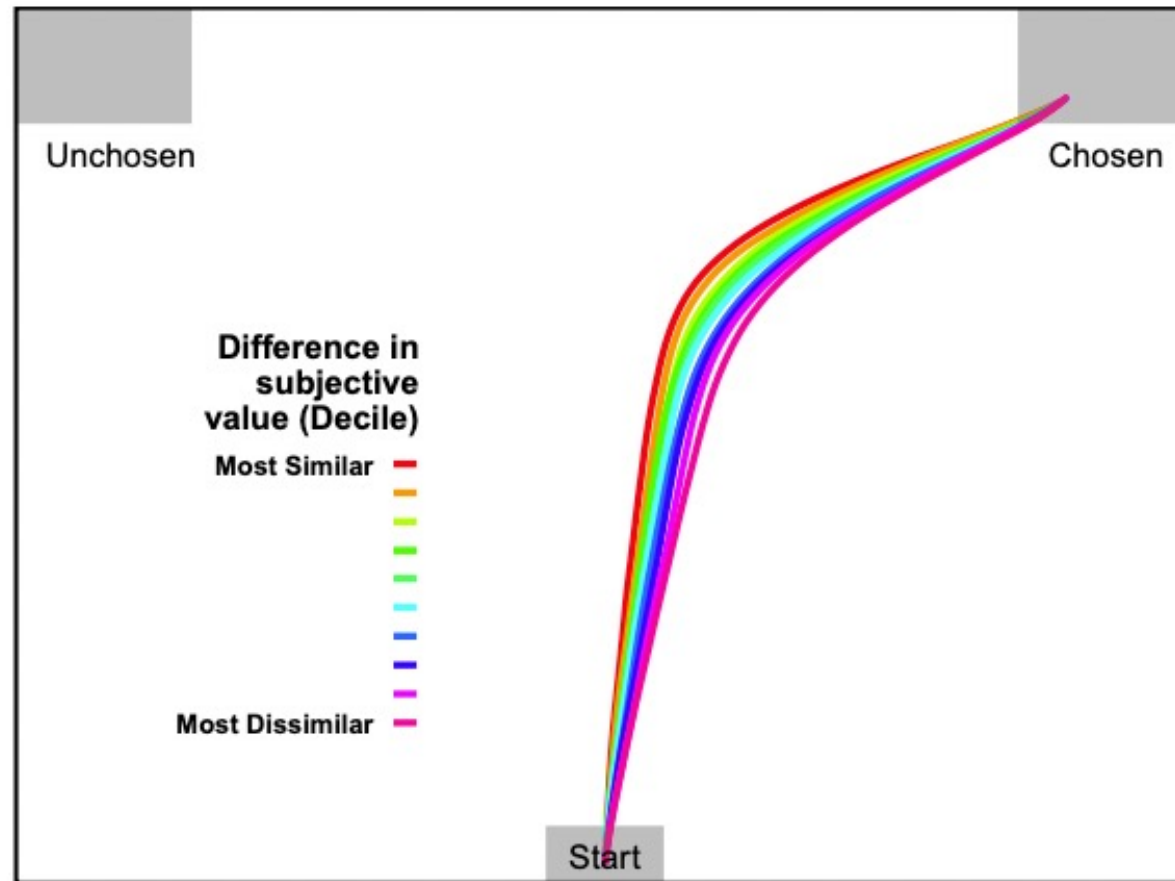


Hand in motion reveals mind in motion



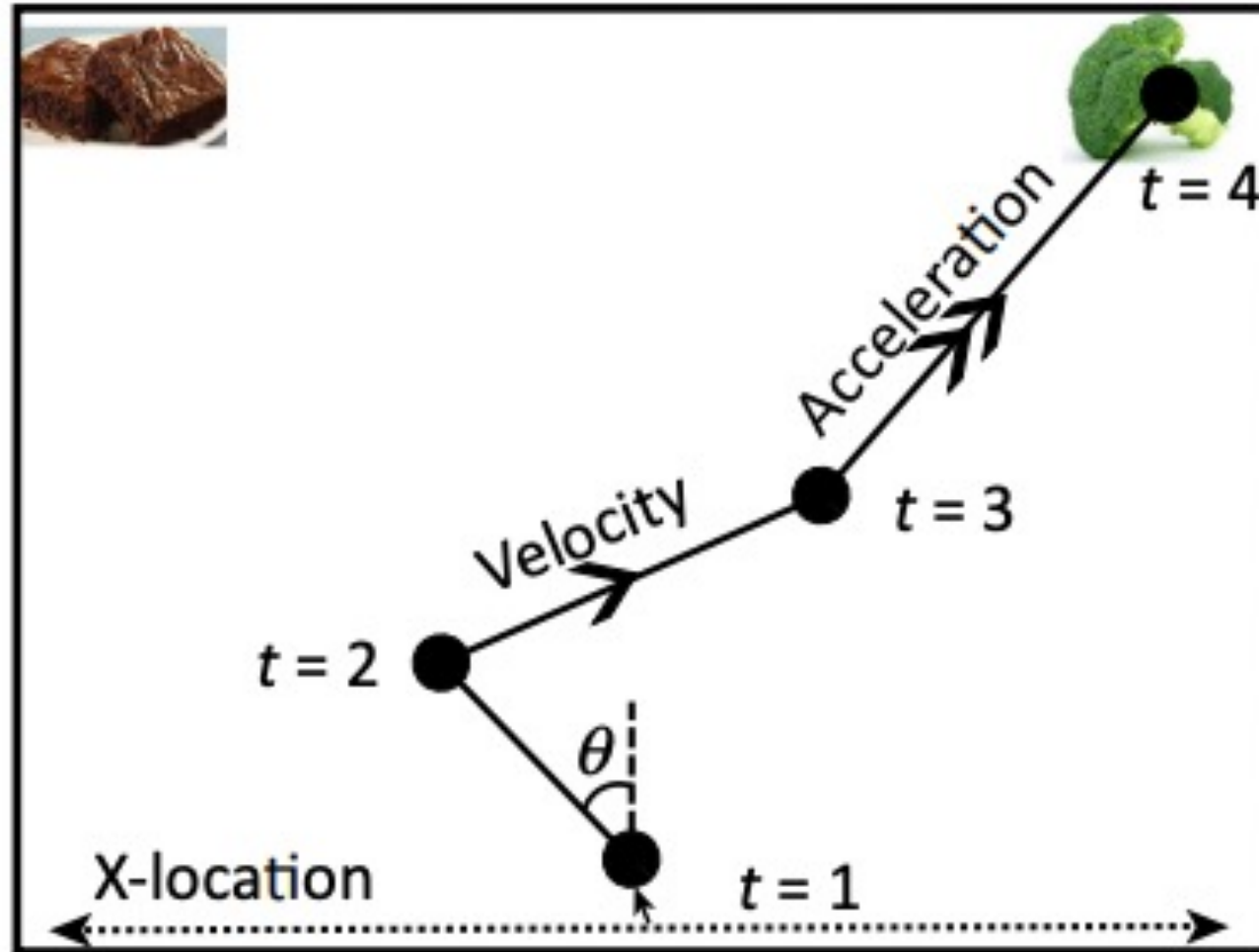
Mouse tracking measures

- Conflict between choices: MD & AUC



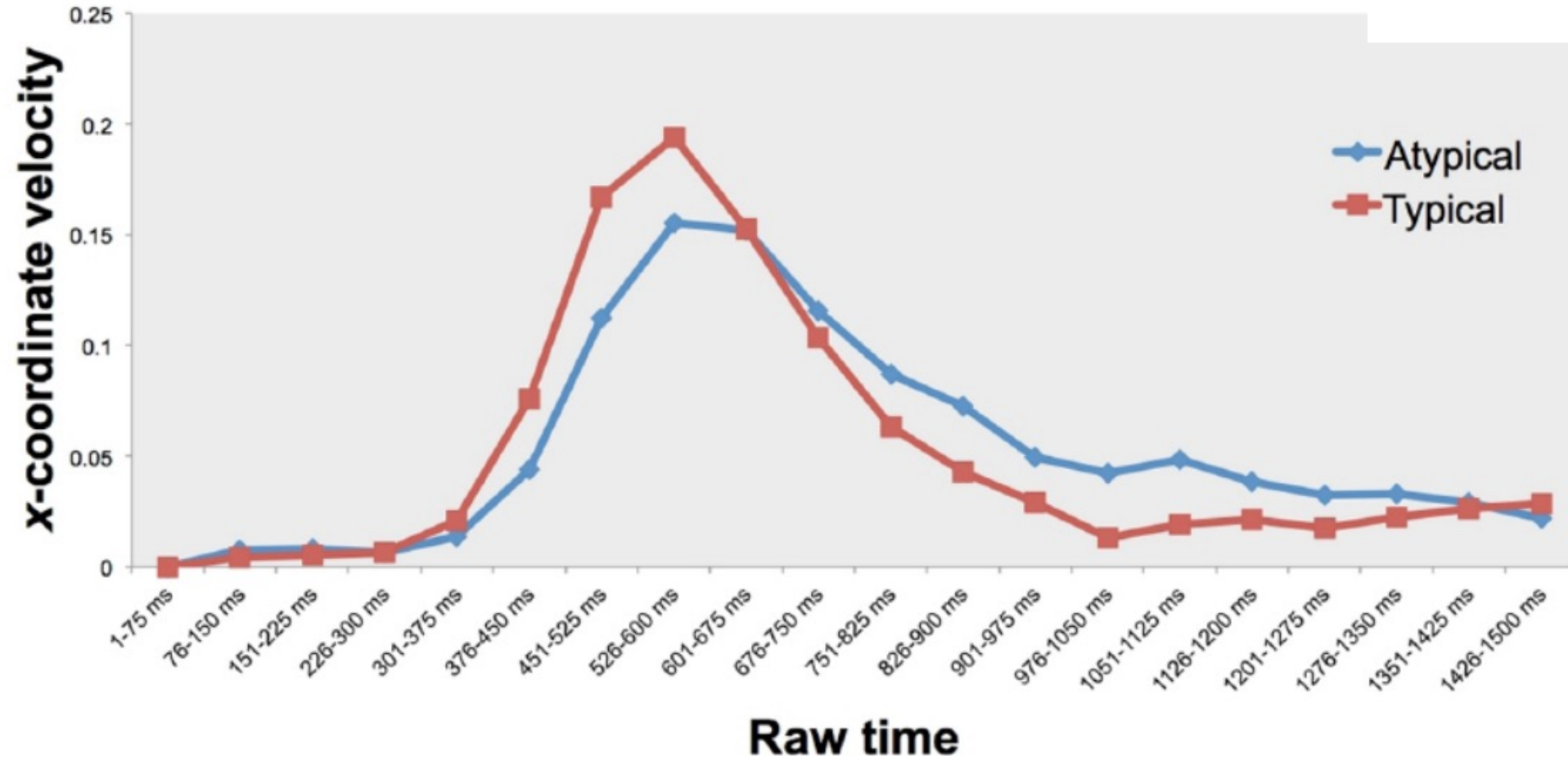
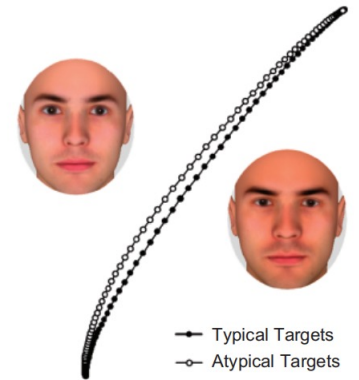
Mouse tracking measures

- Velocity & Acceleration & Angle



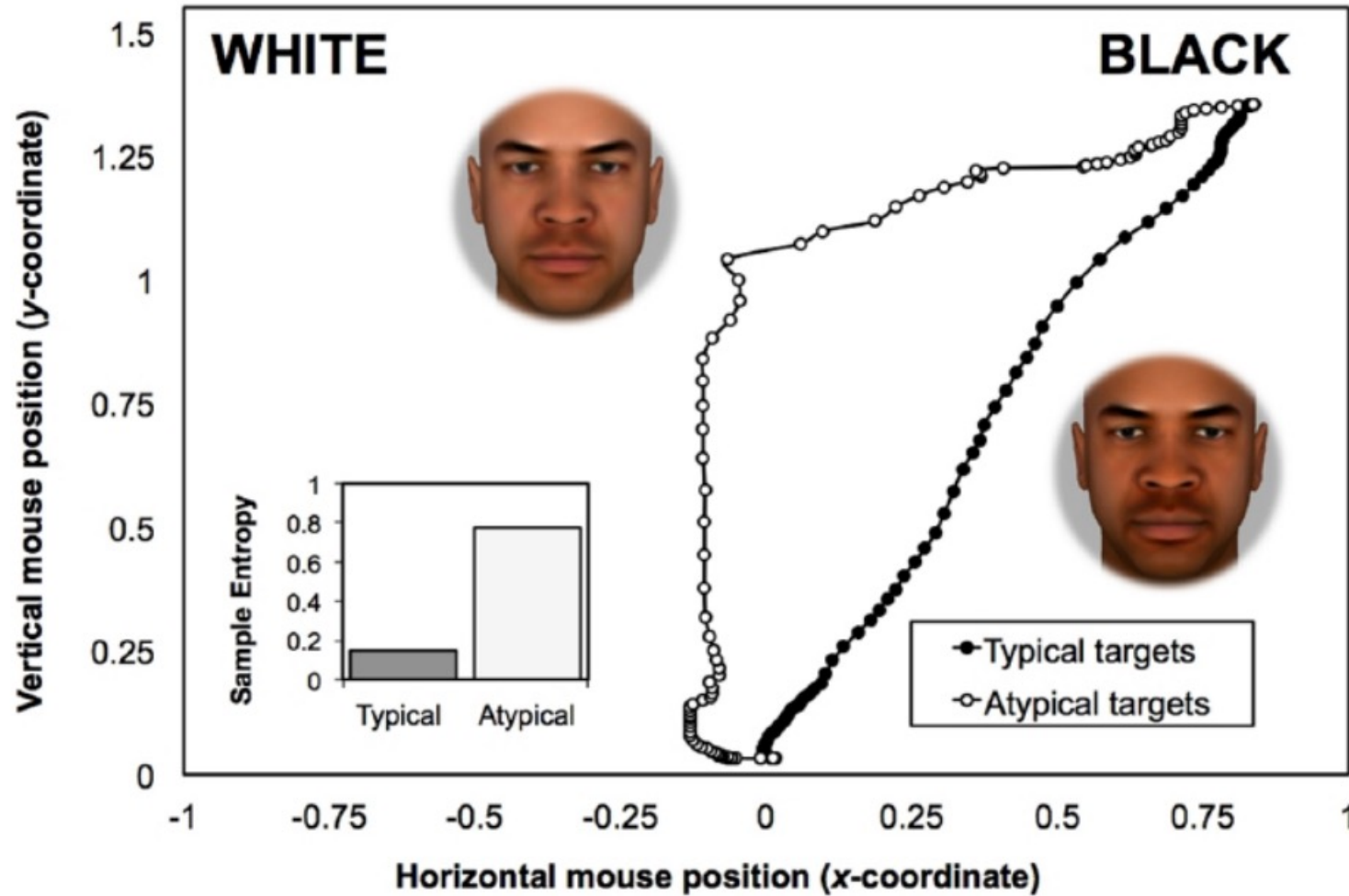
Mouse tracking measures

- Velocity & Acceleration & Angle

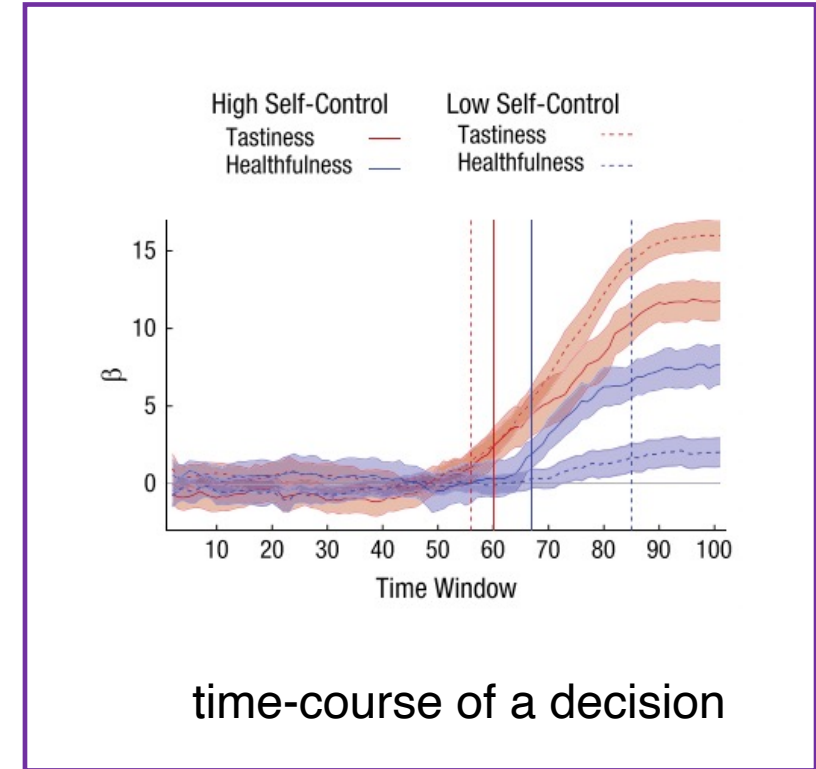
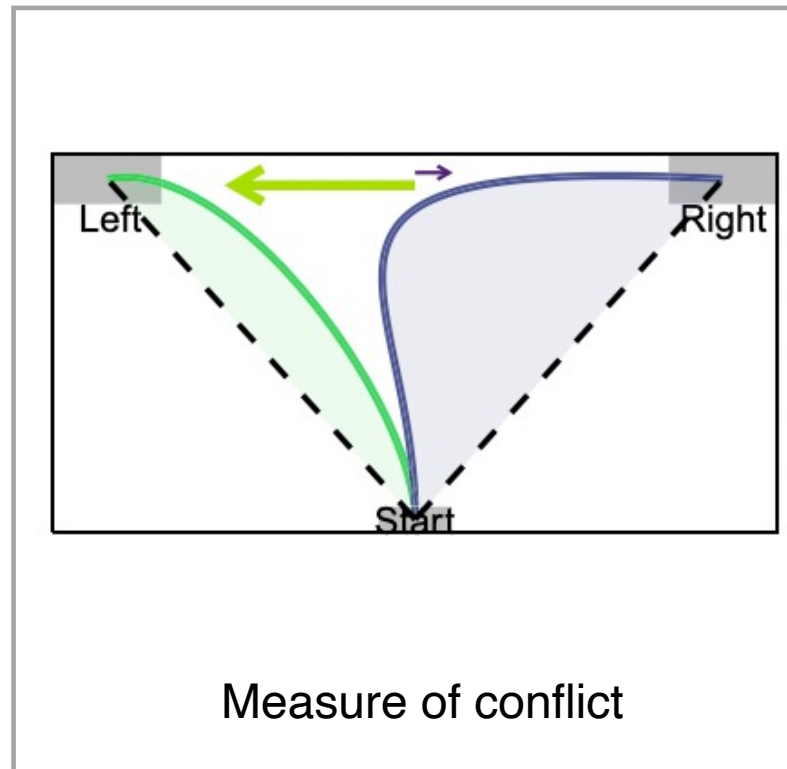
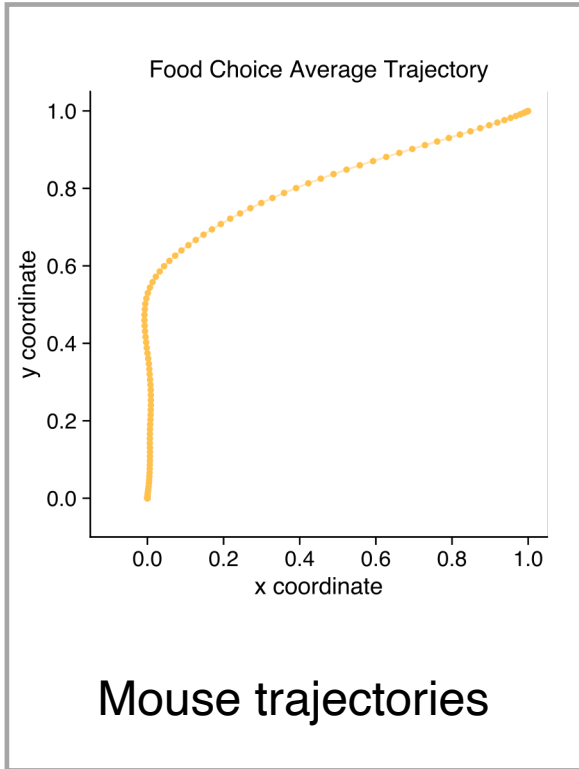


