Familiarity breeds Investment
If you Have the Right Gene
A Gene-Brain-Behavior Study of
Familiarity Bias in Financial Decision Making

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A Complex System

Decision Making Iceberg

Environment   *Environment*

Behavior

Conscious   **System II**

Brain activation

------------------   ------------------

Unconscious   **System I**

Neurotransmitters/hormones
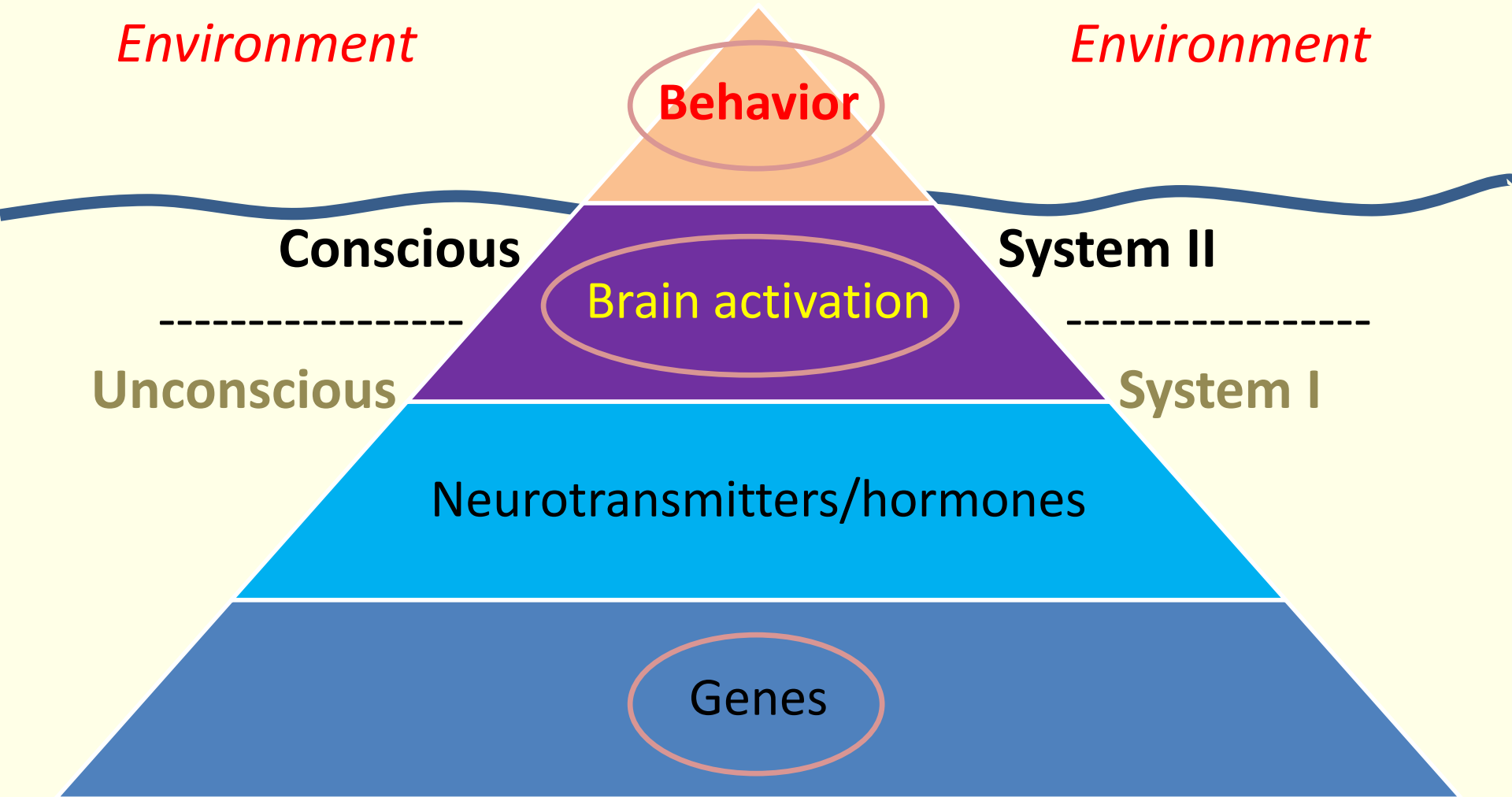
Genes

Bringing in Systems Thinking ***to model the Decision Maker*** ***as a Biological Being***

