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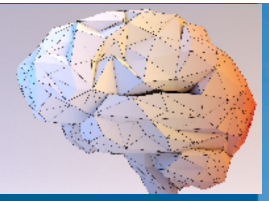
Neuroimaging Methods Workshop



Incorporating mouse tracking in studies: From implementation to data modeling

Haiyan Wu (伍海燕)

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Dec 10, 2022

Centre for Cognitive and Brain Sciences
and Department of Psychology
University of Macau

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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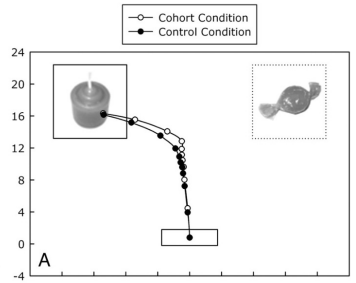
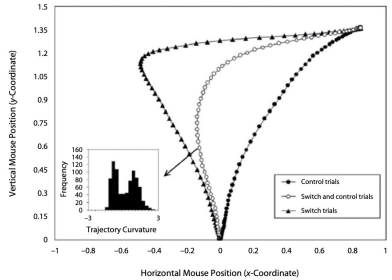
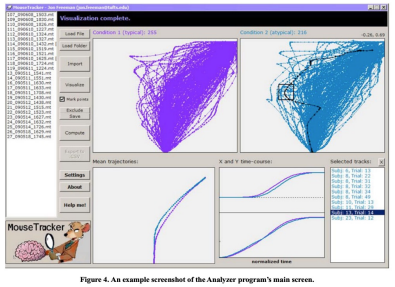


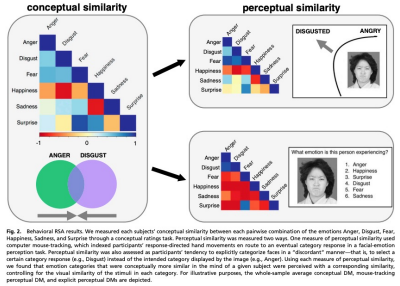
Spivey, Grosjean, and Knoblich (2005)



Freeman et al. (2008)



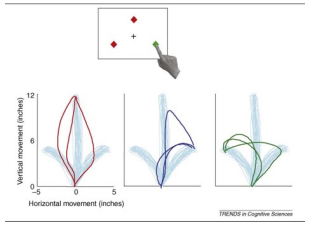
MouseTracker: Software (2010)



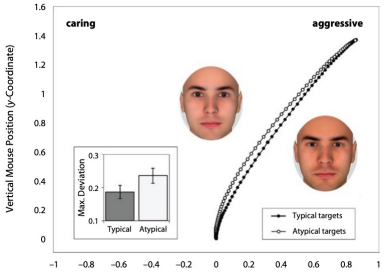
Brooks et al (2019)

History

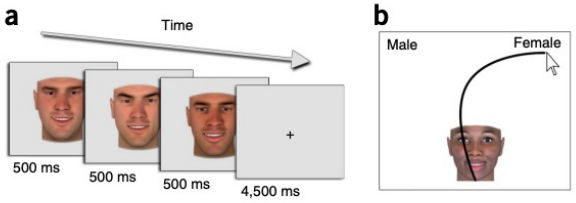
Song, and Nakayama (2006)



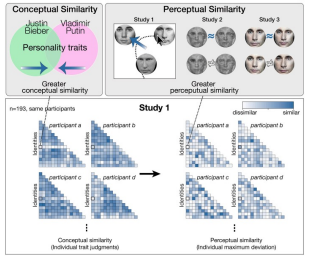
Freeman and Ambady (2009)



Stolier et al (2016)

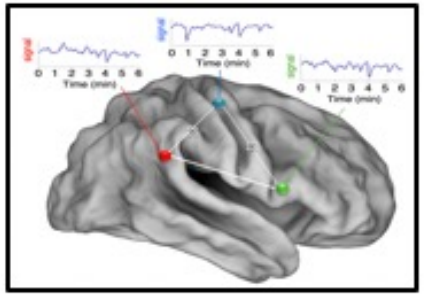


D. Oh et al. (2021)



Mturk

Brain Stimulation



Brain Imaging data processing

EEG + fMRI

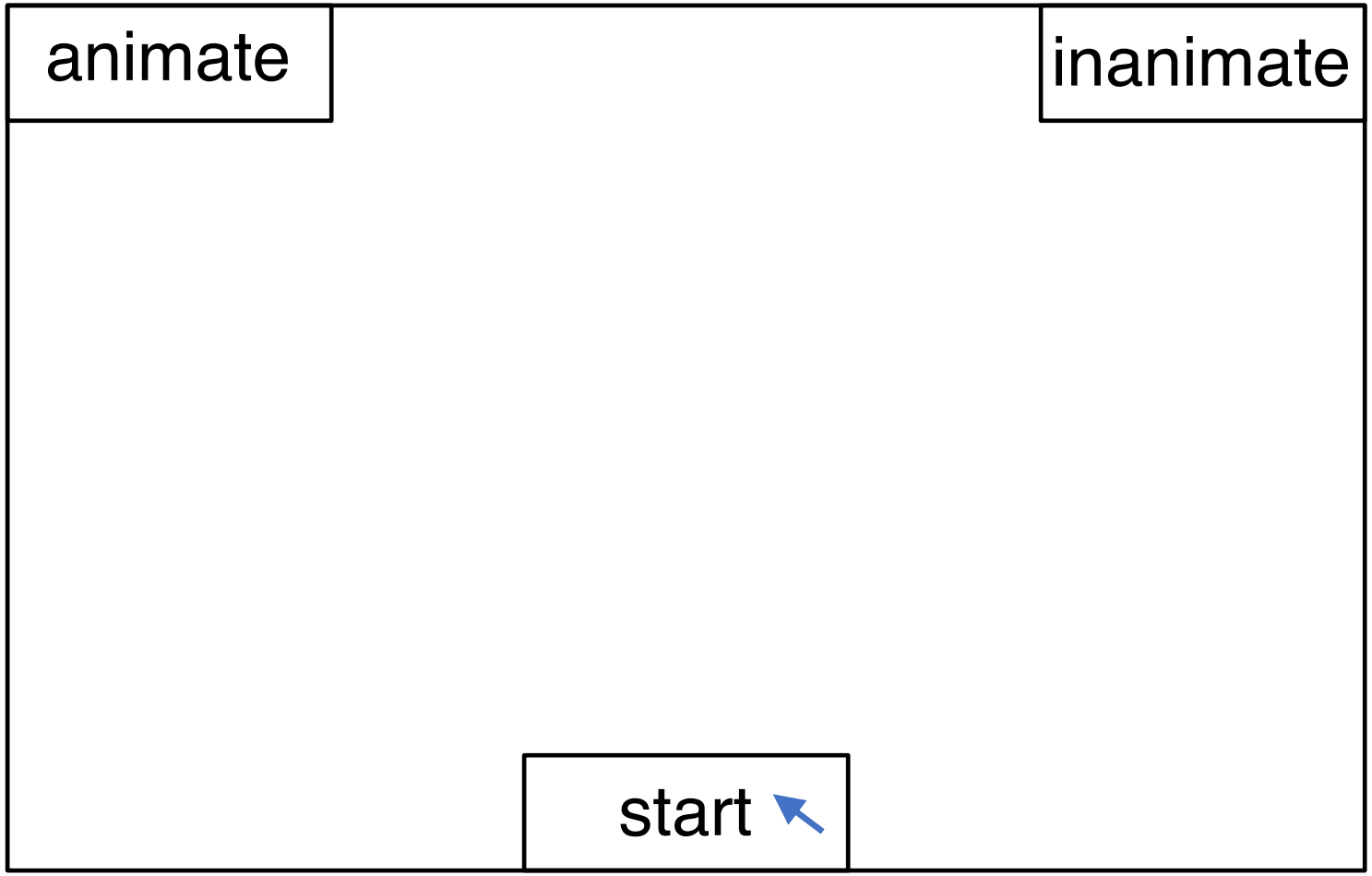
Compatibility with other methods

Introduction of mouse tracking (MT)

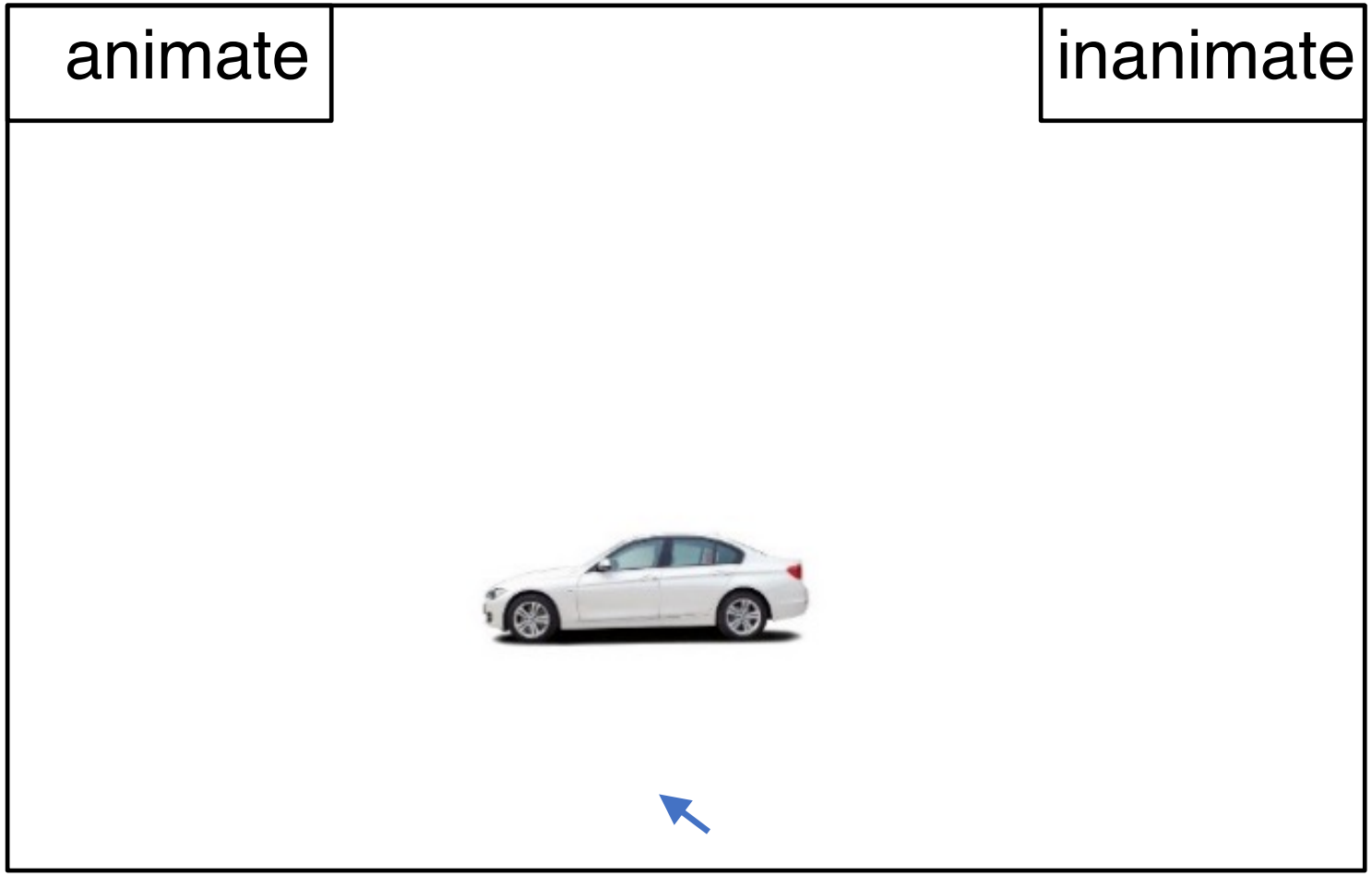
MALE

FEMALE

Paradigm 1

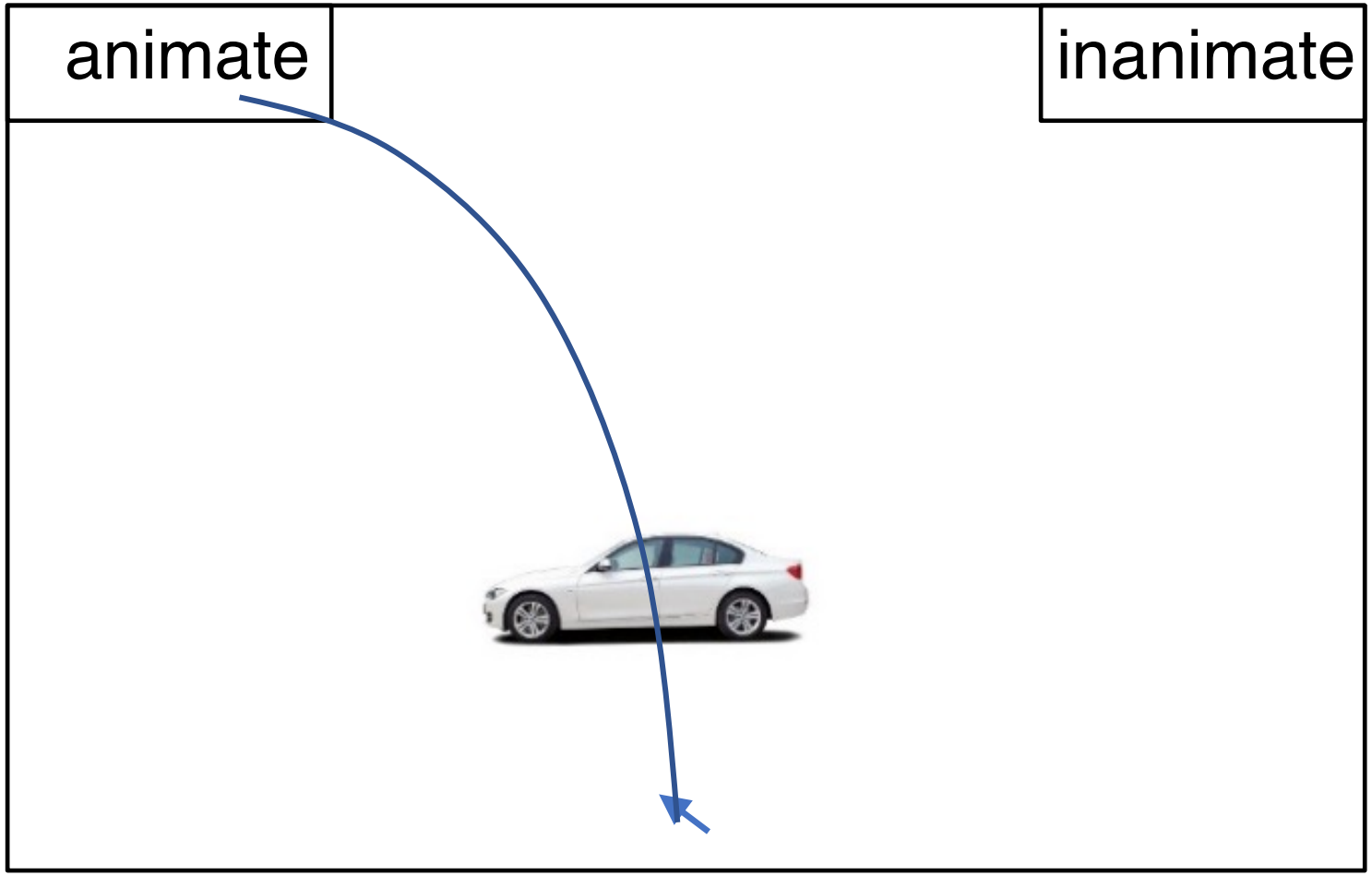


Paradigm 1



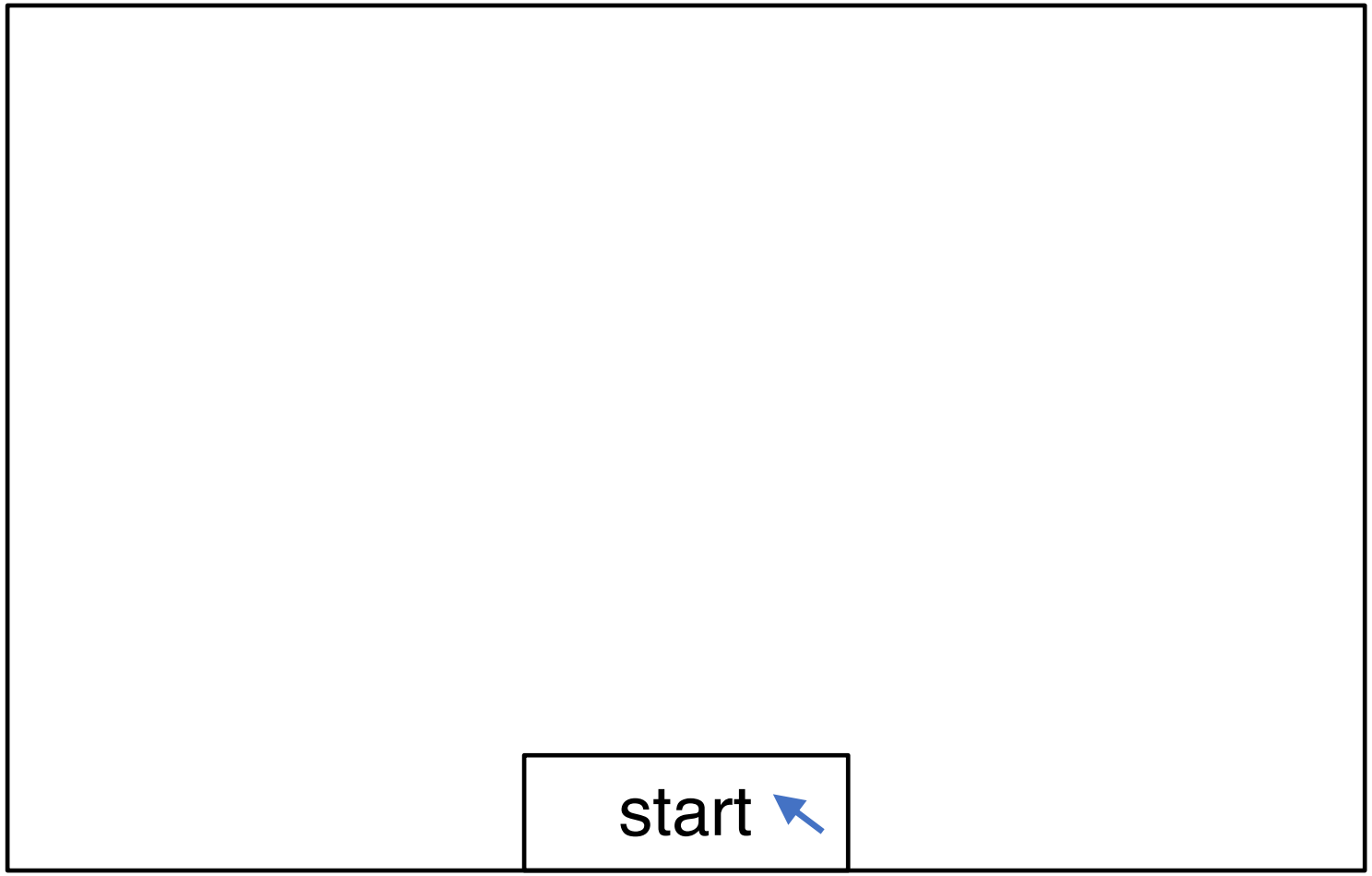
Paradigm 1

Kun Chen



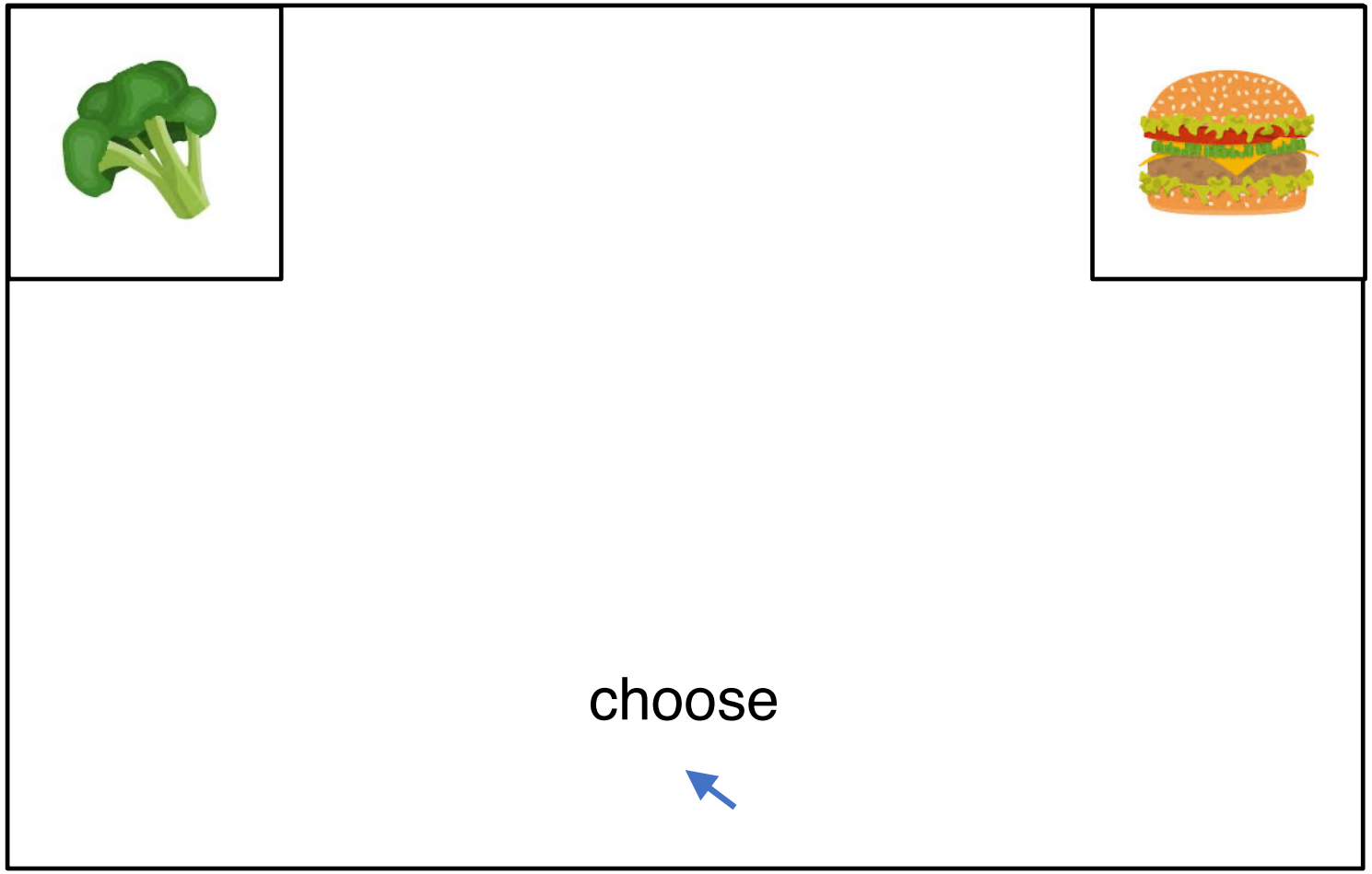
Chen, K., Wang, R., Huang, J., Gao, F., Yuan, Z., Qi, Y., & Wu, H. (2022). A resource for assessing dynamic binary choices in the adult brain using EEG and mouse-tracking. *Scientific data*, 9(1), 1-10.