Mouse tracking measures

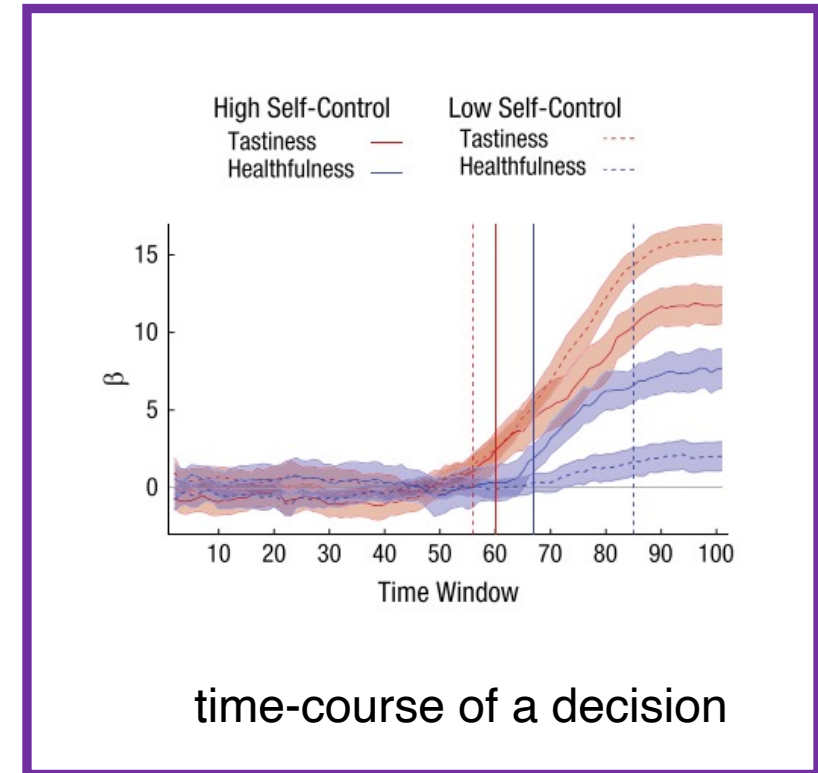
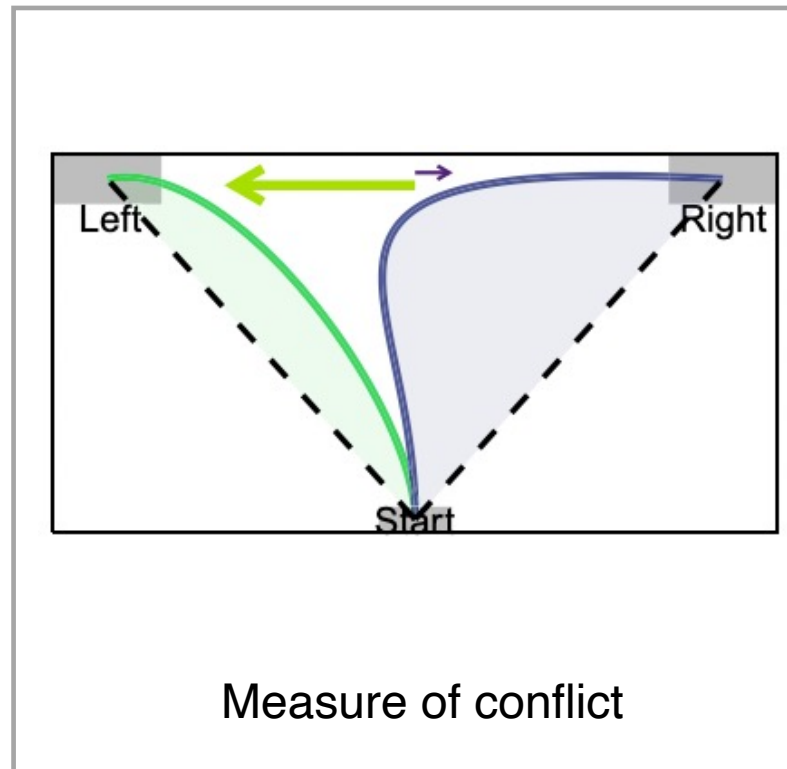
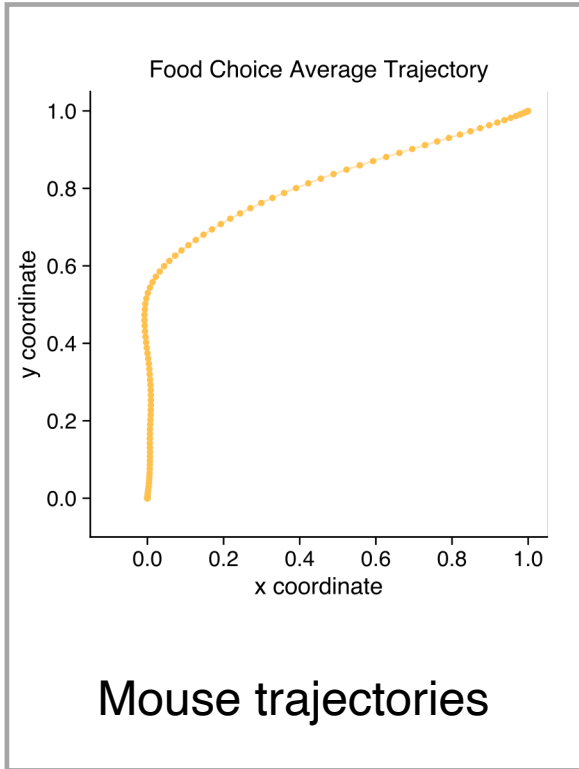
- Flips along the x coordinate & Entropy



Hand in motion reveals mind in motion



Hand in motion reveals mind in motion



Time course of a food choice

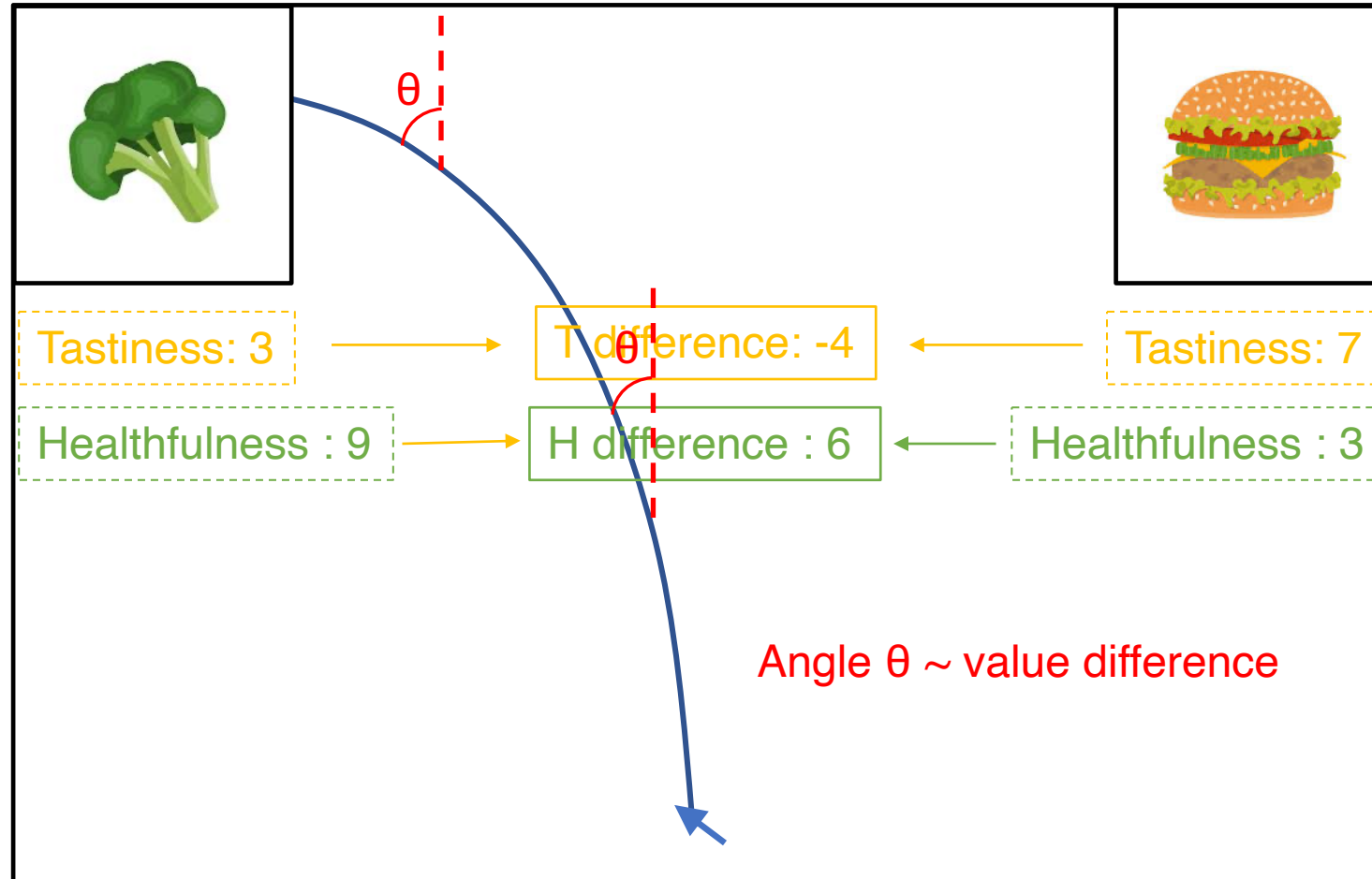


- Rate 160 different foods on three dimensions
 - tastiness
("How tasty is this food?")
 - healthfulness
("How healthy is this food?")
 - overall liking
("How much would you like to eat this food at the end of the experiment?")



- Rate binary choices among randomly selected pairs of foods.

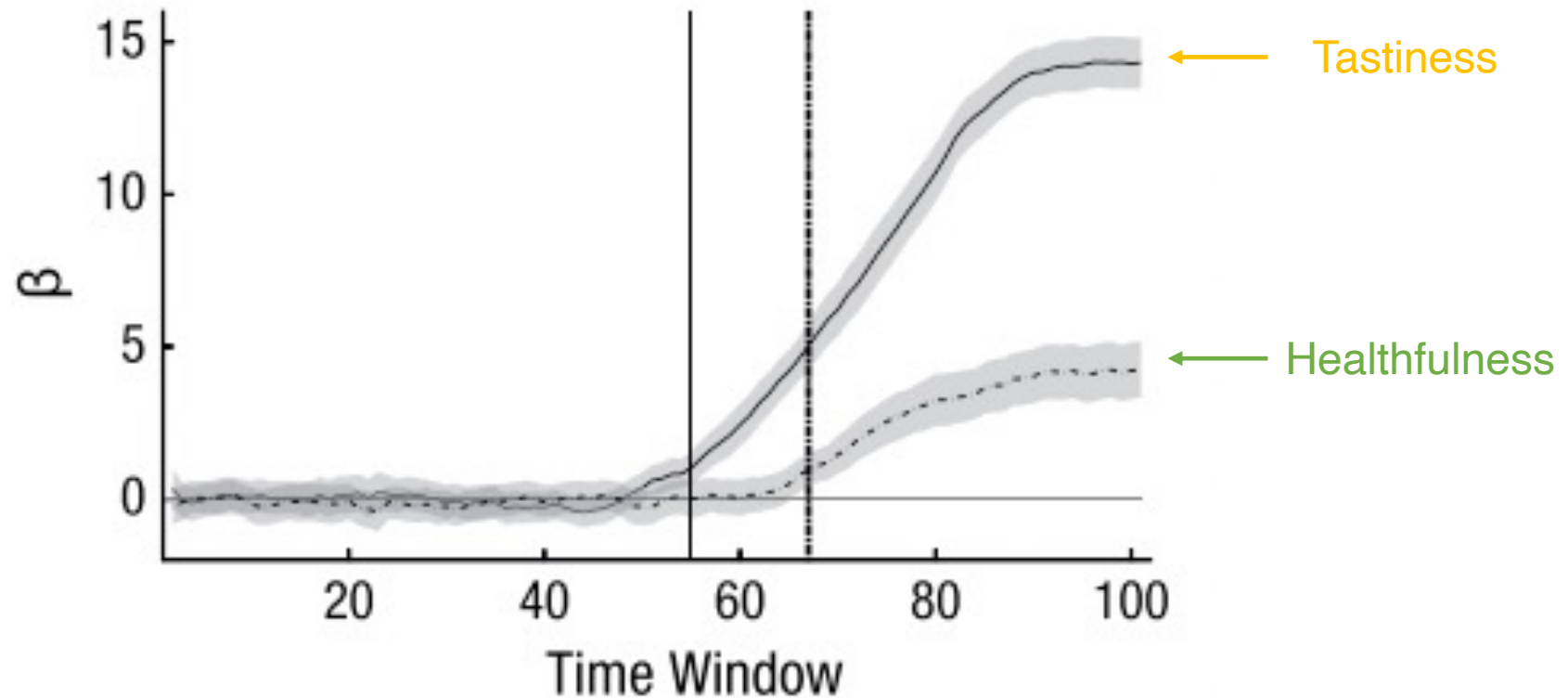
Time course of a food choice



choices between a tasty food (tasty but unhealthy) and a healthy food (healthy but not tasty)

Tastiness comes first

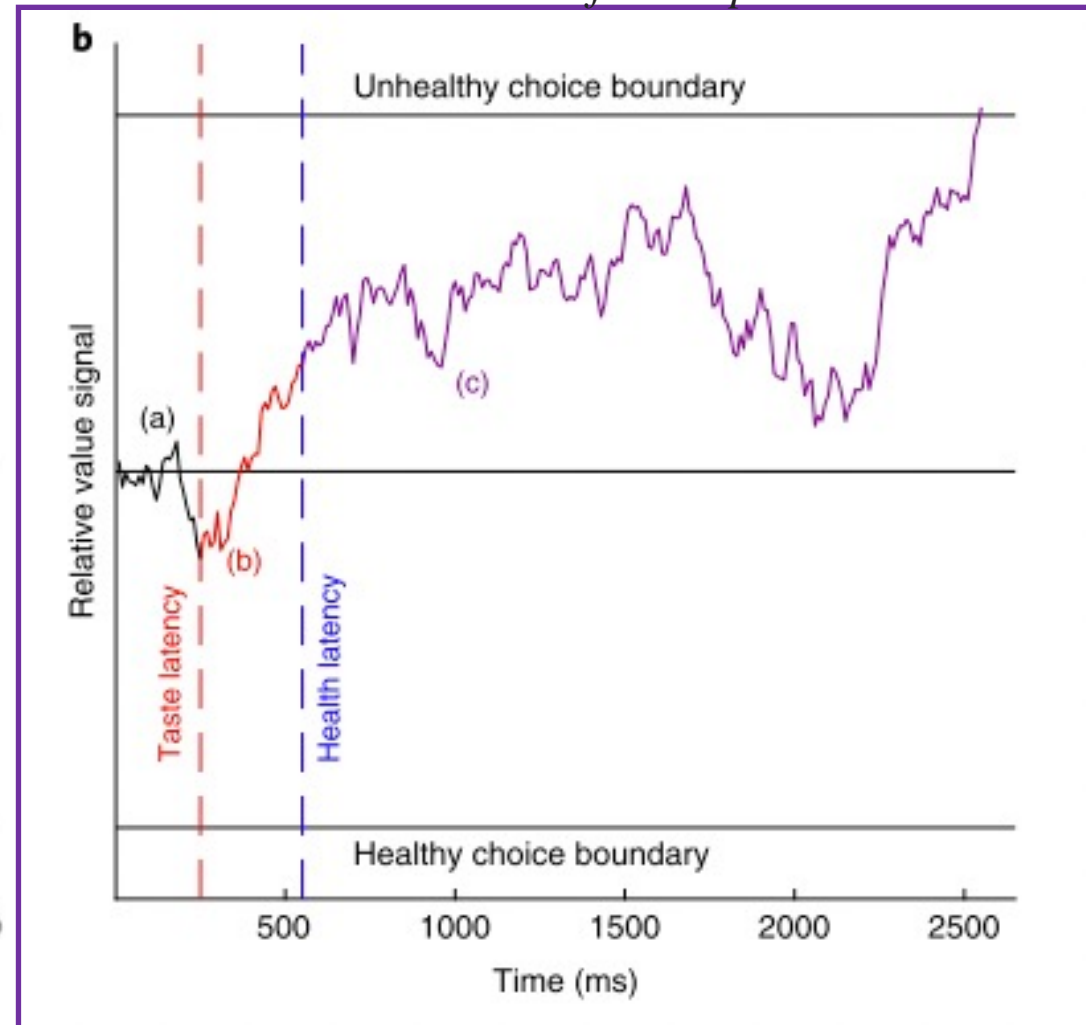
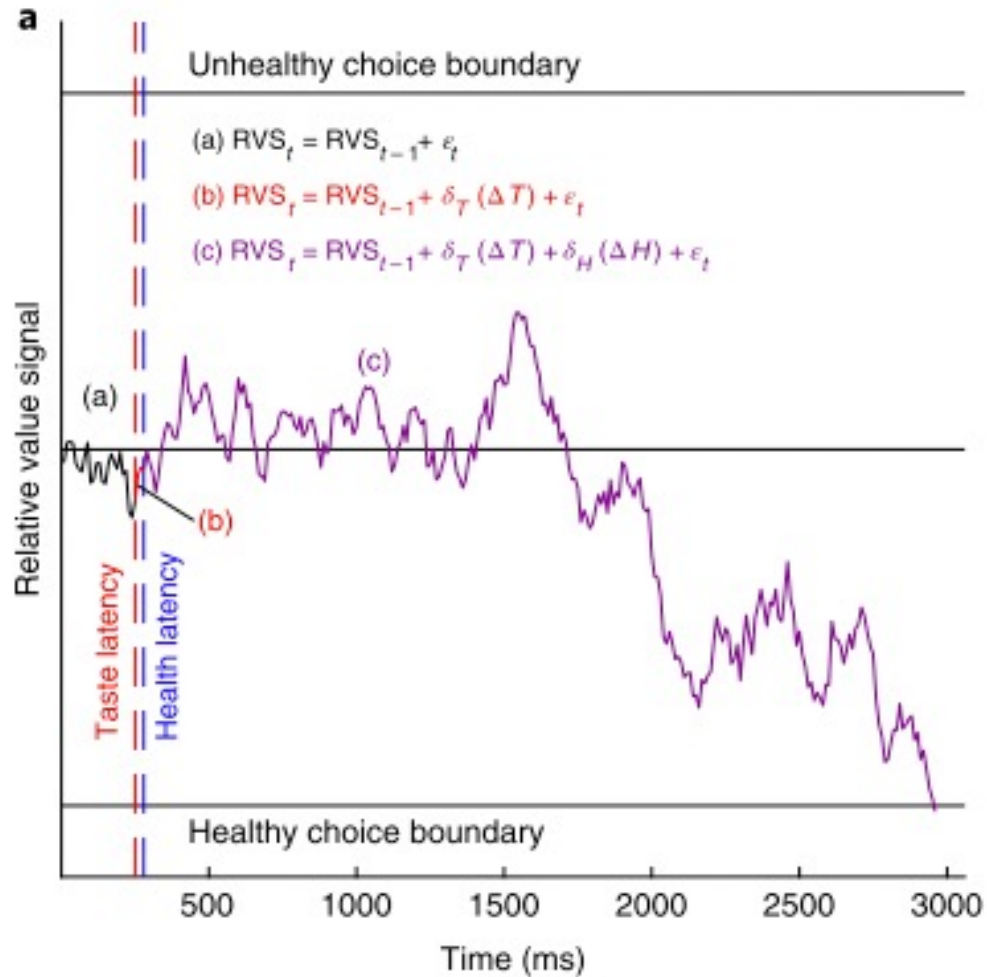
- Angle of every time point \sim value difference



