INI retreat 2023
Experiment and Theory

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Introduction

- experimental evidence is at the core of science

- => understanding better how "experiment" works may be important/interesting to all of us, even those of us who work primarily theoretically or in a technical setting

Introduction

- Today will provide tutorials on experimental design, and statistics

- Tomorrow you will run behavioral experiments and analyze them

- Wednesday we'll discuss these and the interrelation between theory experiment and theory

No experiment without theory

- there is no such thing as a theory-free or "neutral" description of natural phenomena

  - the concepts we use to describe and characterize natural phenomena express theoretical commitments

- Karl Popper: experimental evidence is about hypothesis testing…

  - hypotheses may be rejected… but never proven

- not all hypotheses are theoretically strong…

  - stronger when linked (by theory) to a networks of other hypotheses …

Human decision making …

- "whom to marry", "which phone to buy",… everything in life involves decisions…

- => behavioral economics

- happens to be an area of unsettling incidents about scientific fraud right now:

- https://www.theatlantic.com/science/archive/2023/08/gino-ariely-data-fraud-allegations/674891/

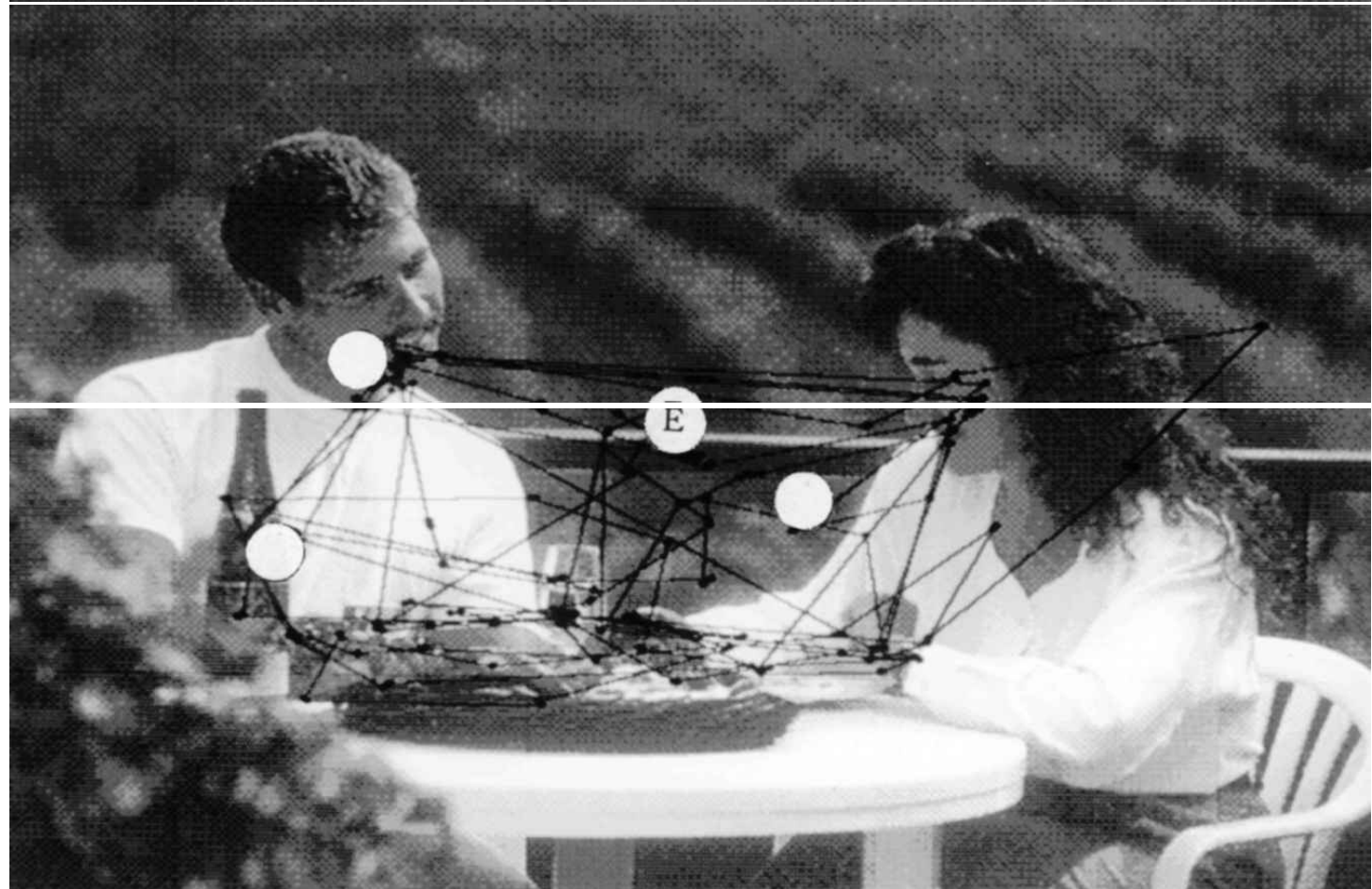- => good exemplary process to understand experimentation..

Human decision making …

■ for our purposes… study decision making at a much lower level…
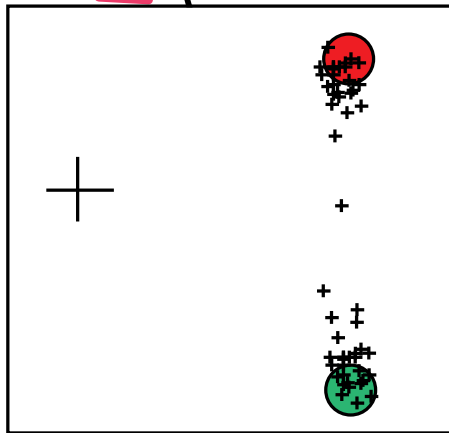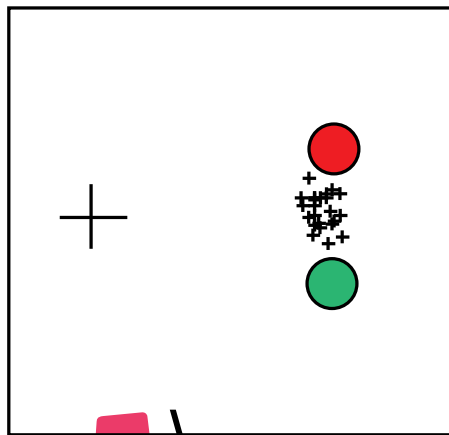
Saccades as "free choice" decisions