Paradigm 2



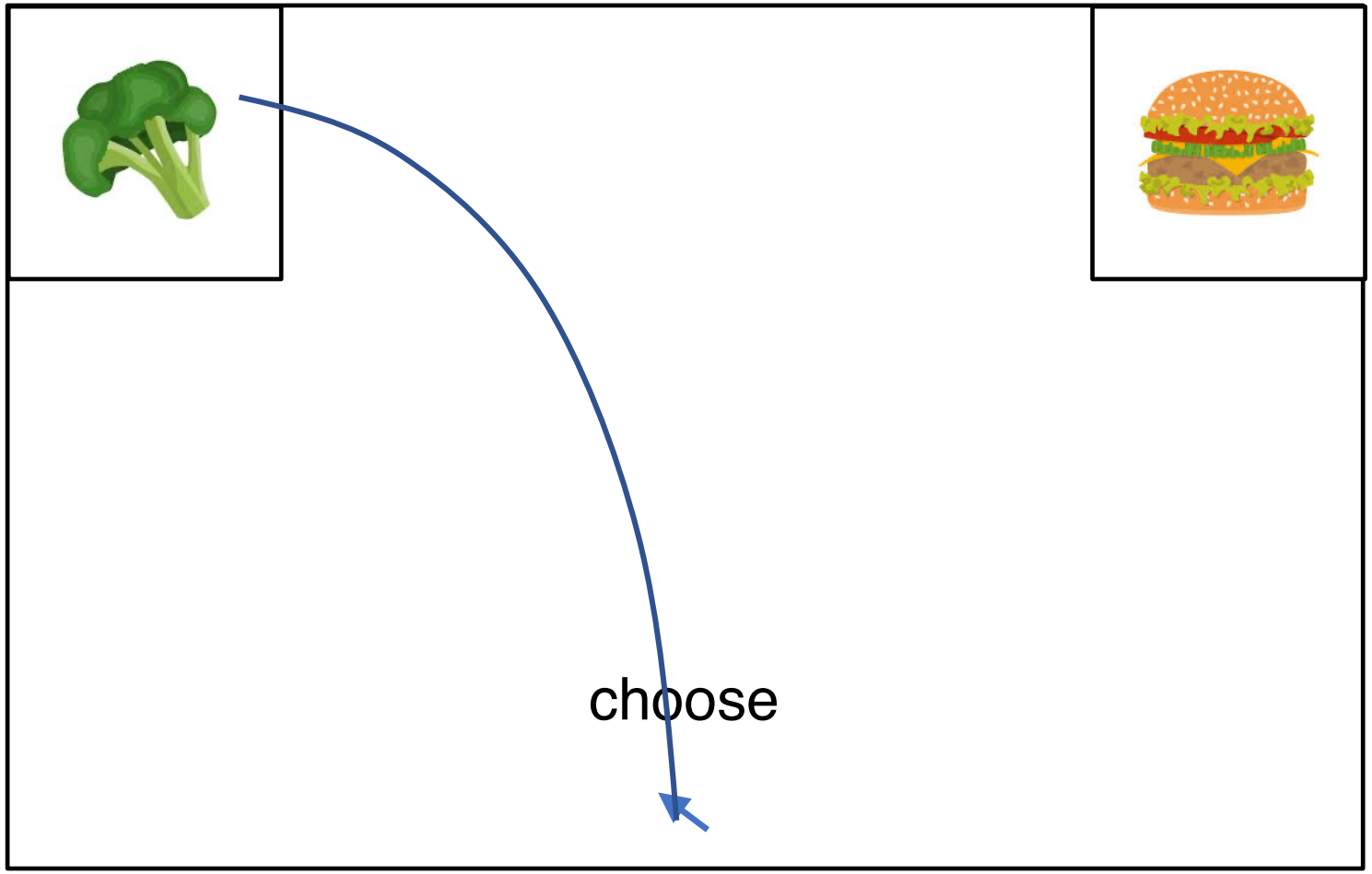
Stillman et al. (2018)

Paradigm 2



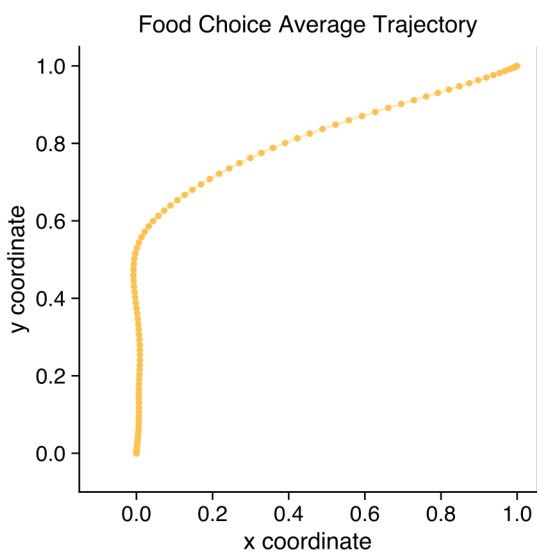
Sullivan et al. (2015)

Paradigm 2

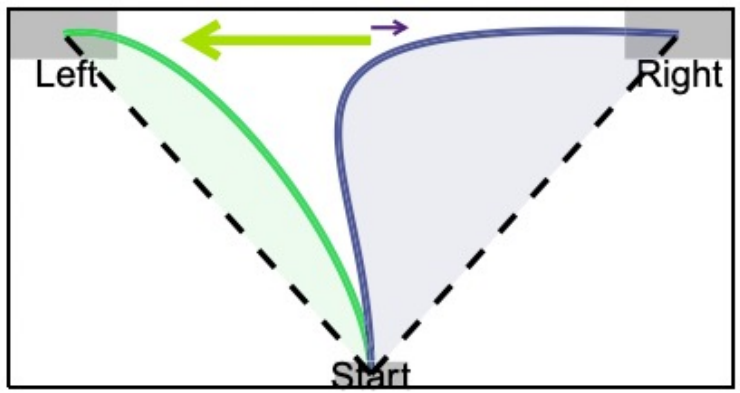


Sullivan et al. (2015)

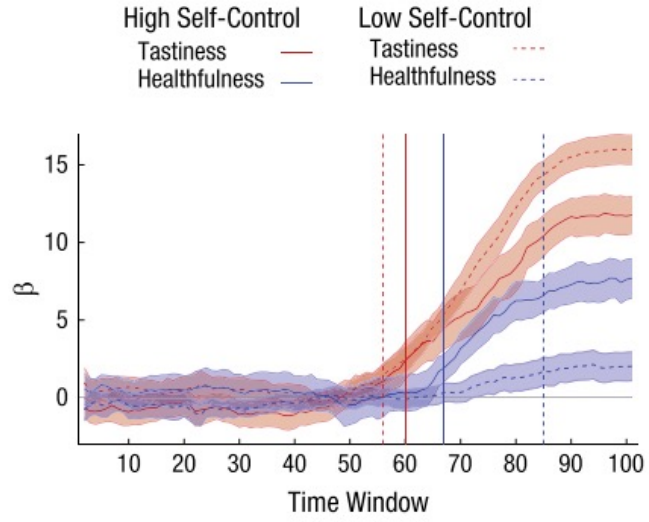
Hand in motion reveals mind in motion



Mouse trajectories

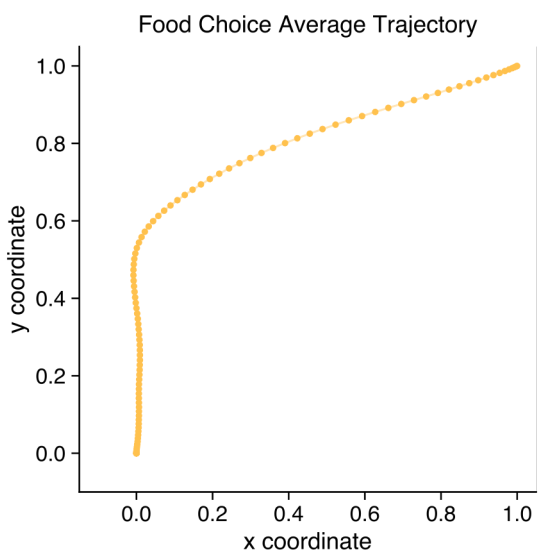


Measure of conflict

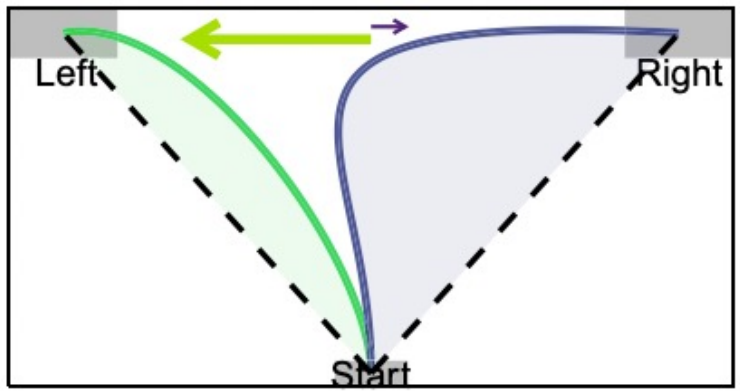


time-course of a decision

Hand in motion reveals mind in motion



Mouse trajectories



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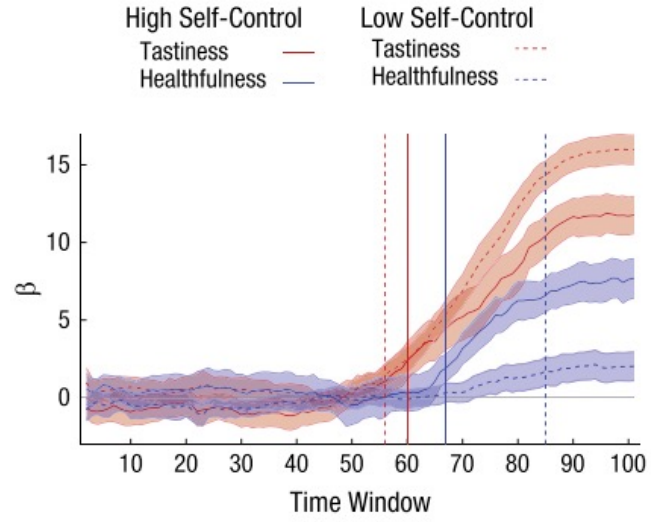
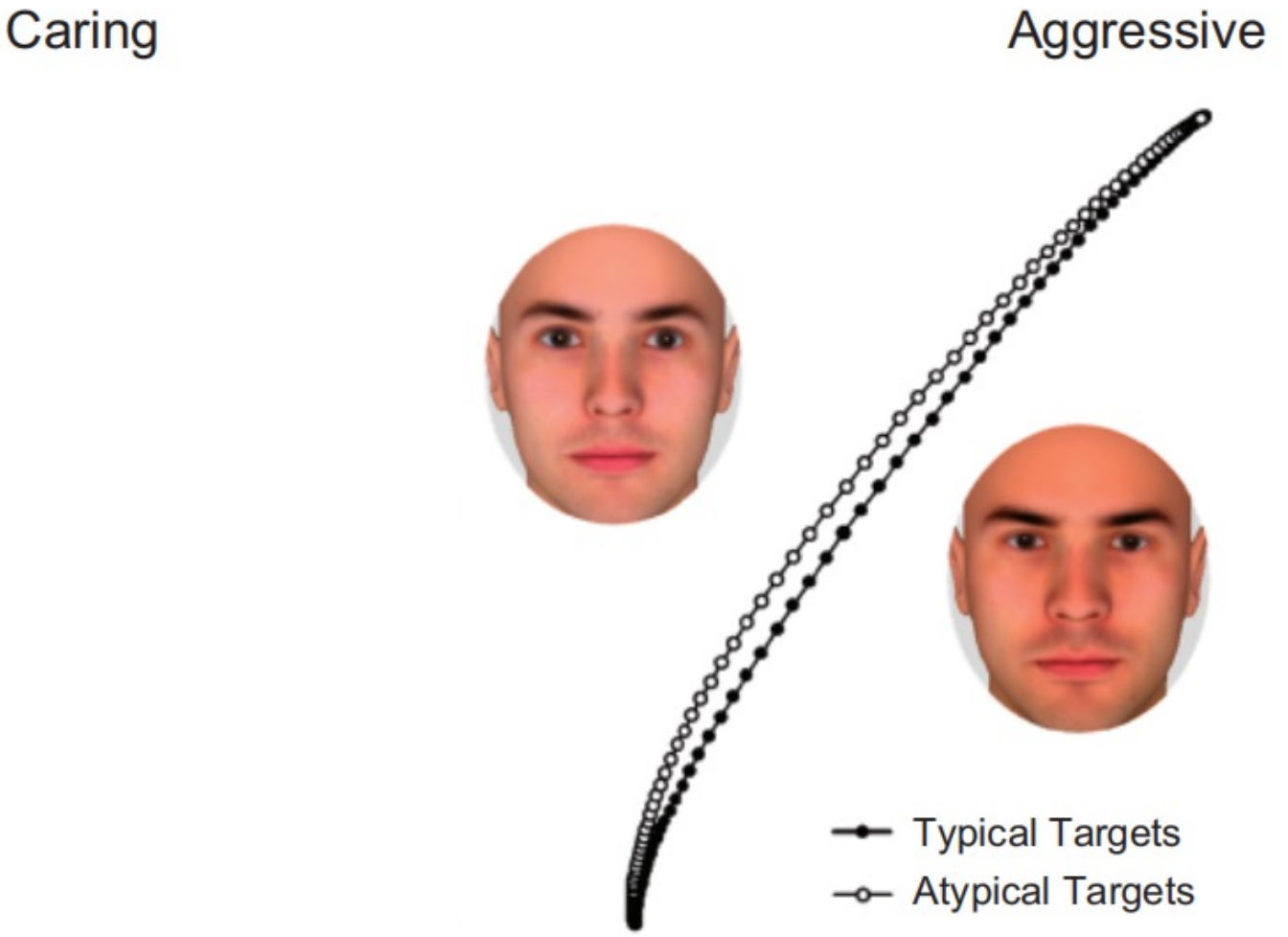


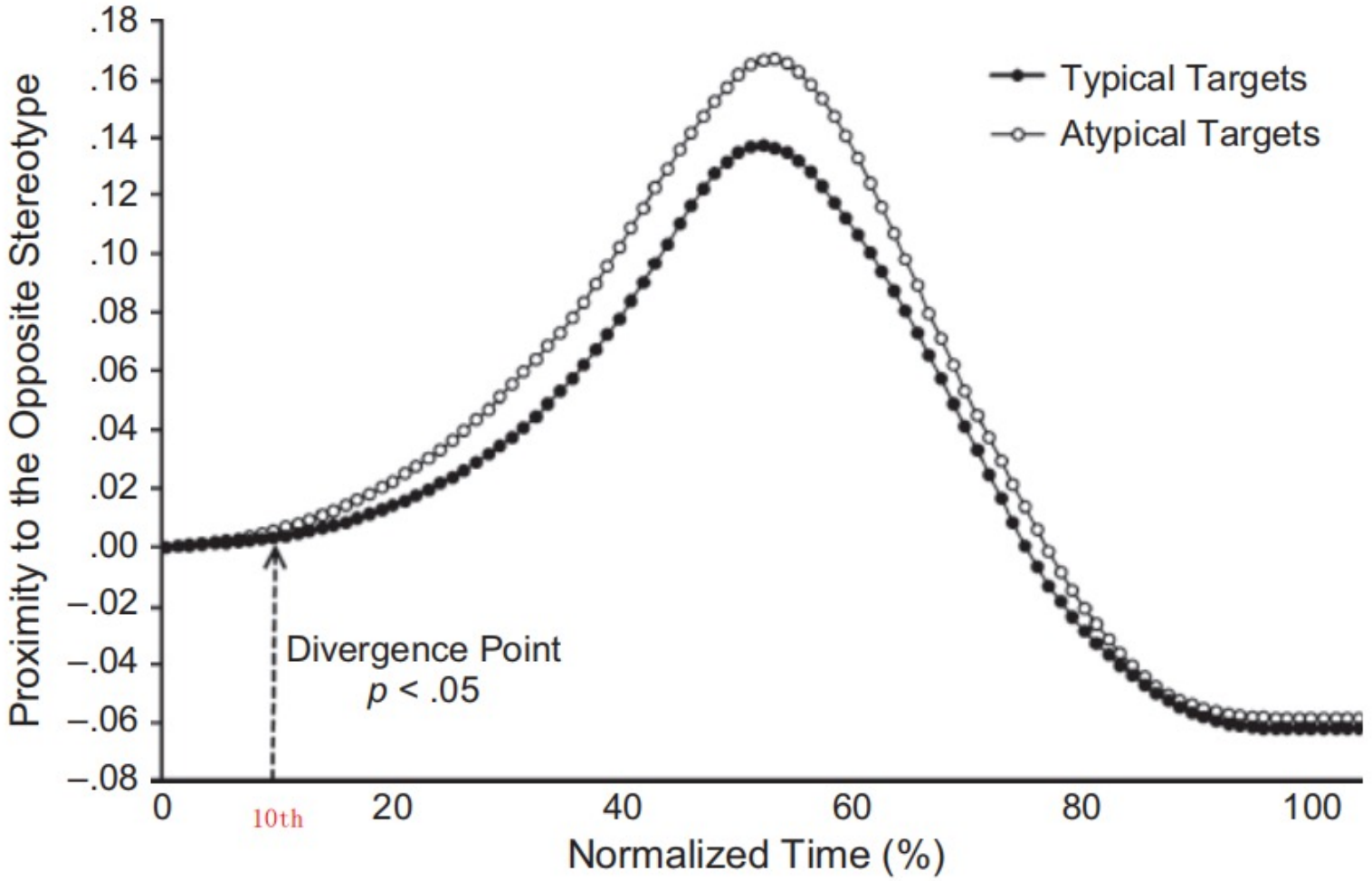
time-course of a decision

Mouse trajectories – different stimuli



Freeman and Ambady (2009)

Mouse trajectories – different stimuli



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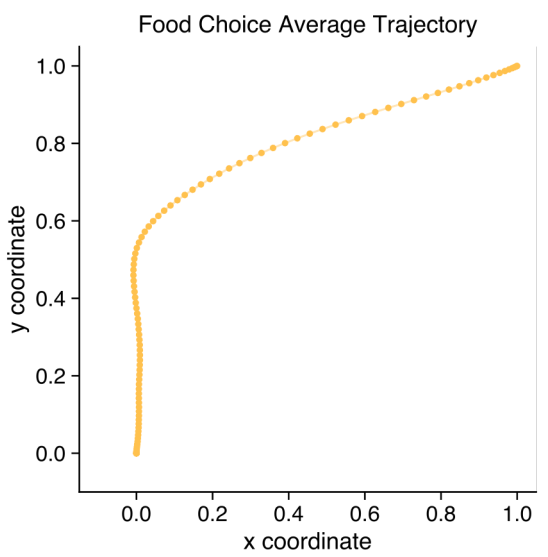
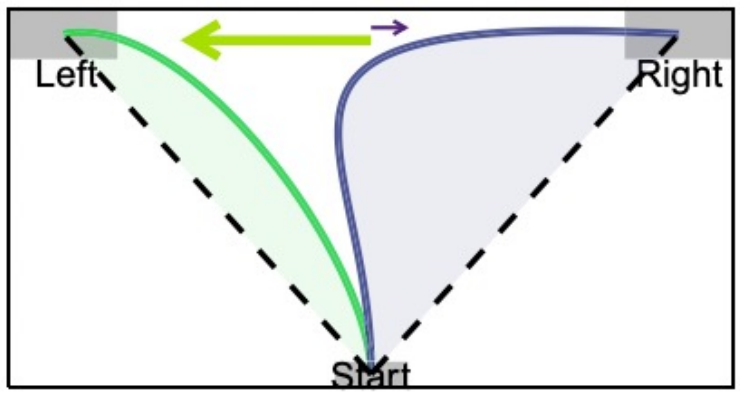


Mouse trajectories



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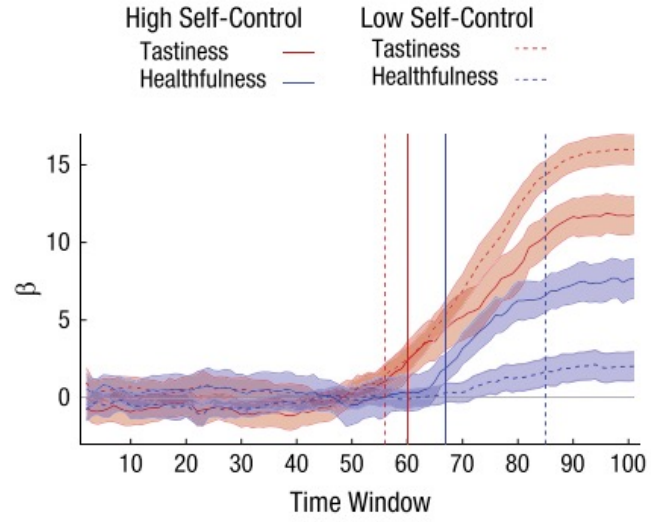

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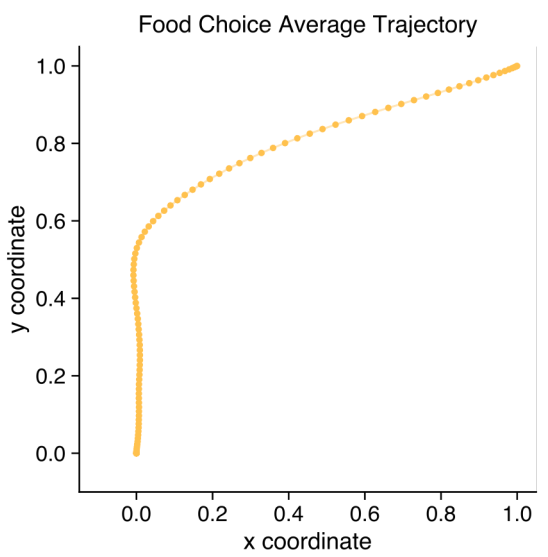

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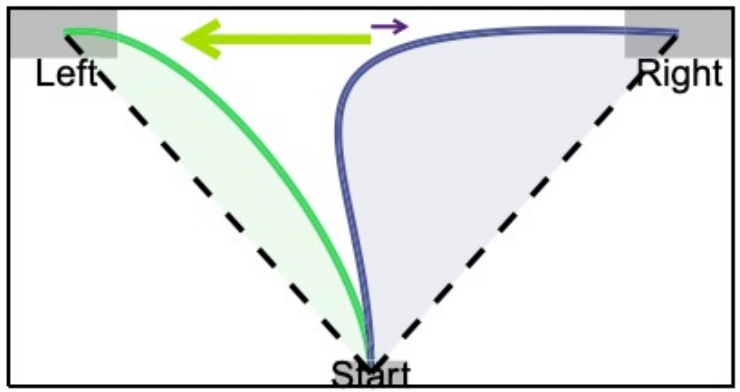
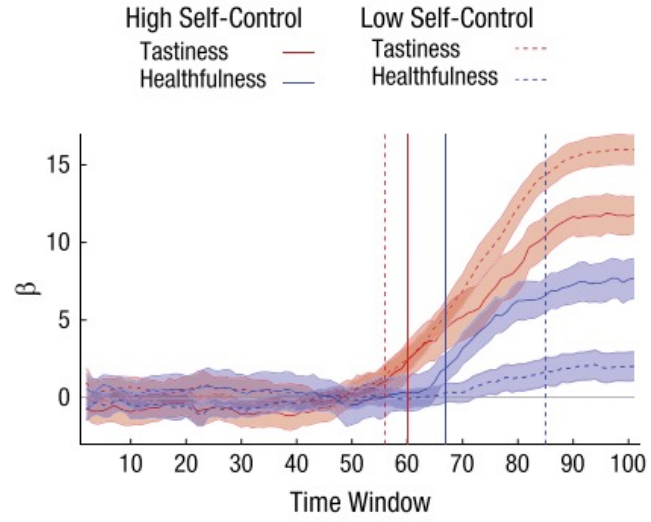