Tastiness comes first

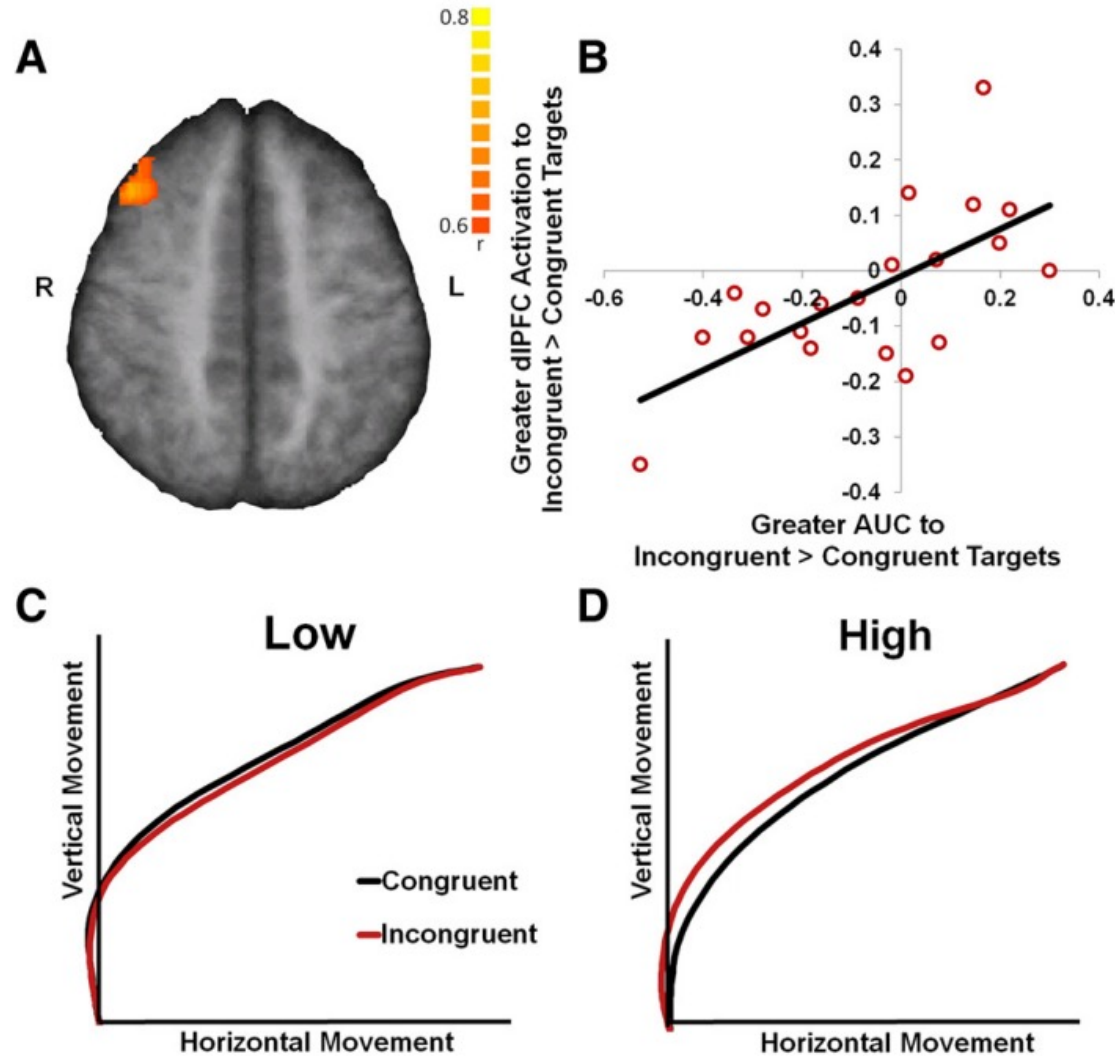
Relative value signal (RVS)

due to a later entry of health to the decision process (at $t^*_H = 500$ ms), it begins contributing to the RVS later than in the left example



Mouse tracking in fMRI

- Univariate



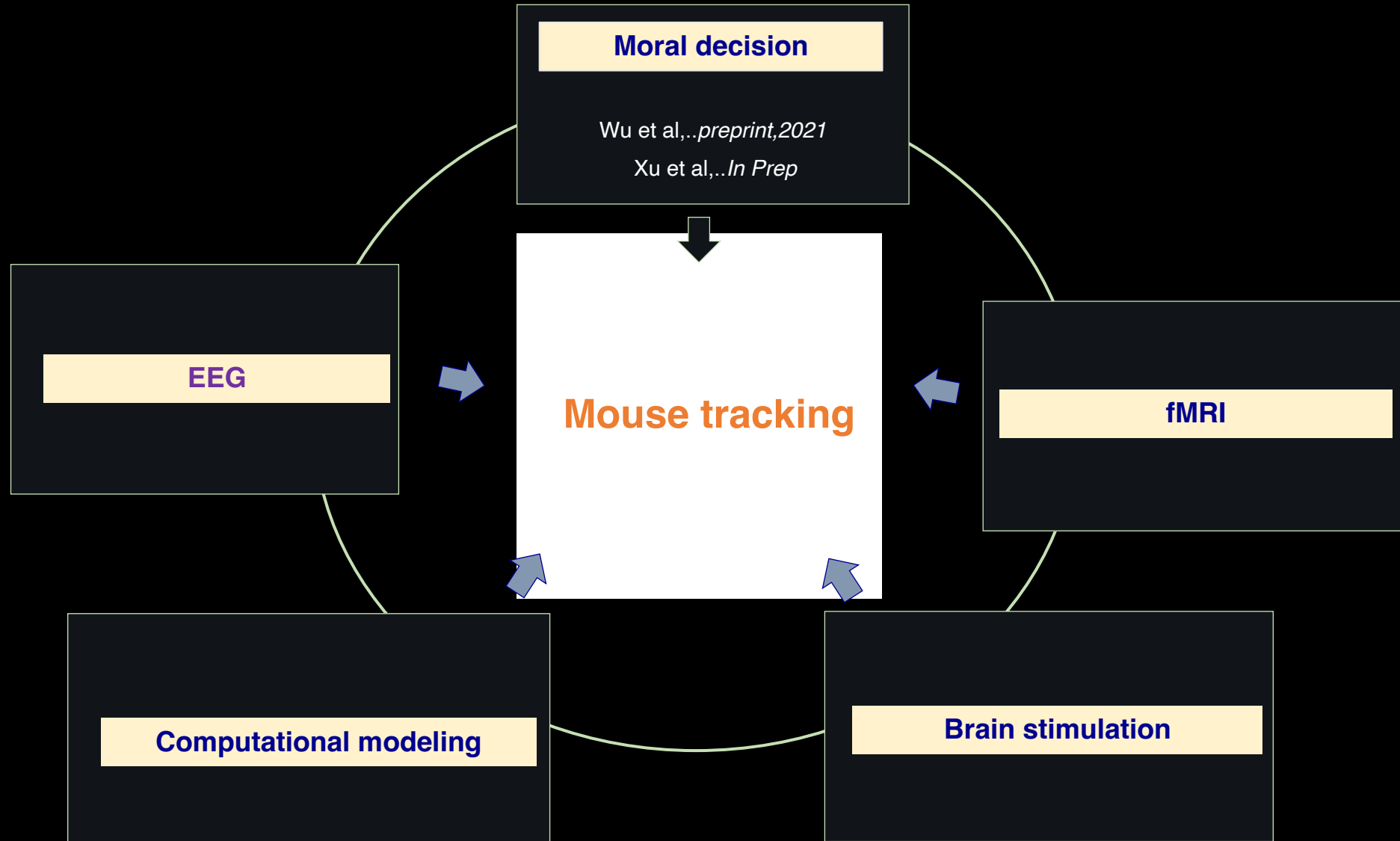
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Research examples



 haiyan0305 Update README.md	ea612ff 17 hours ago	🕒 27 commits
 Part1	Add files via upload	18 hours ago
 Part2	Create MT-opensesame.md	20 hours ago
 Part3	Update psychopy example	20 hours ago
 Part4	Create MT-fMRI.md	20 hours ago
 Part5	Create preprocess.md	20 hours ago
 README.md	Update README.md	17 hours ago

☰ README.md 

MT_workshop

andlab workshop Paper 10.1038/s41597-022-01538-5 @ANDlab3

From [Affective, Neuroscience, and Decision-making Lab](#)

Part 1: mouse tracker with IAT and moral decisions

Some code from Haiyan for mouse tracker and some R code contact: haiyanwu3@gmail.com

mouse tracking behavioral study the decision making task(with mouse tracker by Jon freeman)
[\[https://www.mousetracker.org/\]](https://www.mousetracker.org/)

Wu, H., Cao, S., Bai, C., Chen, K., & Mobbs, D. (2021). Moral by default? The dynamic tradeoffs between honesty and self-interest. [\[https://psyarxiv.com/kr4pw/\]](https://psyarxiv.com/kr4pw/)

Xu, X. J., Liu, X., Hu, X., & Wu, H. (2021). MT-aIAT: Integrating mouse tracking into memory-detection aIAT. [\[https://psyarxiv.com/ny9xq/\]](https://psyarxiv.com/ny9xq/)

Part 2: MT with opensesame

Some code from Haiyan contact: haiyanwu3@gmail.com

OpenSesame

WeChat Official Account



Memory

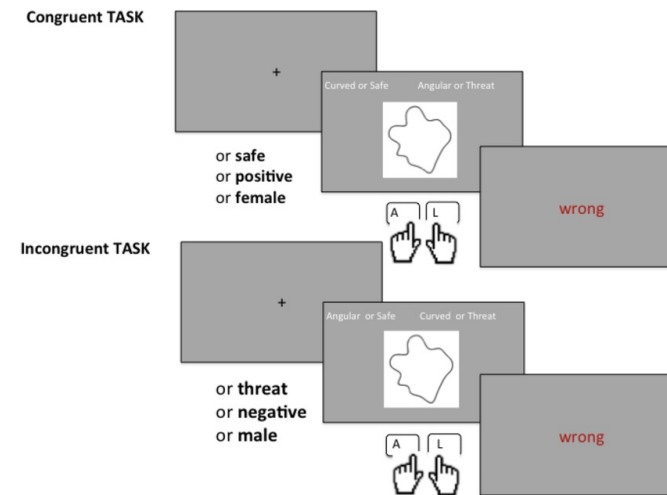
aIAT (autobiographical Implicit Association Test) with MT

- The **autobiographical Implicit Association Test** (aIAT; Sartori et al., 2008) is a variant of the Implicit Association Test (IAT; Greenwald et al., 1998) that is used to establish whether an autobiographical memory is encoded in the respondent's mind/brain.

Block	Number of Trials	Items Assigned to Left-Hand Key ("D")	Items Assigned to Right-Hand Key ("K")
1	20	Self	Others
2	20	Pleasant	Unpleasant
3	20	Self + pleasant	Others + unpleasant
4	40	Self + pleasant	Others + unpleasant
5	20	Others	Self
6	20	Others + pleasant	Self + unpleasant
7	40	Others + pleasant	Self + unpleasant

Note. The order of Blocks 1, 3, 4 and Blocks 5, 6, 7 was counterbalanced across subjects.

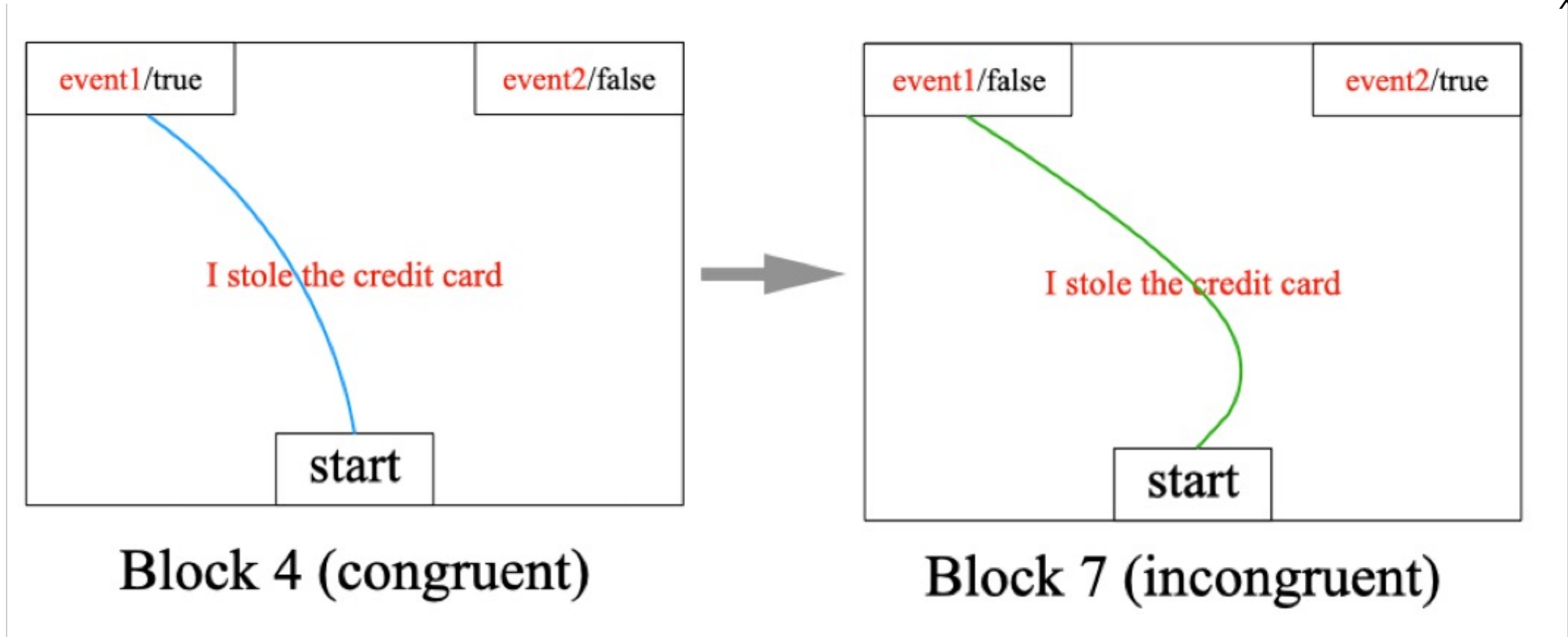
Classic IAT with 7 blocks



The autobiographical IAT



Xinyi Julia Xu

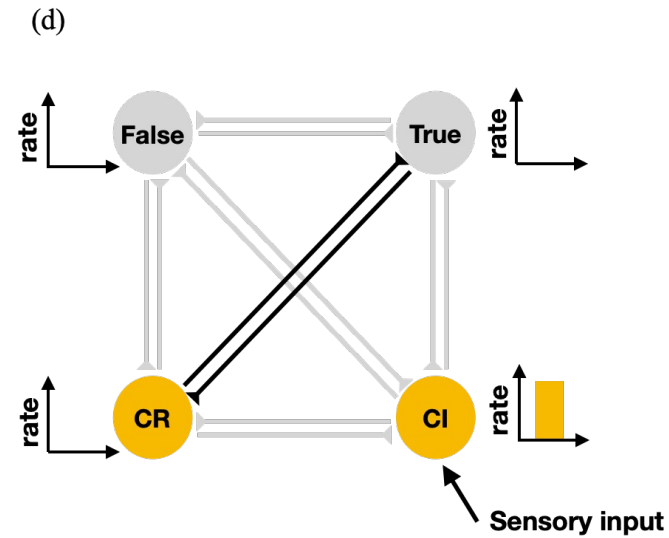
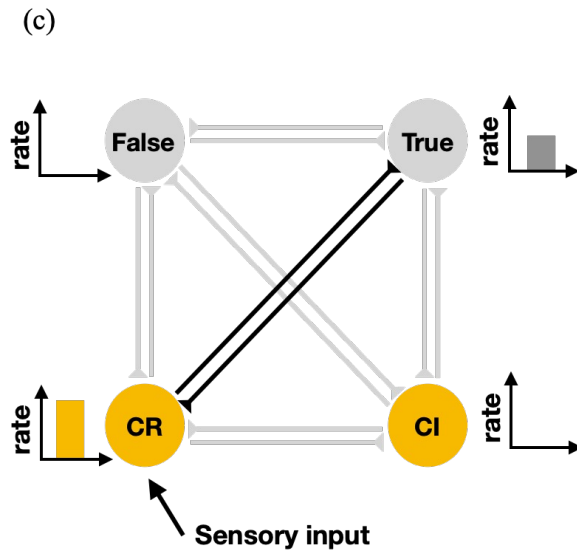
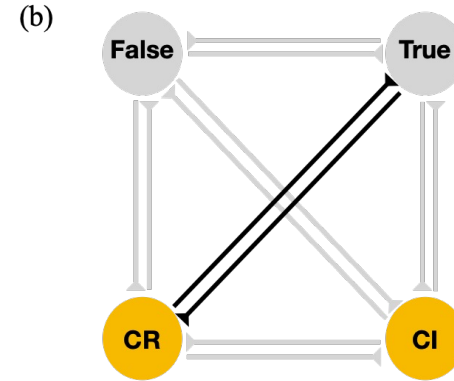
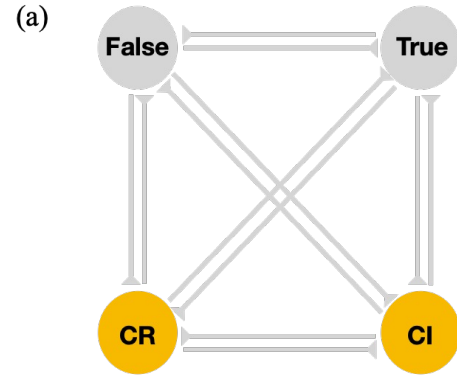


Xu, X. J., Liu, X., Hu, X., & Wu, H. (2021, September 18).

The connectionist model



Xinyi Julia Xu



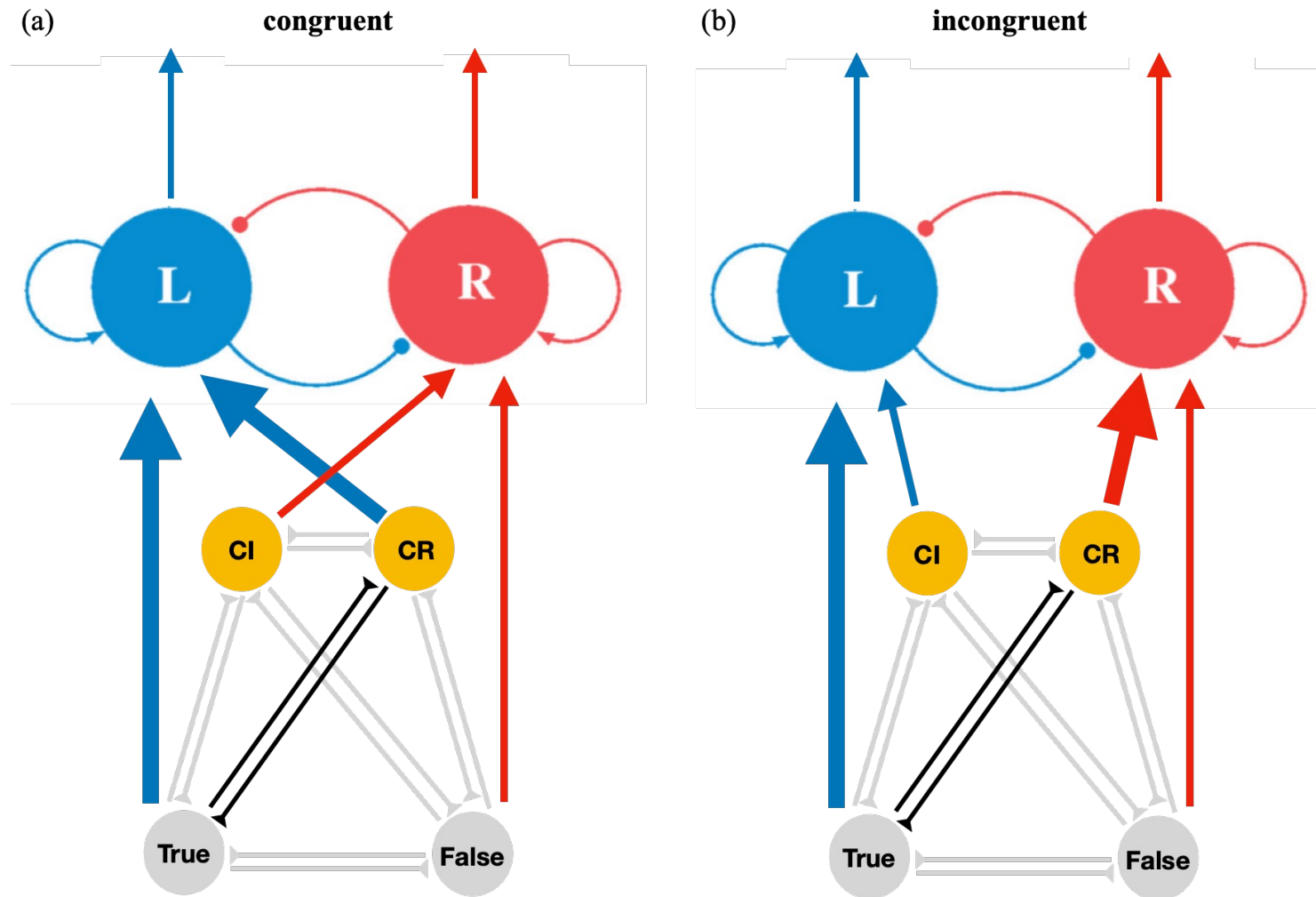
Bedder, R. L., Bush, D., Banakou, D., Peck, T., Slater, M., & Burgess, N. (2019). *Cognition*

Xu, X. J., Liu, X., Hu, X., & Wu, H. (2021, September 18).