■ selecting a new saccadic location every 300 ms

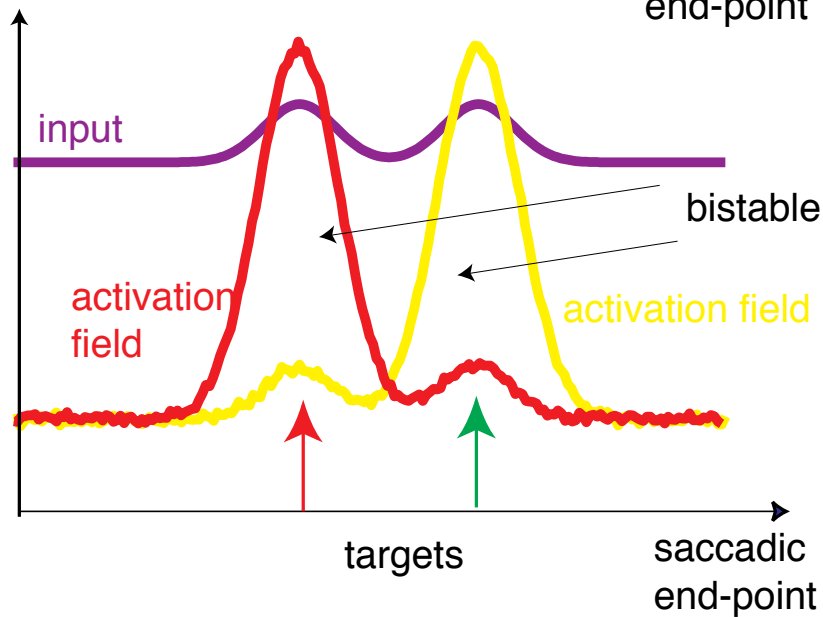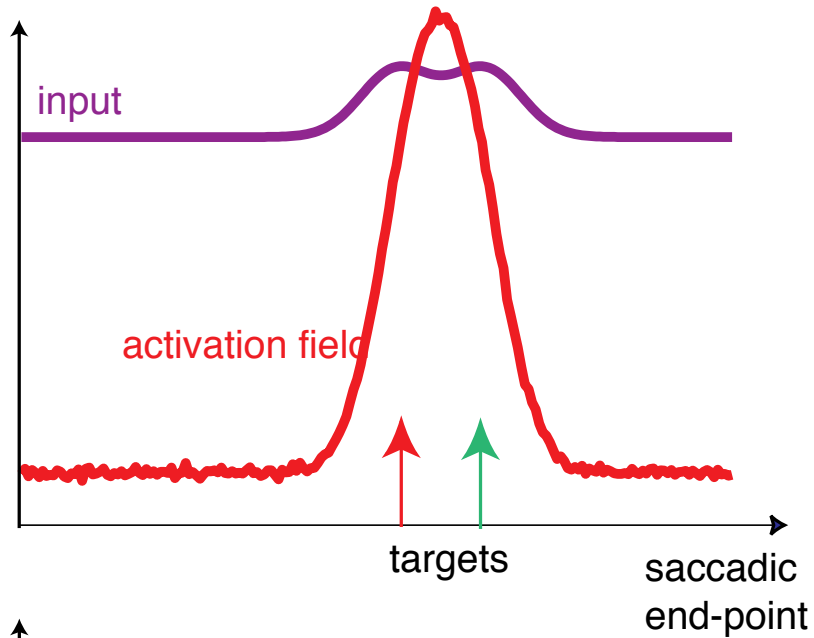■ depending on bottom-up salience, scene memory, task, etc

[O'Reagan et al., 2000]

study saccadic selection decisions in experiment

neural theory of saccadic selection decisions

input

activation field

targets

saccadic end-point

input

bistable

activation field

activation field

targets

saccadic end-point

same input, different outcomes

initial fixation

visual targets

[after: Ottes et al., Vis. Res. 25:825 (85)]

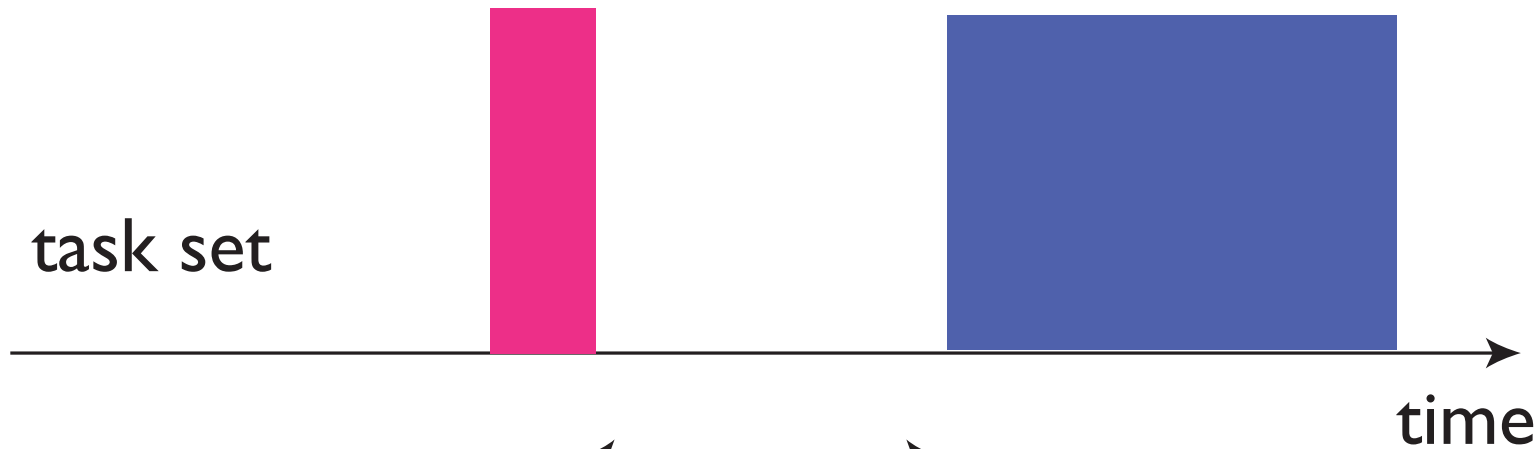[after Kopecz, Schöner: Biol Cybern 73:49 (95)]