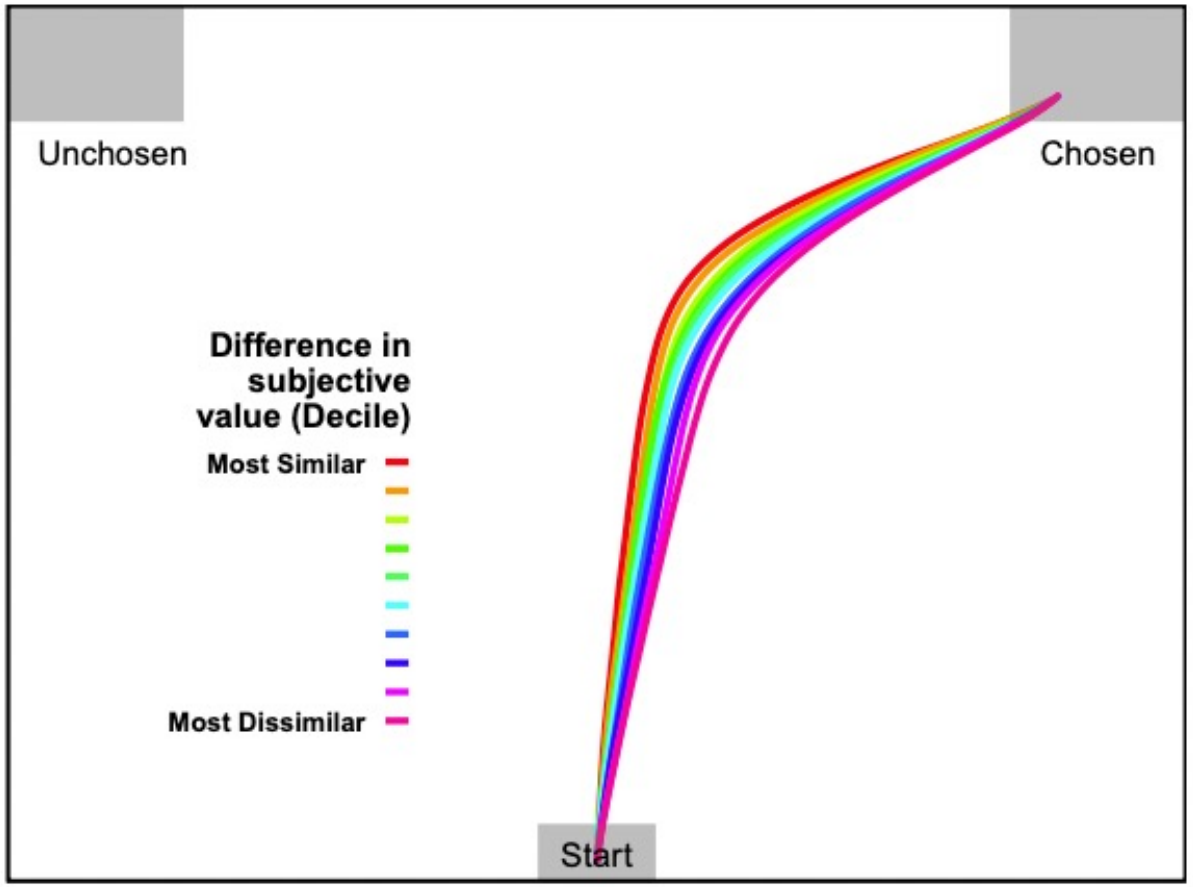
Measure of conflict



time-course of a decision

Mouse tracking measures

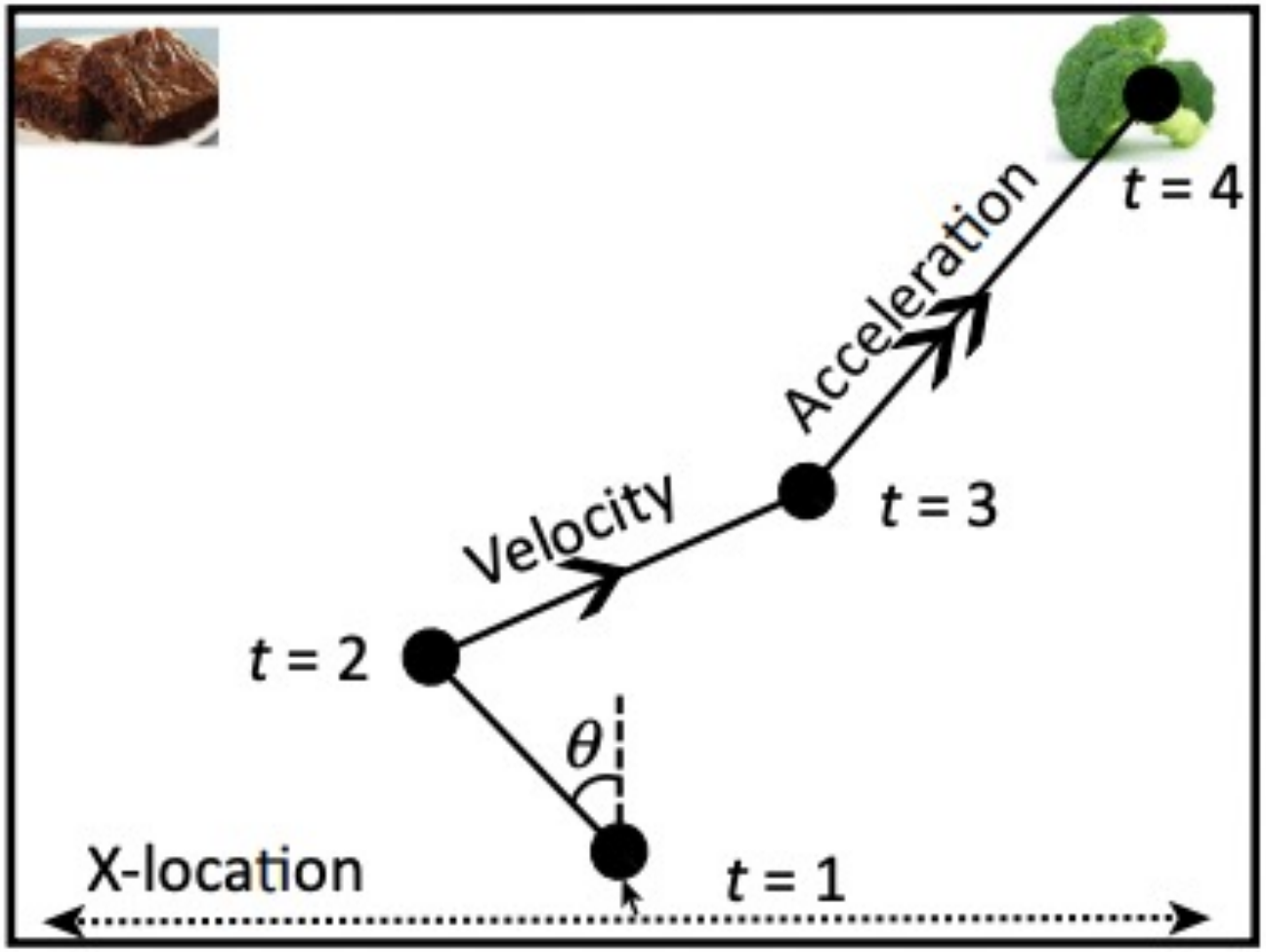
- Conflict between choices: MD & AUC



Stillman, P. E., Krajbich, I., & Ferguson, M. J. (2020). *PNAS*

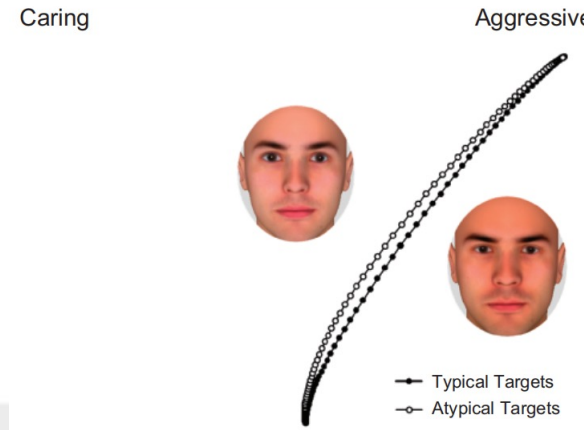
Mouse tracking measures

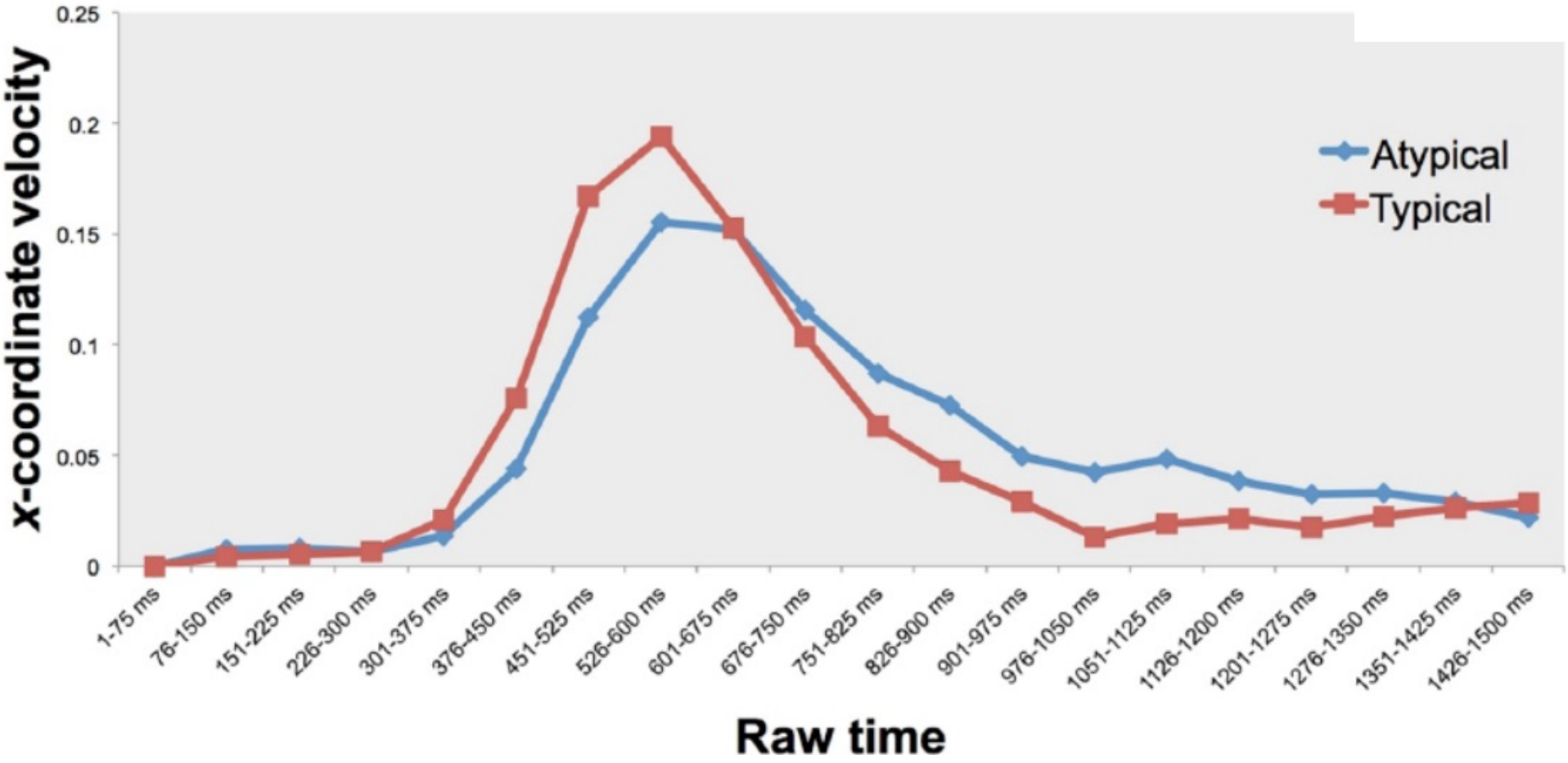
- Velocity & Acceleration & Angle



Mouse tracking measures

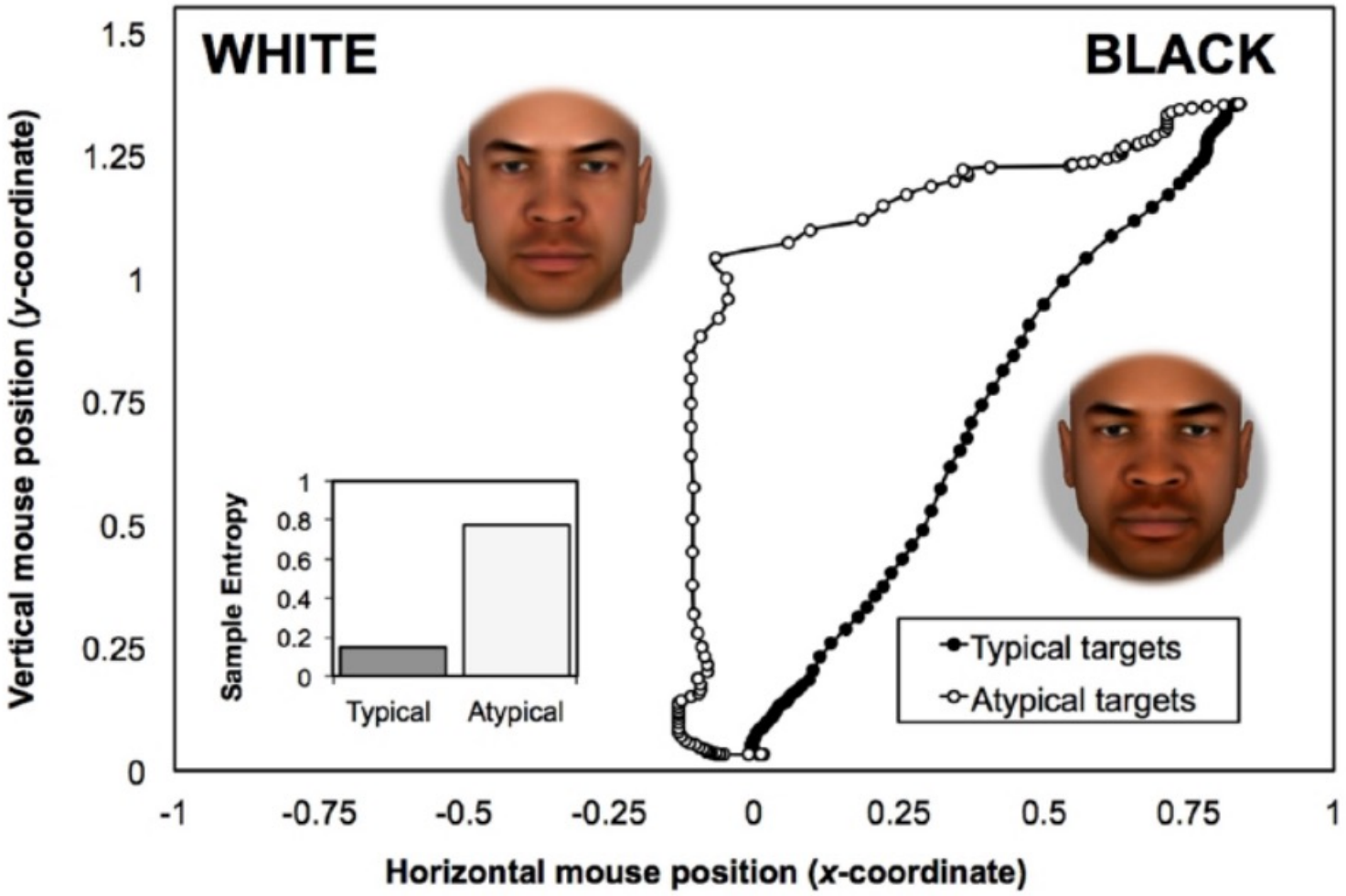
- Velocity & Acceleration & Angle





Mouse tracking measures

- Flips along the x coordinate & Entropy



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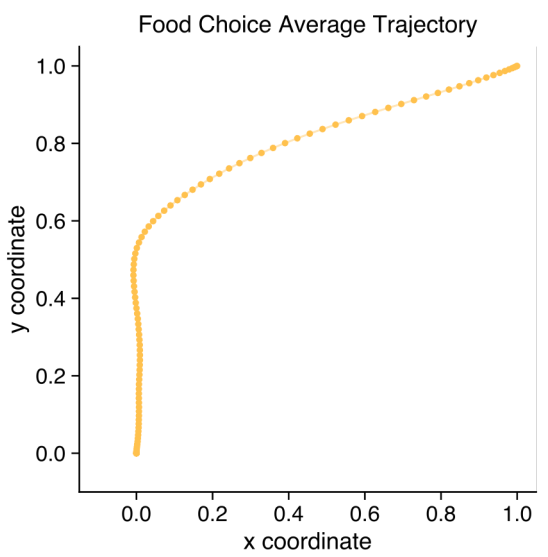
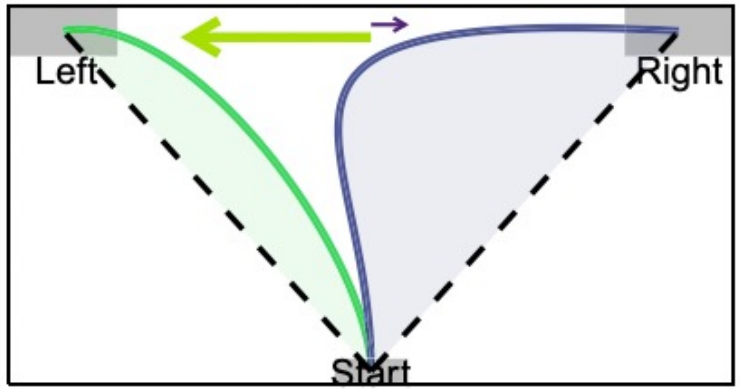
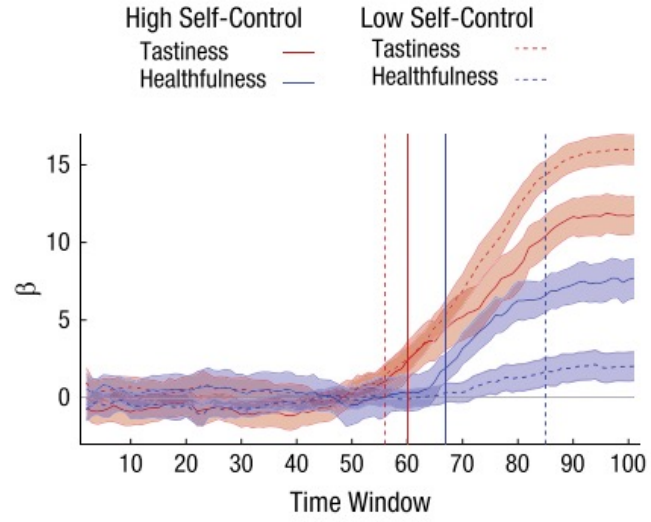


Mouse trajectories



Measure of conflict



time-course of a decision

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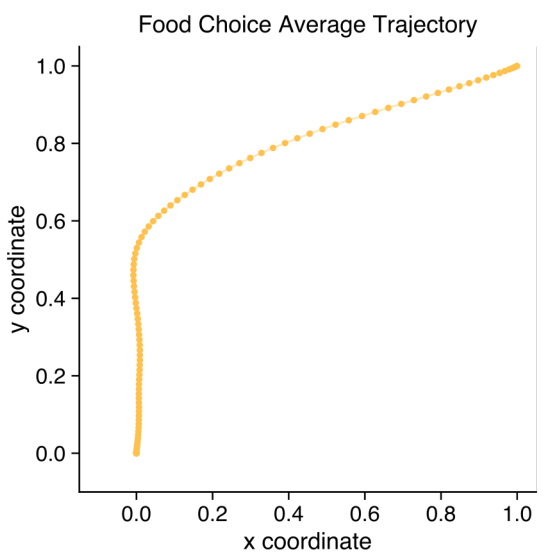

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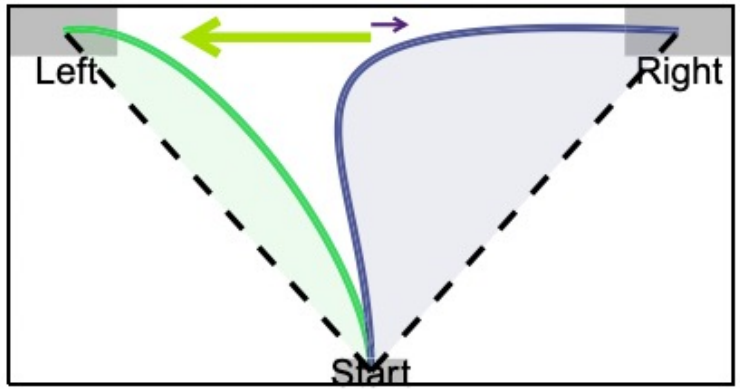

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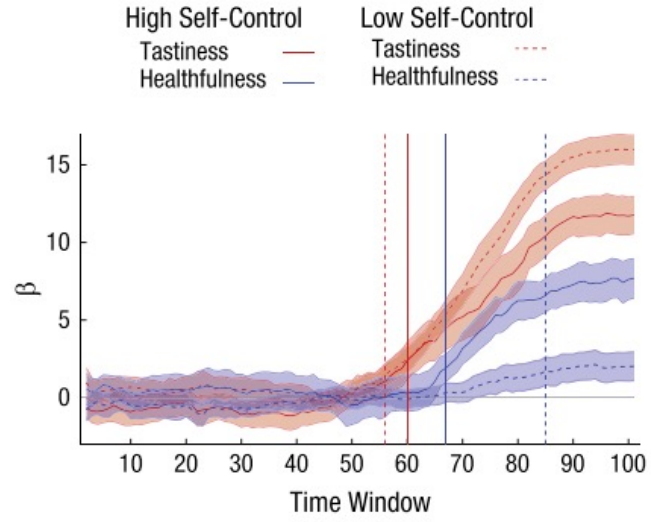


time-course of a decision

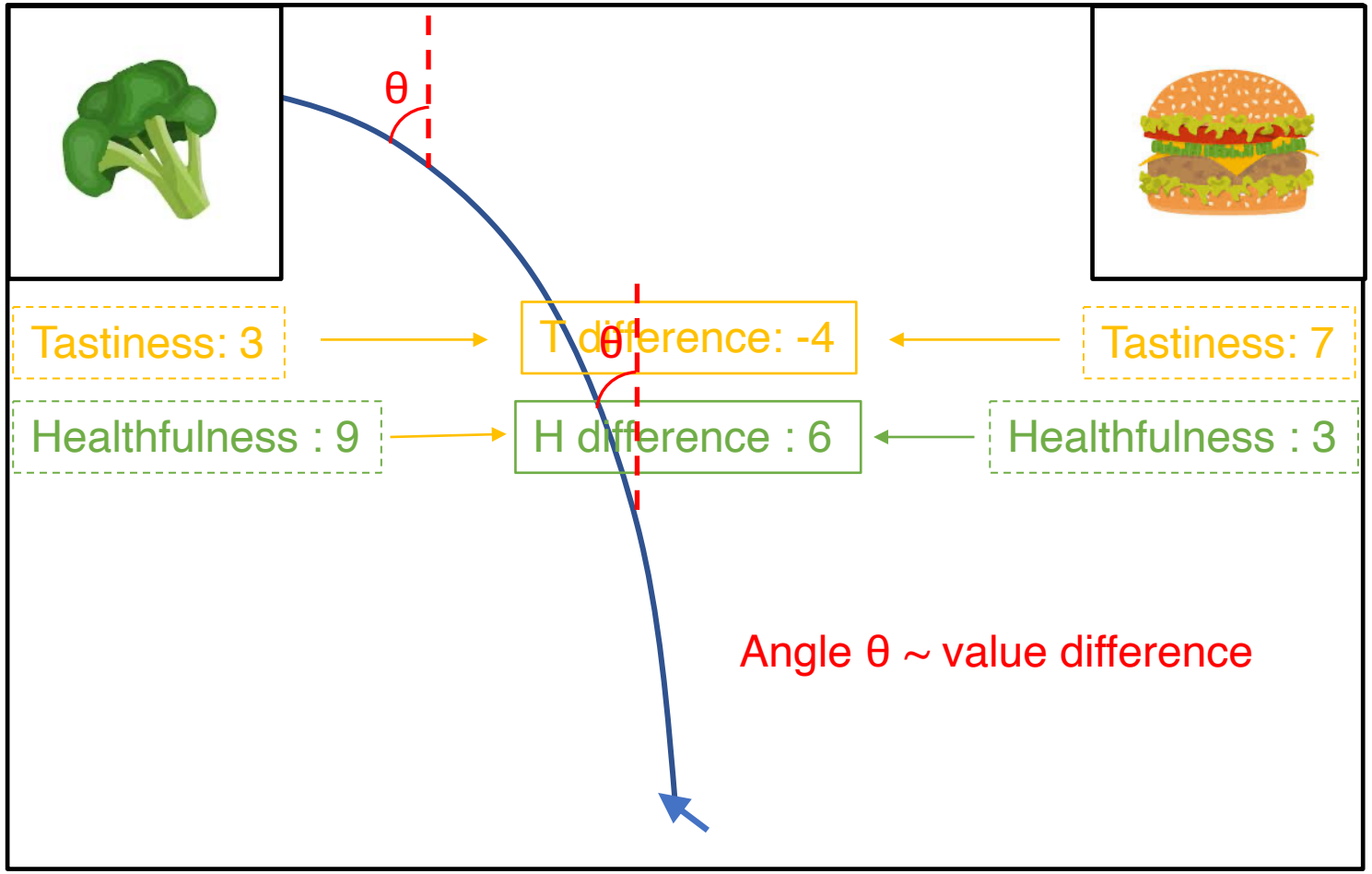
Time course of a food choice

- 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.

Sullivan, N., Hutcherson, C., Harris, A., & Rangel, A. (2015). *Psychological science*

Time course of a food choice

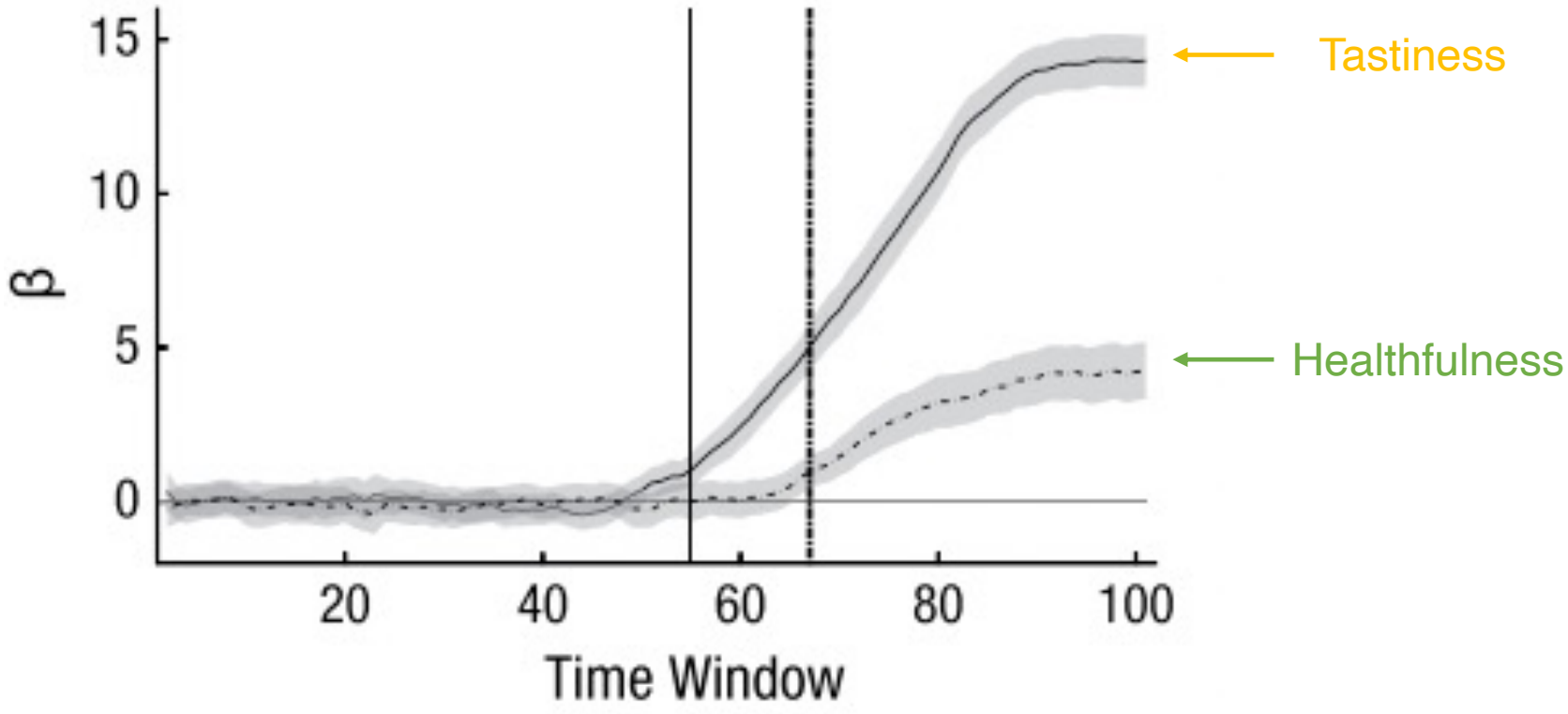


choices between a tasty food (tasty but unhealthy) and a healthy food (healthy but not tasty)

Sullivan, N., Hutcherson, C., Harris, A., & Rangel, A. (2015). *Psychological science*

Tastiness comes first

- Angle of every time point ~ value difference

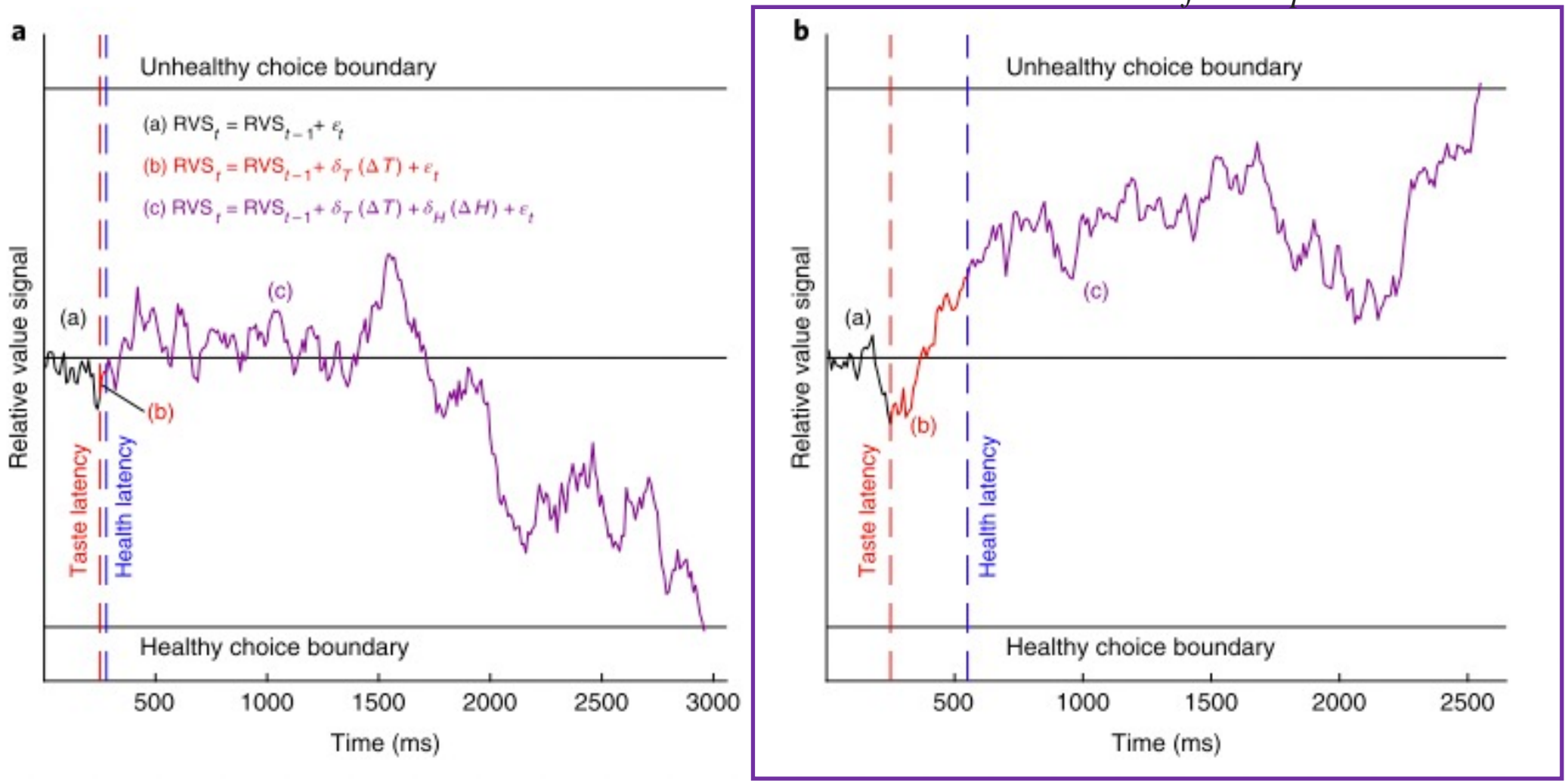


Sullivan, N., Hutcherson, C., Harris, A., & Rangel, A. (2015). *Psychological science*