Model the data with the drift diffusion model (DDM)



Xinyi Julia Xu



Bedder, R. L., Bush, D., Banakou, D., Peck, T., Slater, M., & Burgess, N. (2019). *Cognition*

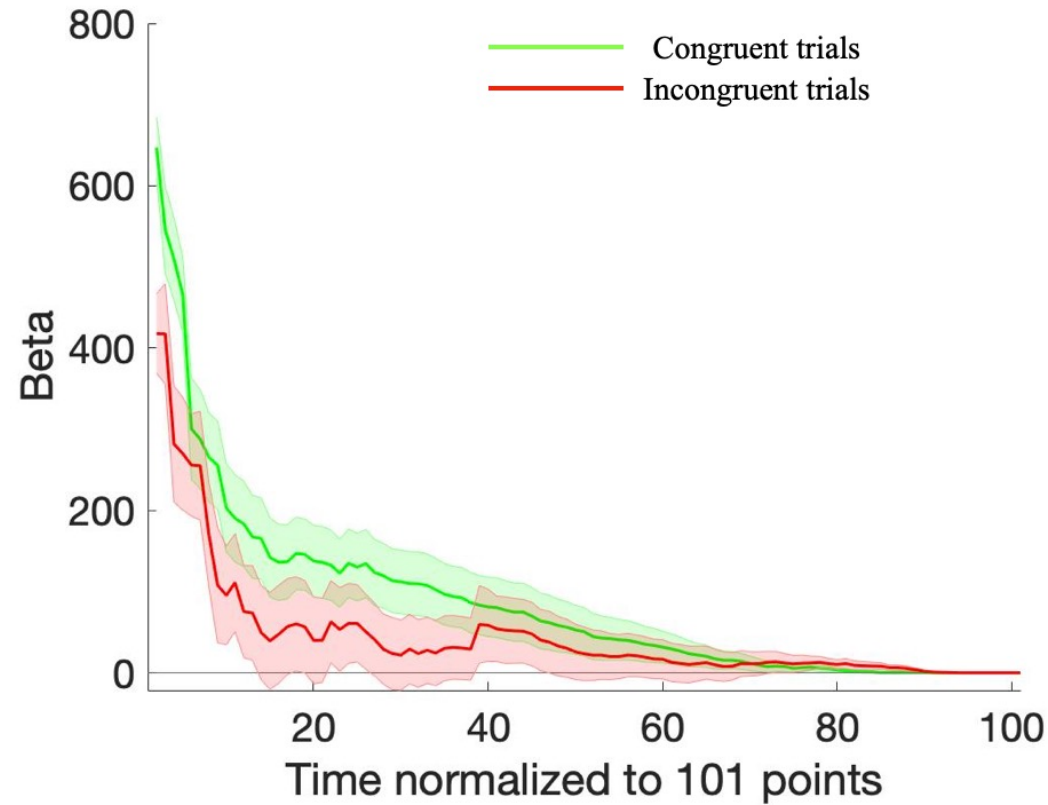
Xu, X. J., Liu, X., Hu, X., & Wu, H. (2021, September 18).

Regression Results



Xinyi Julia Xu

Angle $\theta \sim$ value difference



Sullivan, N., Hutcherson, C., Harris, A., & Rangel, A. (2015). *Psychological science*
Xu, X. J., Liu, X., Hu, X., & Wu, H. (2021, September 18).

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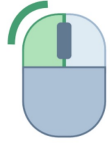
Moral

Example study 1



Moral by default? The dynamic tradeoffs between honesty and self-interest

Instruction 1



Coded by Mouse Tracker



- Before each block, there are two allocation options (A, B) for you and another people. You will send the option to other one and told him/her which option is better for him/her.

- For example, in this trial the A option is

you	other
60	70

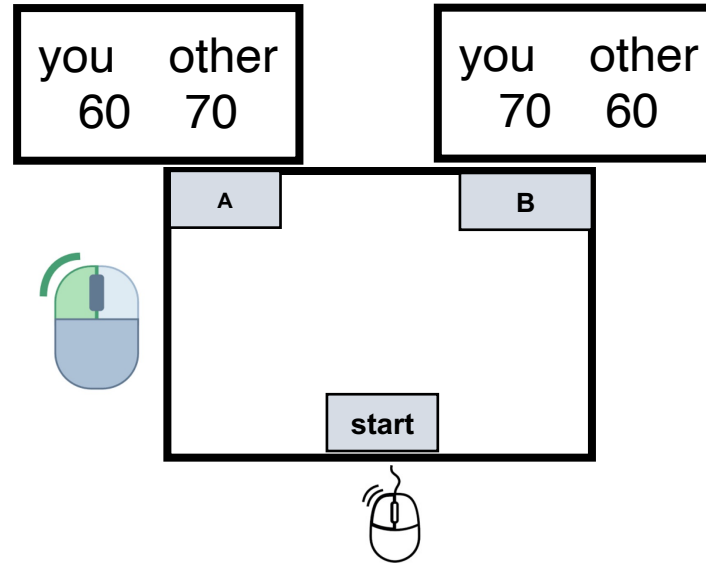
- the B option is

you	other
70	60

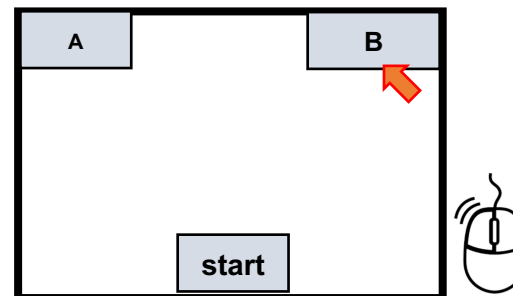
Instruction2



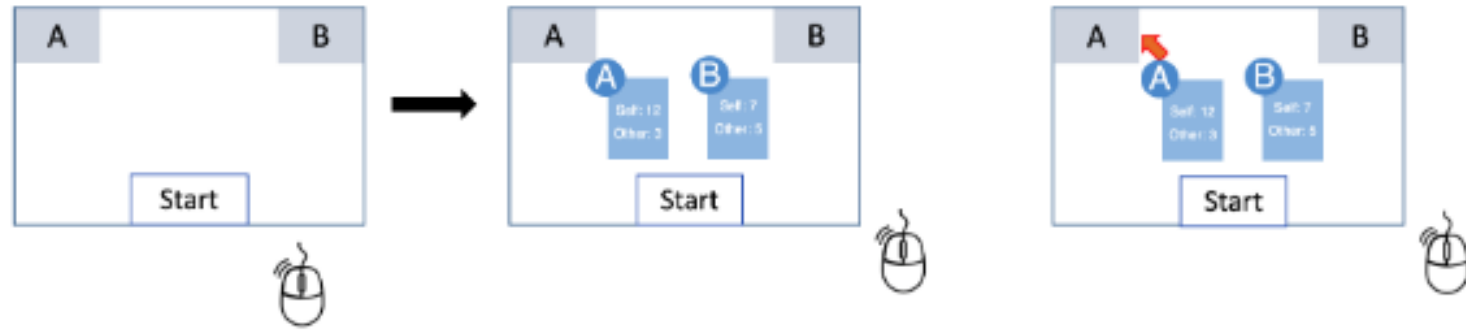
- click start by mouse



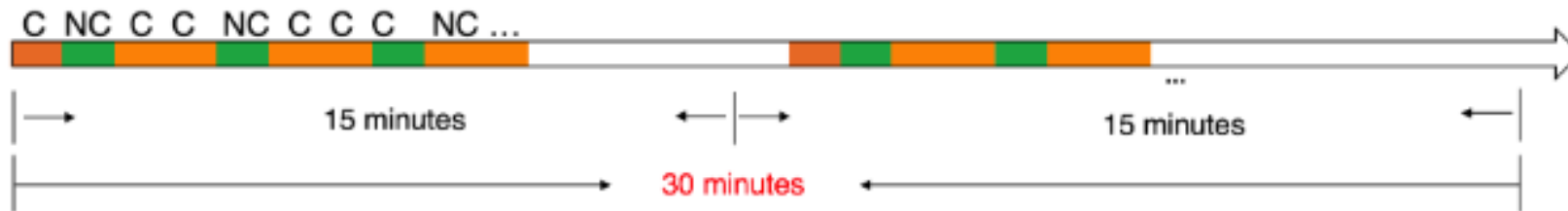
- you will see the two options, and may want tell player 2 the option B is better by lying



- Click one option you want to send to player2

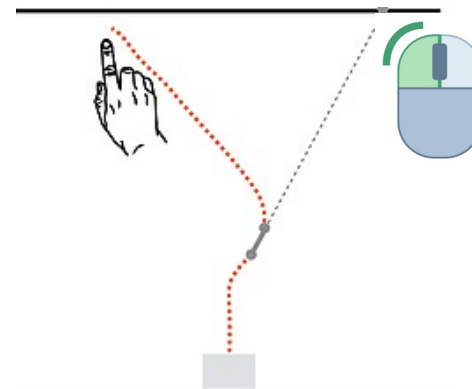
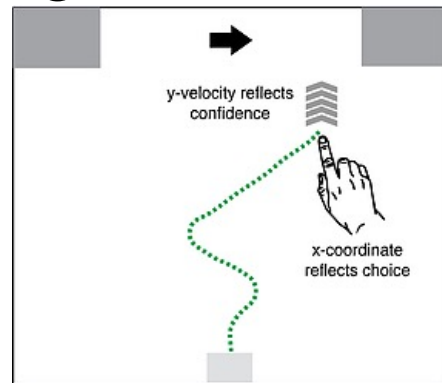


 Non-Conflict trial
 Conflict interest trial  Break/Questionnaire time



Analysis

- The latency of the movement, total time of motion, Area under the Curve, Maximum pull towards the incorrect information etc.(by R);
- Mapping discrete choice, confidence, averaged trajectory for each condition;
- compute trajectory divergence, accumulated evidence, time related regression;



Combine MT with computational model



Computational model

$$U(M_s, M_o) = \left[(\alpha - I \cdot \delta) M_s^\rho + (1 - \alpha + I \cdot \delta) M_o^\rho \right]^{\frac{1}{\rho}}$$

Alpha: relative weight between monetary payoffs for self and other

Delta: biasing effect of honesty concerns

Ra: elasticity of substitution between Ms and Mo

How to implement it in Mouse tracker?

A		B		S_PROFIT	CORRECT	CONDITION
self	other	self	other			
13	3	7	5	A	1	B
13	16	17	3	B	2	A
12	3	4	12	A	1	B
8	5	4	19	A	1	B
17	6	9	8	A	1	B
7	12	12	8	B	2	A
1	6	8	10	B	2	B
10	18	11	11	B	2	A
5	20	7	2	B	2	A
4	17	14	6	B	2	A
18	13	4	12	A	1	A
20	5	6	7	A	1	B
8	17	12	7	B	2	A
7	13	6	14	A	1	B
15	5	6	10	A	1	B
13	2	9	11	A	1	B
5	12	6	3	B	2	A
1	11	19	14	B	2	B
14	13	10	11	A	1	A
10	12	14	7	B	2	A
1	16	13	8	B	2	A
2	7	13	8	B	2	B
11	7	3	10	A	1	B
10	8	11	12	B	2	B
5	13	14	11	B	2	A
8	9	7	2	A	1	A
16	8	6	13	A	1	B
15	5	3	11	A	1	B
4	10	5	16	B	2	B
18	5	7	11	A	1	B
6	9	15	8	B	2	A
16	15	20	14	B	2	A
9	13	16	8	B	2	A
12	9	6	16	A	1	B
2	11	10	15	A	1	B
18	20	2	7	A	1	A
12	16	8	20	A	1	B
4	13	9	5	B	2	A
14	9	18	6	B	2	A
8	12	3	16	A	1	B

1 Trial structure

	A	B	C	D	E	F	G
1	screenres	1024	768				
2	startloc	-0.1;0.2;0.1;0.1					
3	stimloc	0;0.5					
4	stimhcenter	1					
5	stimvcenter	1					
6	resploc	-1;0.3;1.5;0.2	0.7;0.3;1.5;0.2				
7	respbackcolor	0	0	0			
8	respfontname	Arial					
9	respfontcolor	255	255	255			
10	respfontsize	22					
11	respborder	1					
12	screencolor	255	255	255			
13	stimfontname	Arial					
14	stimfontcolor	0	0	0			
15	stimfontsize	28					
16	startfontname	Verdana					
17	startfontsize	18					
18	starttext	START					
19	autoorigin	1					
20	endscreen	end.jpg					
21	endexec	0					
22	ITI1	2000					
23	ITI2	2000					
24	respshwafter	0					
25	respshwafterdelay	0					
26	feedbacktime	0					
27	hovermode	0					
28	hovervspace	0.1					
29	hoverhspace	0.1					
30	timecut	0					
31	timecutmsg	TIME OUT!					
32	timeouttime	3000					
33	initcut	1500					
34	initcutmsg	Please start moving earlier on even if you are not fully certain of a response yet!					
35	horizcut	0					
36	cursorsspeed	10					
37	holdforcompound	1					
38	dragaine	0					

2 set up

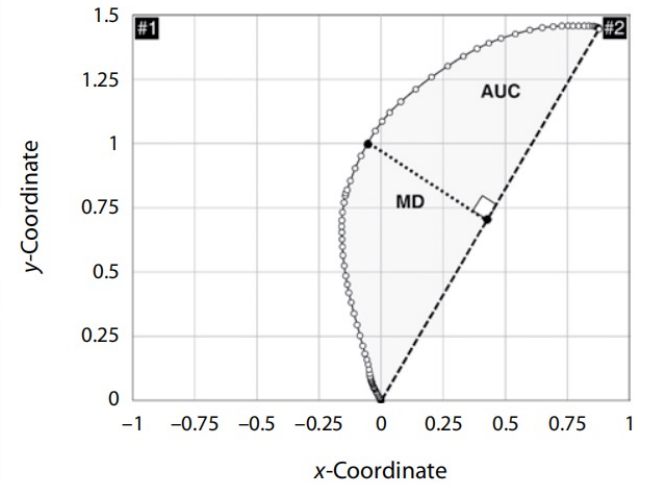
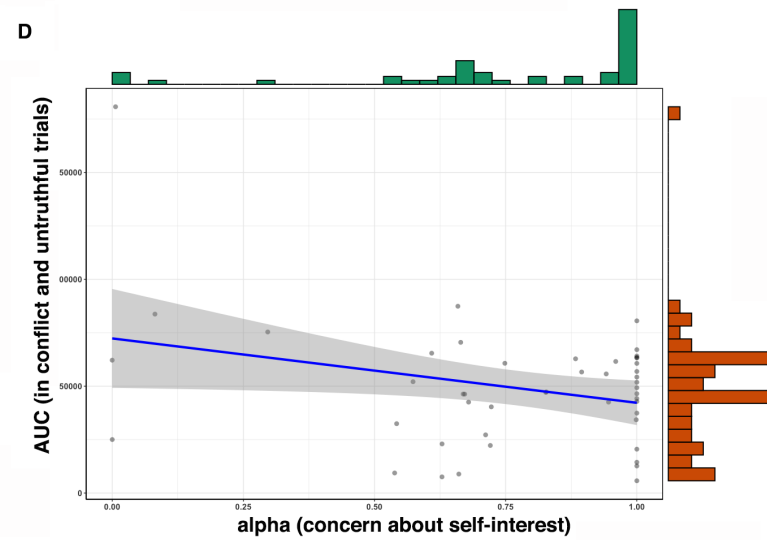
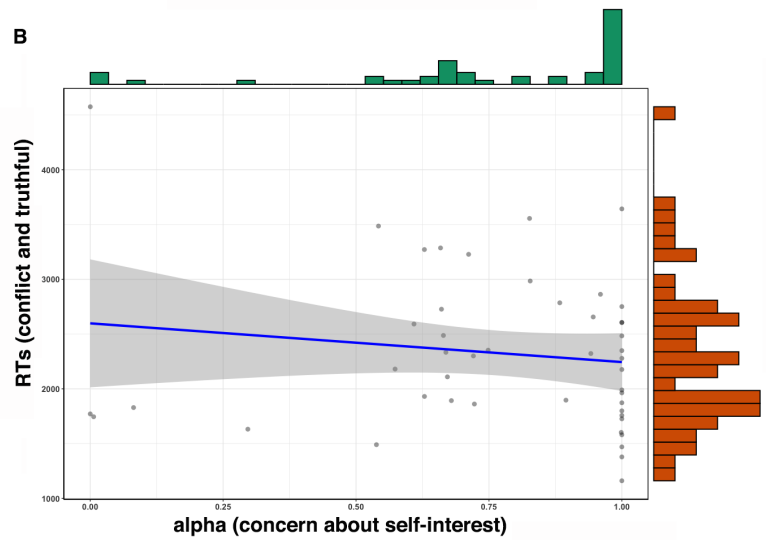
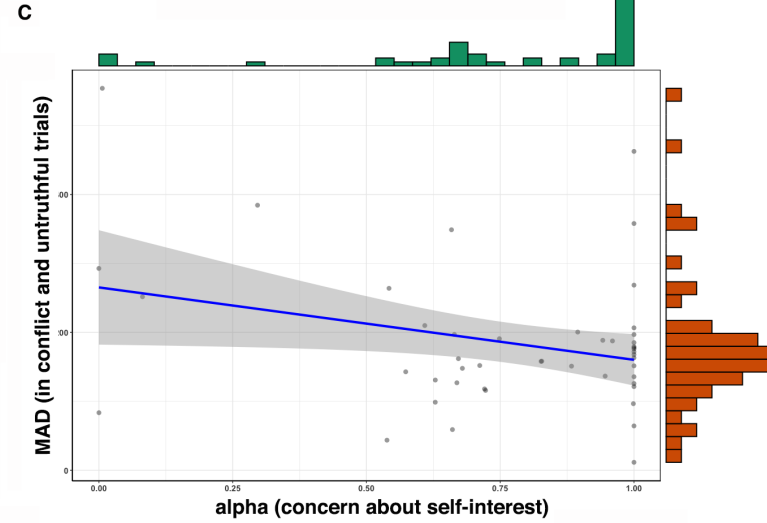
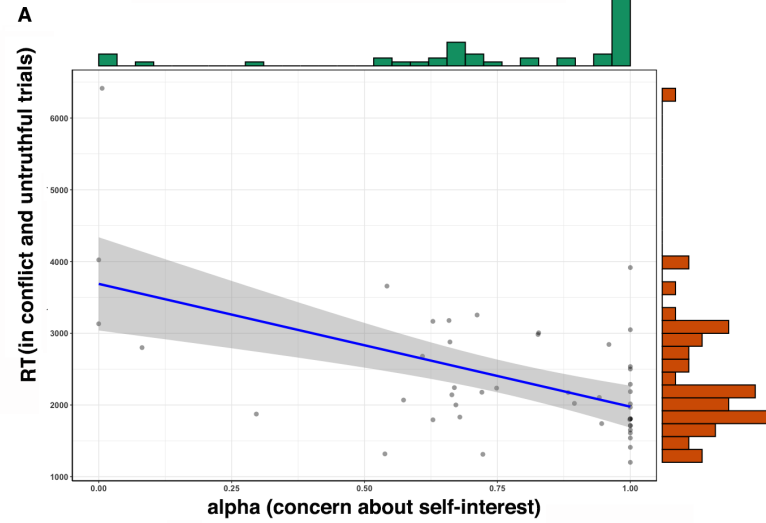
	type	stim	cond	rand	correct	default-com	resp_1	resp_2
41								
42		0 M1.jpg	instruct					
43		0 mes2.jpg	instruct					
44		1 1.jpeg	conflict	1	2	1	A	B
45		1 2.jpeg	conflict	1	1	2	A	B
46		1 3.jpeg	conflict	1	2	1	A	B
47		1 4.jpeg	conflict	1	2	1	A	B
48		1 5.jpeg	conflict	1	2	1	A	B
49		1 6.jpeg	conflict	1	1	2	A	B
50		1 7.jpeg	NC	1	2	1	A	B
51		1 8.jpeg	conflict	1	1	2	A	B
52		1 9.jpeg	conflict	1	1	2	A	B
53		1 10.jpeg	conflict	1	1	2	A	B
54		1 11.jpeg	NC	1	1	2	A	B
55		1 12.jpeg	conflict	1	2	1	A	B
56		1 13.jpeg	conflict	1	1	2	A	B
57		1 14.jpeg	conflict	1	2	1	A	B
58		1 15.jpeg	conflict	1	2	1	A	B
59		1 16.jpeg	conflict	1	2	1	A	B
60		1 17.jpeg	conflict	1	1	2	A	B
61		1 18.jpeg	NC	1	2	1	A	B
62		1 19.jpeg	NC	1	1	2	A	B
63		1 20.jpeg	conflict	1	1	2	A	B
64		1 21.jpeg	conflict	1	1	2	A	B
65		1 22.jpeg	NC	1	2	1	A	B
66		1 23.jpeg	conflict	1	2	1	A	B
67		1 24.jpeg	NC	1	2	1	A	B
68		1 25.jpeg	conflict	1	1	2	A	B
69		1 26.jpeg	NC	1	1	2	A	B
70		1 27.jpeg	conflict	1	2	1	A	B
71		1 28.jpeg	conflict	1	2	1	A	B
72		1 29.jpeg	NC	1	2	1	A	B
73		1 30.jpeg	conflict	1	2	1	A	B
74		1 31.jpeg	conflict	1	1	2	A	B
75		1 32.jpeg	conflict	1	1	2	A	B
76		1 33.jpeg	conflict	1	1	2	A	B
77		1 34.jpeg	conflict	1	1	2	A	B