Human decision making …

■ => input does not uniquely determine decisions…

■ where cognition begins…

■ but: in the lab, constrain the "free" choice

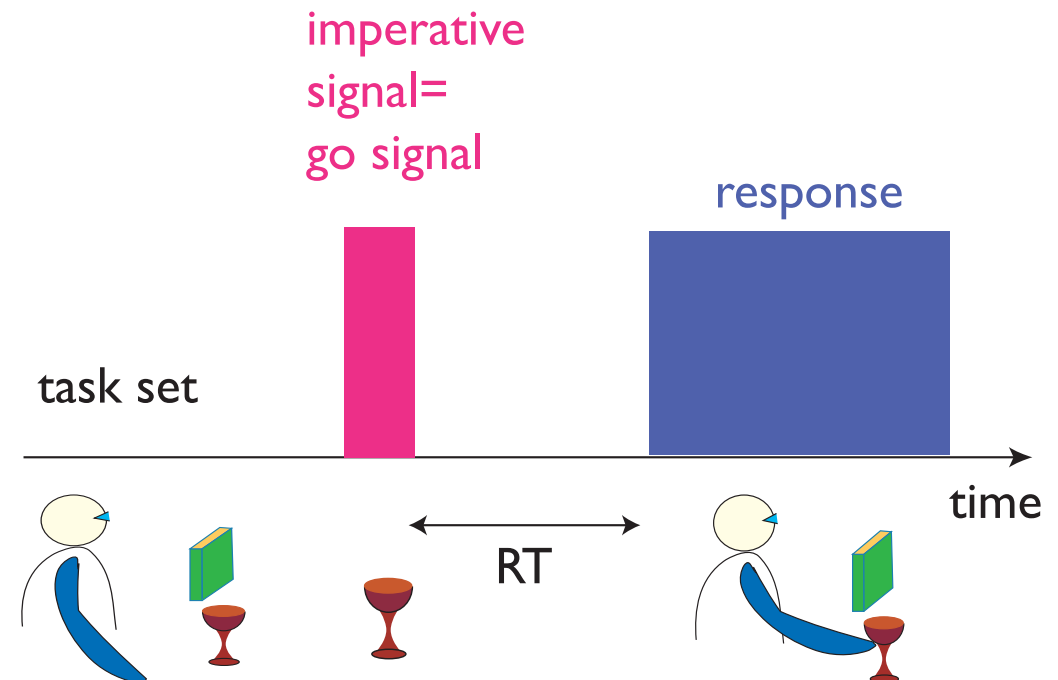# Reaction time (RT) paradigm

imperative
signal=
go signal

response

task set

time

RT

RT paradigm

- the "imperative" signal specifies what the "right" choice is

- the task set/priors specify what the alternatives are…

  - e.g., how many choices. how likely each choice, how "easy" are perception or cognitive effort to select the "right" choice,

  - e.g., semantics, knowledge, cognitive skills

# Theoretical framework 1: information processing

- decision making based on information/certainty

  - notion of "evidence accumulation"

- which motivates scientific questions about information

  - e.g. the probability of choices

  - e.g. the priors of choices

- while what the choices are about (the "contents") is not central to this framework

Diffusion model

- choices as boundaries along a decision dimension, with initial condition in between

- => Robert Schmidt will discuss how diffusion modeling can be used to analyze RT data