Tastiness comes first

Relative value signal (RVS)

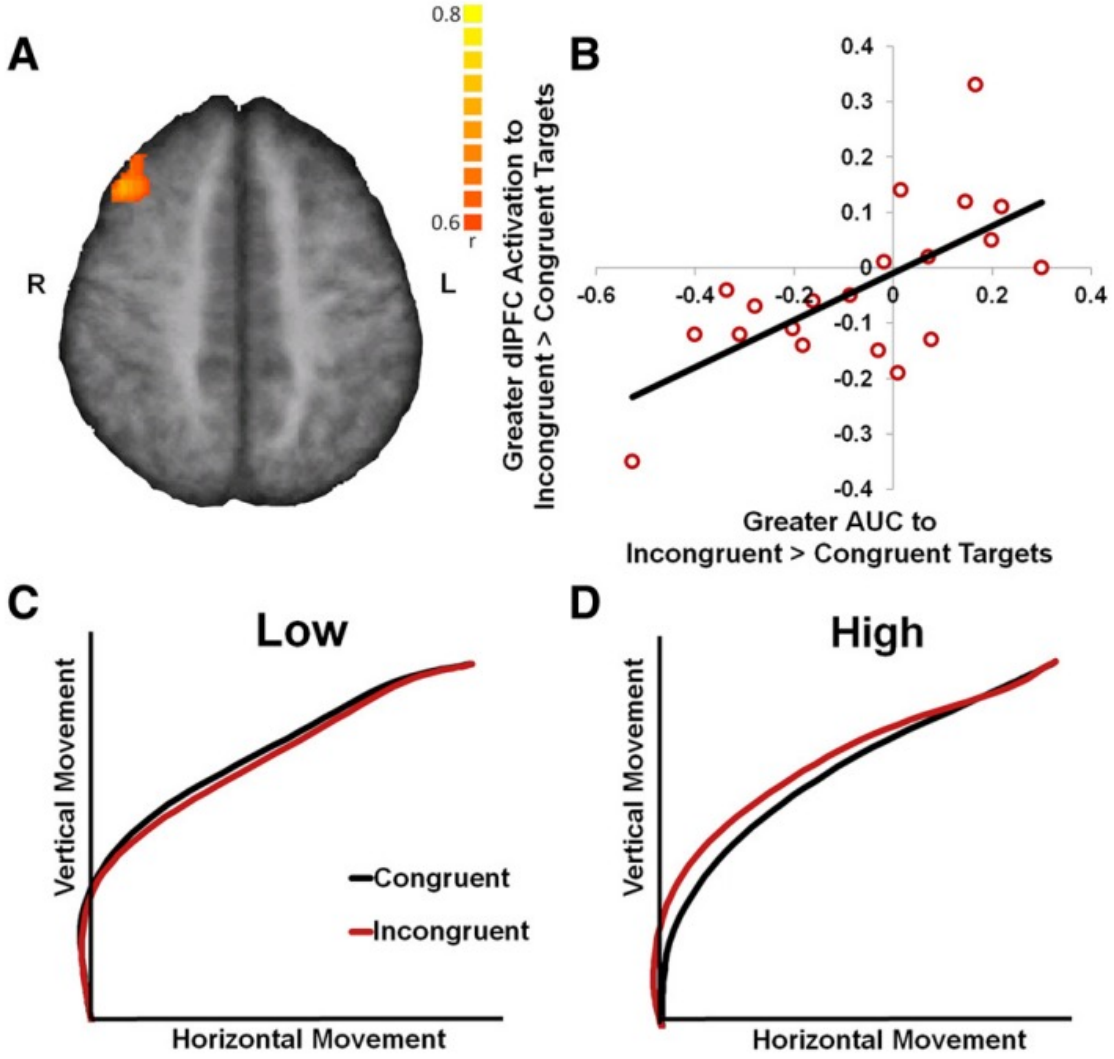
due to a later entry of health to the decision process (at $t^*_H = 500$ ms), it begins contributing to the RVS later than in the left example



Sullivan, N. J., & Huettel, S. A. (2021). *Nature Human Behaviour*

Mouse tracking in fMRI

- Univariate



Hehman, E., Ingbretsen, Z. A., & Freeman, J. B. (2014). *Neuroimage*

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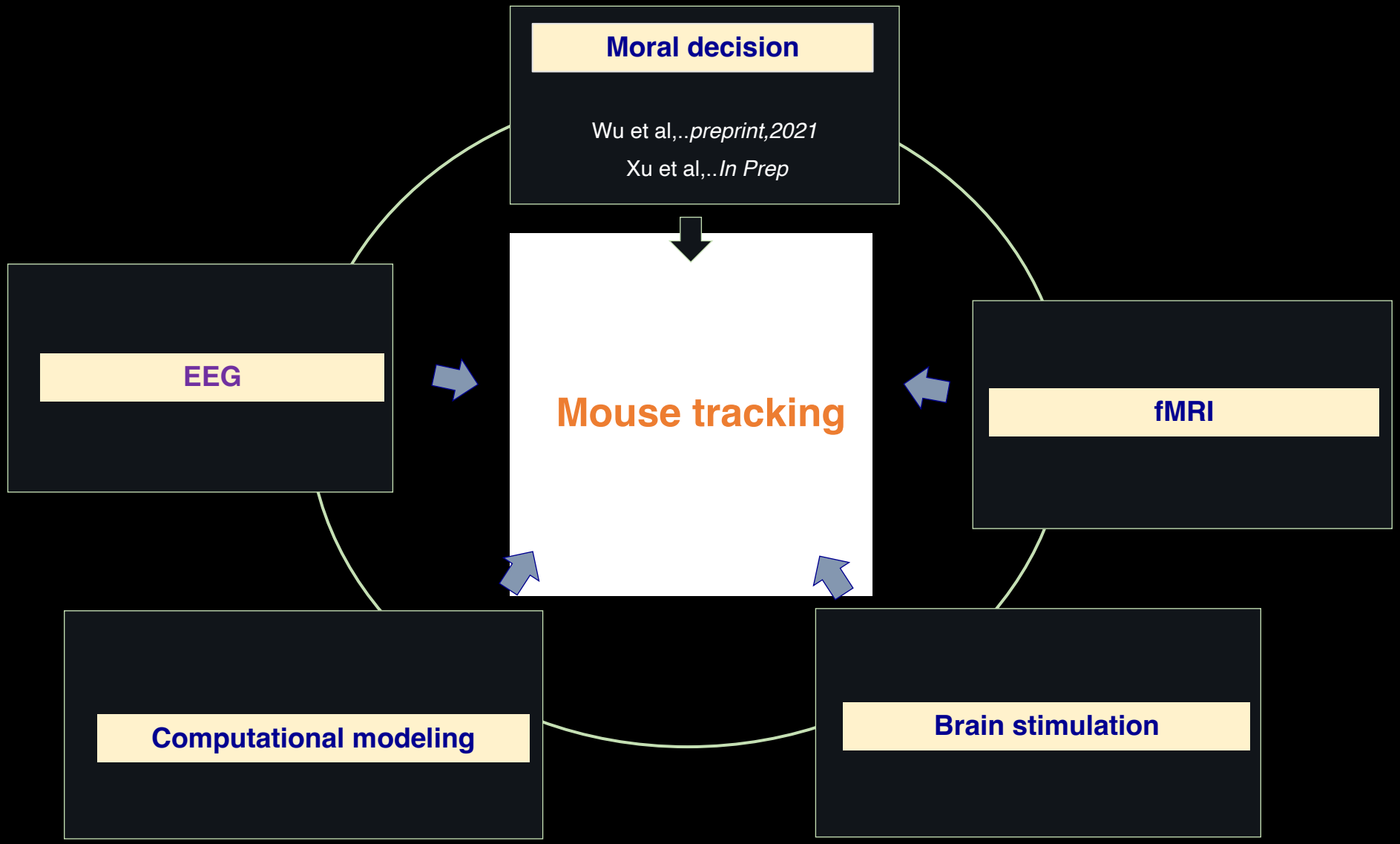
Research examples



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

WeChat Official Account

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 mosue 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/]

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/]

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

Part 2: MT with opensesame

Some code from Haiyan contact: haiyanwu3@gmail.com

OpenSesame

Memory

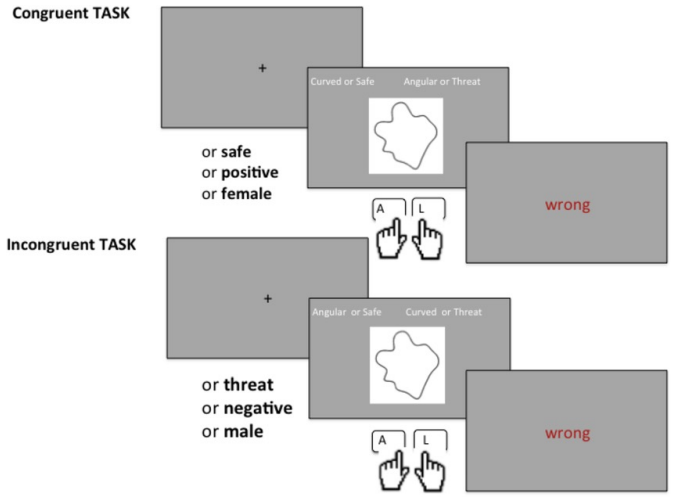
aIAT(autobiographical Implicit Association Test) with MT

- 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

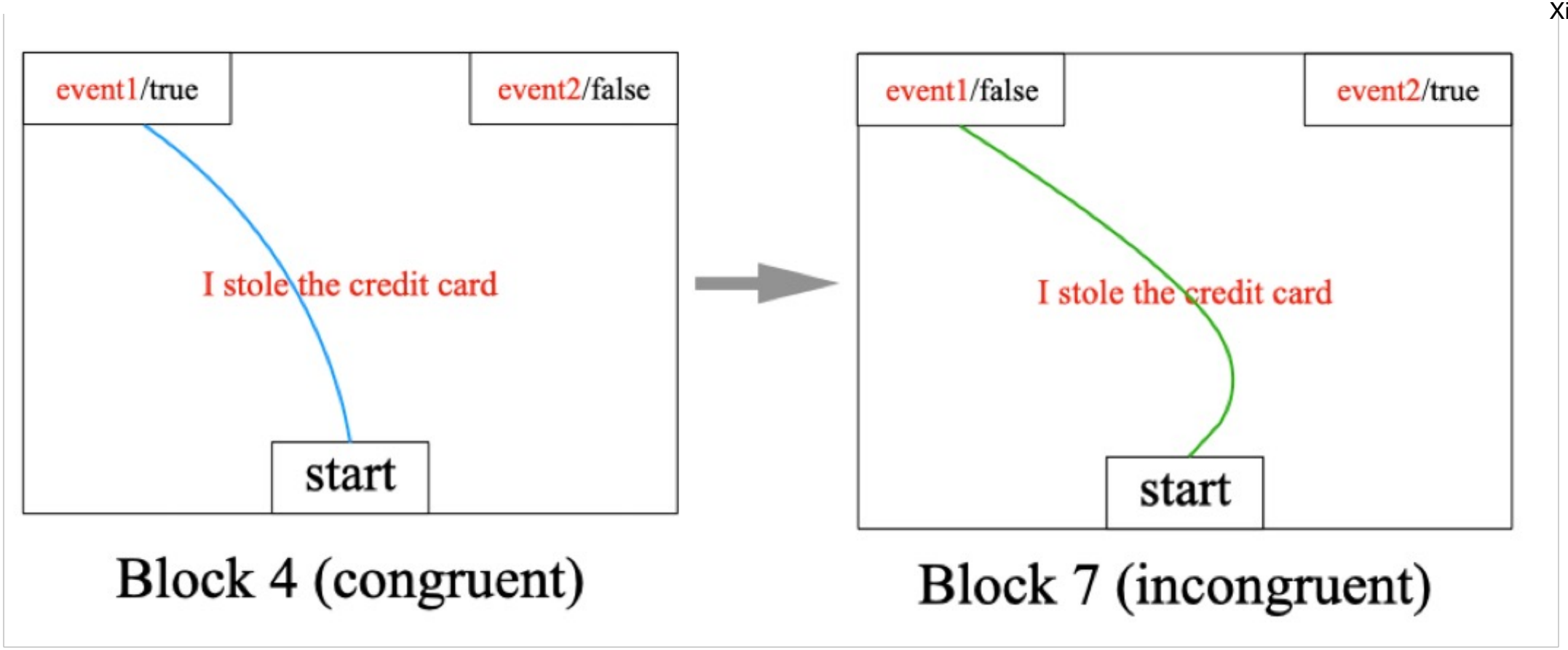
Note. The order of Blocks 1, 3, 4 and Blocks 5, 6, 7 was counterbalanced across subjects.

Classic IAT with 7 blocks



The autobiographical IAT

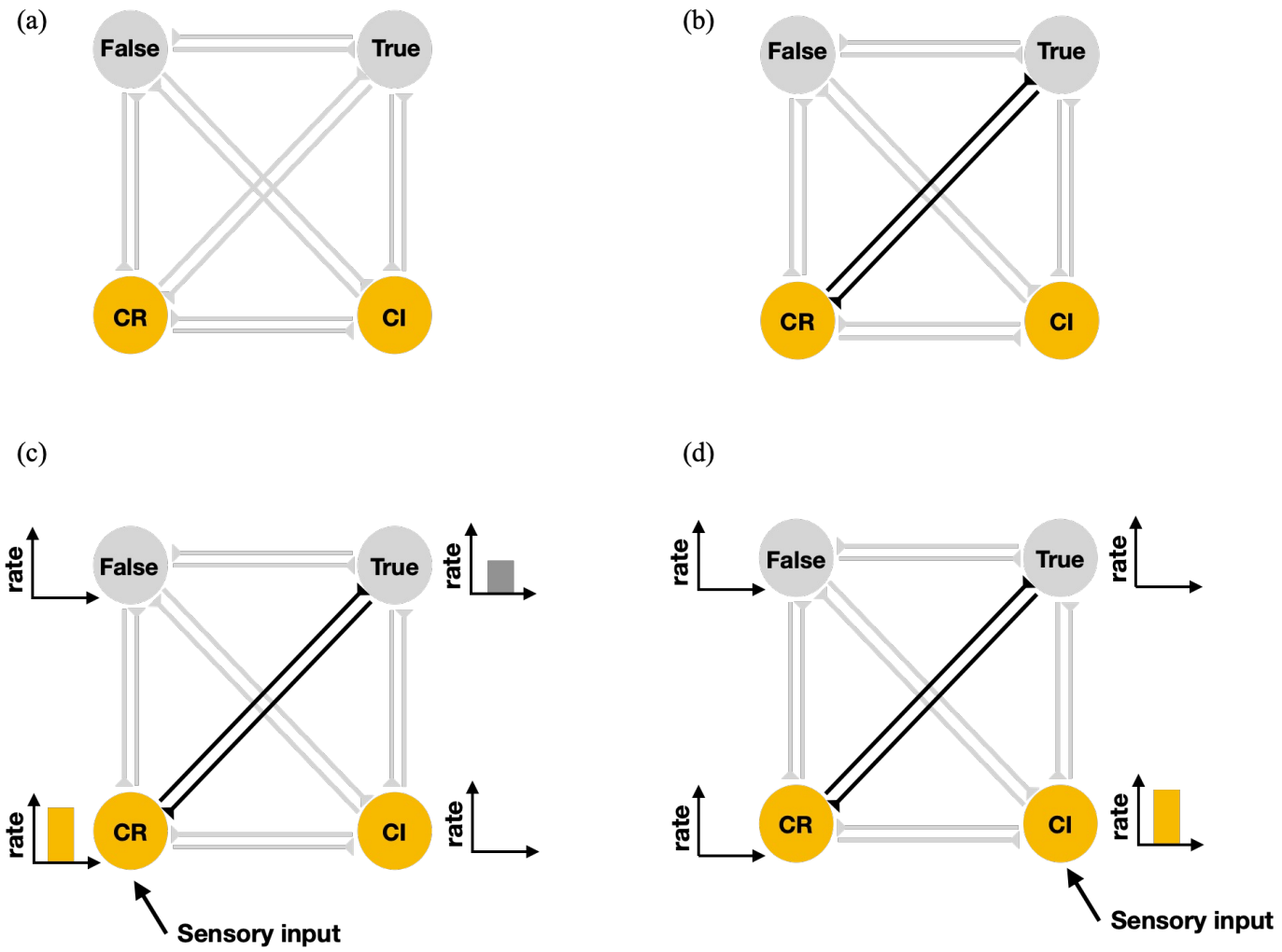
Xinyi Julia Xu



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

The connectionist model

Xinyi Julia Xu

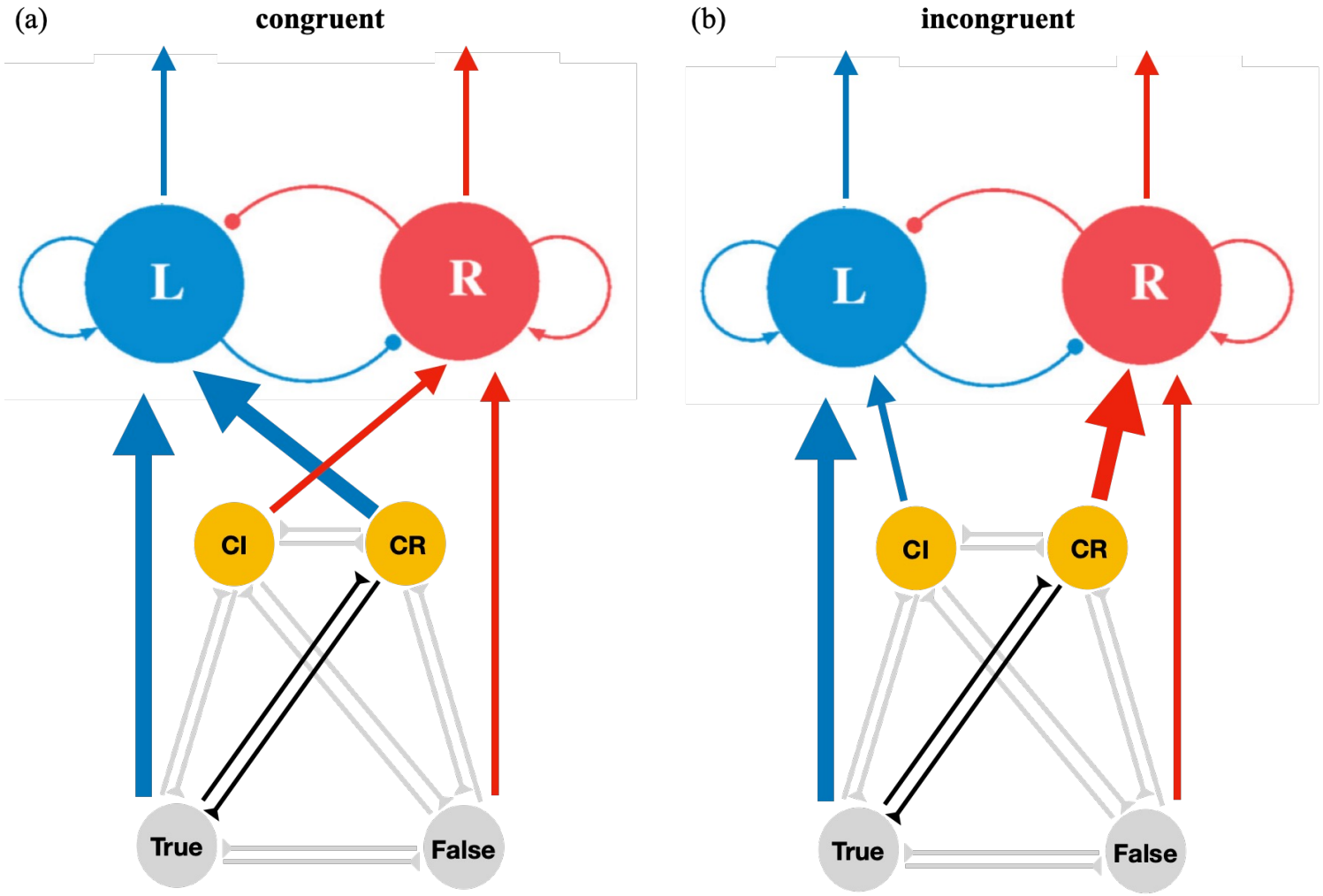


Bedder, R. L., Bush, D., Banakou, D., Peck, T., Slater, M., & Burgess, N. (2019). *Cognition*

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

Model the data with the drift diffusion model(DDM)

Xinyi Julia Xu



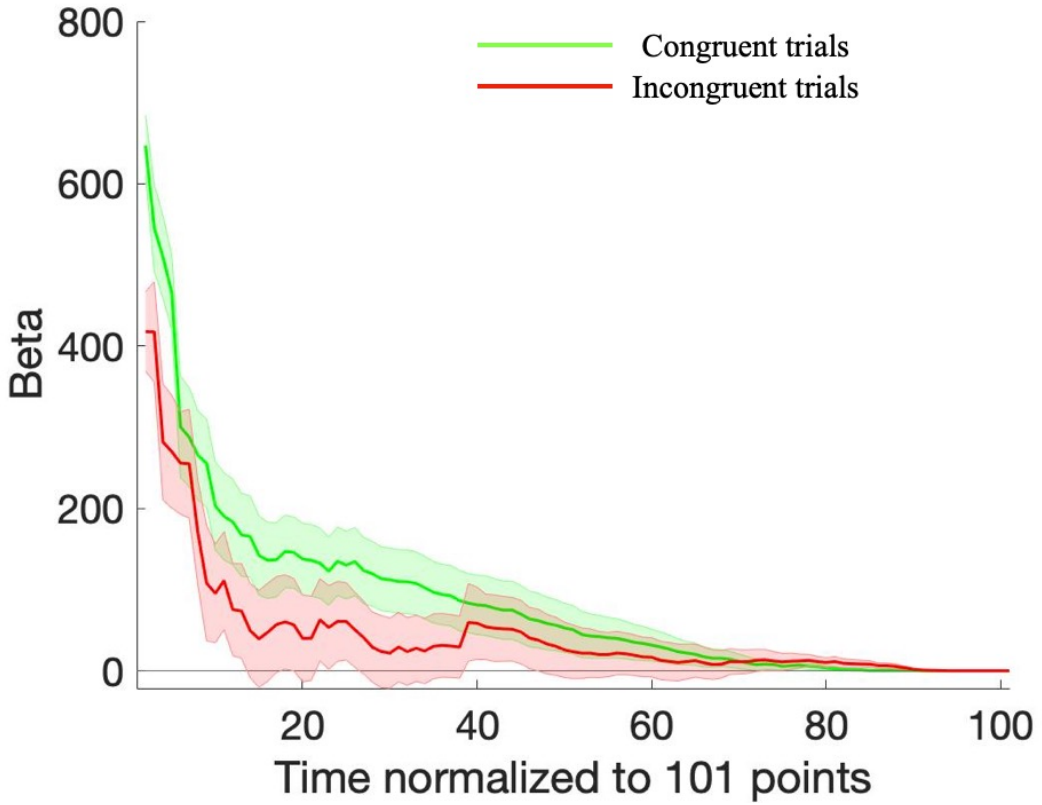
Bedder, R. L., Bush, D., Banakou, D., Peck, T., Slater, M., & Burgess, N. (2019). *Cognition*

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

Regression Resuls

Xinyi Julia Xu

Angle θ ~ 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).

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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Moral

Example study 1

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

Instruction1

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.