Environment

Environment

Behavior

Conscious

System II
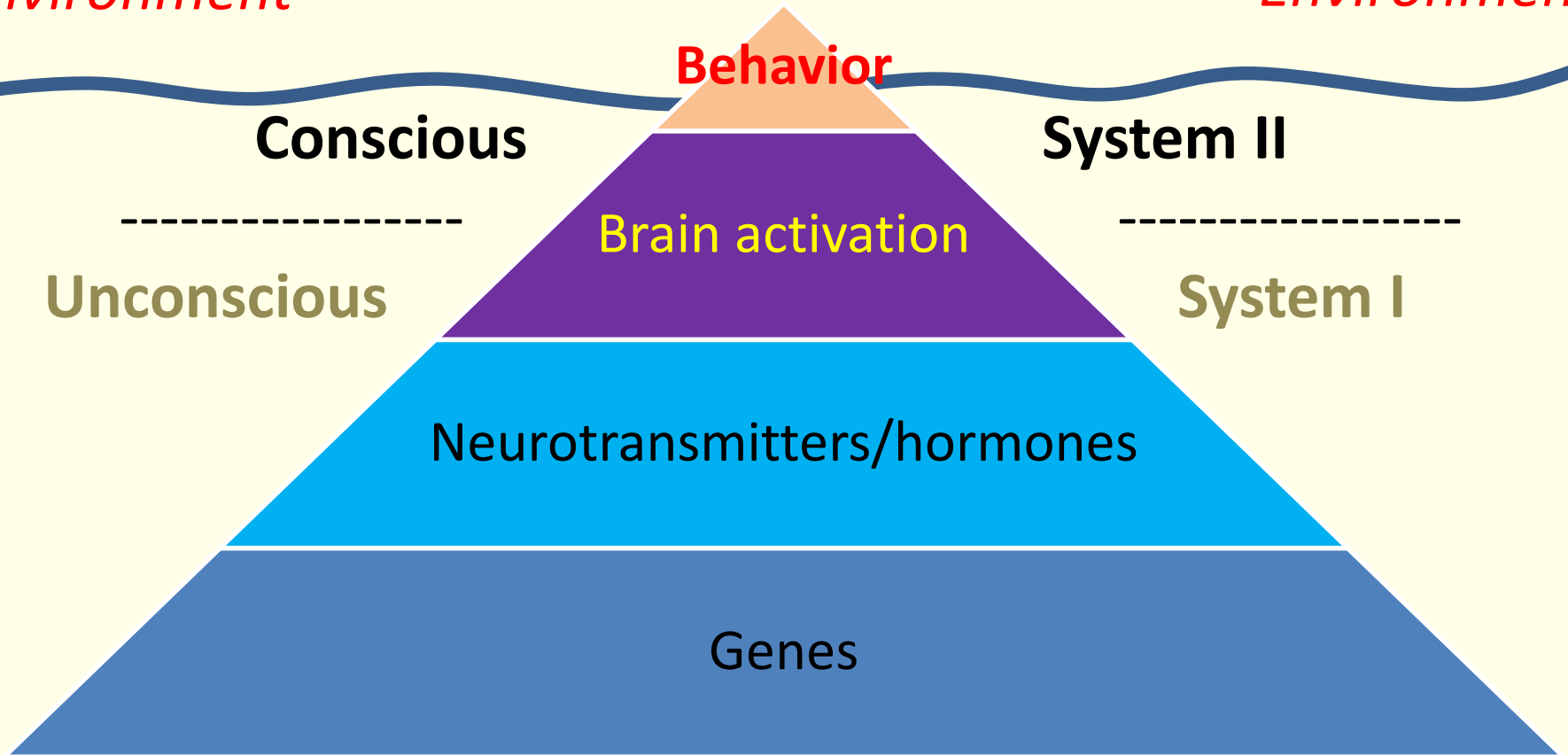

Brain activation
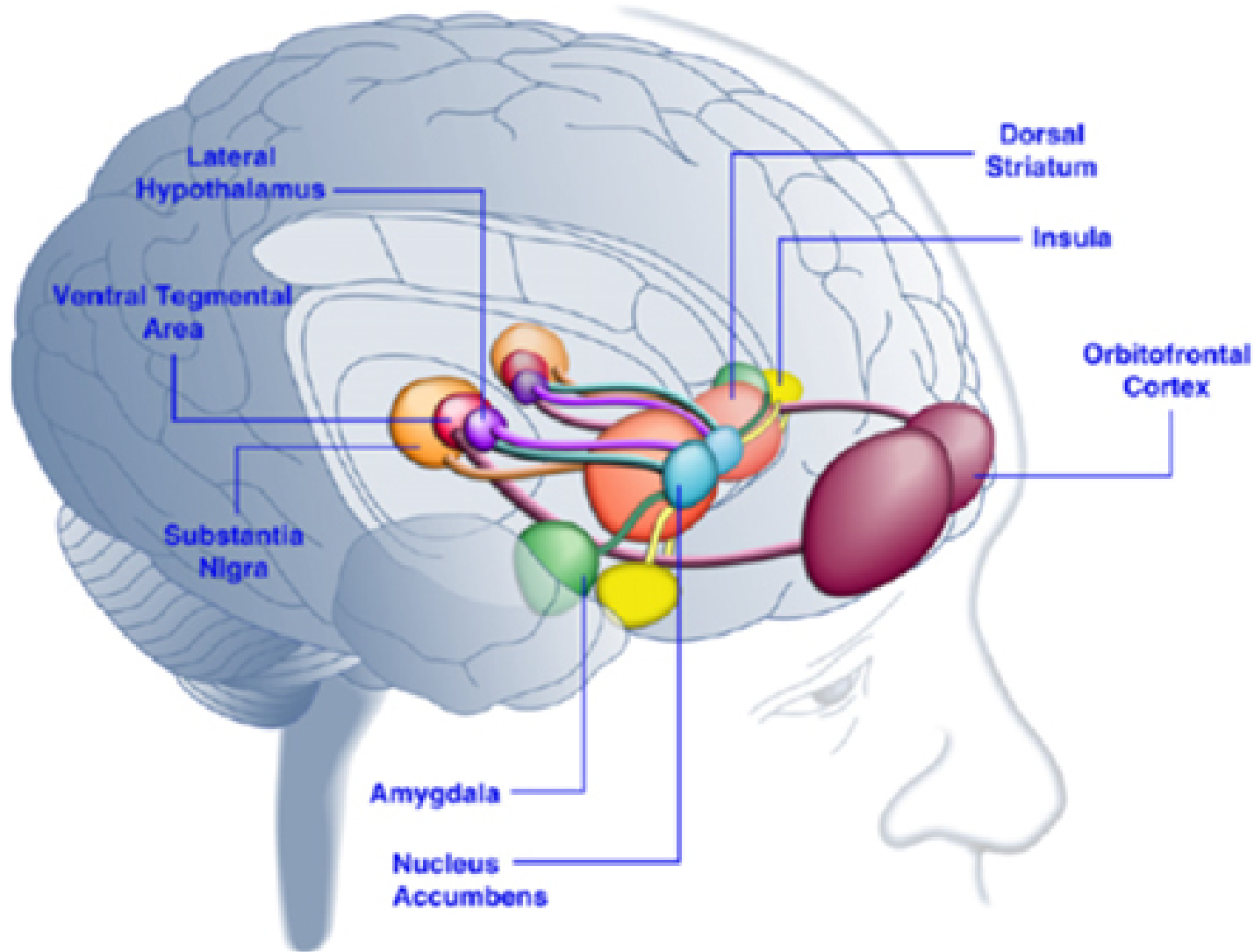
Unconscious

System I

Neurotransmitters/hormones

Genes

An *Excitatory Dual* System
Dopamine-Striatum and Serotonin-Amygdala

Functionality of Striatum and Amygdala

Striatum is dopamine rich which have been implicated in reward processing

Amygdala – emotional brain – is linked to fear conditioning with direct and super fast sensation of "coarse" danger signals.

- There is evidence of unconscious processing.

William James' 1884 quote in " *What is An Emotion"*

"Do we run from a bear because we are afraid or are we afraid because we are running from the bear?"

- James reasoned that emotion followed events beginning with an arousing stimulus which triggers the corresponding emotion.

- Rather viewing the bear as the source of fear, James argued that bodily changes resulting from the perception of the "exciting fact" leads to the psychological sensation called emotion.

- Different situations trigger distinct physiological changes – **Gut feeling –** leading to different emotions.