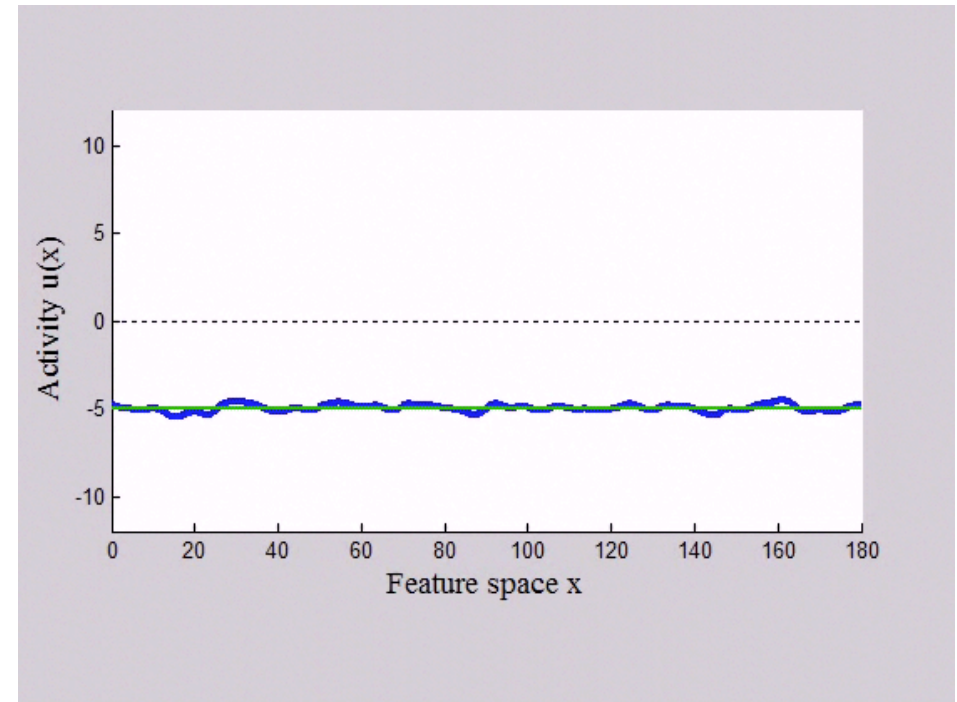drift: imperative signal/ information flow
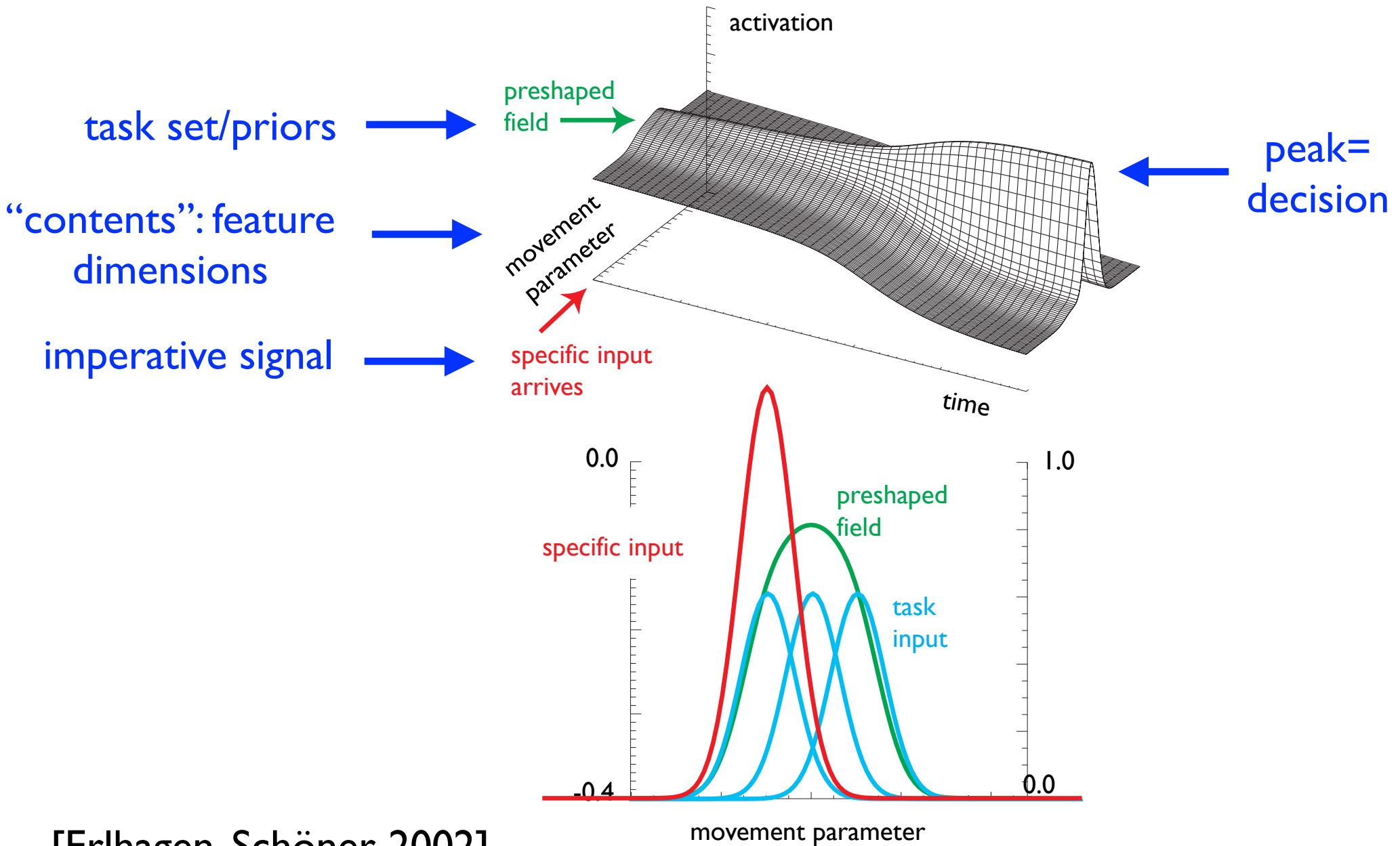
initial position and boundaries: task set/priors
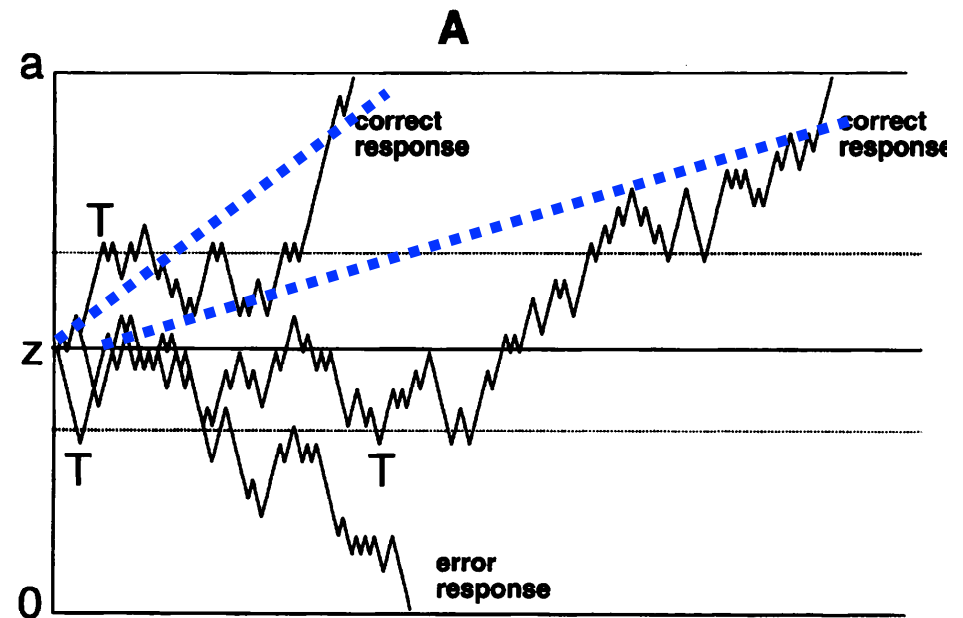
[Radcliff, Rouder, 1998]

Theoretical framework 2: Neural population dynamics

- neural populations/ fields/maps represent feature dimensions/ movement parameters

- peaks of activation represent decisions

[dynamicfieldtheory.org]