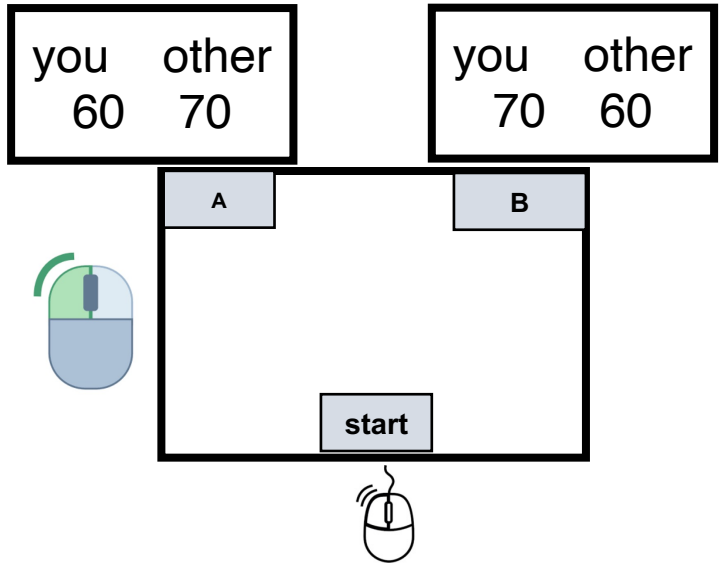
- For example, in this trial the A option is

you	other
60	70

- the B option is

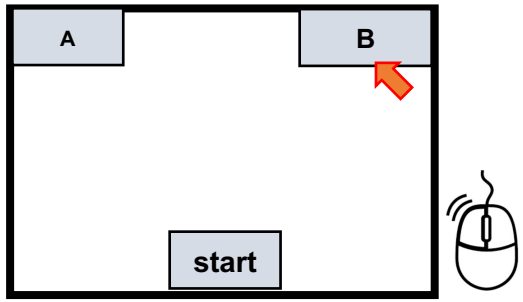
you	other
70	60

Instruction2

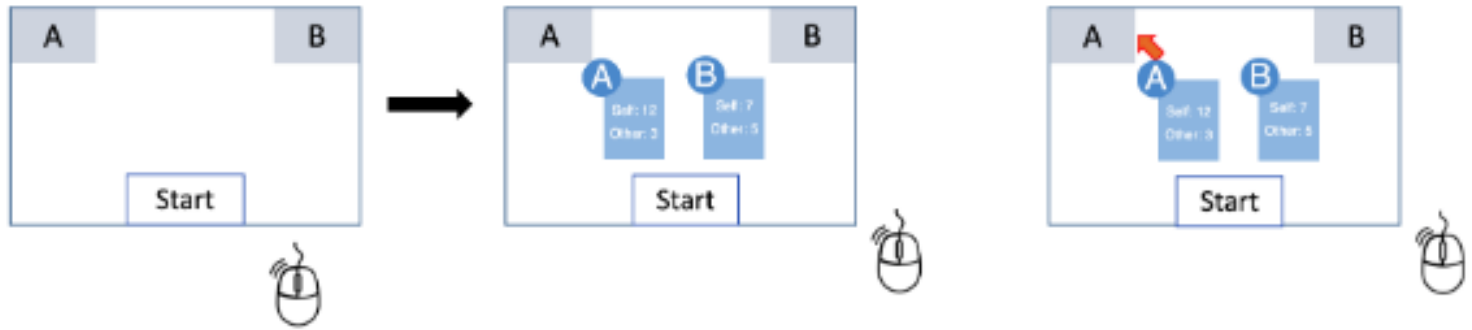


- click start by mouse

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



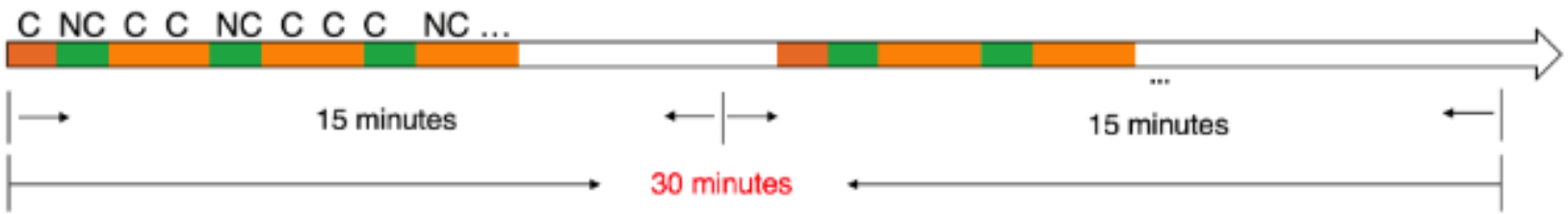
- Click one option you want to send to player2



Non-Conflict trial

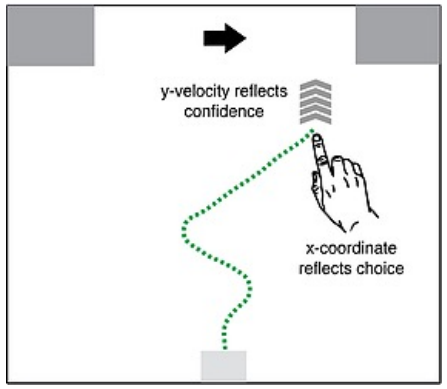
Conflict interest trial

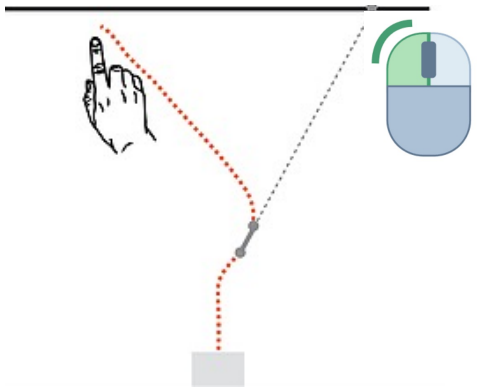
Break/Questionnaire time



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

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	respshowafter	0					
25	respshowafterdelay	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	cursorspeed	10					
37	holdforcompound	1					
38	dragging	0					

2 set up

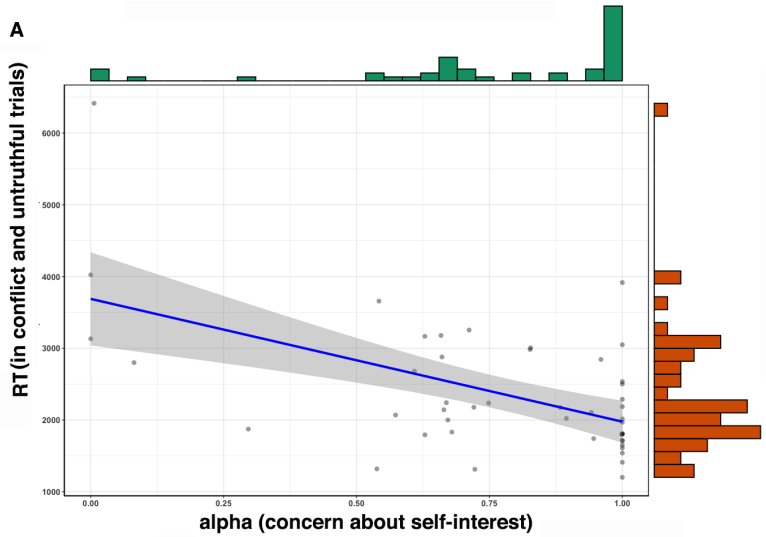
	type	stim	cond	rand	correct	default-com	resp_1	resp_2
41	0	M1.jpg	instruct					
42	0	mes2.jpg	instruct					
43	1	1.jpeg	conflict	1	2	1	A	B
44	1	2.jpeg	conflict	1	1	2	A	B
45	1	3.jpeg	conflict	1	2	1	A	B
46	1	4.jpeg	conflict	1	2	1	A	B
47	1	5.jpeg	conflict	1	2	1	A	B
48	1	6.jpeg	conflict	1	1	2	A	B
49	1	7.jpeg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

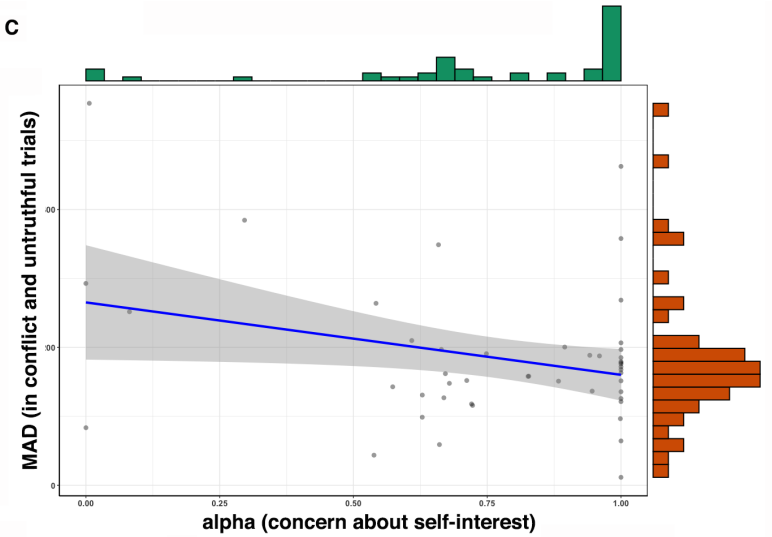
3 Build Trials in csv

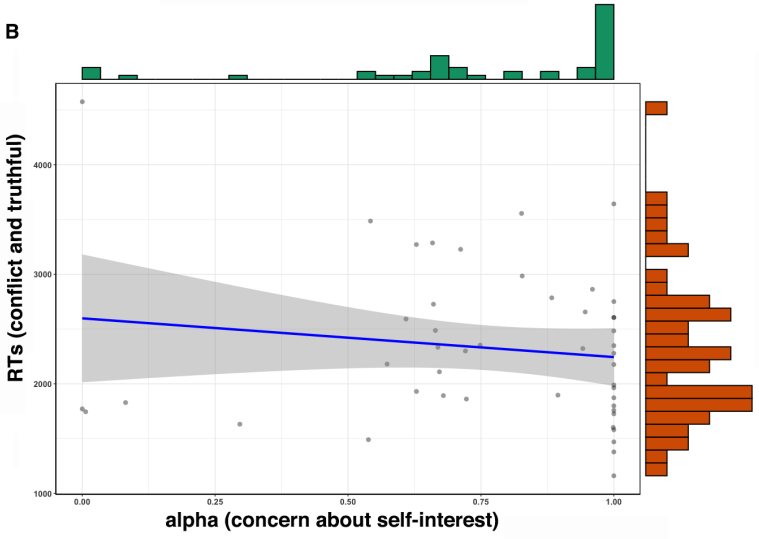
https://github.com/andlab-um/MT_workshop

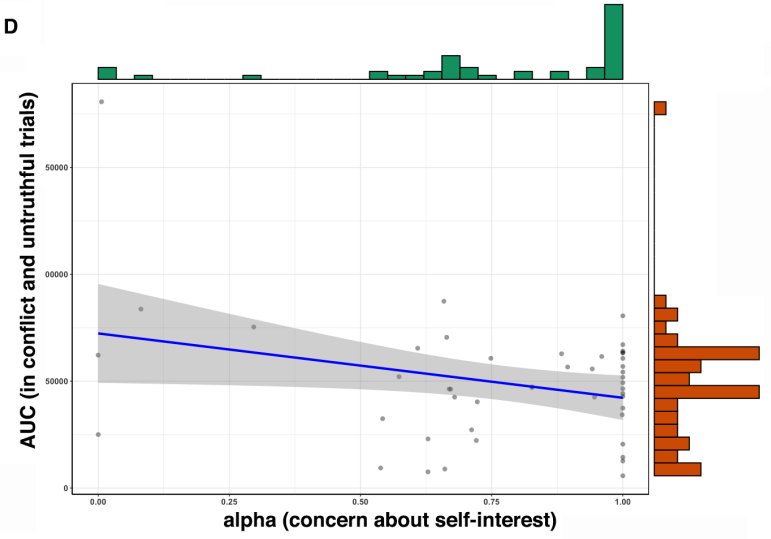
Part 1

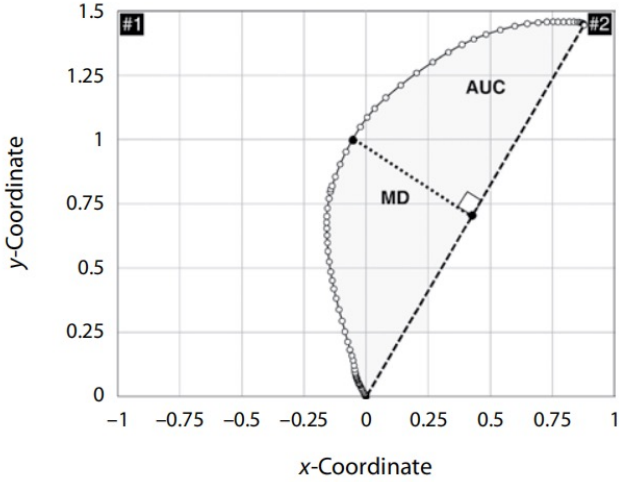
Results


A
RT(in conflict and untruthful trials)
alpha (concern about self-interest)


C
MAD (in conflict and untruthful trials)
alpha (concern about self-interest)


B
RTs (conflict and truthful)
alpha (concern about self-interest)

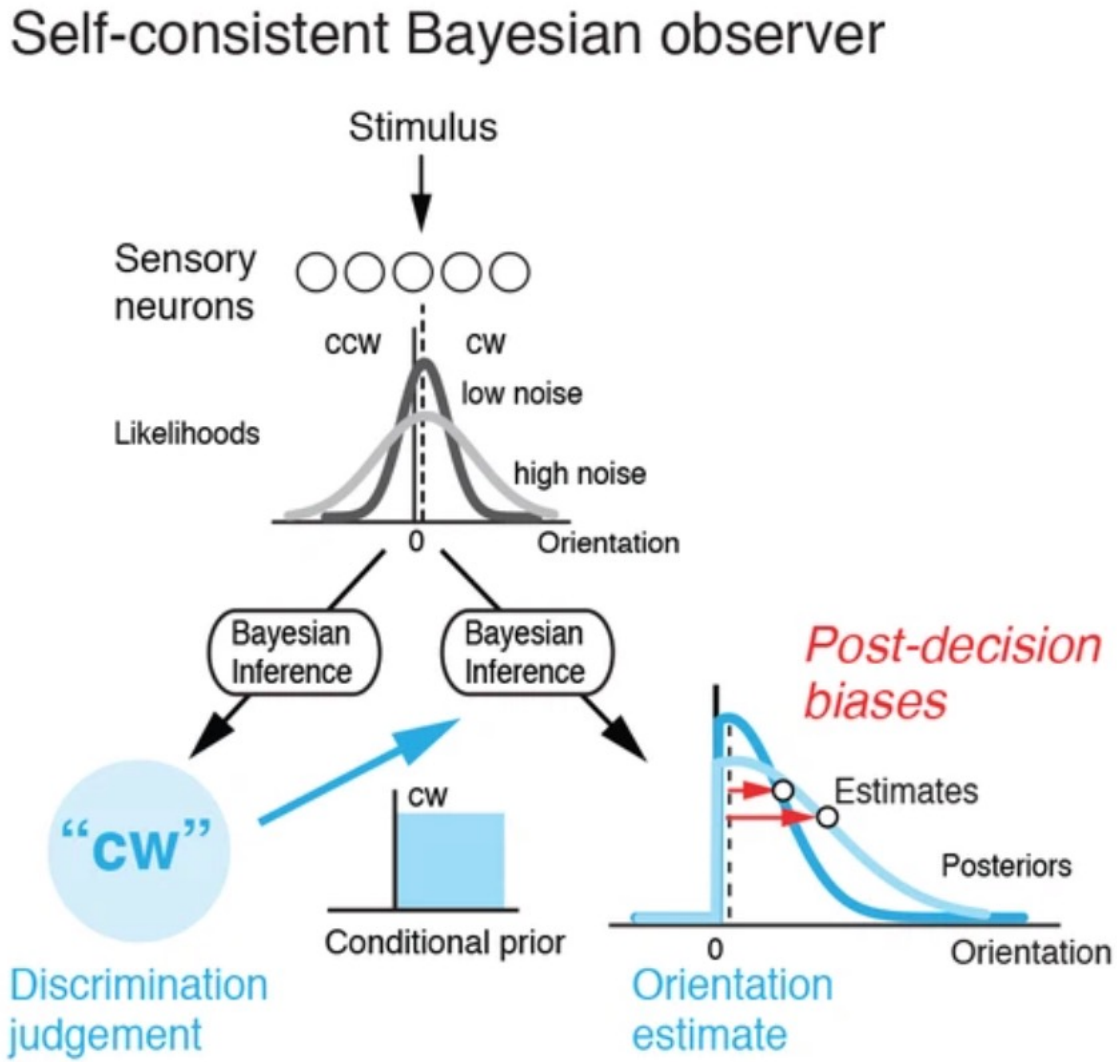

D
AUC (in conflict and untruthful trials)
alpha (concern about self-interest)


#1
#2
AUC
MD
y-Coordinate
x-Coordinate

Example study 2

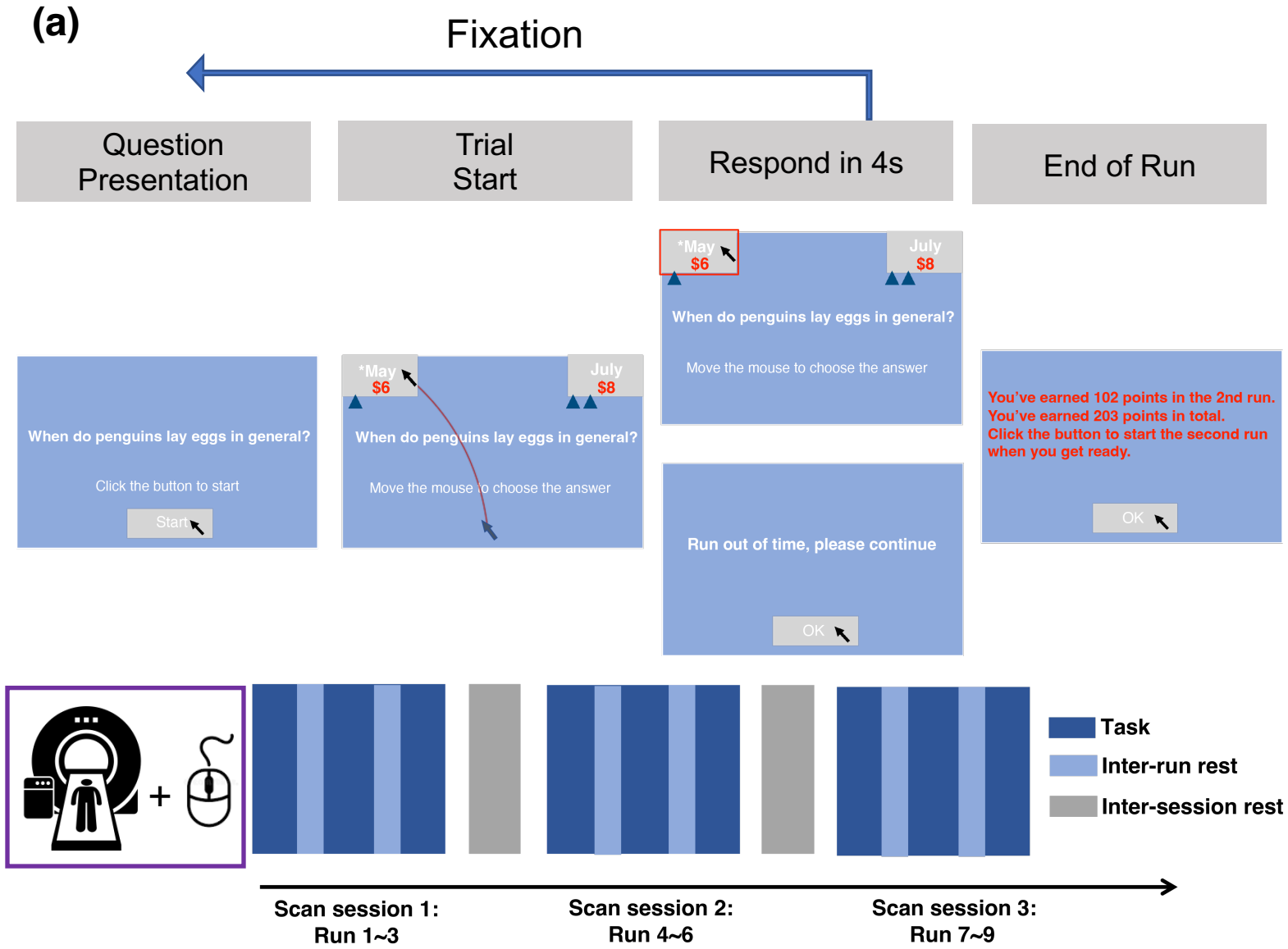
Reward and self-consistency: Dissecting the role of social brain and cognitive control in moral decisions

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



Luu, L et al. (2018)

Paradigm



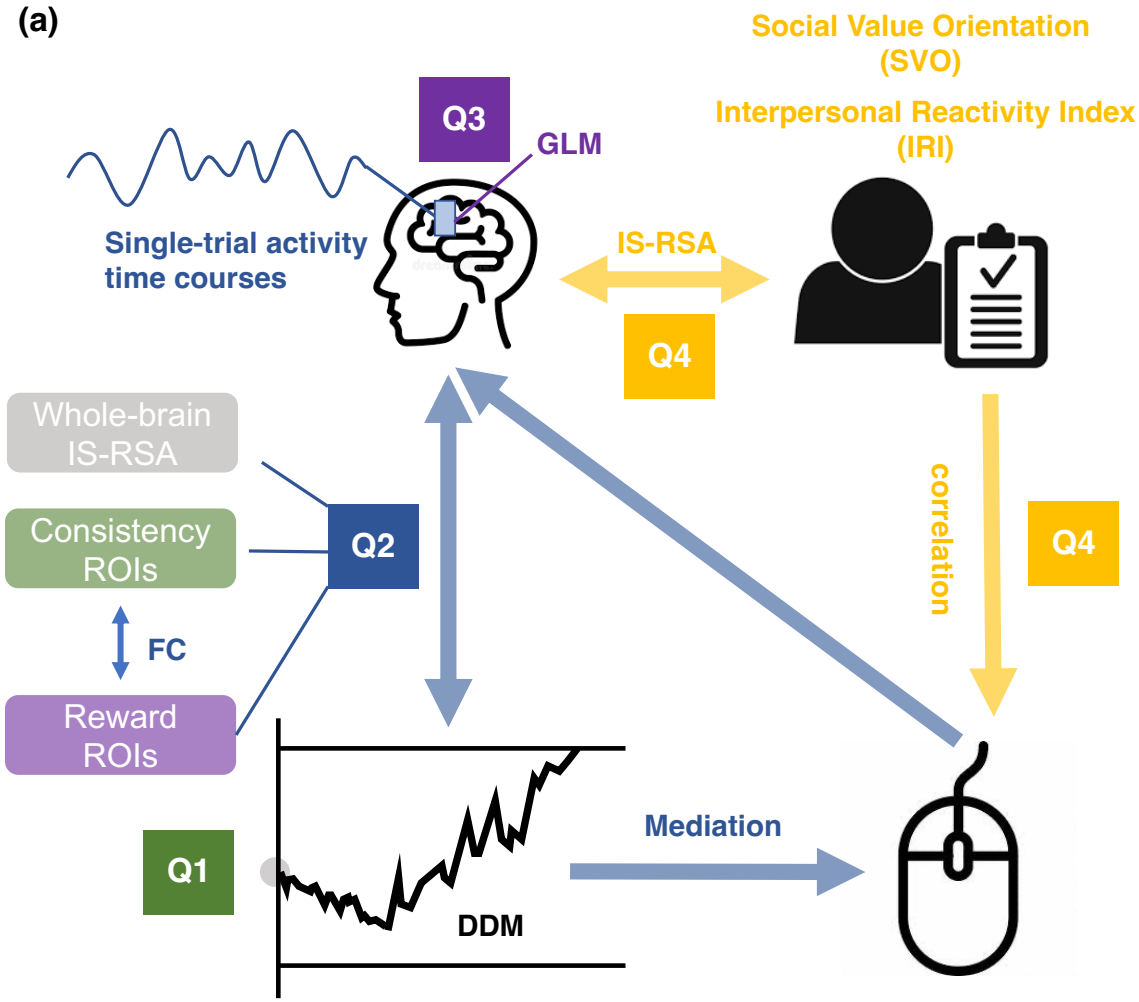
Xu et al (In Prep)

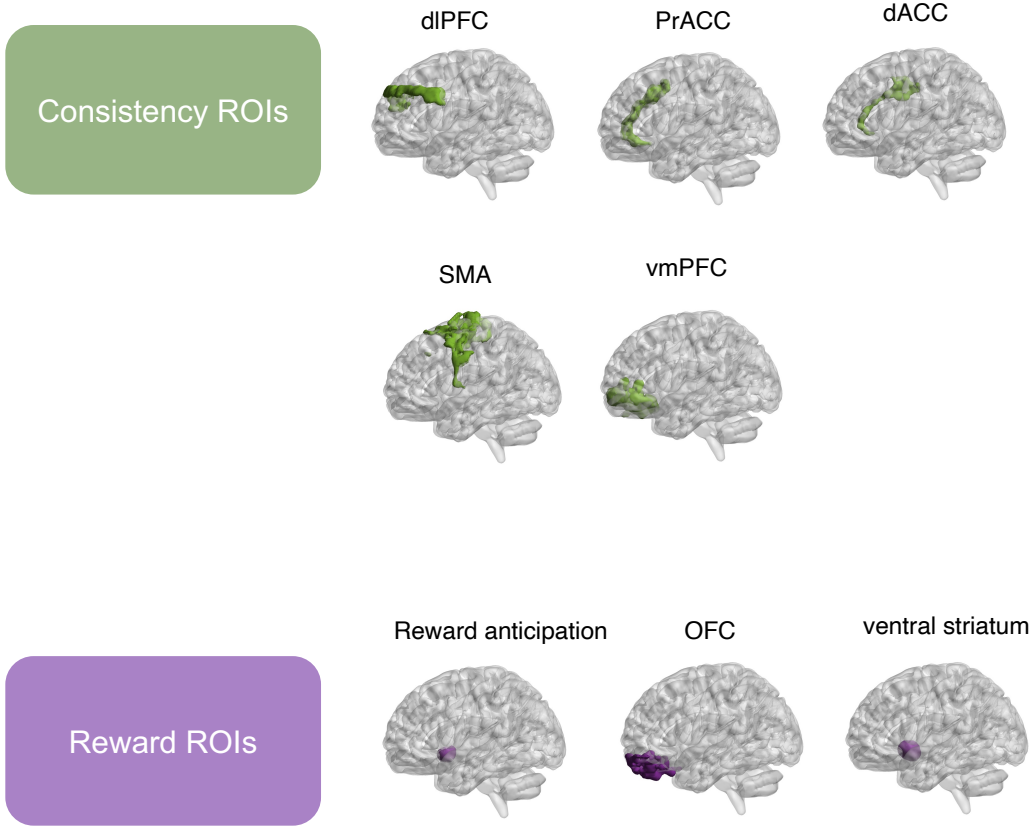
Research Questions

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?