3 Build Trials in csv

https://github.com/andlab-um/MT_workshop

Part 1

Results



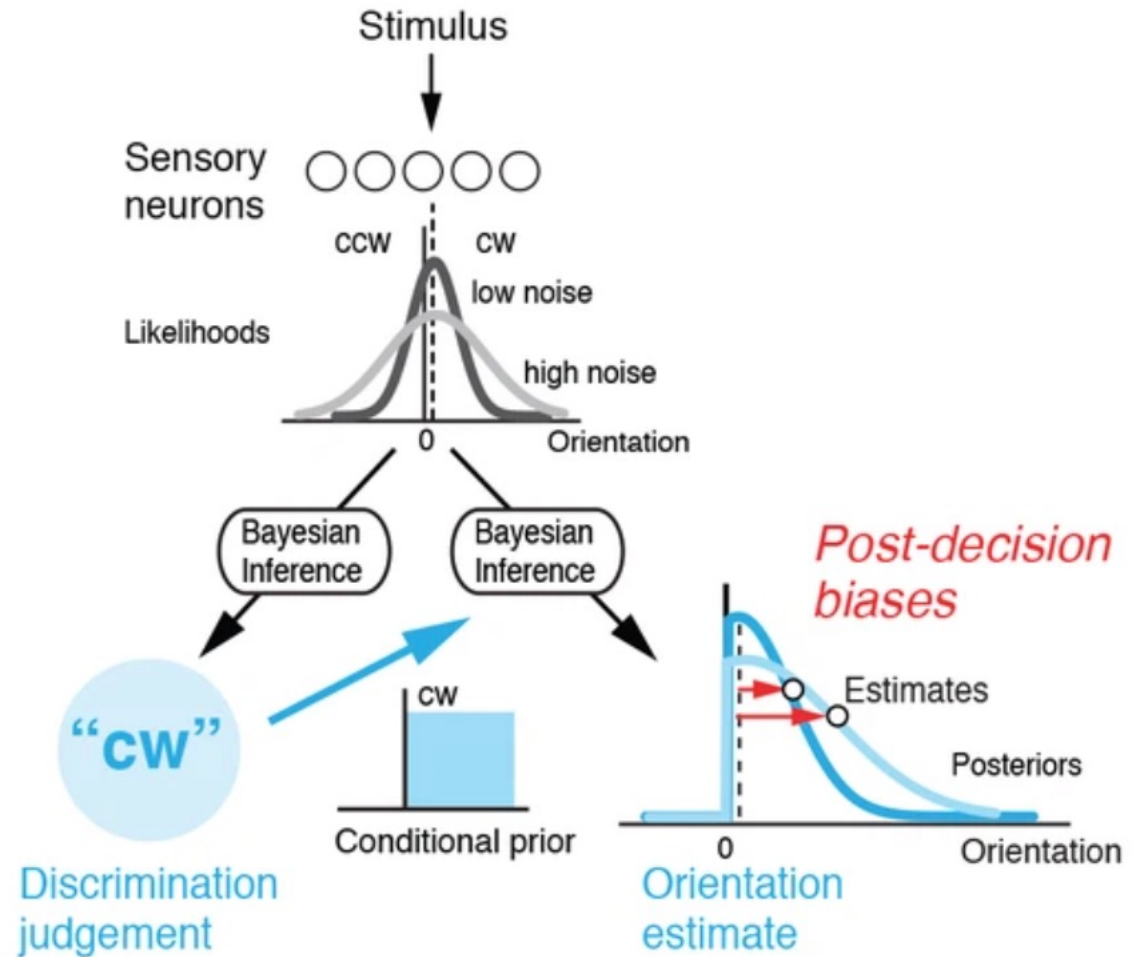
Example study 2

Reward and self-consistency: Dissecting the role of social brain and cognitive control in moral decisions

Reward seeking and self-consistency are both critical in moral decisions

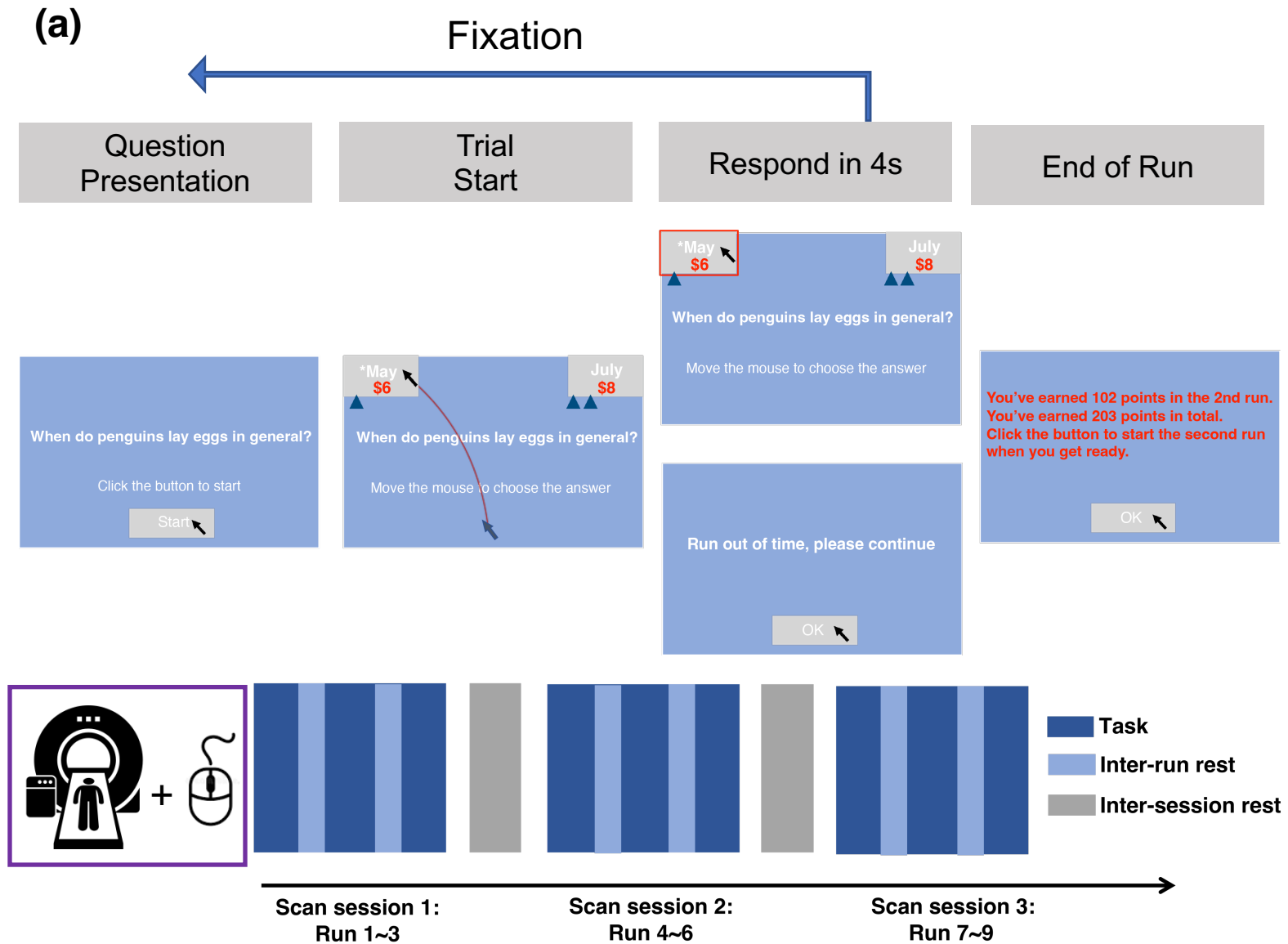


Self-consistent Bayesian observer



Luu, L et al. (2018)

Paradigm



Research Questions

1

How human trade off reward and consistency in weights and in timings

2

How reward and consistency are associated with the cognitive-control and reward related brain regions?

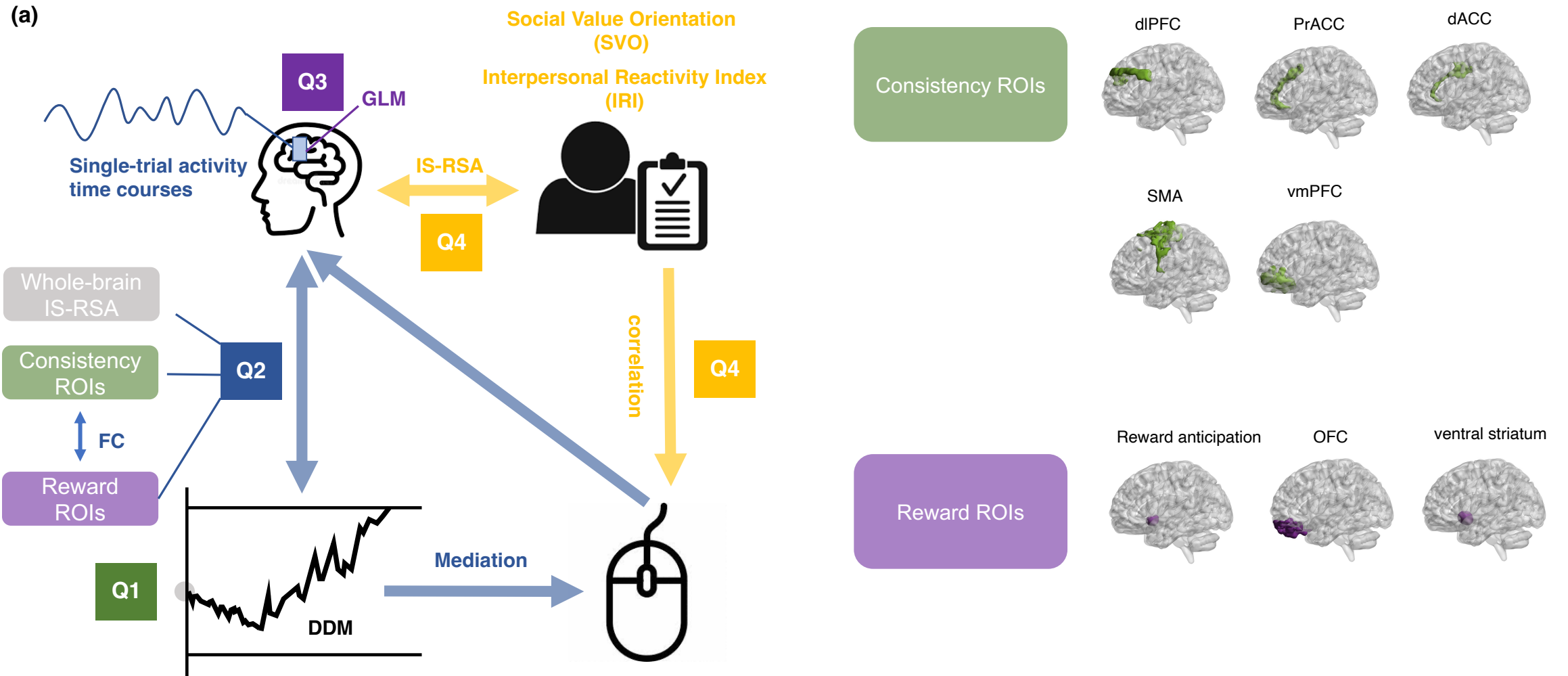
3

How does the activity in the related regions change along the sessions?

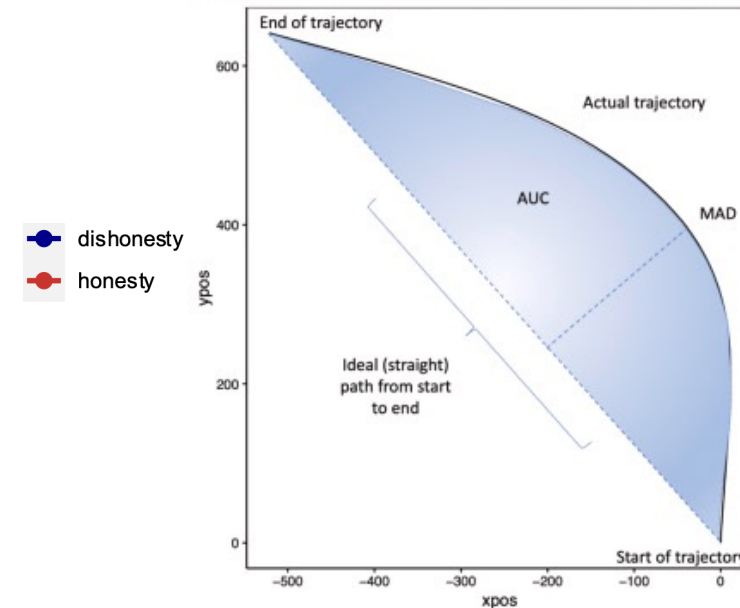
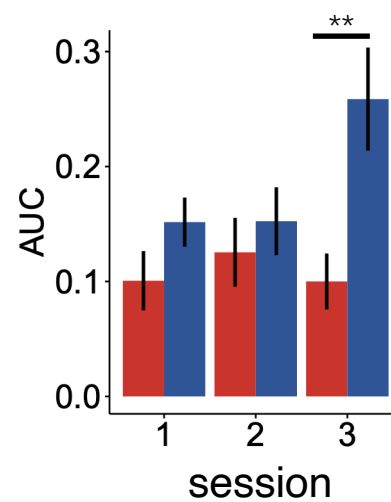
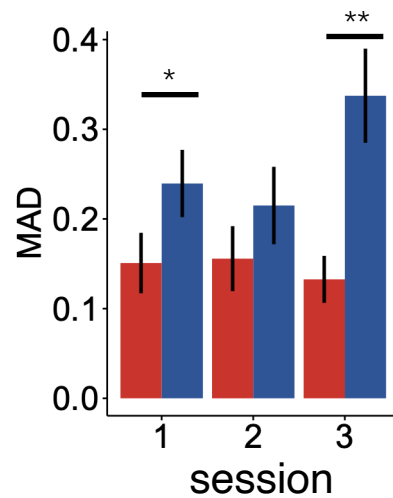
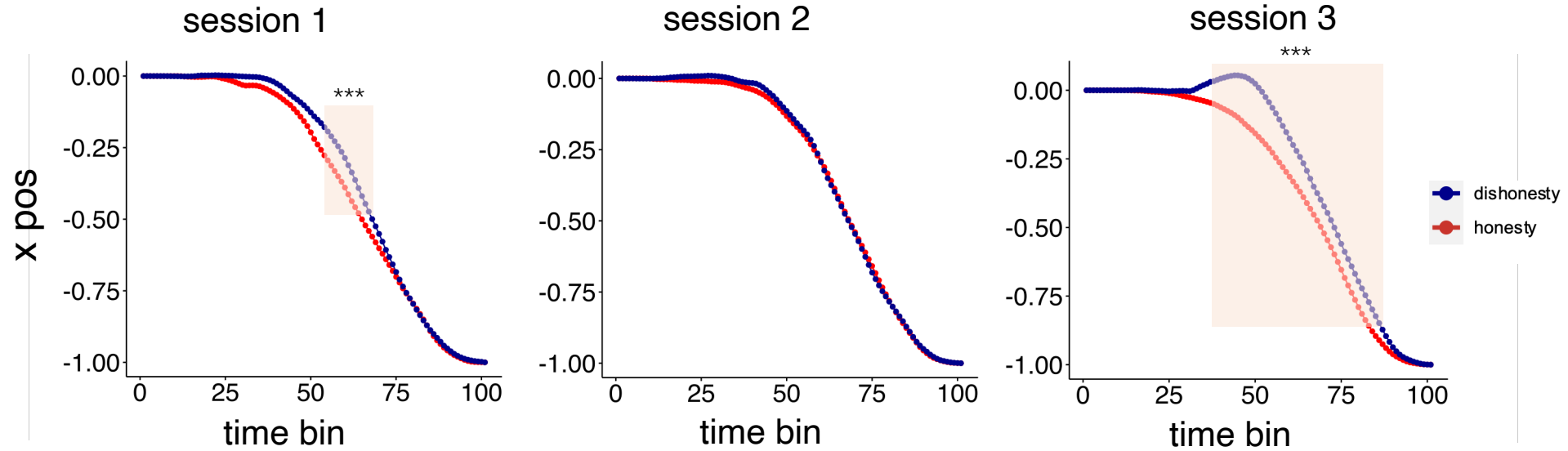
4

how are mouse trajectories and brain activity patterns mediated by personal traits?