DFT

task set/priors

"contents": feature dimensions

imperative signal

preshaped field

activation

movement parameter

specific input arrives

time

peak= decision

0.0

specific input

preshaped field

task input

1.0

-0.4

0.0
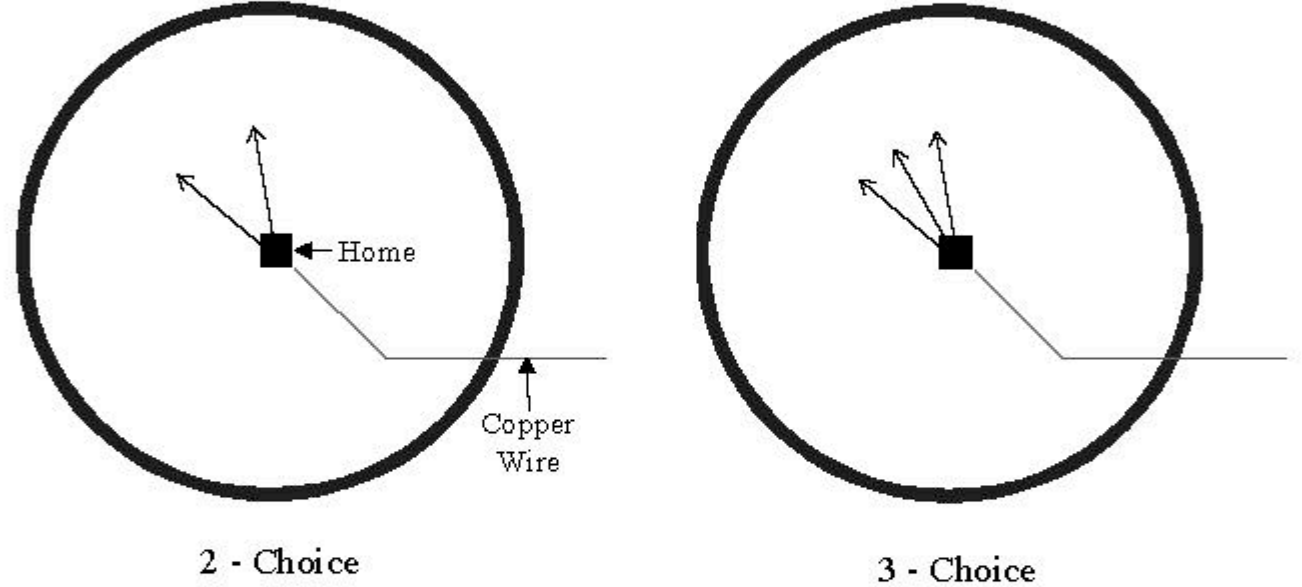
movement parameter

[Erlhagen, Schöner, 2002]

DFT

invites questions about "contents"

e.g. metric effect: predict faster RT for choices that are metrically close than for choices that are metrically far
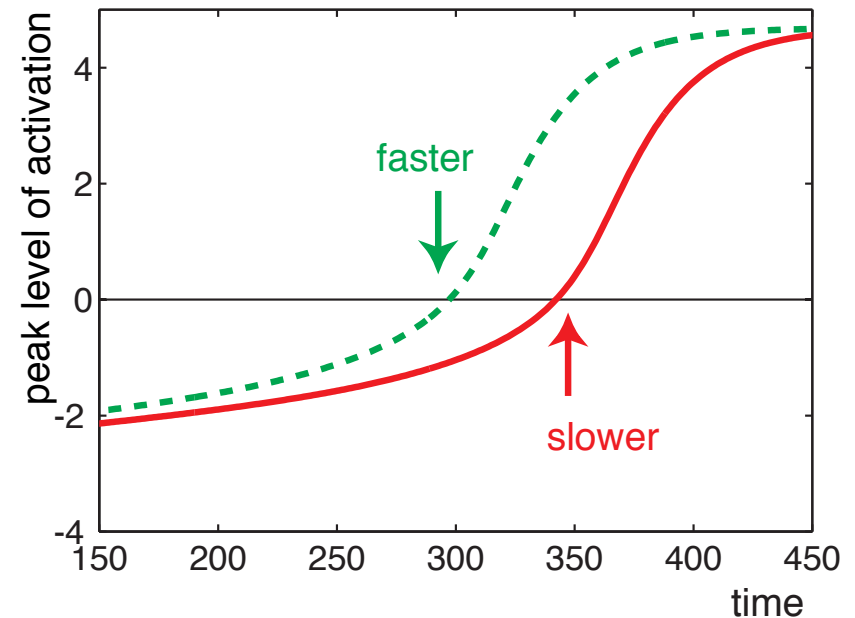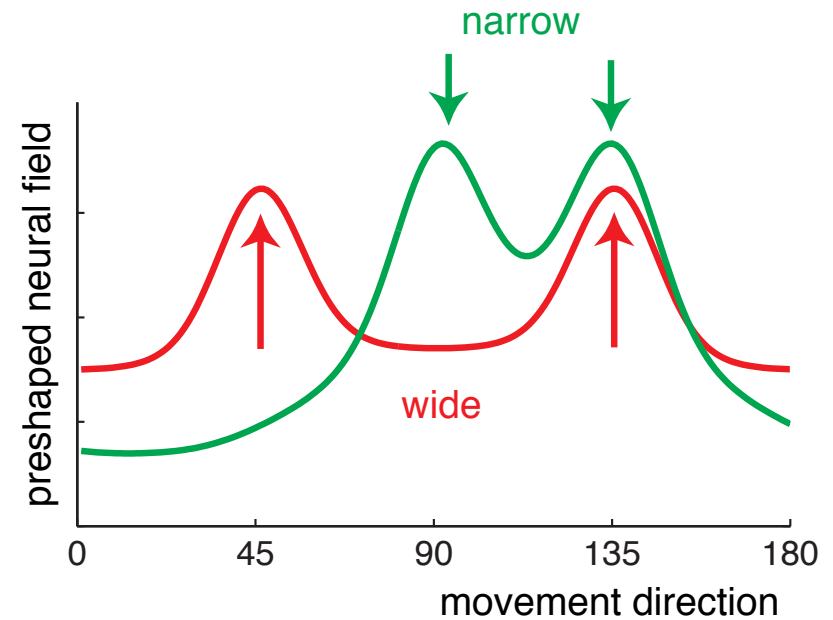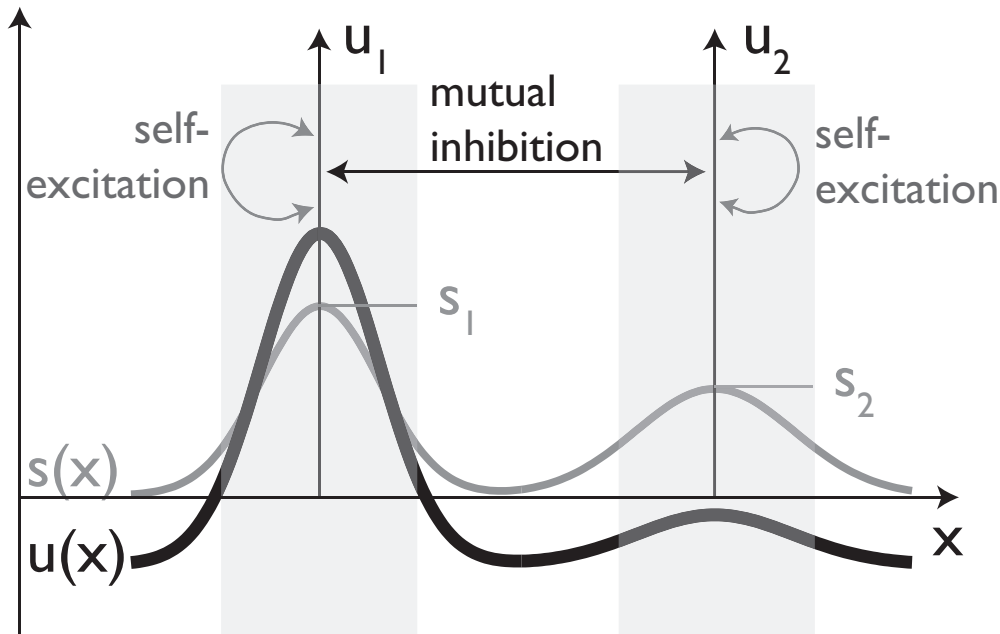