Xu et al (In Prep)

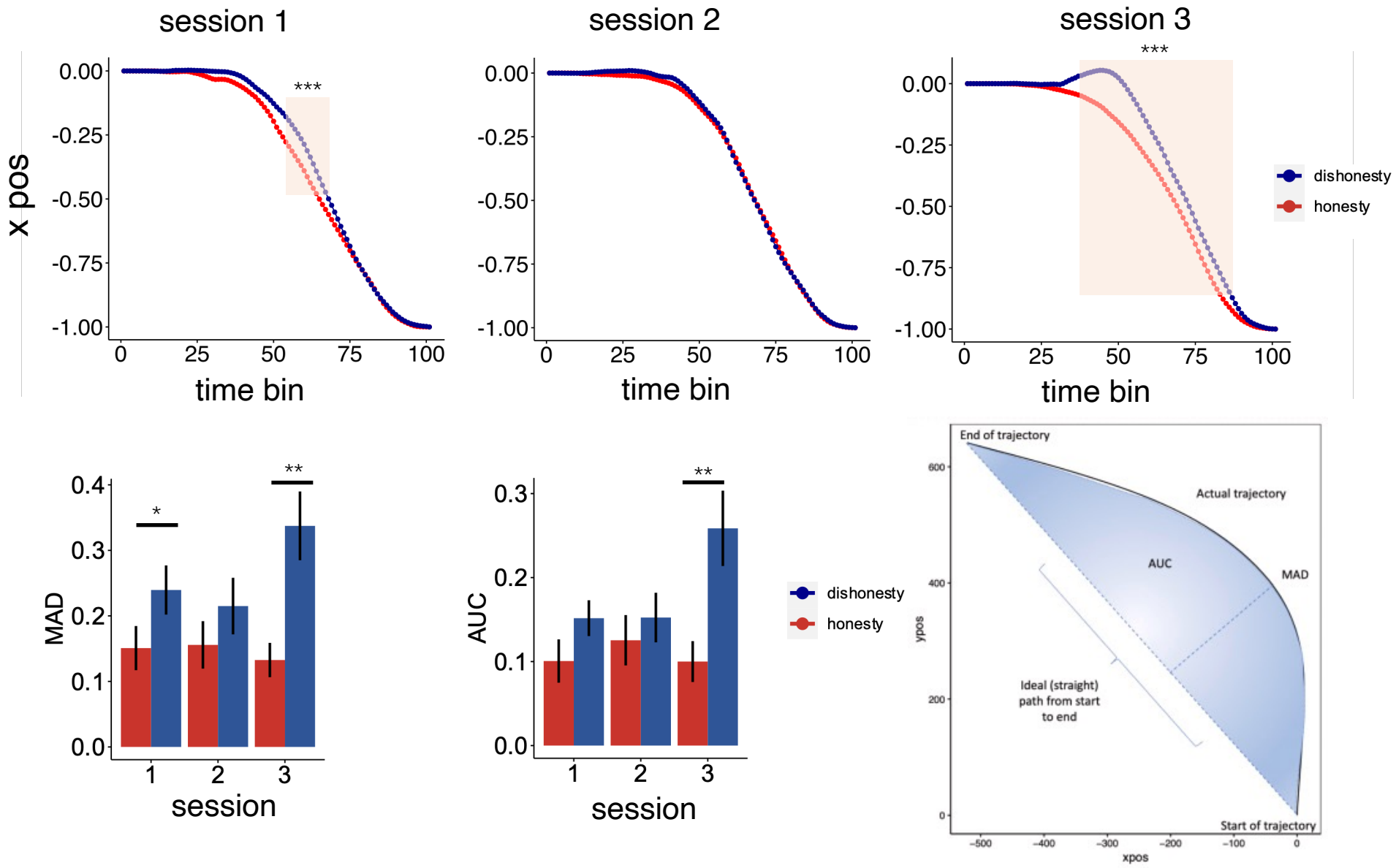
Framework





Xu et al (In Prep)

Dishonesty and honesty responses had different mouse trajectories

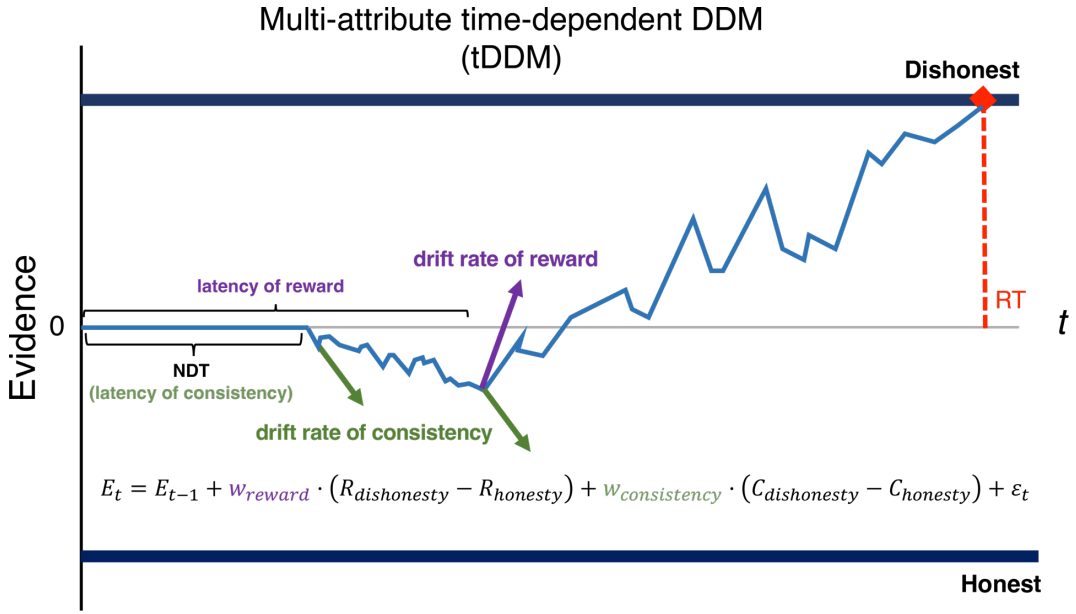


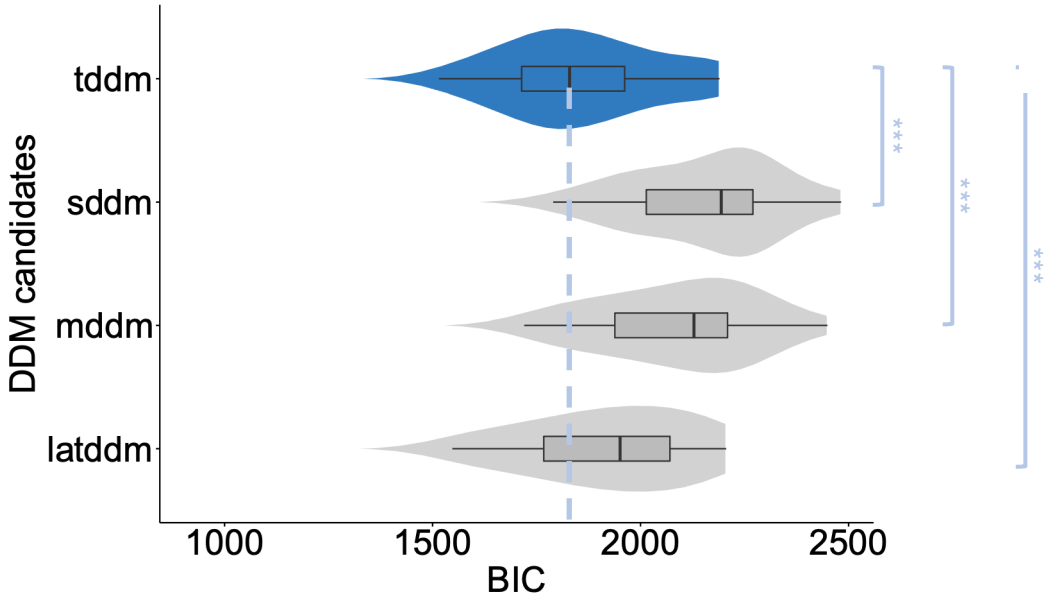
Xu et al (In Prep)

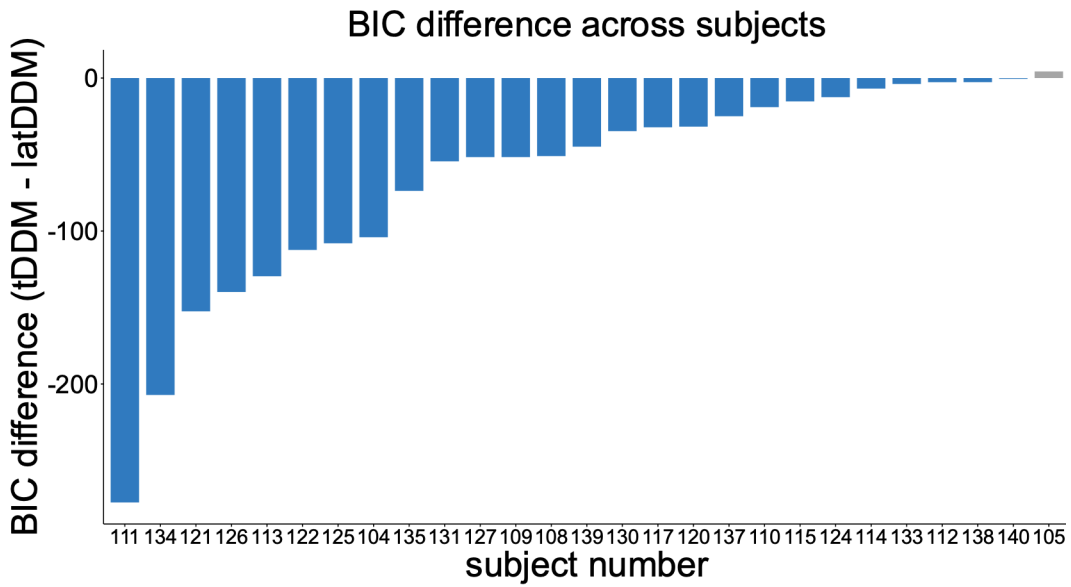
1

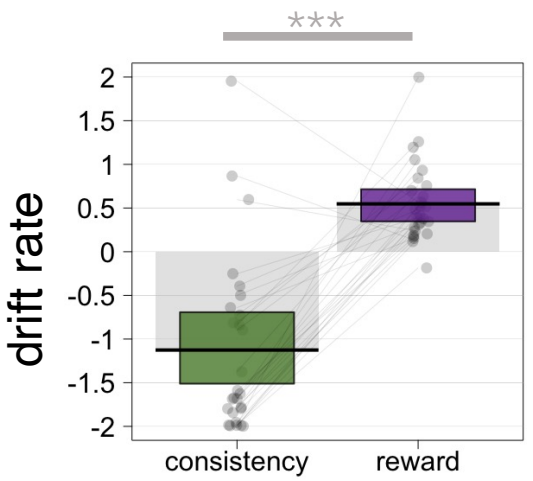
How human trade off reward and consistency in weights and in timings?

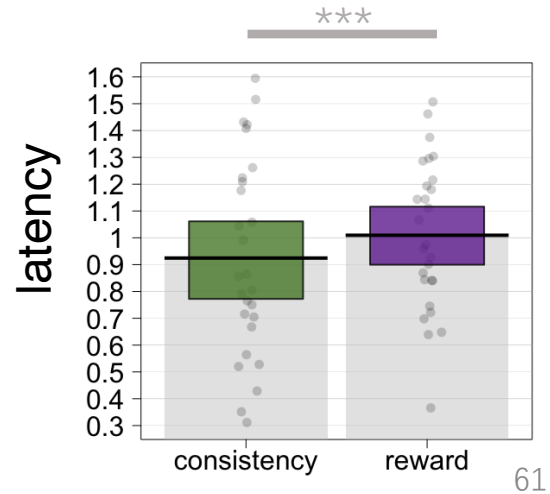
Consistency and reward: different weights, different timings







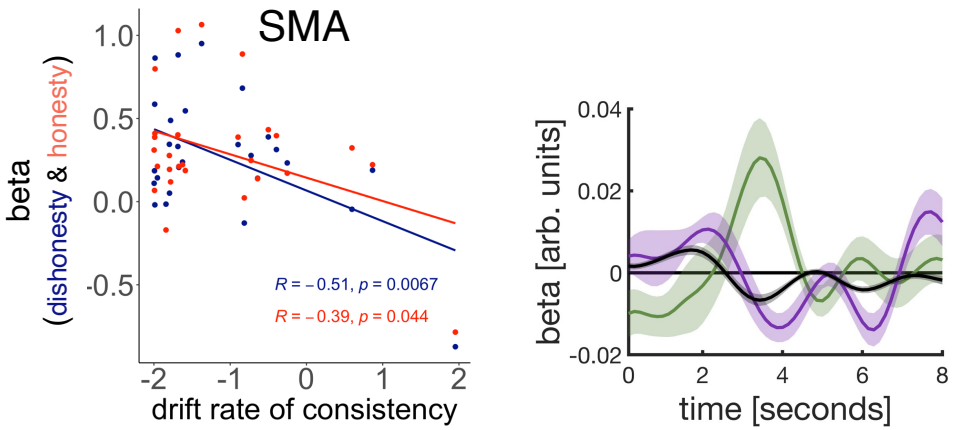


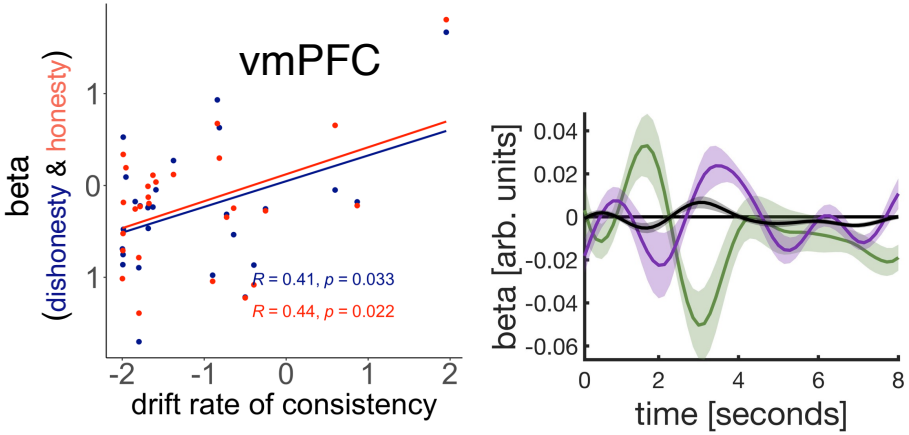


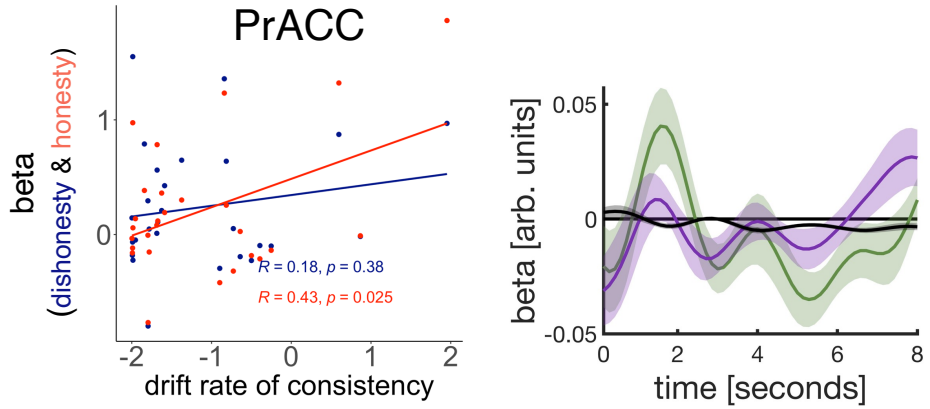
2

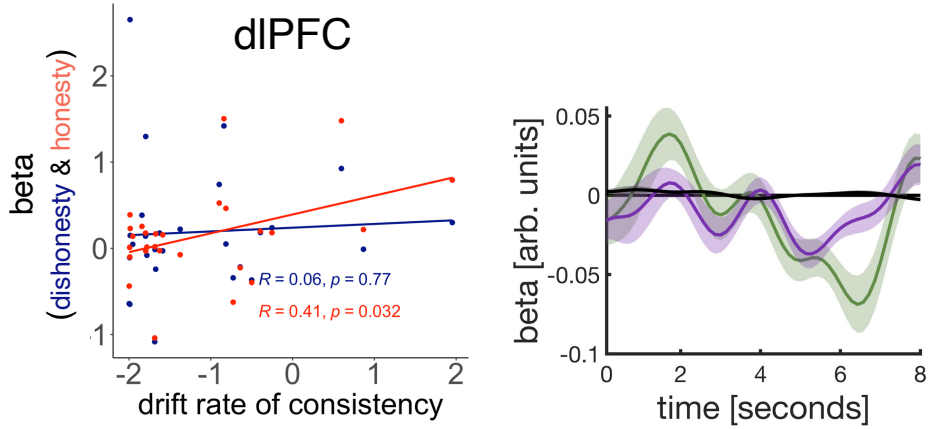
How are the weights of reward and consistency are associated with the **cognitive-control** and **reward** related brain regions?

Weights of consistency: correlated with cognitive control brain regions





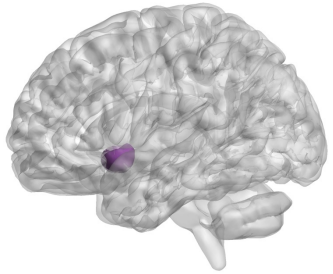




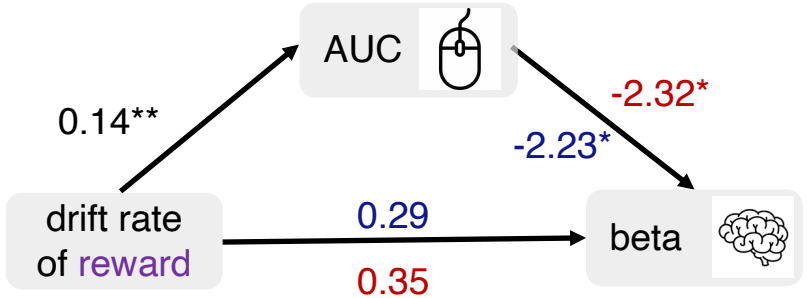
dishonesty
honesty
consistency
reward

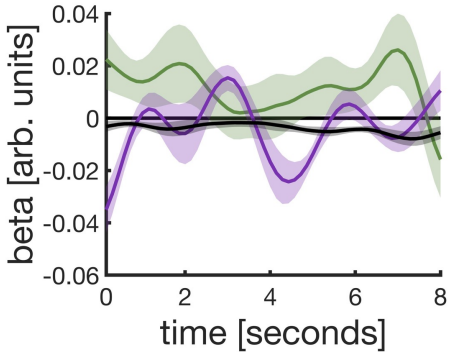
dishonesty
honesty
consistency
reward

Weights of reward: mediated by mouse tracking index AUC

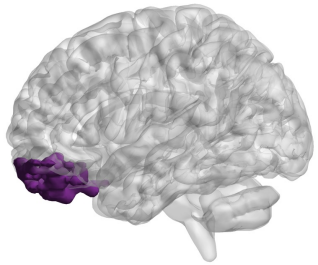


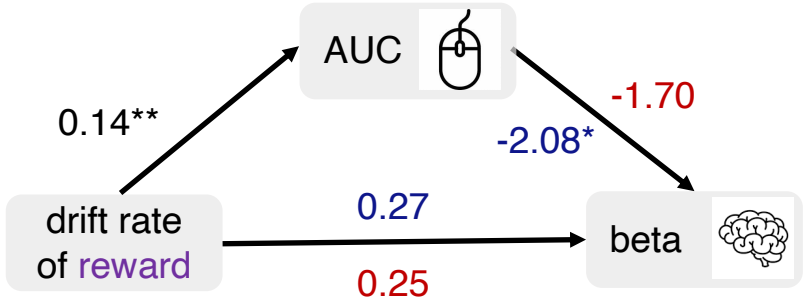
reward anticipation (sgACC)

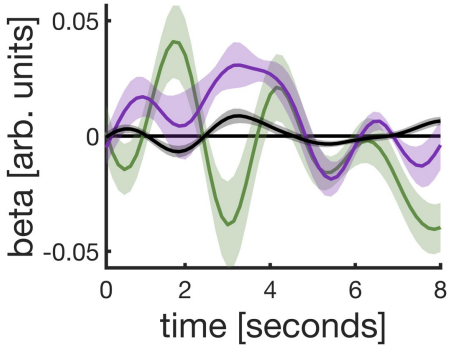




OFC







dishonesty

honesty

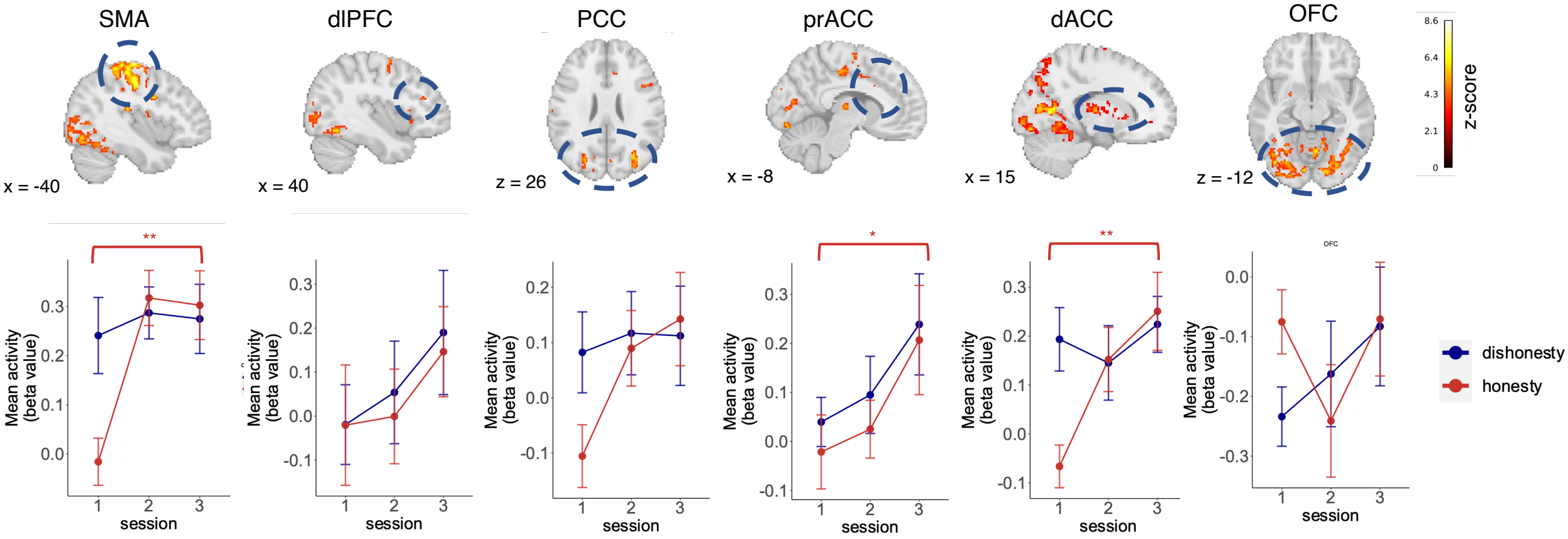
consistency

reward

3

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

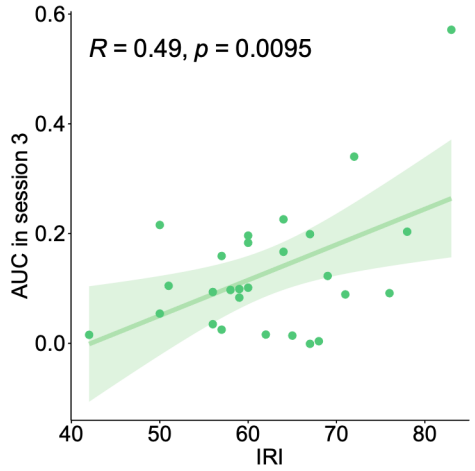
Activations of cognitive control brain regions increased along the sessions

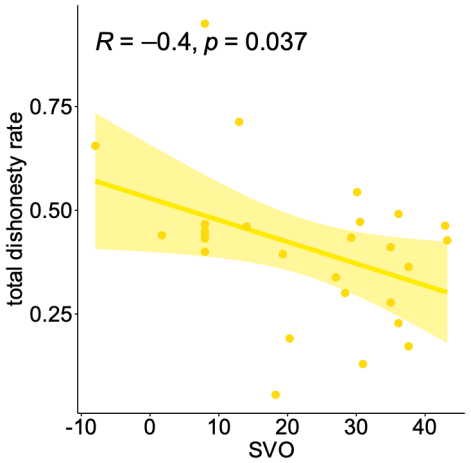


Xu et al (In Prep)

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

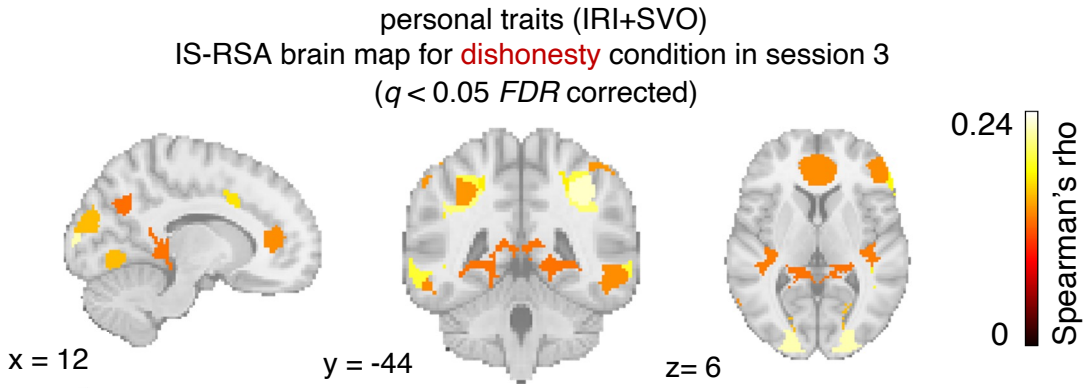
Effects of personal traits on behavior and brain

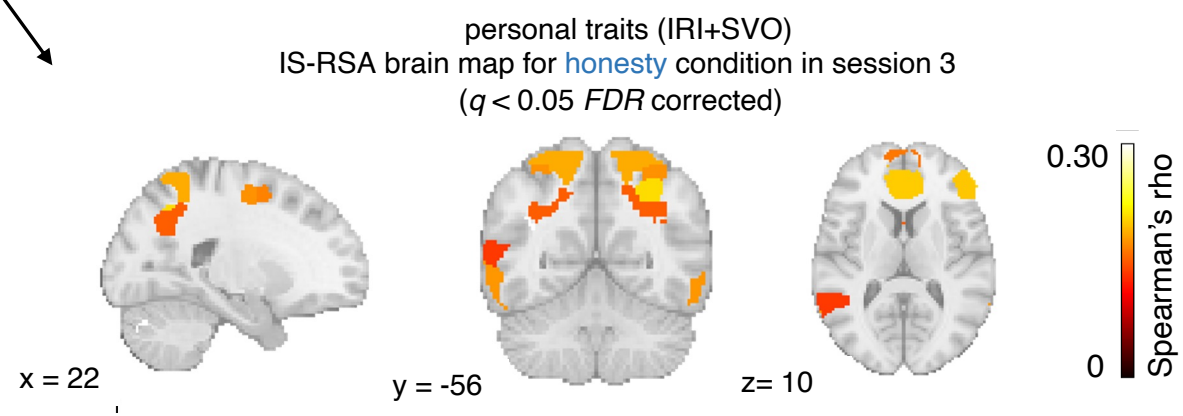




Interpersonal Reactivity Index (IRI)

Social Value Orientation (SVO)





Xu et al (In Prep)