Framework



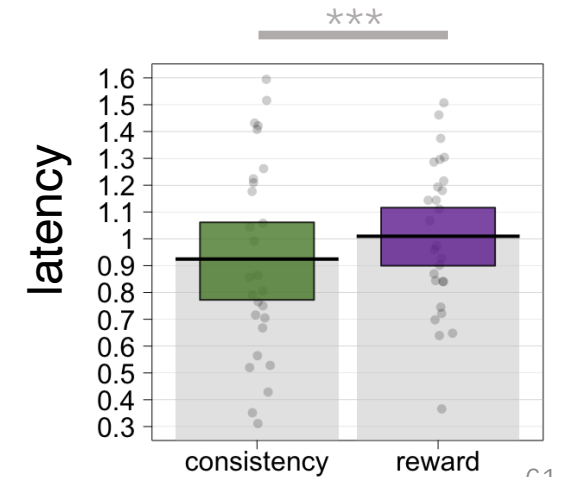
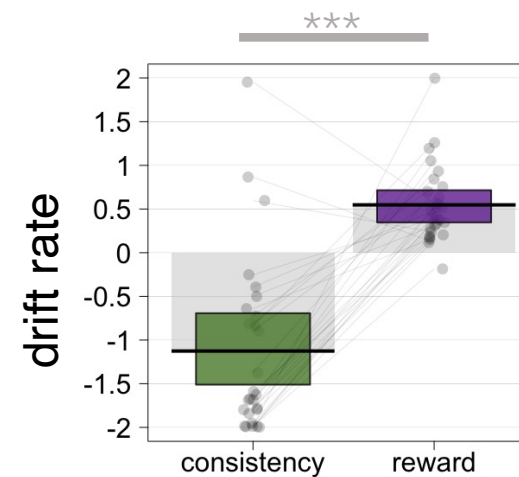
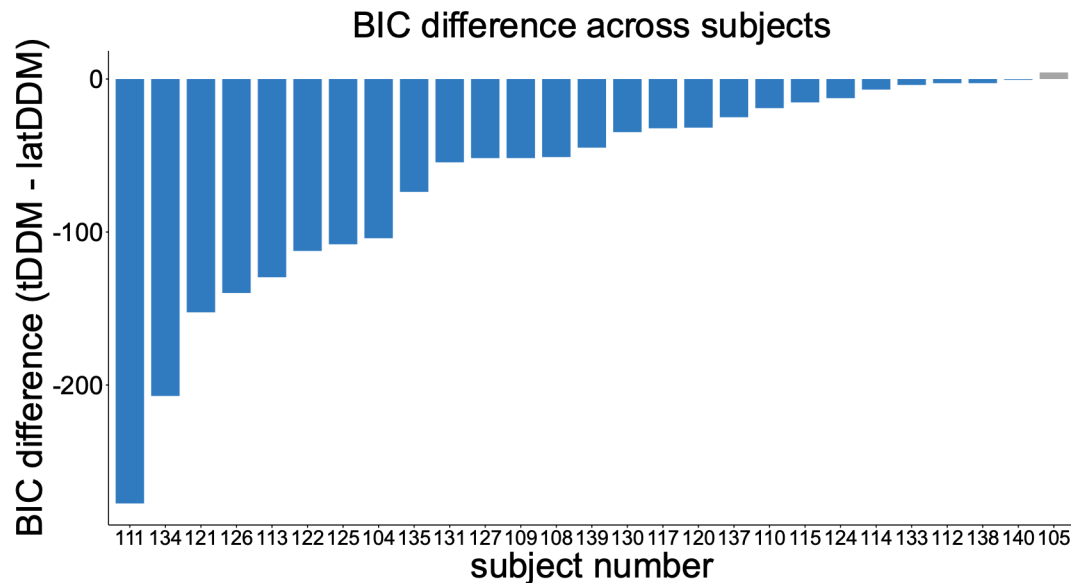
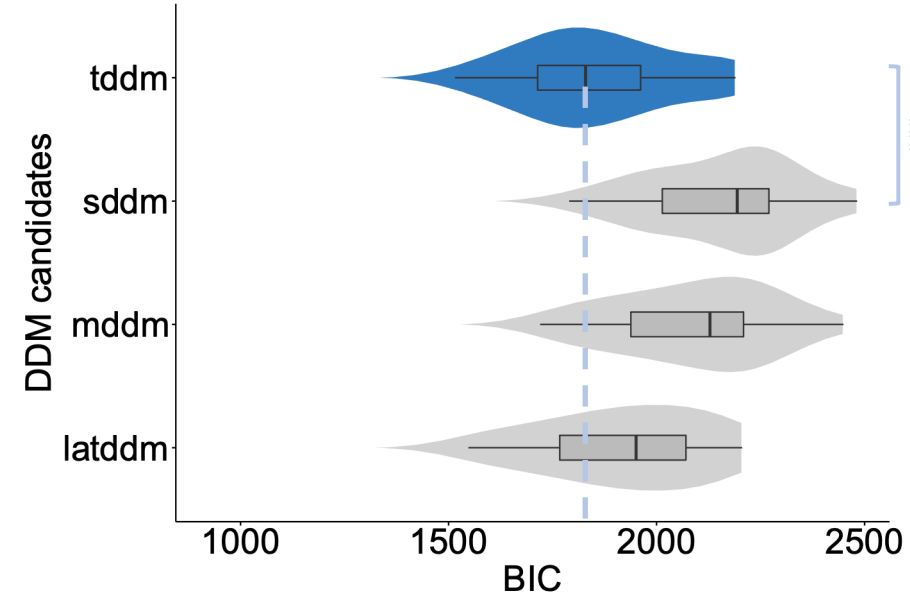
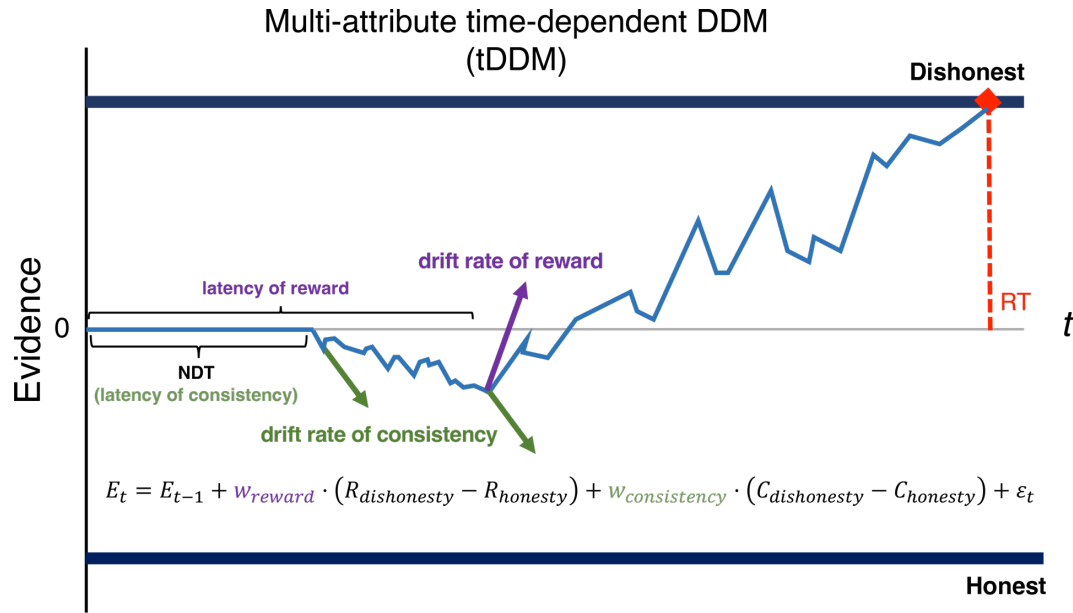
Dishonesty and honesty responses had different mouse trajectories



1

How human trade off reward and consistency in weights and in timings?

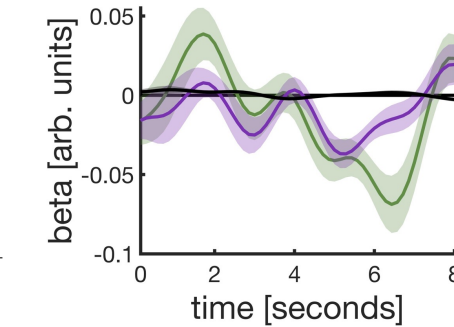
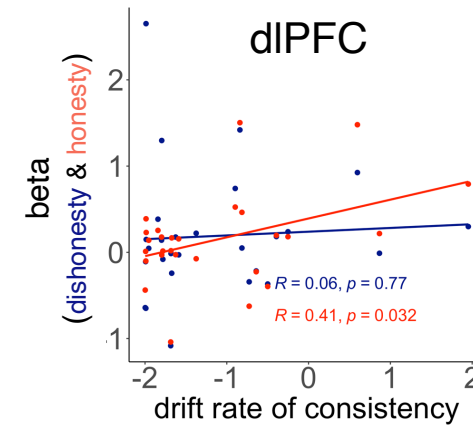
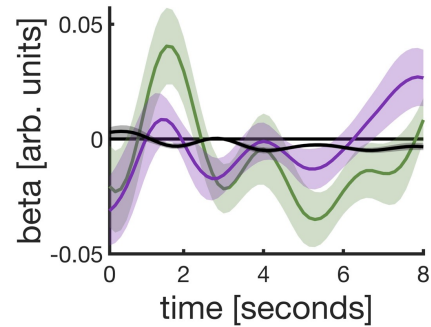
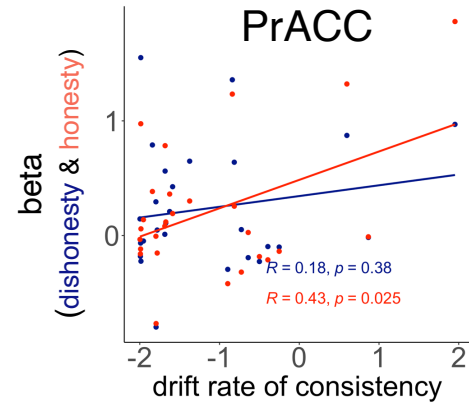
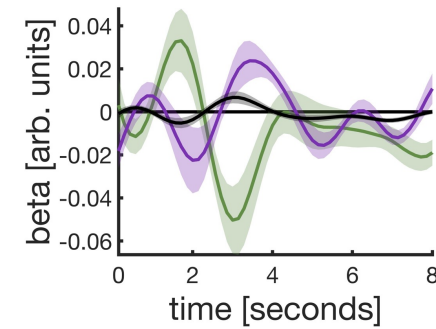
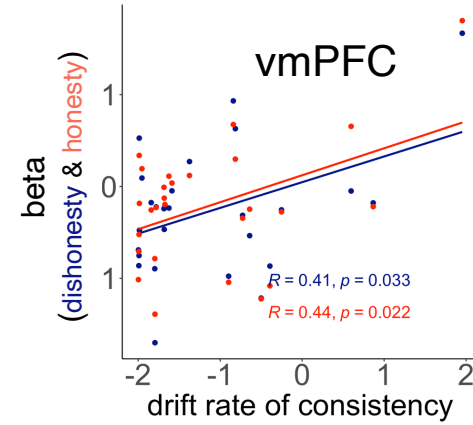
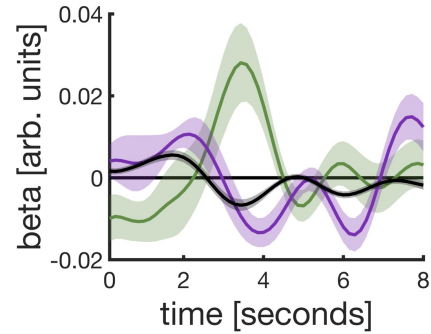
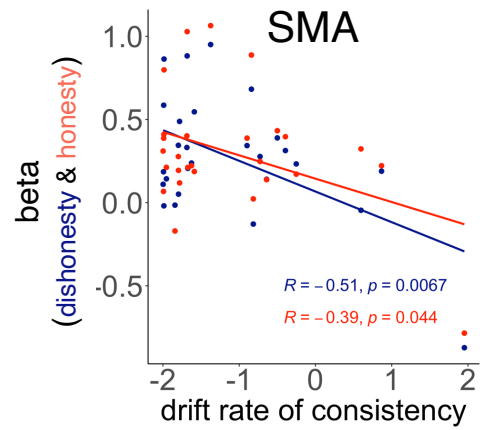
Consistency and reward: different weights, different timings



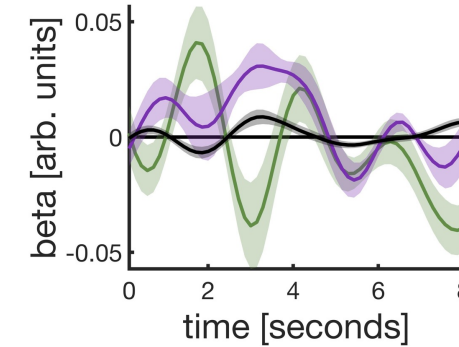
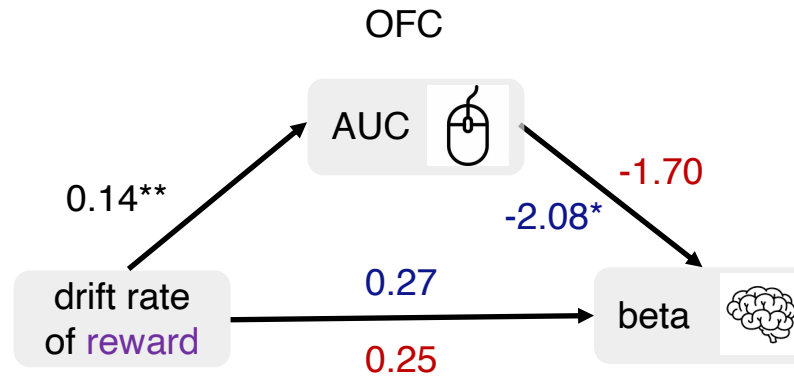
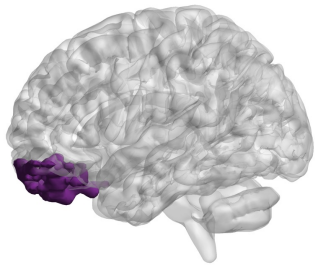
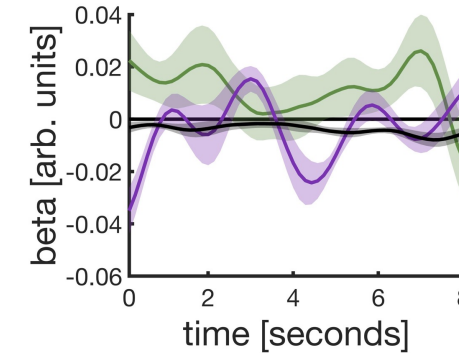
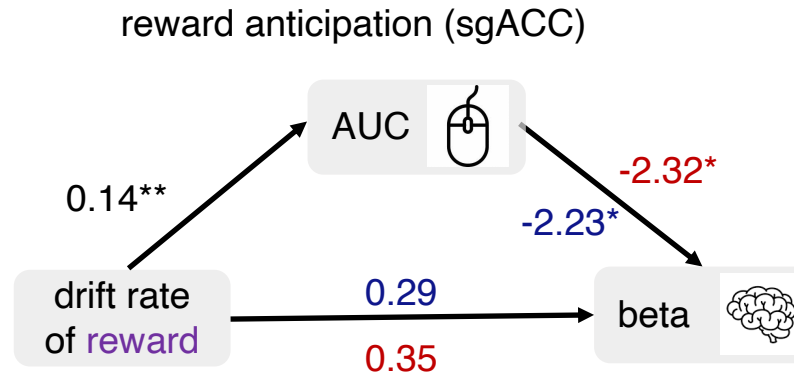
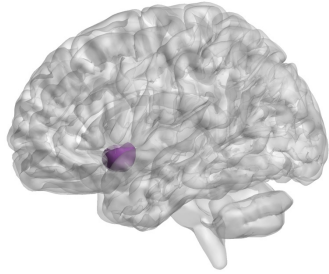
2

How are the weights of reward and consistency associated with the **cognitive-control** and **reward** related brain regions?

Weights of consistency: correlated with cognitive control brain regions



Weights of **reward**: mediated by mouse tracking index AUC



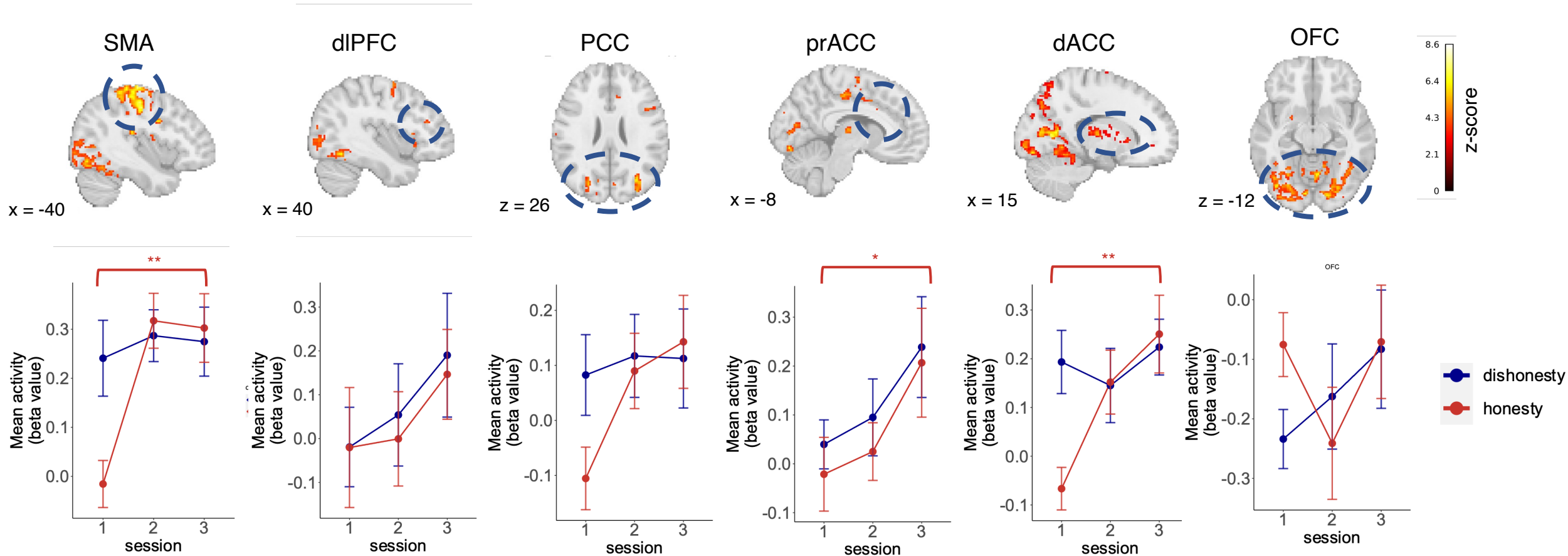
— dishonesty
— honesty

— consistency
— reward

3

How does the activity in the related regions change along the sessions?

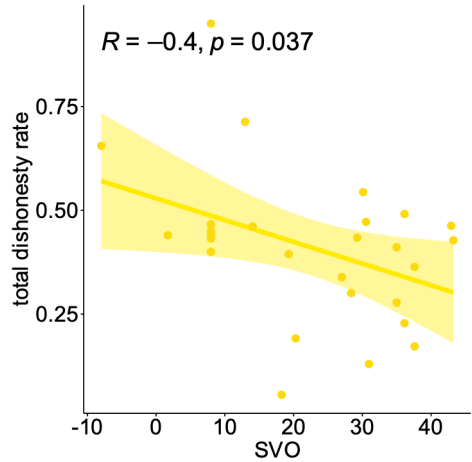
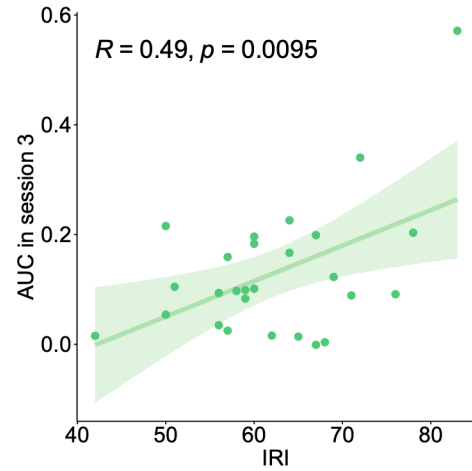
Activations of cognitive control brain regions increased along the sessions



4

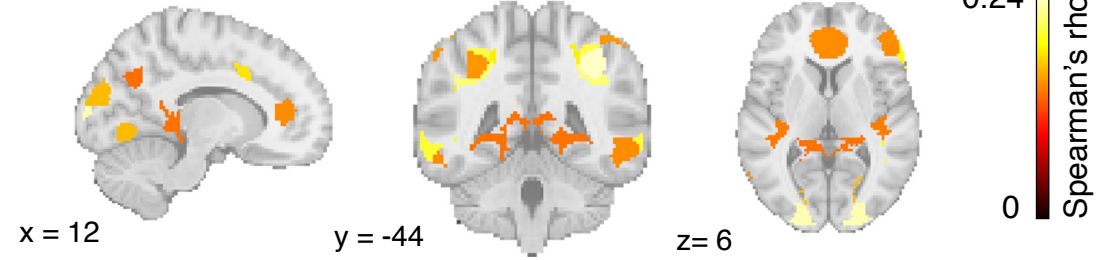
how are mouse trajectories and brain activity patterns mediated by personal traits?