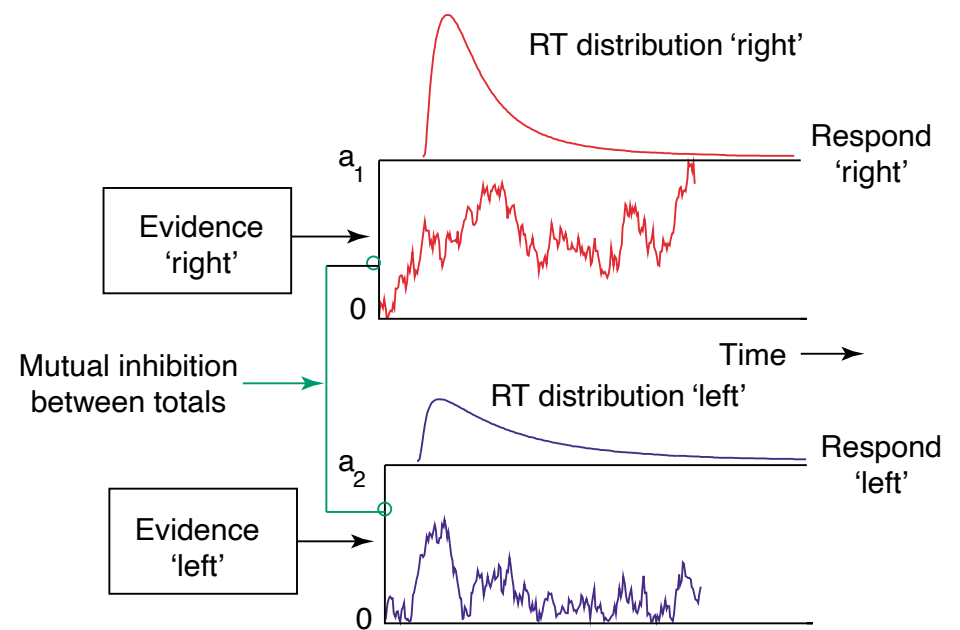[from Schöner, Kopecz, Erlhagen, 1997]

experiment: metric effect

[McDowell, Jeka, Schöner]
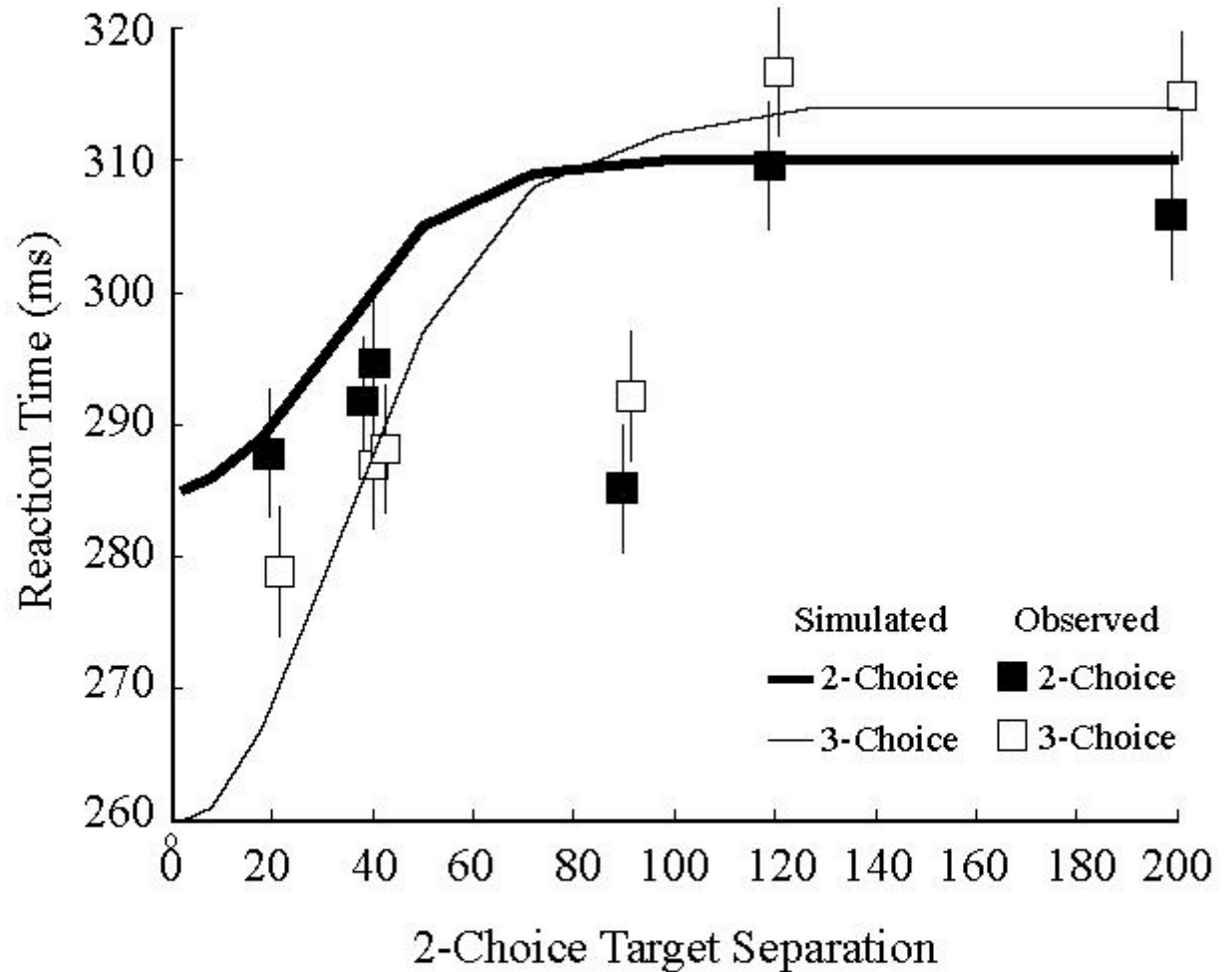
The two theoretical frameworks overlap

[DFT book]