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- Other decisions with MT

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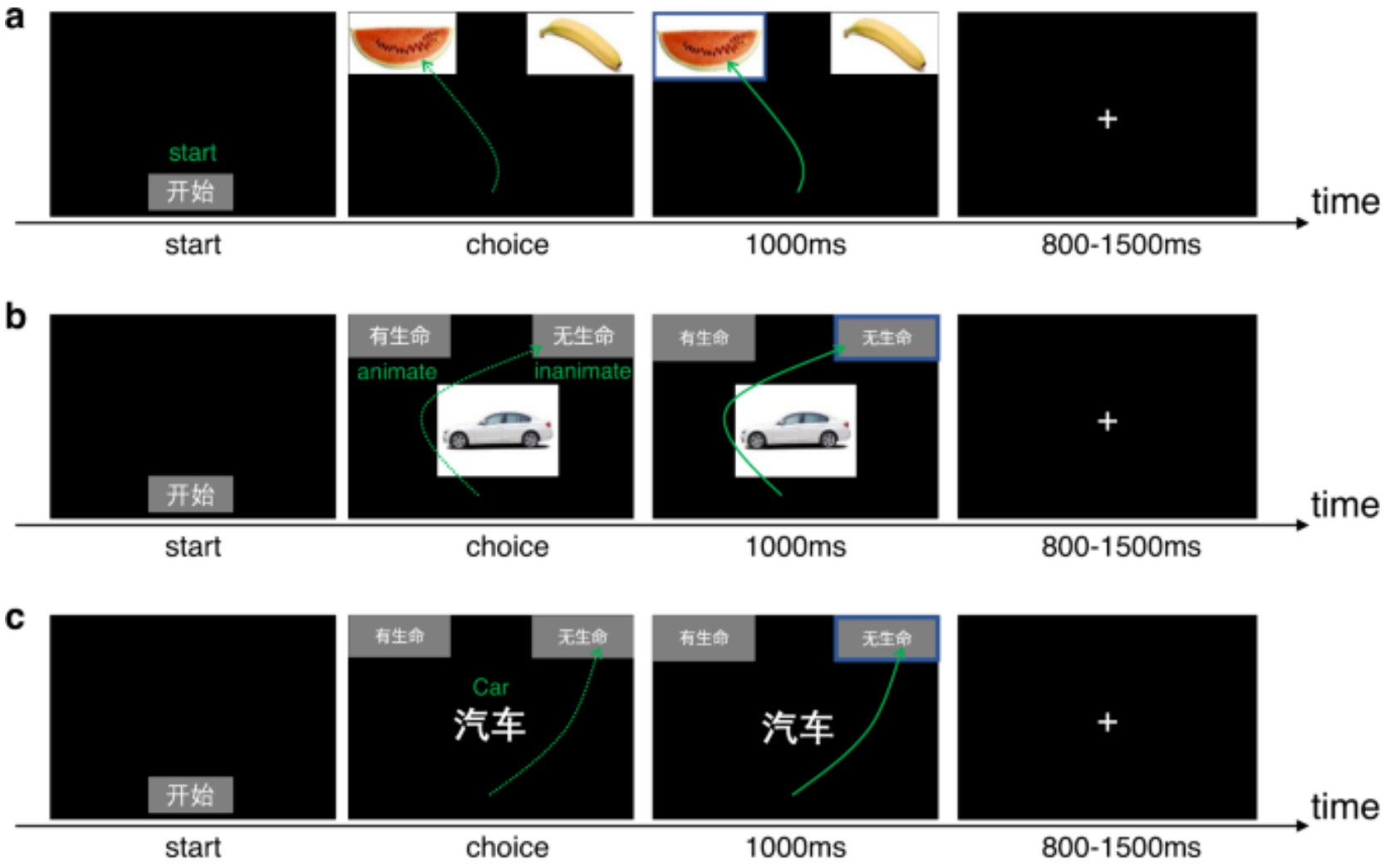
Other Decisions

Paradigm



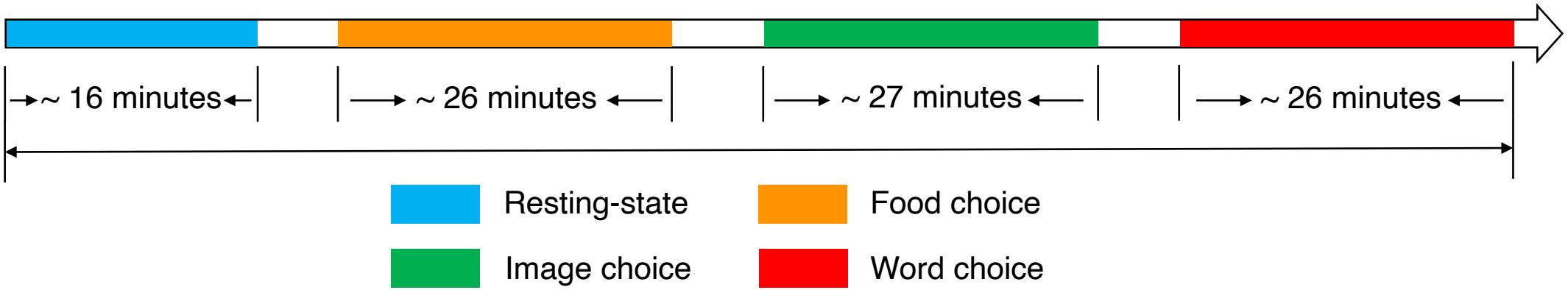
Kun Chen

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.

Task Overview

Kun Chen

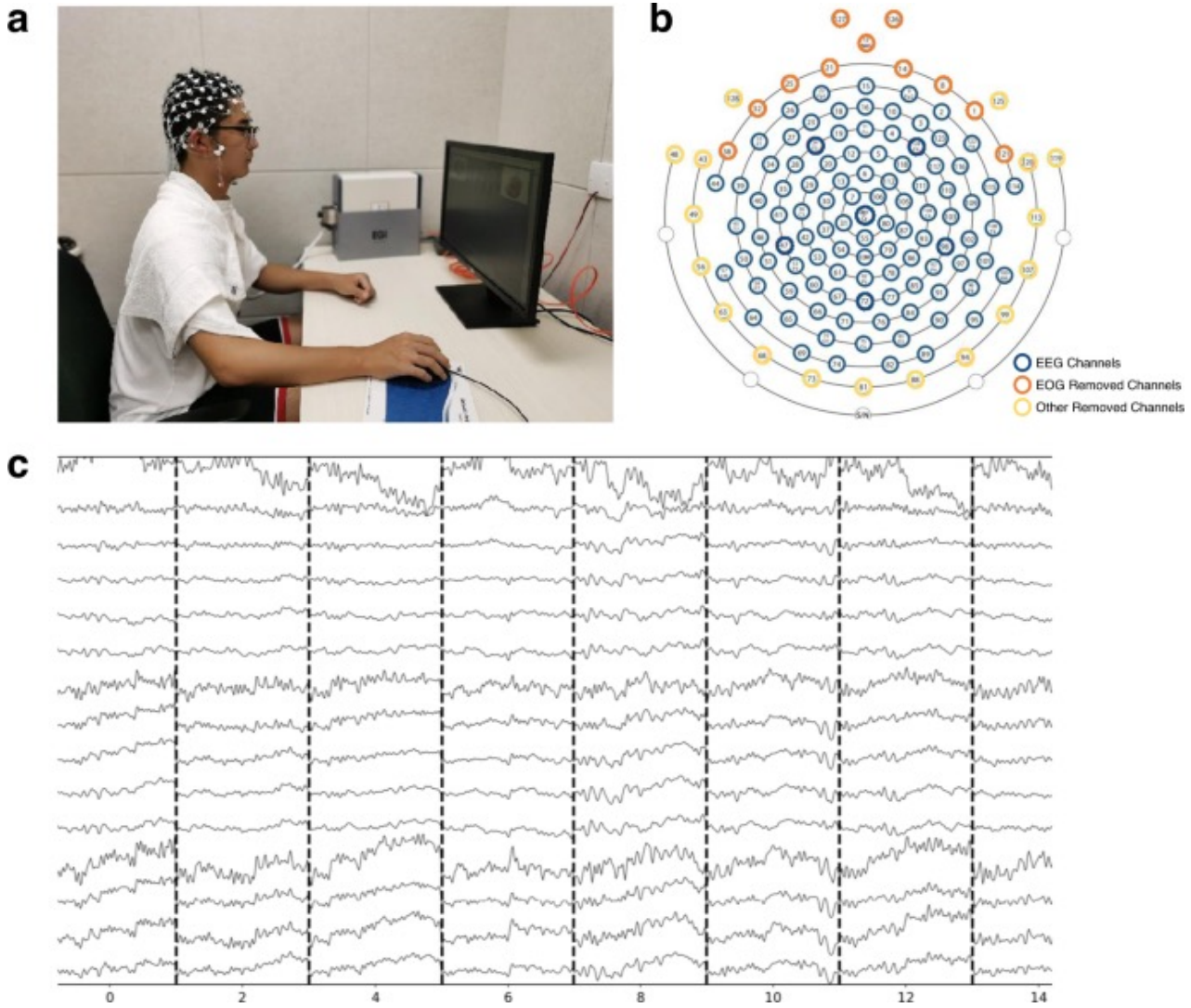
Task	Description
Resting-state	Measures EEG activity during rest.
Food choice	A food preference task based on mouse tracking. Measures the dynamic process and corresponding EEG signals of food preferences.
Image choice	A semantic classification task for image based on mouse tracking. Measures the dynamic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



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.

Data collection platform

Kun Chen



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.

Average mouse trajectories in different tasks

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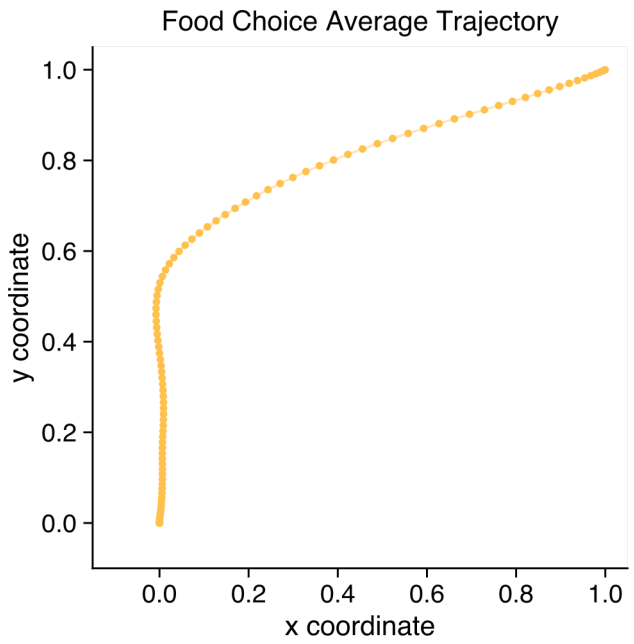
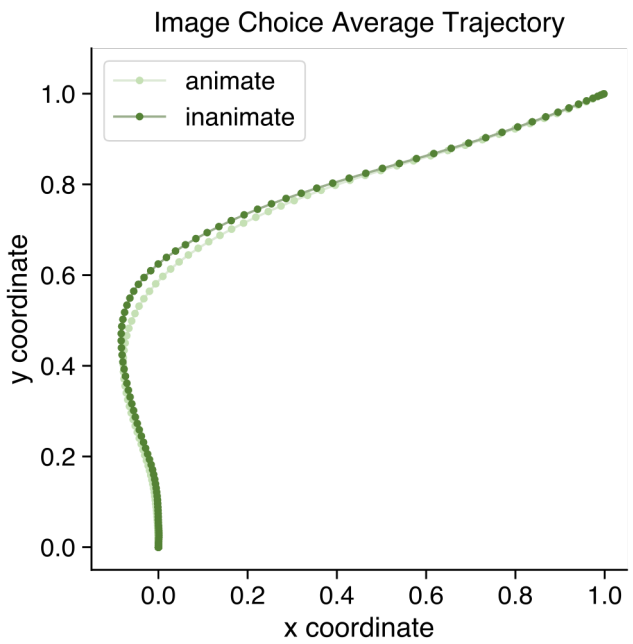
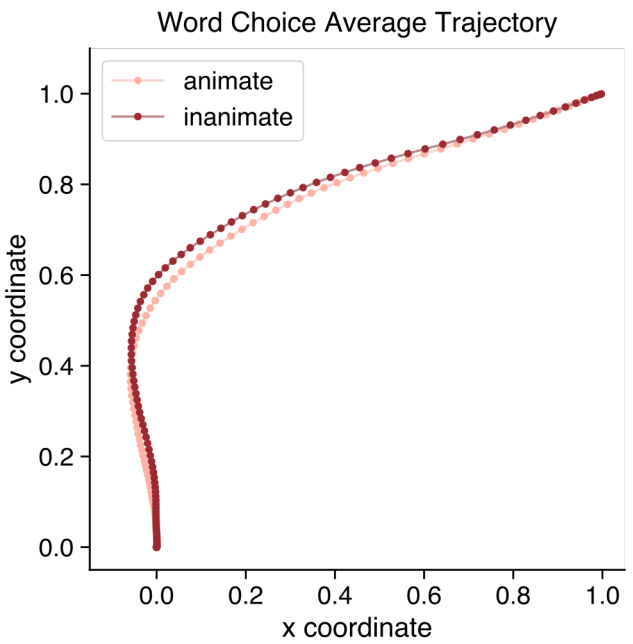
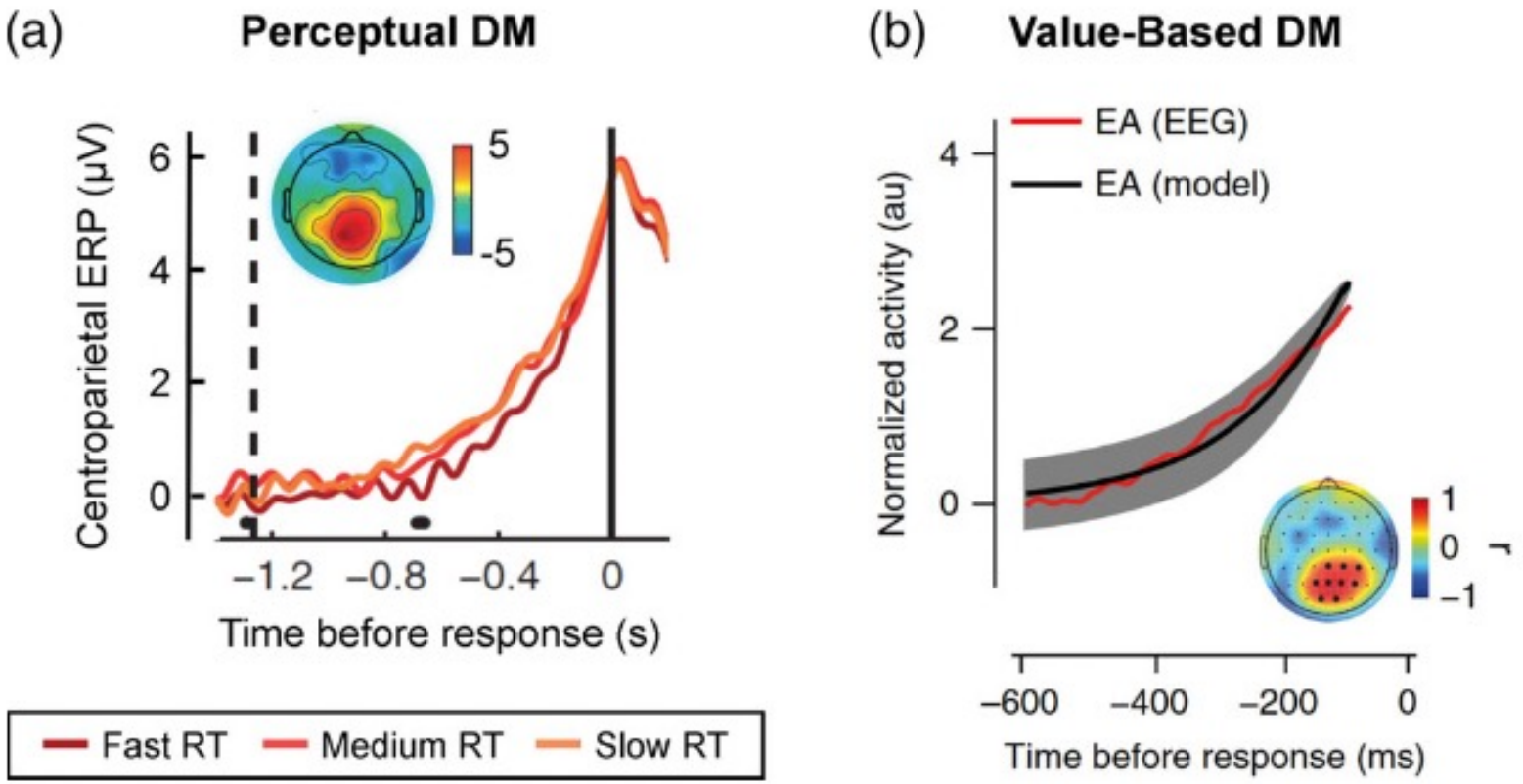






Chen, K., Wang, R., Huang, J., Gao, F., Yuan, Z., Qi, Y., & Wu, H. (2022). A resource for assessing dynamic binary choices in the adult brain using EEG and mouse-tracking. Scientific data, 9(1), 1-10.

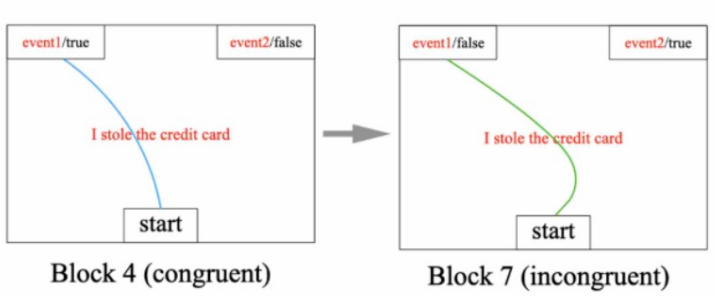
Mouse tracking + EEG + DDM



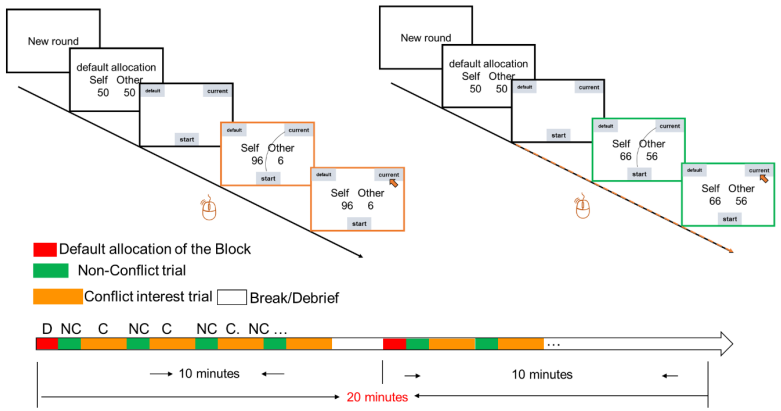
Harris, A., & Hutcherson, C. A. (2022). *Wiley Interdisciplinary Reviews: Cognitive Science*

Hand in motion reveals mind in motion

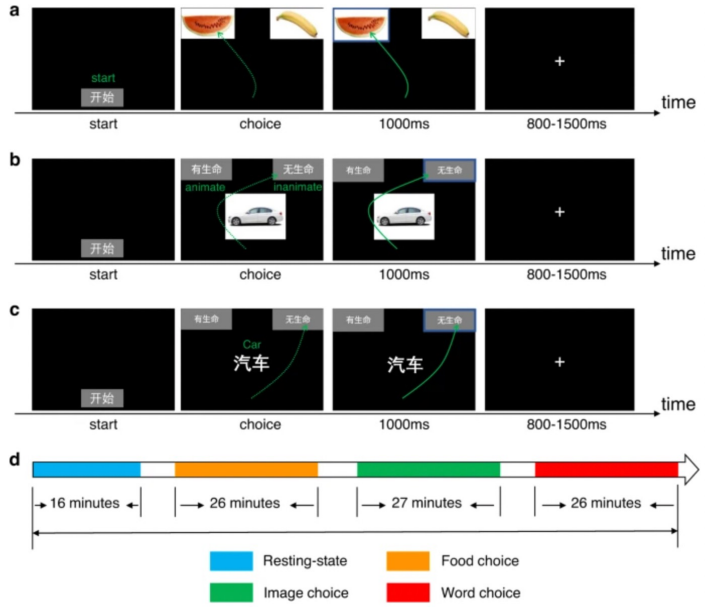
Memory



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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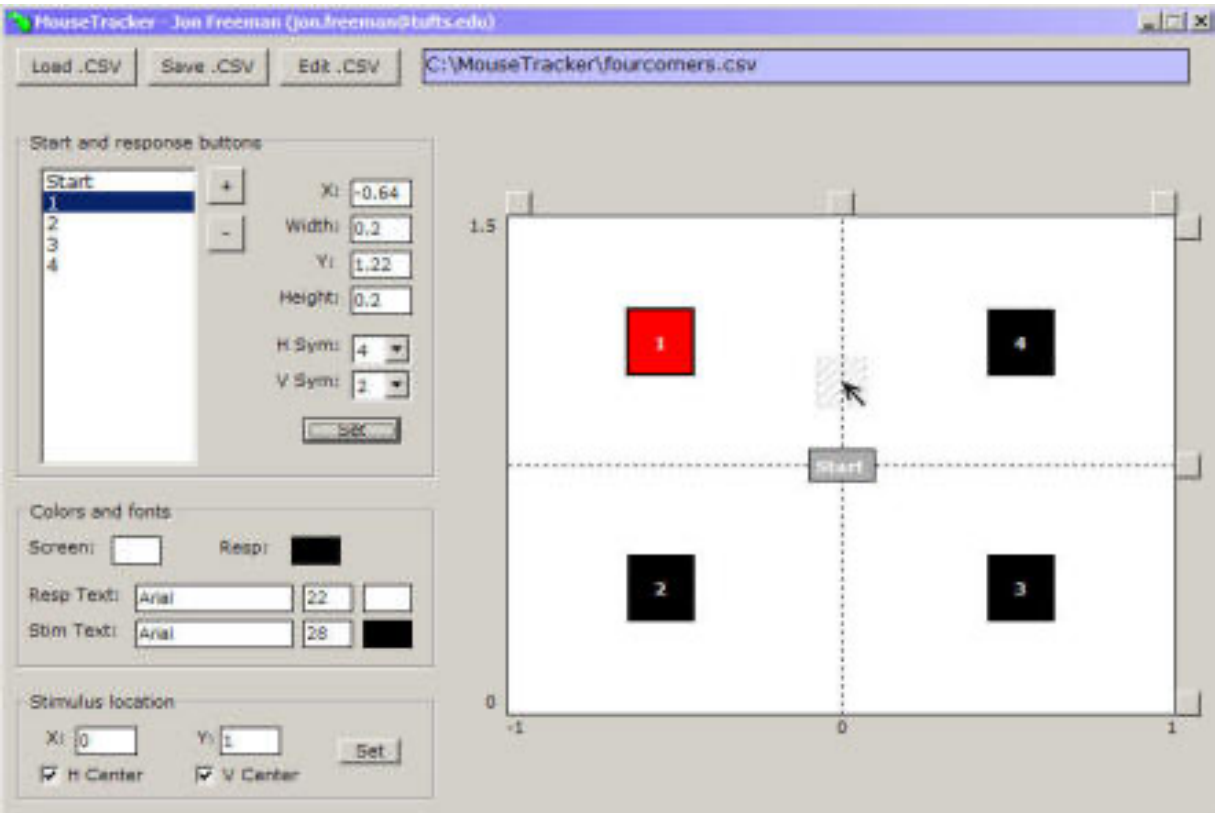
http://www.mousetracker.org/

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@tufts.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: 2
Set
Colors and fonts
Screen:
Resp:
Resp Text: Arial 22
Stim Text: Arial 28
Stimulus location
X: 0
Y: 1
Set
H Center
V Center
1.5
0
-1
0
1
Start


MouseTracker - Jon Freeman
Left-click to select trajectories and right-click for options..
Load File
Load Folder
Import
Visualize
Mark points
Compute
Export to .CSV
Trajectory Functions
Save Changes
Settings
About
Help me!
Condition 1 (Condition 1): 182
Condition 2 (Condition 2): 216
0.11, 0.57
Mean trajectories:
X and Y time-course:
Data
Selected tracks:
X
Y
time
time
MOUSE TRACKER

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

exp2.csv

选项

1.jpeg
2.jpeg
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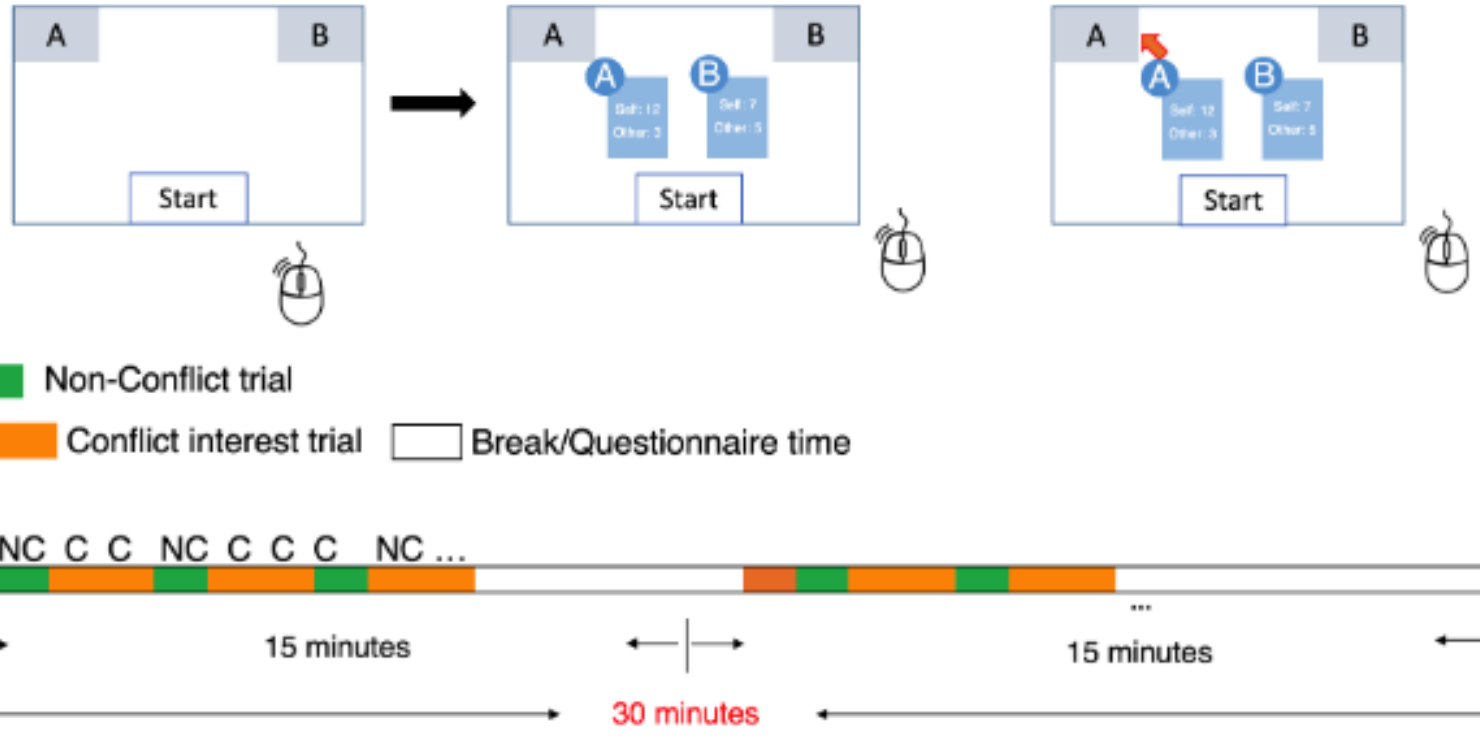