Effects of personal traits on behavior and brain

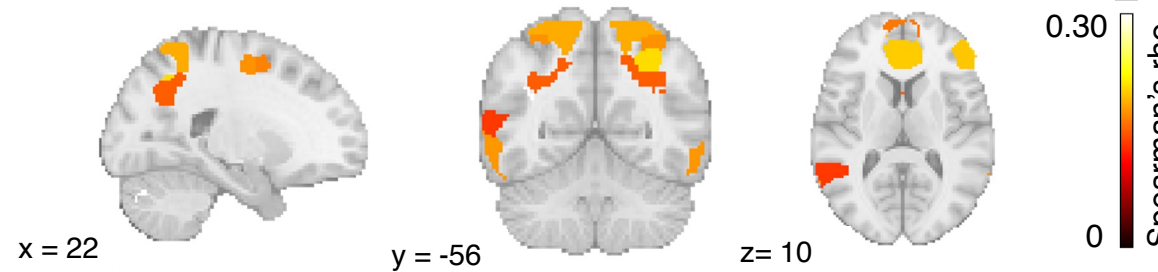


Interpersonal Reactivity Index (IRI)
Social Value Orientation (SVO)

personal traits (IRI+SVO)
IS-RSA brain map for **dishonesty** condition in session 3
($q < 0.05$ FDR corrected)



personal traits (IRI+SVO)
IS-RSA brain map for **honesty** condition in session 3
($q < 0.05$ FDR corrected)



Outline

- **Introduction of mouse tracking (MT)**
- **Research examples**
 - Memory: aIAT with MT
 - Moral decisions with MT
 - Other decisions with MT
- **Implementations and data analysis**
 - Mouse tracker
 - Opensesame
 - Psychopy
 - Combine with EEG and fMRI

Outline

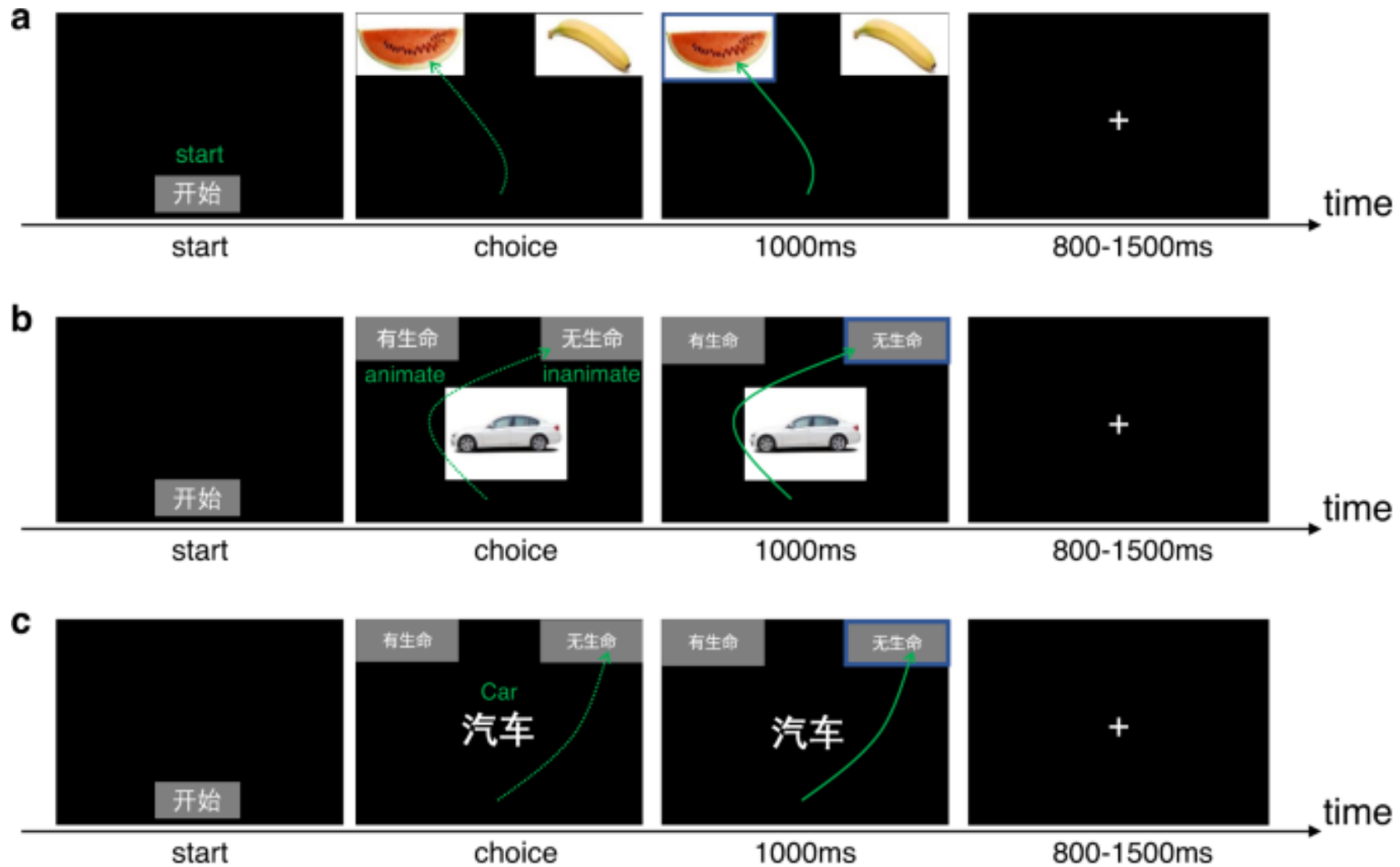
- Introduction of mouse tracking (MT)
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Other Decisions

Paradigm



Kun Chen

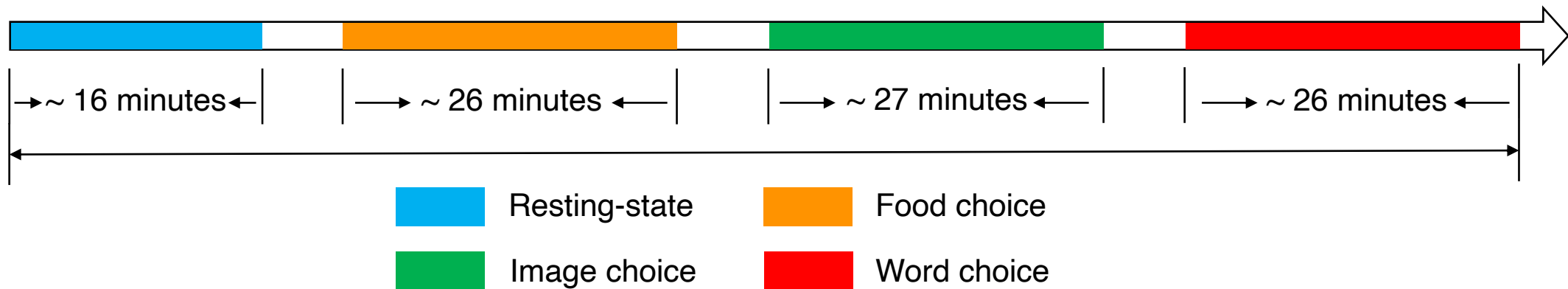


Task Overview



Kun Chen

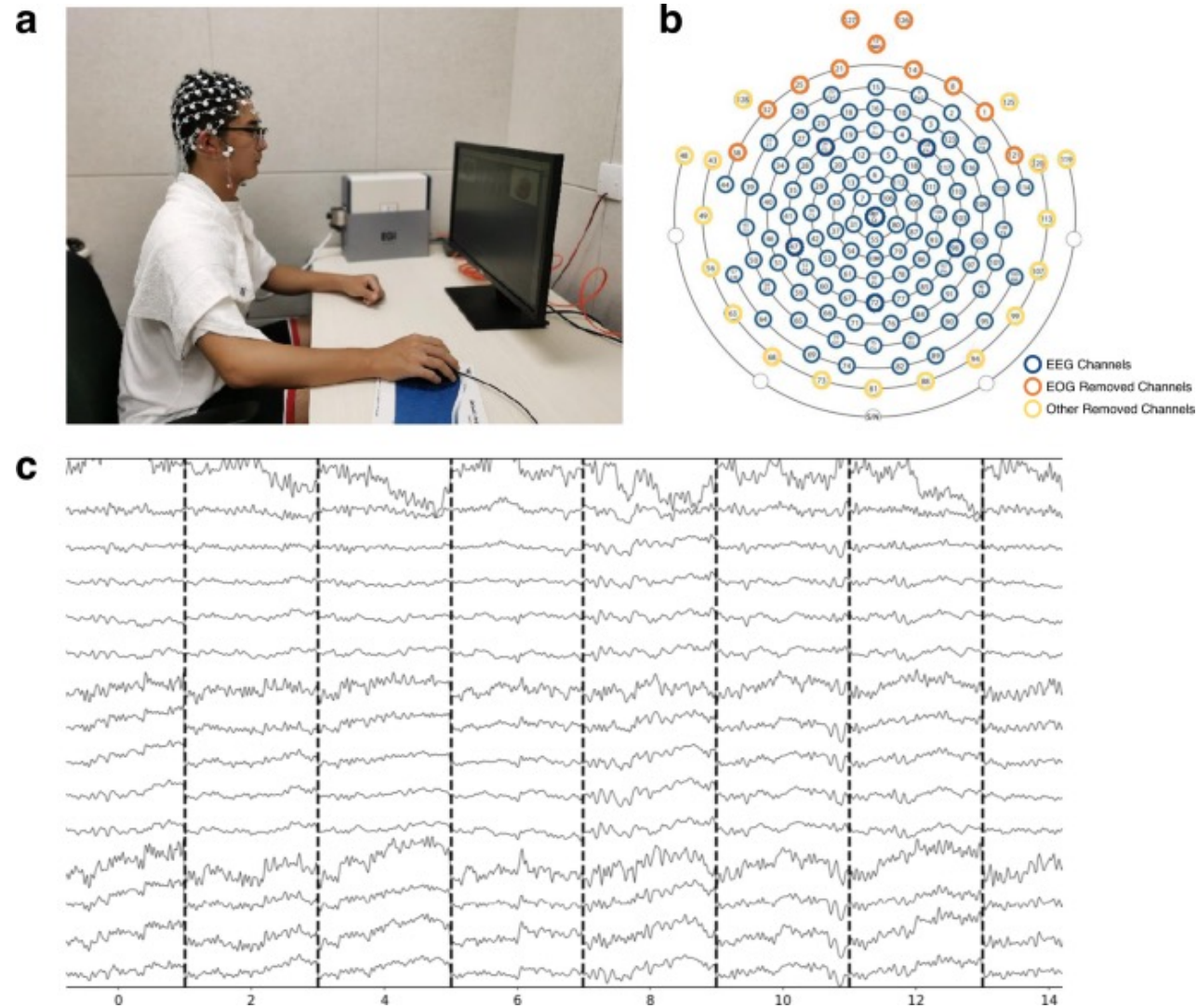
Task	Description
Resting-state	Measures EEG activity during rest.
Food choice	A food preference task based on mouse tracking. Measures the dynamic process and corresponding EEG signals of food preferences.
Image choice	A semantic classification task for image based on mouse tracking. Measures the dynamic semantic process and corresponding EEG signals of binary decisions.
Word choice	A semantic classification task for word based on mouse tracking. Measures the dynamic semantic process and corresponding EEG signals of binary decisions.



Data collection platform



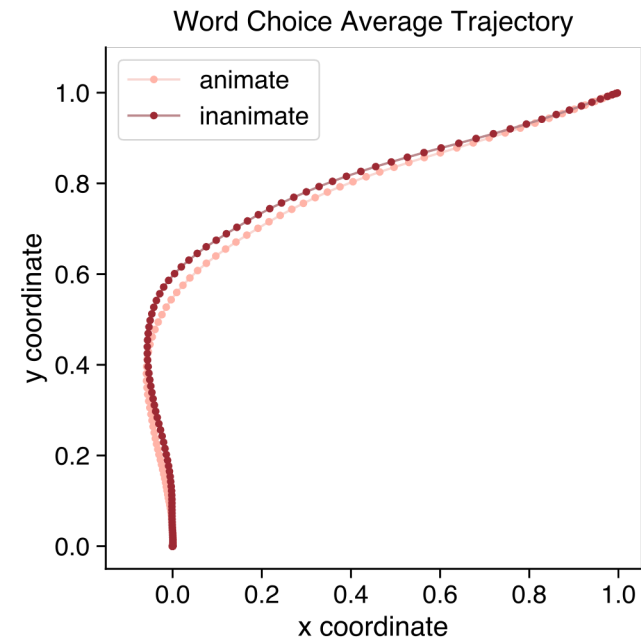
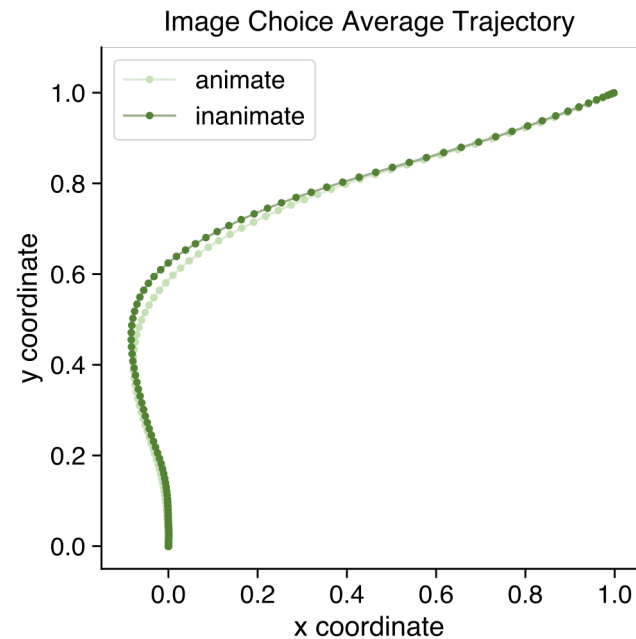
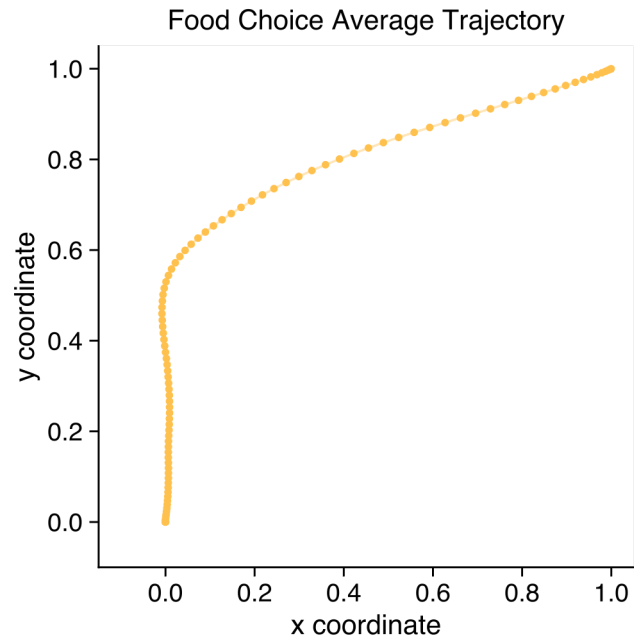
Kun Chen



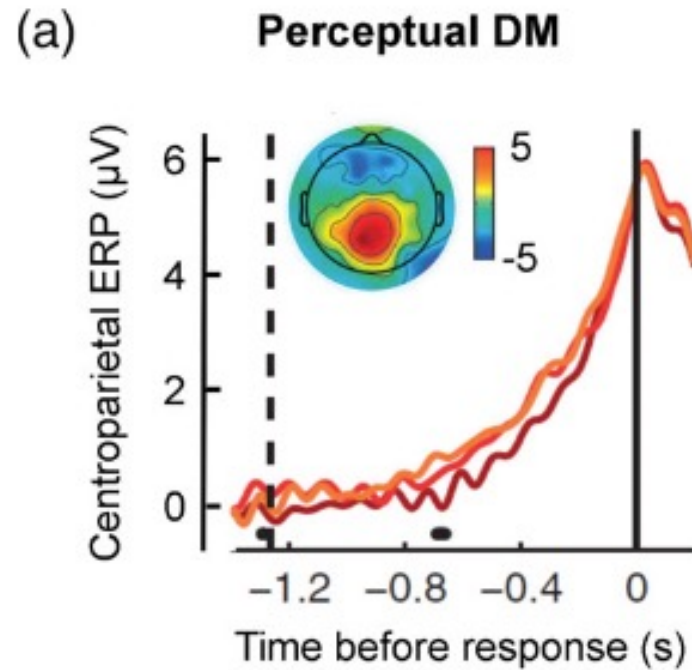
Average mouse trajectories in different tasks



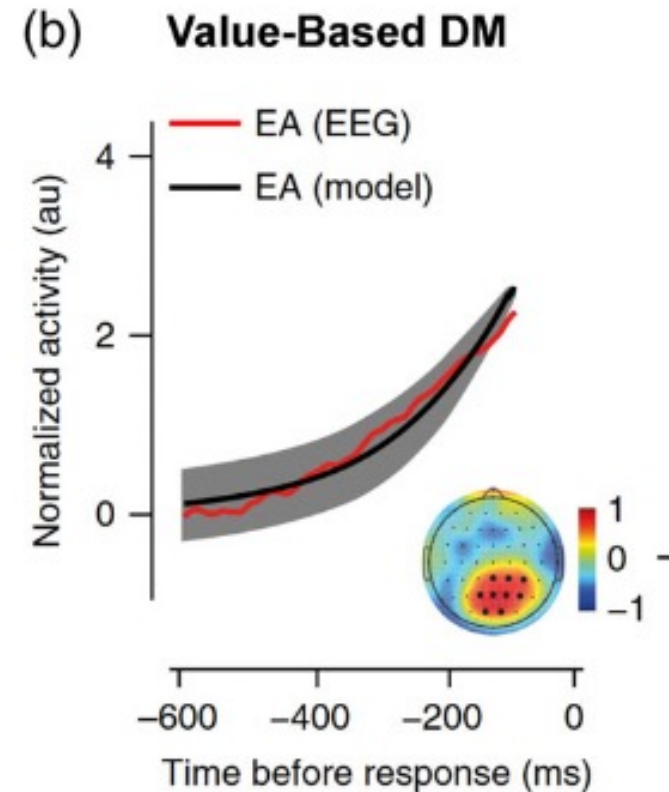
Kun Chen



Mouse tracking + EEG + DDM

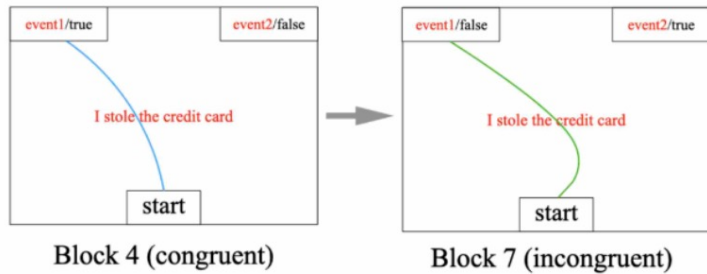


— Fast RT — Medium RT — Slow RT

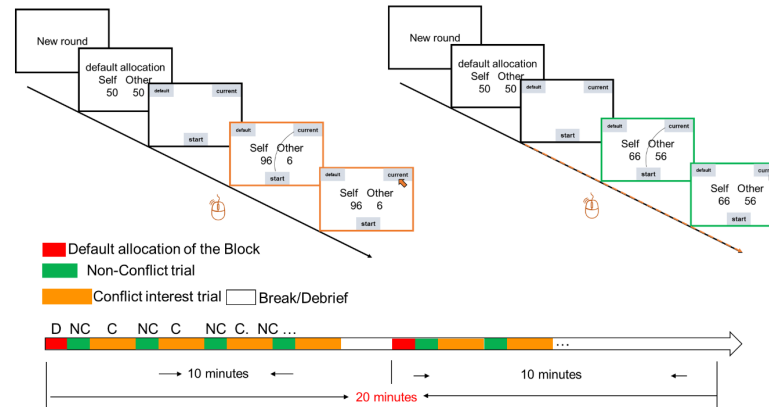


Hand in motion reveals mind in motion

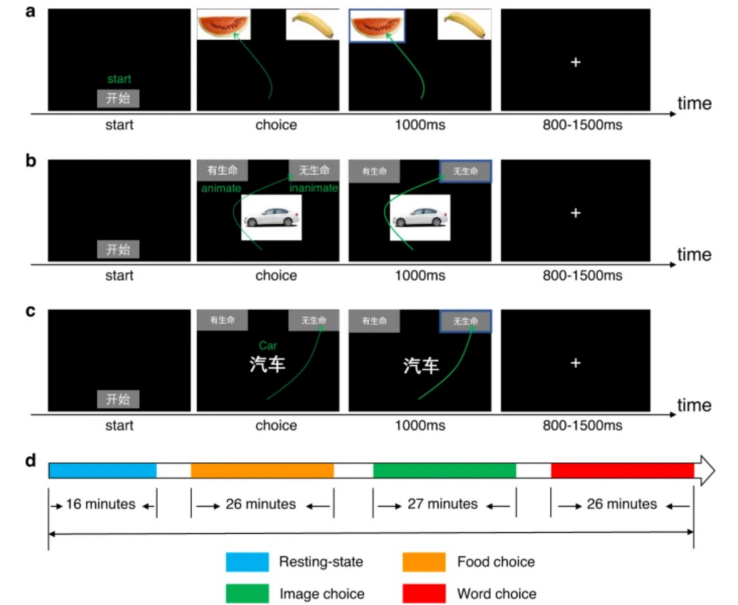
Memory



Moral



Decisions



Xu et al (2021)
preprint

Wu et al (2021)
preprint

Chen et al (2022)
Scientific Data

▶ MT can be combined with computational modeling and investigate the latent process

▶ MT can be combined with EEG and provide more temporal course information

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<http://www.mousetracker.org/>

MouseTracker is a freely available, user-friendly software package that allows researchers to record and analyze hand movements traveling toward potential responses on the screen (via the x, y coordinates of the computer mouse). By looking at the dynamics of how participants' hand movements settle into a response alternative—and how they may be partially pulled toward other alternatives—researchers glean valuable information about real-time cognitive processing. MouseTracker opens up a single reaction time into a continuous stream of rich cognitive output.



Implementation

https://github.com/andlab-um/MT_workshop/tree/main/Part1

MouseTracker - Jon Freeman (jon.freeman@tafts.edu)

Load .CSV Save .CSV Edit .CSV C:\MouseTracker\fourcorners.csv

Start and response buttons

Start: 1, 2, 3, 4

X: -0.64, Width: 0.2, Y: 1.22, Height: 0.2, H Sym: 4, V Sym: 1

Colors and fonts

Screen: [white] Resp: [black]

Resp Text: Arial 22, Stim Text: Arial 28

Stimulus location

X: 0, Y: 1, H Center, V Center

MouseTracker - Jon Freeman

Left-click to select trajectories and right-click for options..

Condition 1 (Condition 1): 182, Condition 2 (Condition 2): 216, 0.11, 0.57

Load File, Load Folder, Import, Visualize, Mark points, Compute, Export to .CSV

Mean trajectories: [Graph], X and Y time-course: [Graphs]

Selected tracks: [List]

MOUSE TRACKER

MO: 0.26, AUC: 0.26, SF: 1.1, WF: 1.2
 MD: 0.32, AUC: 0.37, SF: 1.2, WF: 1.2

main ▾

[MT_workshop / Part1 /](#)

Go to file

Add file ▾

⋮



haiyan0305 Add files via upload ...

156c09e 18 hours ago [History](#)

..