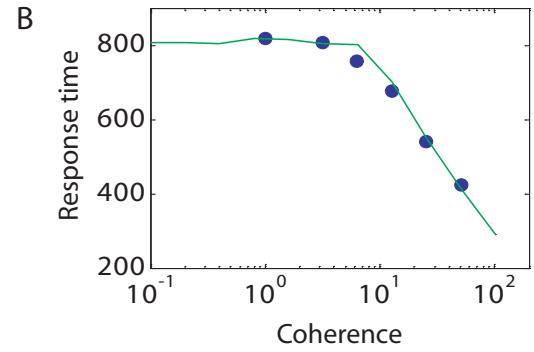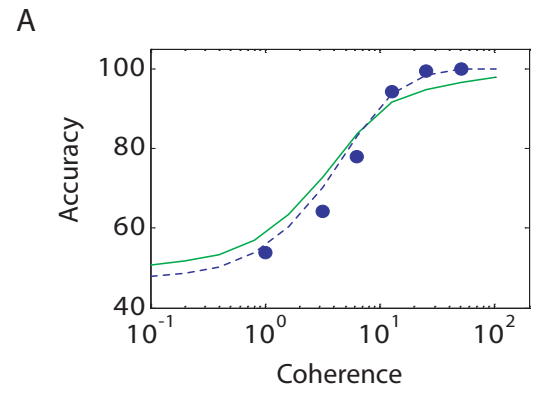[Usher McClelland model, 1995; Figure from Smith, Ratcfliff, 2004]

Neural basis for decision making

A

Fixation — RF
Targets
Motion
Saccade
RT
Time

B

Probability correct

RT (ms)

Motion Strength (%coh)

A

Accuracy

Coherence

B

Response time

Coherence

C

Response (spikes/s)

200 ms

Time

DFT

C

Firing rate (spikes/s)

51.2%
25.6%
12.8%
6.4%
3.2%
0.0%

Buildup rate (z-score)
Motion Strength

Time from motion onset (ms)

D

Firing rate (spikes/s)

RT (ms)
400
500
600
700
800
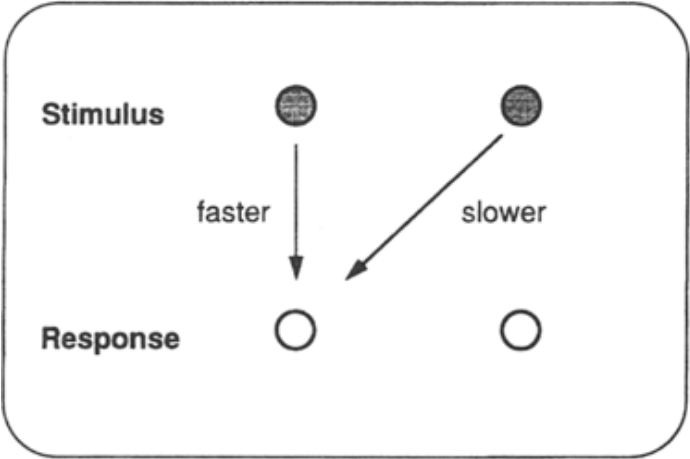900

Time from saccade (ms)

D

Response

Time
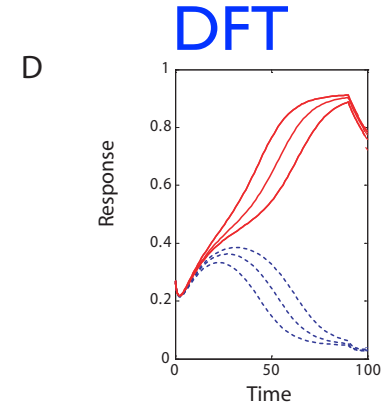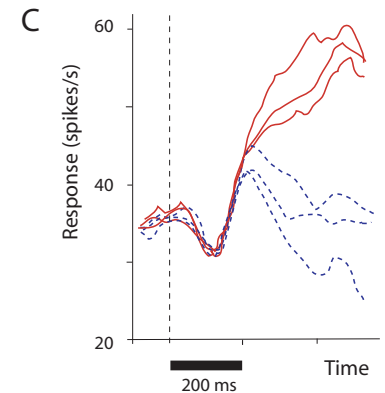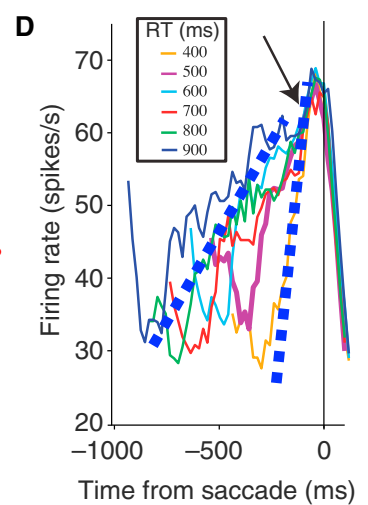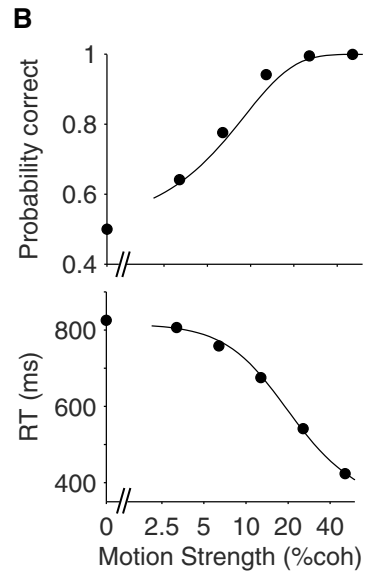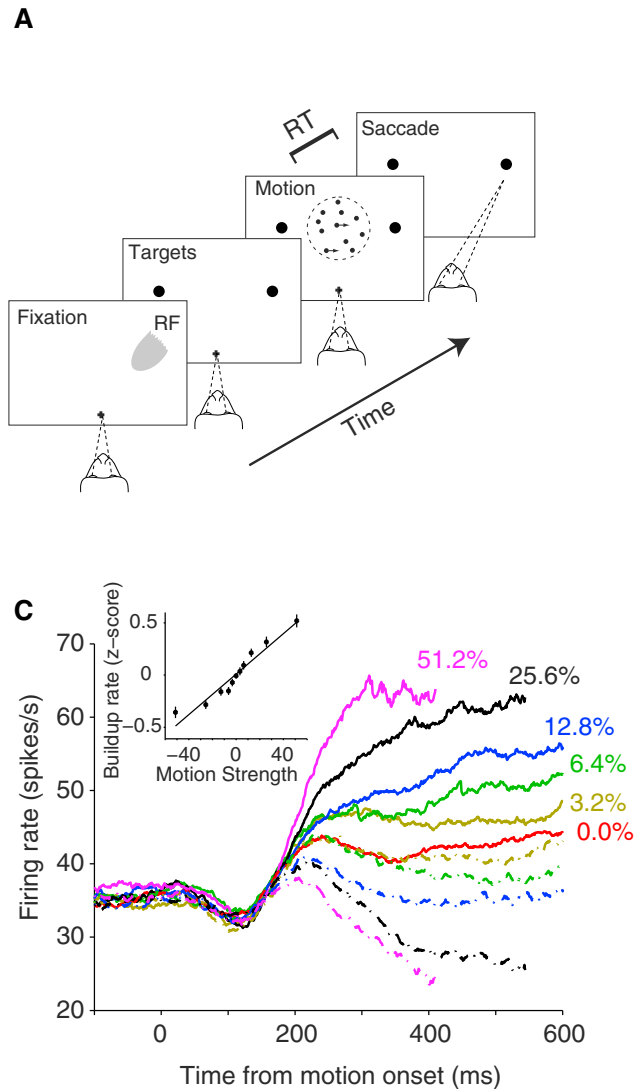
motion strength~
input strength