- Does your gut influence decision making?

Damasio's Follow Up
## *Somatic Marker Hypothesis*

- Somatic states triggered by primary inducers via **amygdala** are fast, automatic, obligatory, without much thought/effort before one can figure out what happened.

- Somatic states influence decision making **nonconsciously** via brainstem and ventral striatum and **consciously** via higher cortical cognitive processing.

- **Hypothesis:** Somatic markers direct **attention** towards advantageous options, simplifying decision making.

- **Bottom line: Gut feeling** involving somatic markers inducing associated affective states – physiological and neural, i.e.:

  – Gut influencing decision making, naturally …☺

Brake in our Brain
GABA – Gamma-Aminobutyric acid

GABAₐ Receptor Complex

Major inhibitory neurotransmitter in nervous system acting as **brake** to modulate excitatory transmission, e.g., dopaminergic or serotoninergic, from reaching GABAergic-neuron rich regions
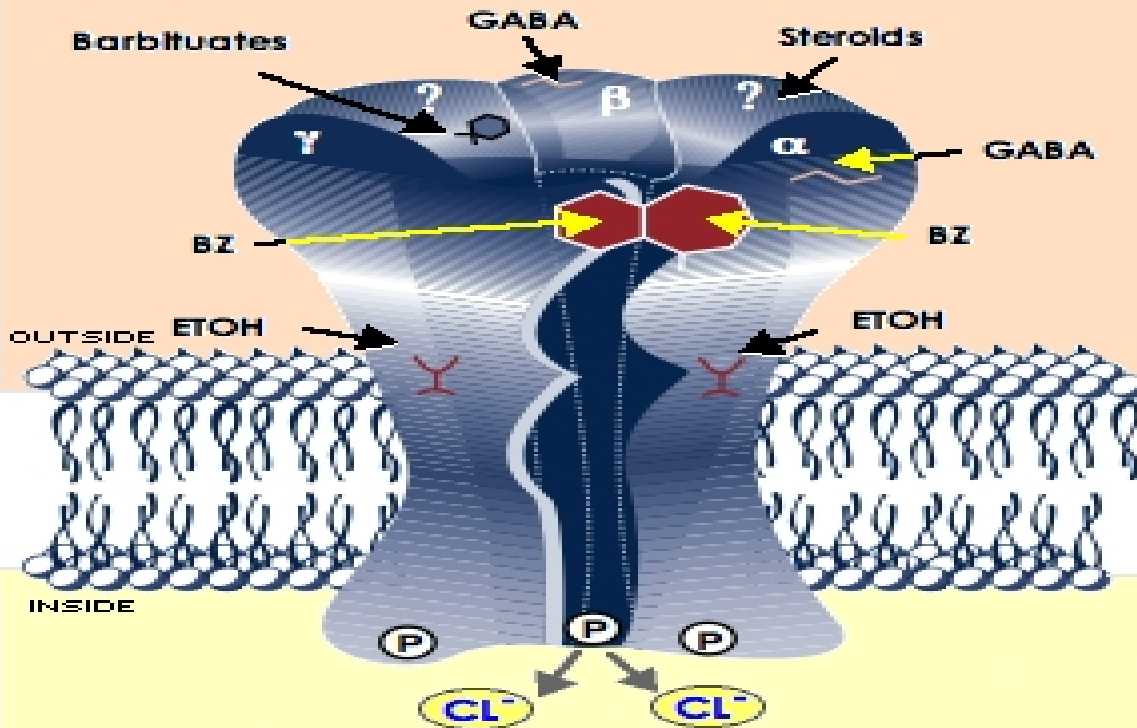
GABA and Anxiety
as with Yager's talk

GABA and Anxiety

- Evidence supports notion that dysfunction of GABAergic system contributes to anxiety (see review by Kalueff and Nutt, 1996)

- Diazepam, e.g., Valium, as agonists for Type A GABA receptor ($GABA_A$), used for anxiety disorders (Haefely, 1992; Sieghart, 1992)

- Proliferation of GABA food, drink, etc

Sampled half a bottle purchased from Seven-Eleven for about US$3+ in Singapore

GABA and Anxiety

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Keynes' insight in his "A Treatise on Probability"

Keynes distinguishes between probability and the knowledge/ degree of confidence underpinning its assessment:

"If two probabilities are equal in degree, ought we, in choosing our course of action, to prefer that one which is based on a greater body of knowledge?"