IAT and Moral.md

Create IAT and Moral.md

21 hours ago



exp2mt.zip

Add files via upload

18 hours ago

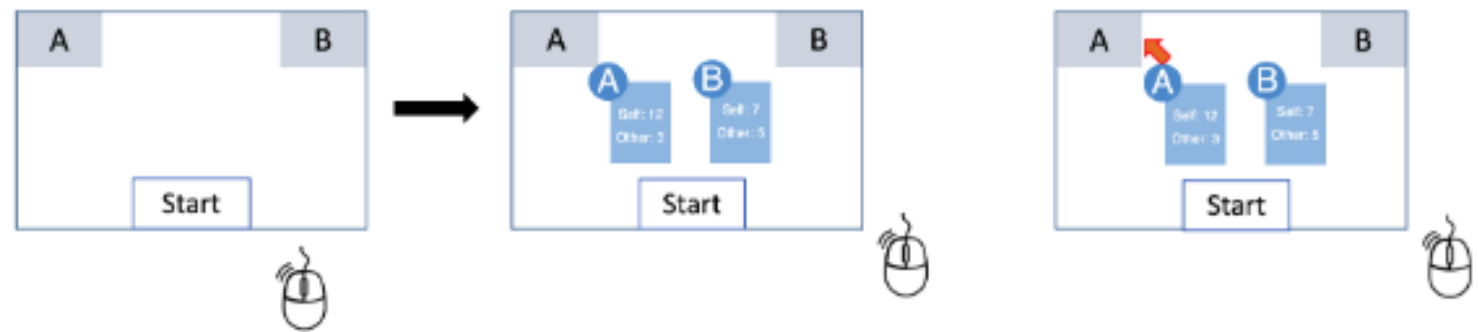


mousetracker.exe

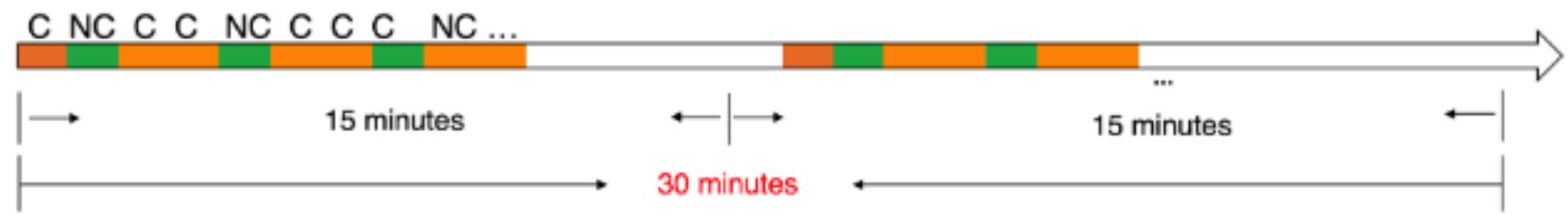
Add files via upload

21 hours ago

- 1.jpeg
- 2.jpeg
- 3.jpeg
- 4.jpeg
- 5.jpeg
- 6.jpeg
- 7.jpeg
- 8.jpeg
- 9.jpeg
- 10.jpeg
- 11.jpeg
- 12.jpeg
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- 27.jpeg
- 28.jpeg
- 29.jpeg
- 30.jpeg
- 31.jpeg
- 32.jpeg
- 33.jpeg



Non-Conflict trial
Conflict interest trial **Break/Questionnaire time**



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MT with Opensesame

OpenSesame

Edit on GitHub

- <https://osdoc.cogsci.nl/>

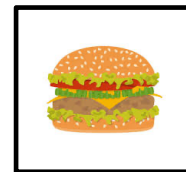
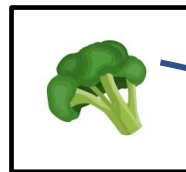
OpenSesame is a program to create experiments for psychology, neuroscience, and experimental economics. The latest stable version is 3.3.14 *Lentiform Loewenfeld*, released on Dec 7, 2022 ([release notes](#)).

Download

Tutorial

Get support

- https://github.com/andlab-um/MT_workshop/tree/main/Part2



choose

MT with Opensesame

The screenshot displays the Opensesame software interface. On the left is a file browser showing a directory structure for 'MT_workshop / Part2 /'. It includes a 'main' dropdown, a user profile 'haiyan0305' with an 'Add files via upload' button, and a list of files: 'MT-opensesame.md' (with a 'Create MT-opensesame.md' button) and 'step0_selfpref_pre.osexp' (with an 'Add files via upload' button). The central 'Overview' panel shows a hierarchical tree of the experiment structure, including 'MouseTrack True or False', 'experiment' (with sub-items like 'new_inline_script', 'new_notepad', 'new_sketchpad', and 'setup_script'), 'trial_loop', 'trial_sequence' (with 'question_script' and 'logger'), and 'Unused items (0)'. The right panel is a code editor titled 'setup_script - inline script' with the subtitle 'Executes Python code'. It contains Python code for setting up mouse and keyboard input routines. The code includes imports from 'openexp.mouse', 'openexp.keyboard', and 'openexp.canvas', and initializes global variables 'my_mouse', 'my_keyboard', and 'my_canvas'. It also sets up a 'totalCorrect' counter and a log file path.

```
1 # Create our input and output routines
2 from openexp.mouse import mouse
3 from openexp.keyboard import keyboard
4 from openexp.canvas import canvas
5 #from random import randint
6
7 # Declare them as global, so we can use them later on.
8 global my_mouse, my_keyboard, my_canvas
9
10
11 my_mouse = mouse(exp, visible=True)
12 my_keyboard = keyboard(exp)
13 my_canvas = canvas(exp)
14
15
16 var.totalCorrect = 0
17 var.myAcc = None
18
19 #log.close()
20 #log.open('/Users/orlacomus/Desktop/ua-code0715/paradigm/paradigm20220819/testdata/subject-%s_self-
  pre.csv'%subject_nr)
```

MT with Opensesame

The screenshot displays the Opensesame interface. On the left, a file browser shows the current directory structure: `main` / `MT_workshop / Part2 /`. Below the browser, there are options to add files via upload, including `MT-opensesame.md` and `step0_selfpref_pre.osexp`. The central panel shows an 'Overview' tree with a hierarchical structure: `MouseTrack True or False` (expanded) contains `experiment` (expanded), which includes `new_inline_script`, `new_notepad`, `new_sketchpad`, and `setup_script`. Below `experiment` is `trial_loop` (expanded), containing `trial_sequence` (expanded) with `question_script` and `logger`. At the bottom of the tree is `Unused items (0)`. The right panel shows a code editor for `setup_script - inline script`, which executes Python code. The code includes imports for `openexp.mouse`, `openexp.keyboard`, and `openexp.canvas`, and initializes variables `my_mouse`, `my_keyboard`, and `my_canvas`. It also sets `var.totalCorrect = 0` and `var.myAcc = None`, and includes logging statements.

```
1 # Create our input and output routines
2 from openexp.mouse import mouse
3 from openexp.keyboard import keyboard
4 from openexp.canvas import canvas
5 #from random import randint
6
7 # Declare them as global, so we can use them later on.
8 global my_mouse, my_keyboard, my_canvas
9
10
11 my_mouse = mouse(exp, visible=True)
12 my_keyboard = keyboard(exp)
13 my_canvas = canvas(exp)
14
15
16 var.totalCorrect = 0
17 var.myAcc = None
18
19 #log.close()
20 #log.open('/Users/orlacomus/Desktop/ua-code0715/paradigm/paradigm20220819/testdata/subject-%s_self-
   pre.csv'%subject_nr)
```

MT with Opensesame

The screenshot shows the Opensesame software interface. On the left, a sidebar contains a list of items: 'new_inline_s...', 'new_notepad', 'new_sketchp...', 'setup_script', 'trial_loop', 'trial_sequ...', 'questi...' (highlighted with a red box), and 'logger'. Below this is 'Unused items (0)'. The main area displays a Python script with the following code:

```
1 # Constants
2 max_response_time = 4000
3 fixation_length = 900
4 error_message_duration = 1000
5 max_init_time = 800
6 sample_rate = 5
7 #p=randint(1, 9)
8 import os, random, sys, glob, time
9
10
11
12 # Images
13 start_button = exp.get_file('materials/start.png')
14 probe = exp.get_file('materials/you.png')
15 degree_prefer = exp.get_file('materials/degree_prefer.png')
16 ans1 = exp.get('answer1')
17 ans2 = exp.get('answer2')
18 #p1 = exp.get('prob1')
19 #p2 = exp.get('prob2')
20
21 # Text
22 timeout_message = "Too slow!\n\
23 Try to respond more quickly.\n\
24 Press any key to continue."
25 slow_start_message = "\
26 Please try to move the mouse as soon\n\
27 as you see the target, even if you're not\n\
28 sure of your response yet\n\
29 Press any key to continue."
30 error_message = "<span color='red'>wrong answer!</span>"
31 # Turn our OpenSesame variables into plain Python ones
32 #probe = exp.get('probe')
33 correct_response = exp.get('correct_response')
```

Annotations in blue text are placed over the code: 'set up' is next to line 8; 'present sti' and 'start->foo' are next to lines 13-15; 'warning for slow responses' is next to lines 25-29; and 'data saving' is next to line 48. A 'Prepare' button is highlighted with a red box at the top right of the script editor.

The screenshot shows the Opensesame software interface for a trial script. The title bar reads 'question_script - inline script' and 'Executes Python code'. A 'Prepare' button is visible at the top right. The main area displays a Python script with the following code:

```
28 sure of your response yet\n\
29 Press any key to continue."
30 error_message = "<span color='red'>wrong answer!</span>"
31 # Turn our OpenSesame variables into plain Python ones
32 #probe = exp.get('probe')
33 correct_response = exp.get('correct_response')
34
35 # Some dimensions
36 # Our start button is 80x80 pixels.
37 # Change these values if using a different sized image.
38 half_start_w = 40
39 half_start_h = 40
40 # Likewise for the response images
41 response_w = 270
42 response_h = 100
43 # Get the size of the screen
44 mx = my_canvas.xcenter()
45 my = my_canvas.ycenter()
46
47 # Some empty lists for recording mouse data
48 xList, yList, tList = [], [], []
```

Annotations in blue text are placed over the code: 'start area' is next to lines 38-39; 'response area' is next to lines 41-42; and 'data saving' is next to line 48. A red circle highlights the code from line 35 to line 48.

Outline

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 - Opensesame
 - **Psychopy**
 - Combine with EEG and fMRI



Kun Chen

MT with Psychopy

main ▾ MT_workshop / Part3 / example_wordChoice / Go to file Add file ▾ ⋮

const7 Update psychopy example 268335b 21 hours ago 🕒 History

..

README.md	Update psychopy example	21 hours ago
guide.png	Update psychopy example	21 hours ago
trialVar.csv	Update psychopy example	21 hours ago
wordChoice.psyexp	Update psychopy example	21 hours ago
wordChoice_lastrun.py	Update psychopy example	21 hours ago

README.md

Wordchoice task

There are 3 blocks and 320 trials in total. The first 2 blocks include 107 trials and the last block includes 106 trials.

The participant need to press the "space" key to continue experiment after break.

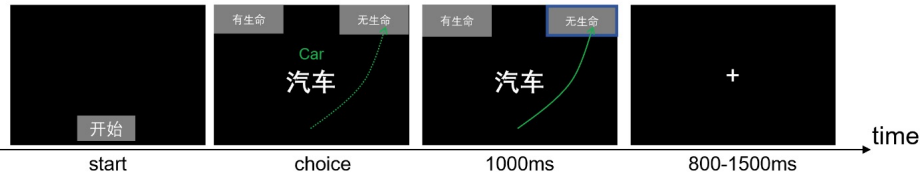
See more information in the paper.

https://github.com/andlab-um/MT_workshop/tree/main/Part3



Kun Chen

MT with Psychopy



```

162
163 # Initialize components for Routine "word"
164 wordClock = core.Clock()
165 mouse = event.Mouse(win=win)
166 x, y = [None, None]
167 mouse.mouseClock = core.Clock()
168 word_item = visual.TextStim(win=win, name='word_item',
169 text='default text',
170 font='Songti SC',
171 pos=(0, 0), height=90, wrapWidth=None, ori=0,
172 color='white', colorSpace='rgb', opacity=1,
173 languageStyle='LTR',
174 depth=-2.0);
175 rect_left = visual.Rect(
176 win=win, name='rect_left',
177 width=(300, 200)[0], height=(300, 200)[1],
178 ori=0, pos=(-810, 440),
179 lineWidth=1, lineColor='black', lineColorSpace='rgb',
180 fillColor='grey', fillColorSpace='rgb',
181 opacity=1, depth=-3.0, interpolate=True)
182 rect_right = visual.Rect(
183 win=win, name='rect_right',
184 width=(300, 200)[0], height=(300, 200)[1],
185 ori=0, pos=(810, 440),
186 lineWidth=1, lineColor='black', lineColorSpace='rgb',
187 fillColor='grey', fillColorSpace='rgb',
188 opacity=1, depth=-4.0, interpolate=True)
189 op_left = visual.TextStim(win=win, name='op_left',
190 text='default text',
191 font='Songti SC',
192 pos=(-810, 440), height=80, wrapWidth=None, ori=0,
193 color='white', colorSpace='rgb', opacity=1,
194 languageStyle='LTR',
195 depth=-5.0);
196 op_right = visual.TextStim(win=win, name='op_right',
197 text='default text',
198 font='Songti SC',
199 pos=(810, 440), height=80, wrapWidth=None, ori=0,
200 color='white', colorSpace='rgb', opacity=1,
201 languageStyle='LTR',
202 depth=-6.0);

```

mouse tracking data process

```

class mouseData:
    ...
    def preprocess(self):
        self.dataformat()
        ...
        self.cal_metrics()
    def dataformat(self):
        # data clean
        self.data["x"] = self.data.xTrajectory.map(
            squeak.list_from_string)
        ...
    def cal_metrics(self):
        # Mouse Stats
        self.data["md"] = self.data.apply(lambda trial:
            squeak.max_deviation(trial["nx"], trial["ny"]), axis=1)
        ...
# instantiation
food_df = mouseData(tmp_beh_path, foodtask)
food_df.preprocess()

```

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 - MT data processing
 - Combine with DDM

Combine with EEG



Kun Chen

EGI recording

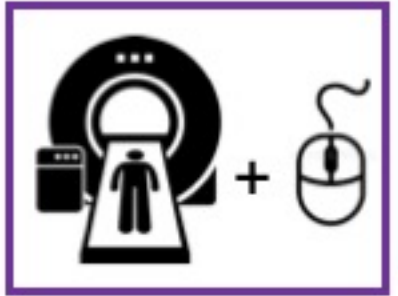
```
# EGI netstation initialization
if netstation:
    import egi.simple as egi
    ns = egi.Netstation()
    print("import pynetstation")
    # set ip address
    ns.connect("10.10.10.42", 55513)
    ns.BeginSession()
    print("connected to netstation")
    if recording:
        ns.StartRecording()
        print("start recording")

# send marker
def send_to_NS(key_):
    if netstation:
        ns.sync()
        ns.send_event(key=key_)

send_to_NS("0400")
```



Combine with fMRI



Xu et al (In prep)

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Tools & data Import

mousetrap

Mouse-tracking, the analysis of mouse movements in computerized experiments, is a method that is becoming increasingly popular in the cognitive sciences. The `mousetrap` package offers functions for importing, preprocessing, analyzing, aggregating, and visualizing mouse-tracking data.



```
mt_data <- mt_import_wide(mt, xpos_label = "X", ypos_label = "Y",  
                          timestamps_label = "T", pos_sep = "_")
```

A	B	C	D	E	IE	IF	IG	IH	II	RH	RI	RJ	RK	RL	RM	RN
	X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4	Y_5	T_1	T_2	T_3	T_4	T_5	T_6	T_7

```
iat <- read_bulk("iat", fun=read_mt, extension=".mt")  
iat <- mt_import_wide(iat)
```

iat	list [2] (S3: mousetrap)	List of length 2
data	list [13200 x 19] (S3: data.frame)	A data.frame with 13200 rows and 19 columns
trajectories	integer [13200 x 5457 x 3]	0 0 0 0 0 15 15 16 15 16 15 31 31 31 31 31 31 46 46 47 47 47 46 62 62 63 62 63 ...

Preprocessing

- Remapping to the left side

```
mt_data <- mt_remap_symmetric(mt_data)
```

- Temporal normalization: The duration of each trial was sliced into 101 identical time bins using linear interpolation to permit the average of their length across multiple trials.

```
mt_data <- mt_time_normalize(mt_data)
```

- Spatial normalization: standard coordinate space (top left: [-1, 1]; top right: [1, 1])

```
mt_data <- mt_align_start_end(mt_data)
```

Basic processing

- Calculate the measures
- Plot the trajectories












https://github.com/andlab-um/MT_workshop

Part 5

main ▾ MT_workshop / Part5 / sampledata /

haiyan0305 Add files via upload

..

 001_190228_0806.mt	Add files via upload
 002_190228_0833.mt	Add files via upload
 003_190228_0846.mt	Add files via upload
 004_190228_0937.mt	Add files via upload
 005_190228_1007.mt	Add files via upload
 006_190228_1037.mt	Add files via upload
 007_190228_1101.mt	Add files via upload
 008_190228_1133.mt	Add files via upload
 009_190228_1209.mt	Add files via upload
 010_190228_1236.mt	Add files via upload
 exp2	Create exp2

```
31 - ``{r}
32
33 library(readbulk)
34 #setwd("~/Desktop/Mousetrackingdata/")
35 setwd("~/Documents/Talk/cityU/MTbeha-master/3Exps/")
36 mt_data_raw2 <- read_bulk("exp2mt", fun=read_mt, extension=".mt")
37
38 mt_data2 <- mt_import_wide(mt_data_raw2)
39 mt_2 <- mt_remap_symmetric(mt_data2)
40 mt_2 <- mt_align_start_end(mt_2)
41 mt_2 <- mt_time_normalize(mt_2)
42 mt_data2 <- mt_measures(mt_2)
43 ```
44 # Preprocessing
45 ## Spatial transformations
46 ``{r}
47 # Remap trajectories
48 mt_data2 <- mt_remap_symmetric(mt_data2)
49
50 # Align trajectories to common start position
51 mt_data2 <- mt_align_start(mt_data2, start=c(0,0))
52 ```
53
54 ## Resampling
```

36:34  Chunk 3 ▾

Console Terminal × Jobs ×

~/Documents/Talk/cityU/MTbeha-master/3Exps/ ↻

```
Reading 002_190228_0833.mt
Reading 003_190228_0846.mt
Reading 004_190228_0937.mt
Reading 005_190228_1007.mt
Reading 006_190228_1037.mt
Reading 007_190228_1101.mt
Reading 008_190228_1133.mt
Reading 009_190228_1209.mt
Reading 010_190228_1236.mt
Reading 011_190228_1310.mt
Reading 012_190228_1338.mt
Reading 013_190228_1402.mt
Reading 014_190228_1427.mt
Reading 015_190228_1504.mt
Reading 016_190228_1608.mt
Reading 017_190228_1637.mt
Reading 018_190228_1706.mt
Reading 019_190228_1729.mt
Reading 020_190228_1807.mt
Reading 021_190228_1858.mt
Reading 022_190301_0817.mt
Reading 023_190301_0836.mt
```

https://github.com/andlab-um/MT_workshop

Part 5

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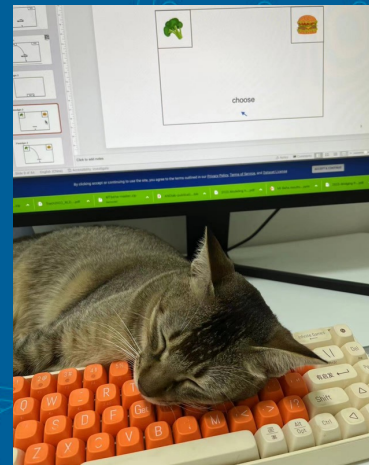
Acknowledgement



Xinyi Julia Xu



Kun Chen



Yuanyuan



Thanks for all the lab mates of ANDlab !

<https://andlab-um.com/>

We are hiring

- PhD博士生 (2023年2月28日截止)
- RA (长期有效)
- Postdoc博士后 (长期有效)

Contact: haiyanwu@um.edu.mo



深圳市科技创新委员会

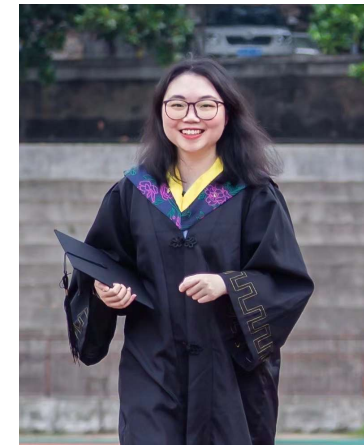


广东省科学技术厅



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