motion strength~
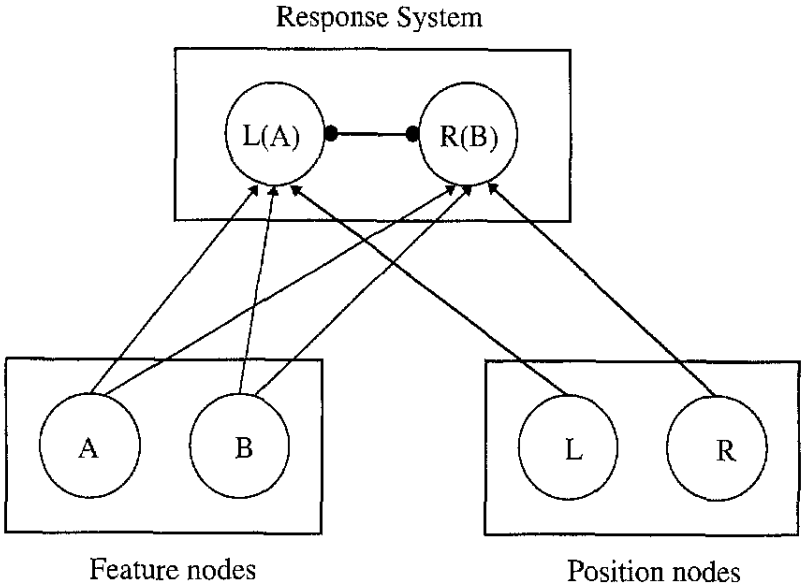information flow

[Shadlen, Kiani, 2013]

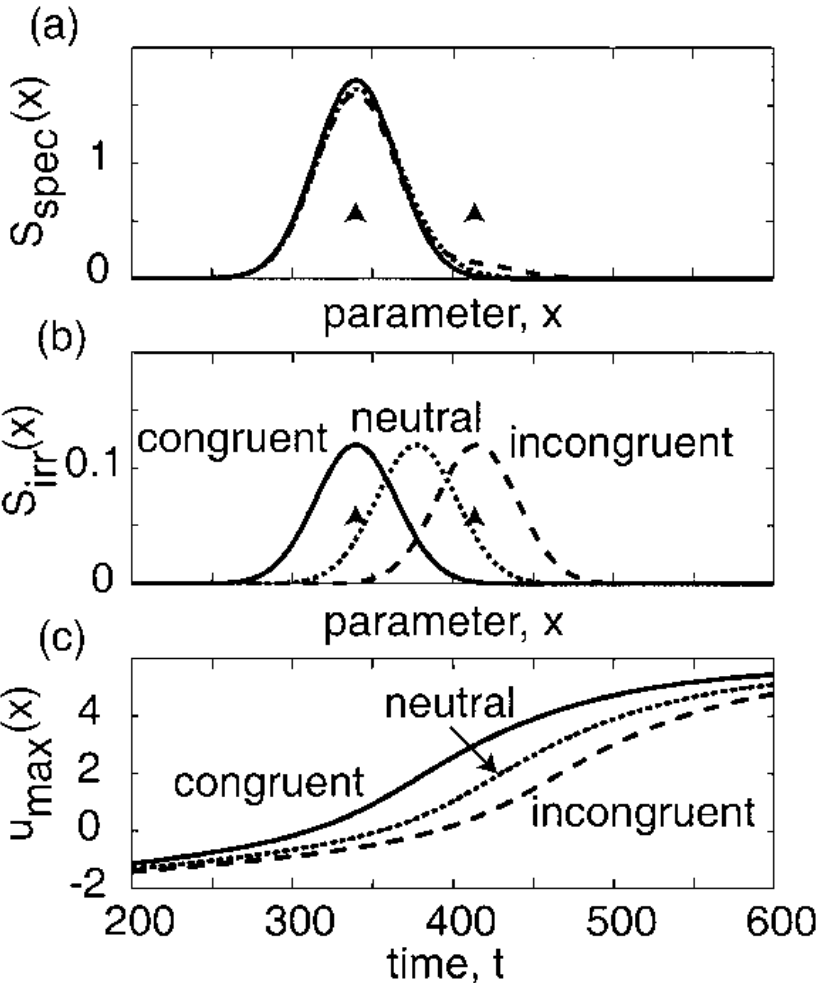[Trappenberg, 2008]

Simon effect

Relevant stimulus dimension: Color
Irrelevant stimulus dimension: Position

[Lu, Proctor, 1995]

[Zorzi, Umilta, 1995]

[Erlhagen, Schöner, Psych Rev 2002]

Program today

- Introduction [GS]

- Decision making and adaptation [Robert Schmidt]

- Experimental design [Raul Grieben]

- Experiments in the Tatool environment [Minseok Kang]

- Experimental statistics [Raul Grieben]

- Experimental statistics: hands-on [Minesok Kang]

- Forming work groups

Program Tuesday

- Working on projects in groups

- Break-out sessions (your choice)

  - Experimental statistics 2 [Raul Grieben]

  - ANOVA [Stephan Sehring]

  - Post-hoc tests [Daniel Sabinasz]

- Hiking excursion

Program Wednesday

- Group projects wrap up and prepare presentations

- Group presentations

- Discussion

  - decision making

  - theory-experiment relation

  - modeling vs. theory

  - …. what does it mean to understand decision making..