Posthumously famous antecedent
The typical case,. ..., may be illustrated by the two cases following of balls drawn from an urn (known). ... ; in the first case we know that the urn contains black and white in equal proportions; in the second case the proportion of each colour is unknown (unknown), ...

Keynes' Example, commonly known as Ellsberg's 2-urn paradox (appeared in Ellsberg (1961, QJE), cited in his dissertation)

Pays $100 if color of ball drawn is guessed correctly
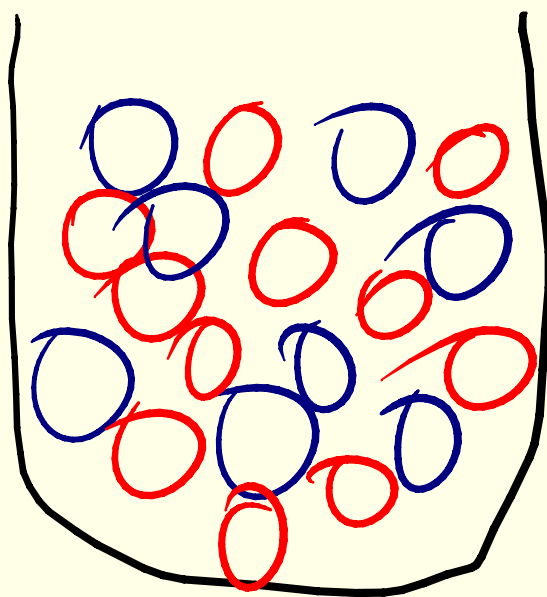
50 Red
50 Blue
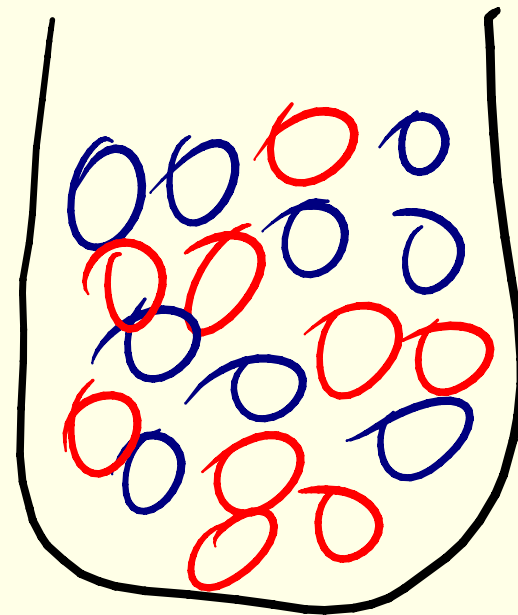
100 { Red Blue

Ambiguity Aversion/Affinity

Huge literature following Ellsberg (1961)

Familiarity Preference/Bias

Smaller, recent strand of thinking initiated by Fox and Tversky (1995, QJE)