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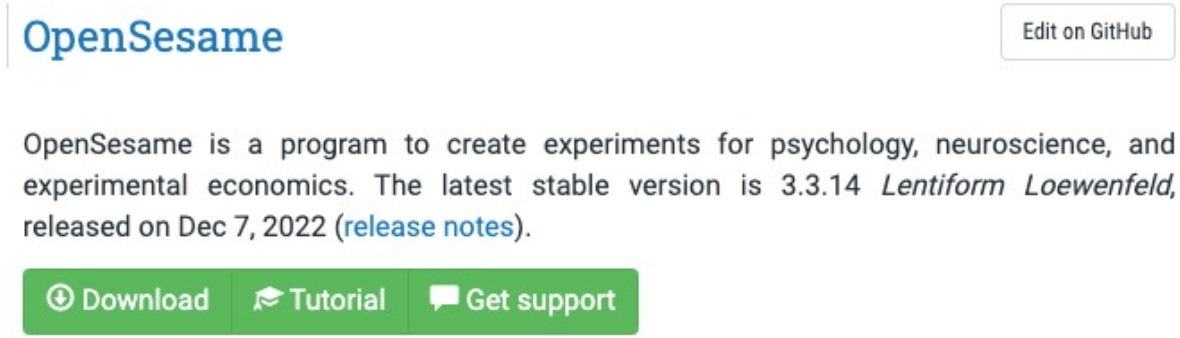
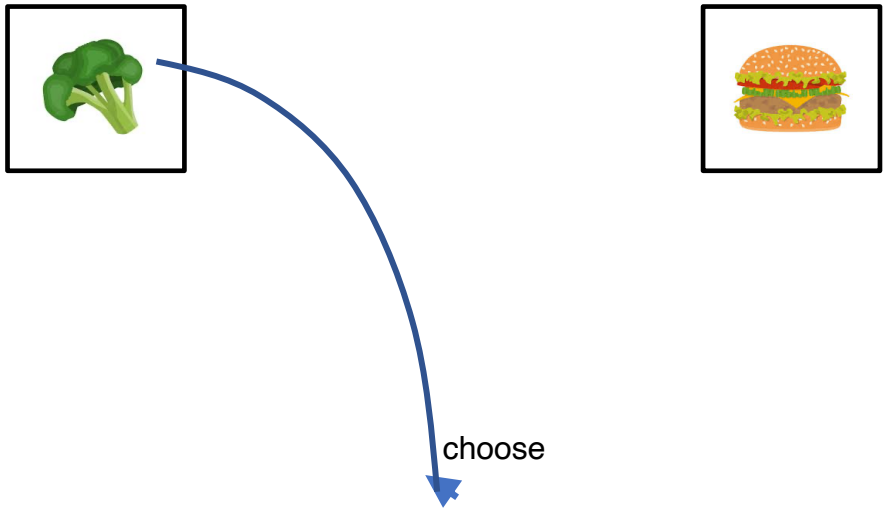
MT with Opensesame

- https://osdoc.cogsci.nl/



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



MT with Opensesame

main MT_workshop / Part2 /

haiyan0305 Add files via upload

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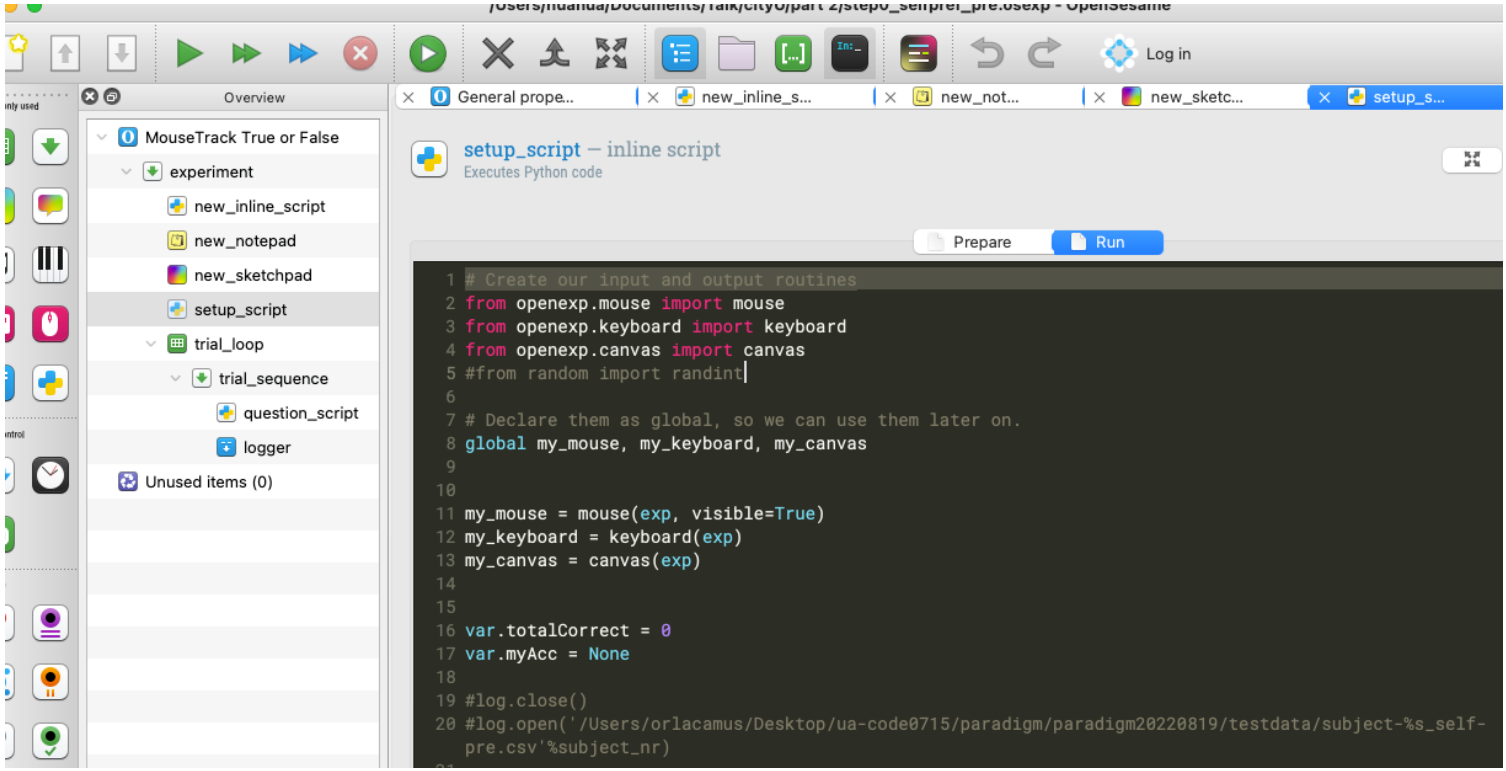
MT-opensesame.md	Create MT-opensesame.md
step0_selfpref_pre.osexp	Add files via upload



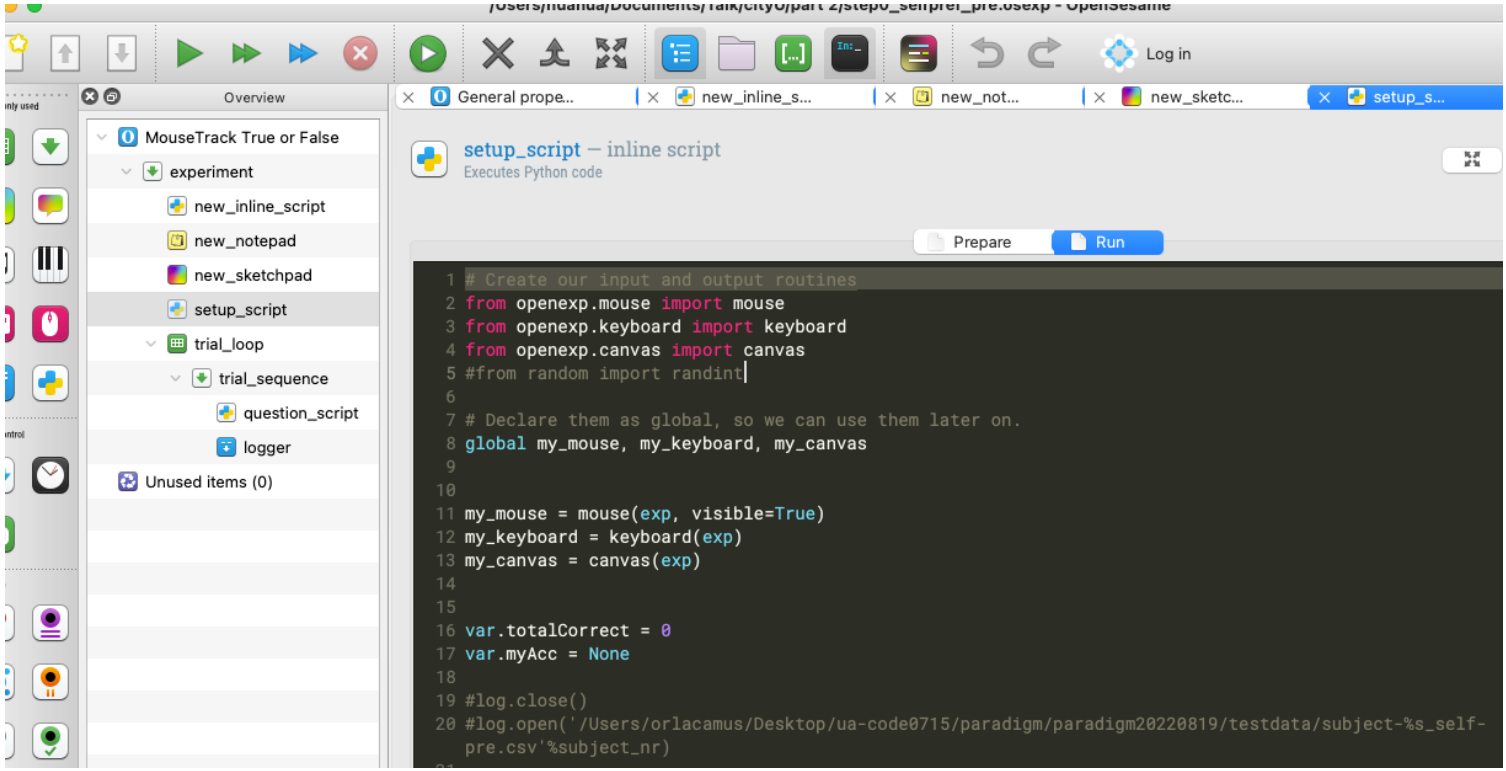
MT with Opensesame

main MT_workshop / Part2 /

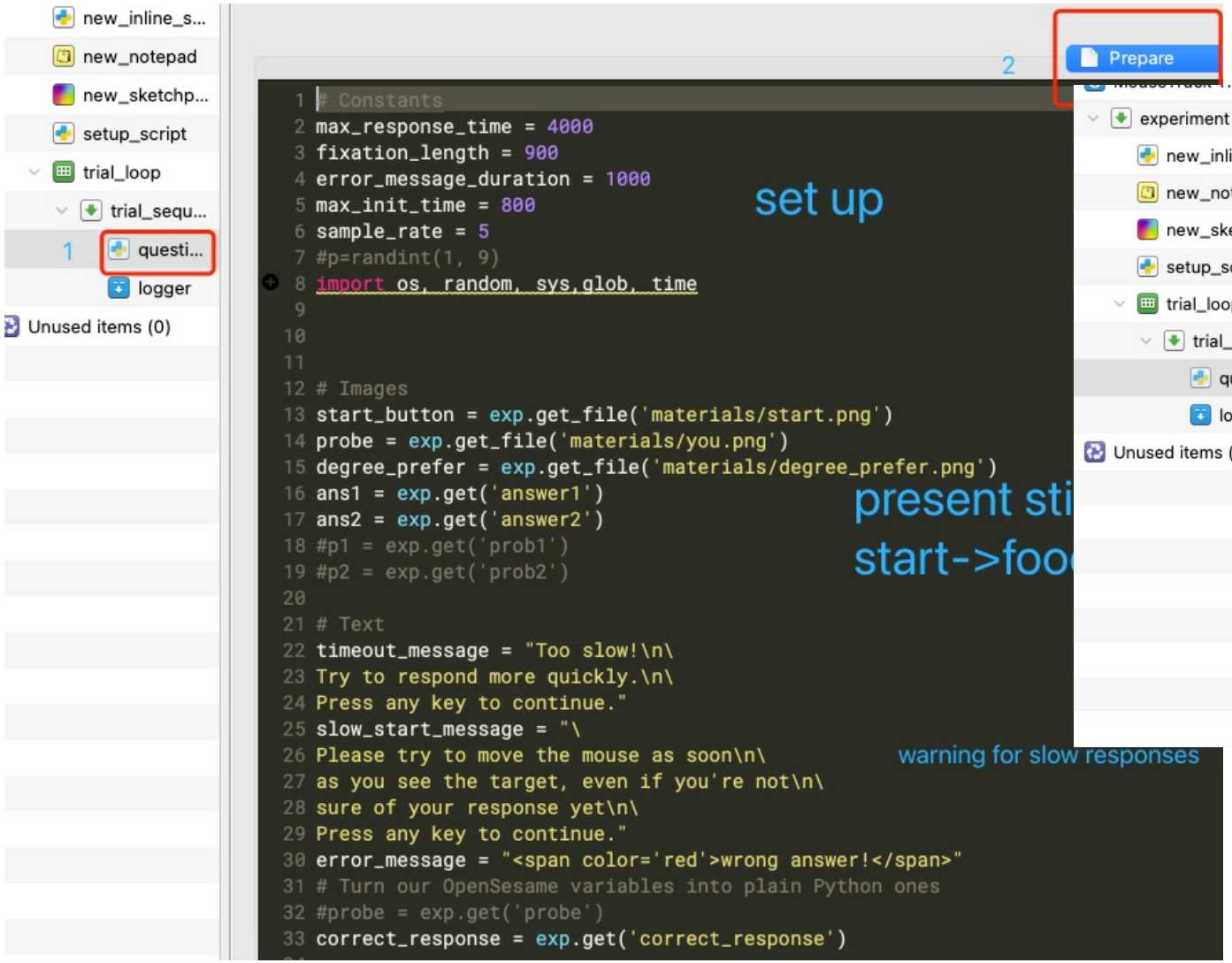
haiyan0305 Add files via upload

..

MT-opensesame.md	Create MT-opensesame.md
step0_selfpref_pre.osexp	Add files via upload



MT with Opensesame



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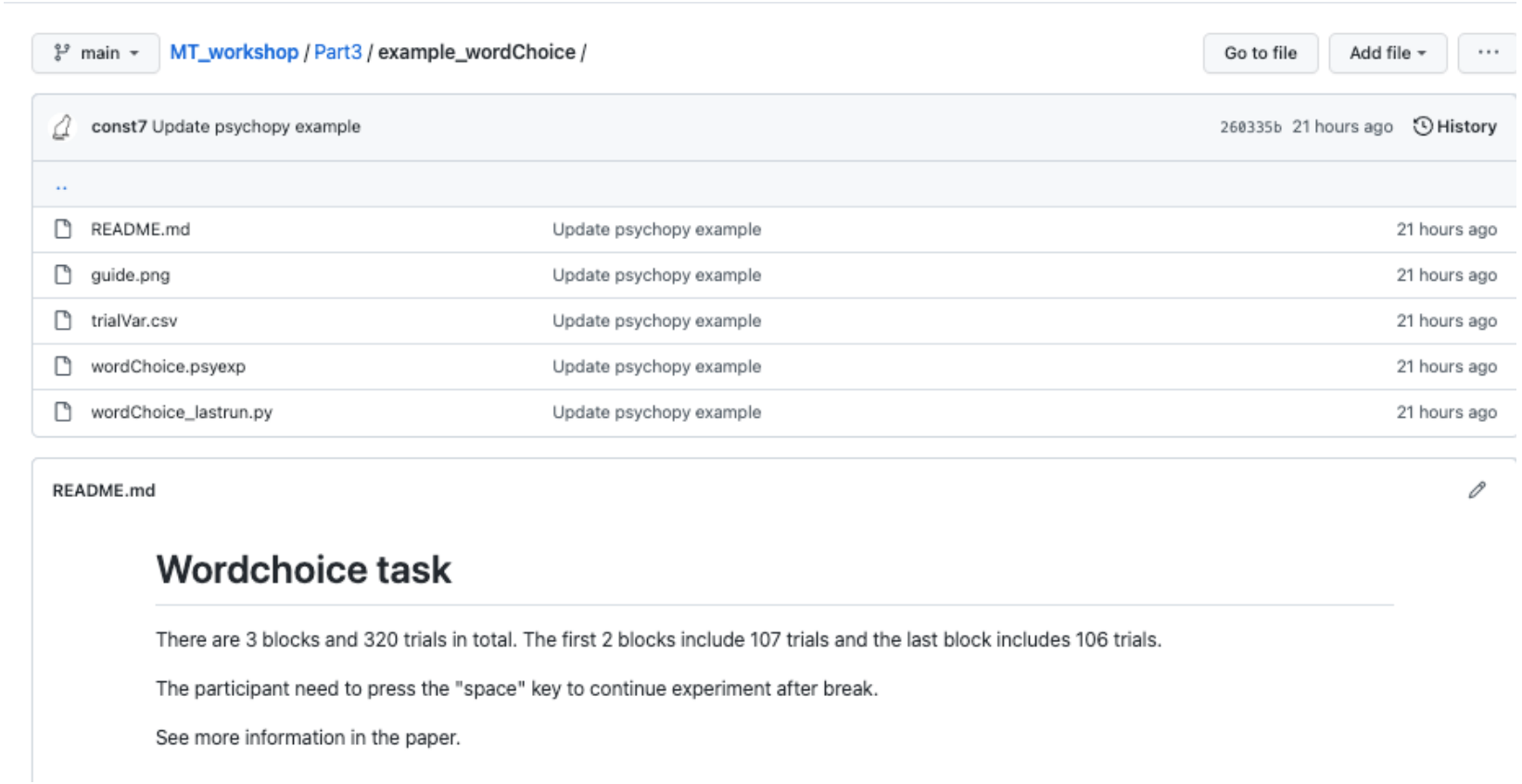
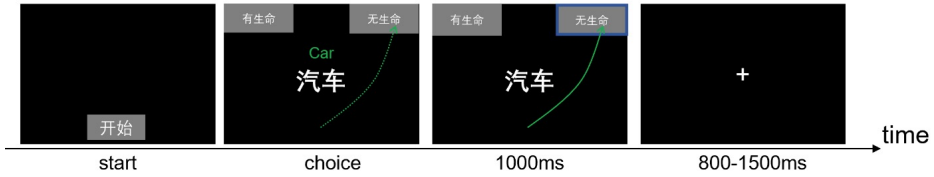
MT with Psychopy

Kun Chen



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

MT with Psychopy




```
# Initialize components for Routine "word"
wordClock = core.Clock()
mouse = event.Mouse(win=win)
x, y = [None, None]
mouse.mouseClock = core.Clock()
word_item = visual.TextStim(win=win, name='word_item',
    text='default text',
    font='Songti SC',
    pos=(0, 0), height=90, wrapWidth=None, ori=0,
    color='white', colorSpace='rgb', opacity=1,
    languageStyle='LTR',
    depth=-2.0);
rect_left = visual.Rect(
    win=win, name='rect_left',
    width=(300, 200)[0], height=(300, 200)[1],
    ori=0, pos=(-810, 440),
    lineWidth=1, lineColor='black', lineColorSpace='rgb',
    fillColor='grey', fillColorSpace='rgb',
    opacity=1, depth=-3.0, interpolate=True)
rect_right = visual.Rect(
    win=win, name='rect_right',
    width=(300, 200)[0], height=(300, 200)[1],
    ori=0, pos=(810, 440),
    lineWidth=1, lineColor='black', lineColorSpace='rgb',
    fillColor='grey', fillColorSpace='rgb',
    opacity=1, depth=-4.0, interpolate=True)
op_left = visual.TextStim(win=win, name='op_left',
    text='default text',
    font='Songti SC',
    pos=(-810, 440), height=80, wrapWidth=None, ori=0,
    color='white', colorSpace='rgb', opacity=1,
    languageStyle='LTR',
    depth=-5.0);
op_right = visual.TextStim(win=win, name='op_right',
    text='default text',
    font='Songti SC',
    pos=(810, 440), height=80, wrapWidth=None, ori=0,
    color='white', colorSpace='rgb', opacity=1,
    languageStyle='LTR',
    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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https://github.com/andlab-um/MT_workshop/tree/main/Part3

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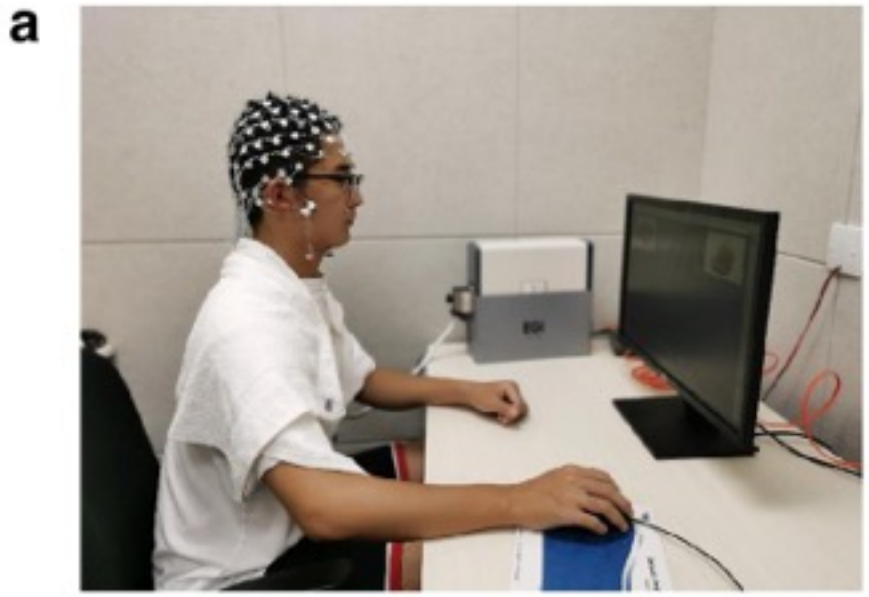
- MT data processing
- Combine with DDM

Combine with EEG

Kun Chen



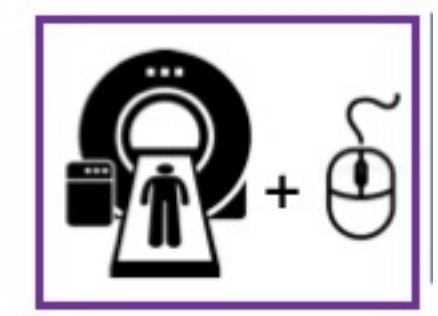
EGI recording

```
# 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")
```

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

Part 3

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.fra	A data.frame with 13200 rows and 19 columns
trajectories	integer [13200 x 5457 x 3]	0 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 ...

Wulff, D. U., Kieslich, P. J., Henninger, F., Haslbeck, J. M. B., & Schulte-Mecklenbeck, M. (2021). PsyArXiv.

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

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

Part 5

````
```{r}

library(readbulk)
#setwd("~/Desktop/Mousetrackingdata/")
setwd("~/Documents/Talk/cityU/MTbeha-master/3Exps/")
mt_data_raw2 <- read_bulk("exp2mt", fun=read_mt, extension=".mt")

mt_data2 <- mt_import_wide(mt_data_raw2)
mt_2 <- mt_remap_symmetric(mt_data2)
 mt_2 <- mt_align_start_end(mt_2)
mt_2 <- mt_time_normalize(mt_2)
mt_data2 <- mt_measures(mt_2)
```
# Preprocessing
## Spatial transformations
```{r}
# Remap trajectories
mt_data2 <- mt_remap_symmetric(mt_data2)

# Align trajectories to common start position
mt_data2 <- mt_align_start(mt_data2, start=c(0,0))
```

## 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
```

References

- Freeman, J.B., Ambady, N. MouseTracker: Software for studying real-time mental processing using a computer mouse-tracking method. *Behavior Research Methods* **42**, 226–241 (2010).
- Stillman, P. E., Shen, X., & Ferguson, M. J. (2018). How mouse-tracking can advance social cognitive theory. *Trends in cognitive sciences,* 22(6), 531-543.
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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

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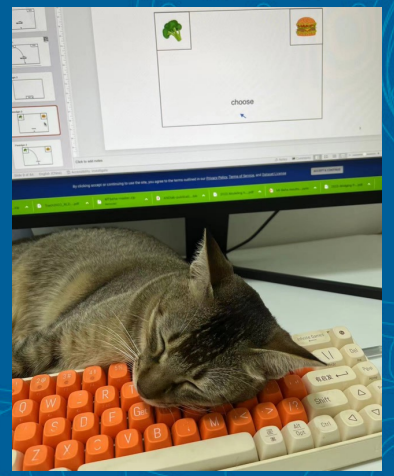
Kun Chen



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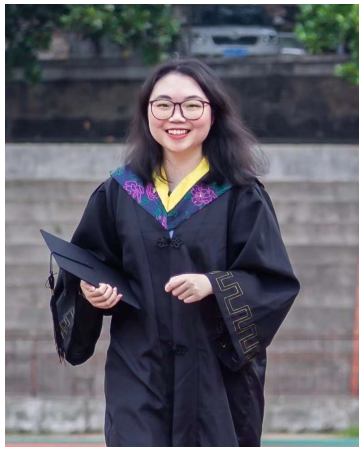
Outline

- 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
- MT data processing
- Combine with DDM



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