Familiarity Bias with Temperature Bets

- 325 Beijing based subjects
- Betting on whether temperature is odd or even

Beijing: RMB 11   Tokyo: RMB **13**

Familiarity Bias with Temperature Bets

- Part of 325-subject gene-brain-behavior study
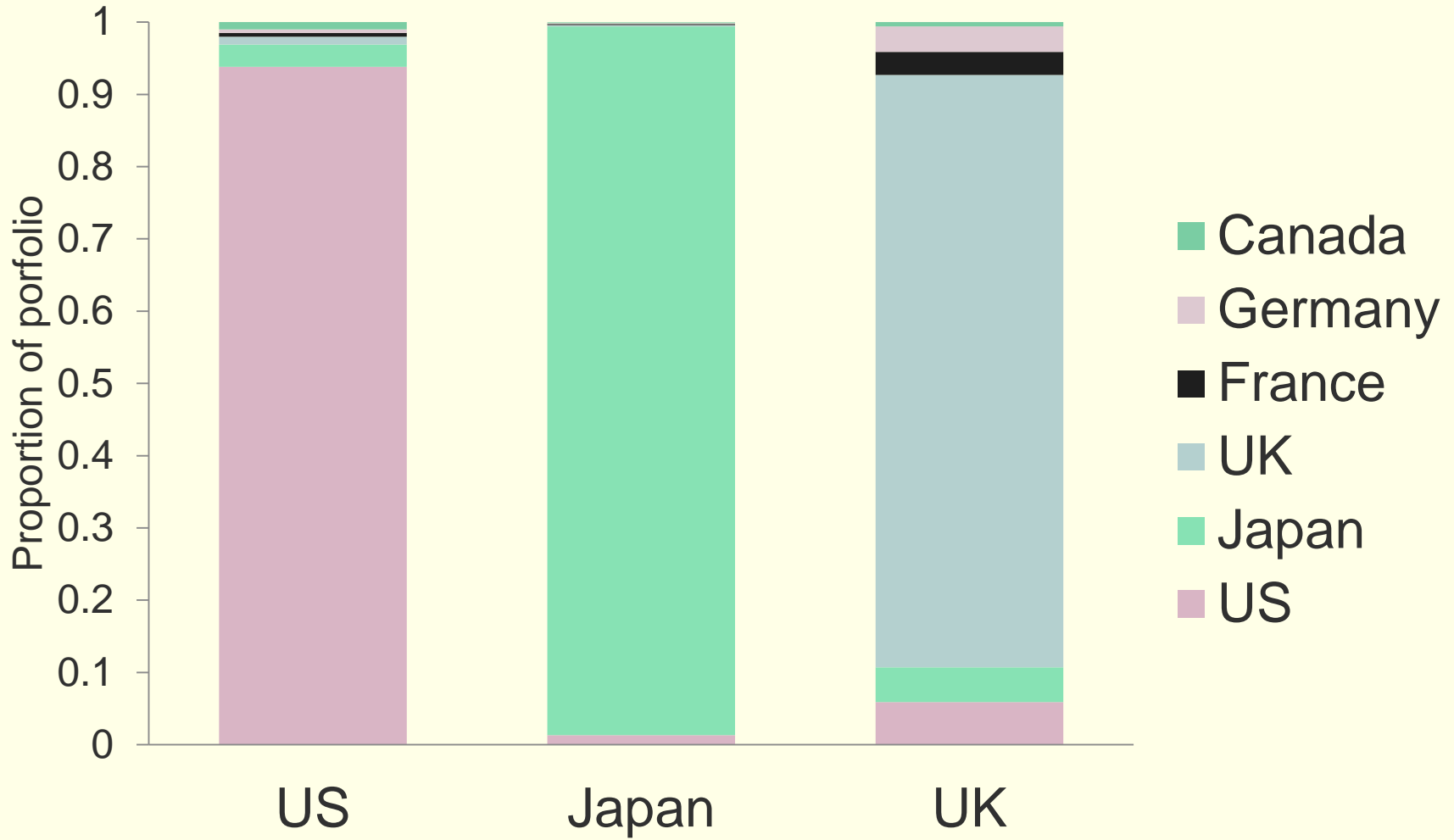- Odd or even of the temperature of a city

Beijing: RMB 11 (40%)

Tokyo: RMB **13 (60%)**

F&T suggested a link to **International Home Market Bias**

French & Poterba (1991)

Familiarity breeds Investment

Huberman (2001, RFS)

Shareholders of a Regional Bell Operating Company (RBOC) tend to live in the area which it serves, and an RBOC's customers tend to hold its shares rather than other RBOCs' equity. The geographic bias ... is closely related ... to the home country bias in the international arena. Together, these phenomena provide compeling evidence that people invest in the familiar while often ignoring the principles of portfolio theory.

- Also, "**Home Market Bias at Home**" Coval and Moskowitz (2002, JF)

Portfolio Choice Experiment@Max Planck

Experimental Assets based on Trailing Digits of Closing Stocks Prices

Stock	R
L	2.5
P	2.5
V	2.5
W	2.5
F	2.7
H	2.7
I	2.7

- **Endowed** with 10000 points (*10 Euro*) + 2.5 *Euro in* show-up fee
- **Bet** on whether the trailing digit of the closing price of a chosen stock is odd/even
- **WIN**: receive **R** x number of points invested in the stock
- **Portfolio Choice**: Cash + up to 3 stocks

Individual Portfolio Choice

Cash [_____] points

	Stock Code	Points	Odd	Even
Stock 1	[_____]	[_____]	O	O
Stock 2	[_____]	[_____]	O	O
Stock 3	[_____]	[_____]	O	O

Note: At least 100 points for each stock chosen
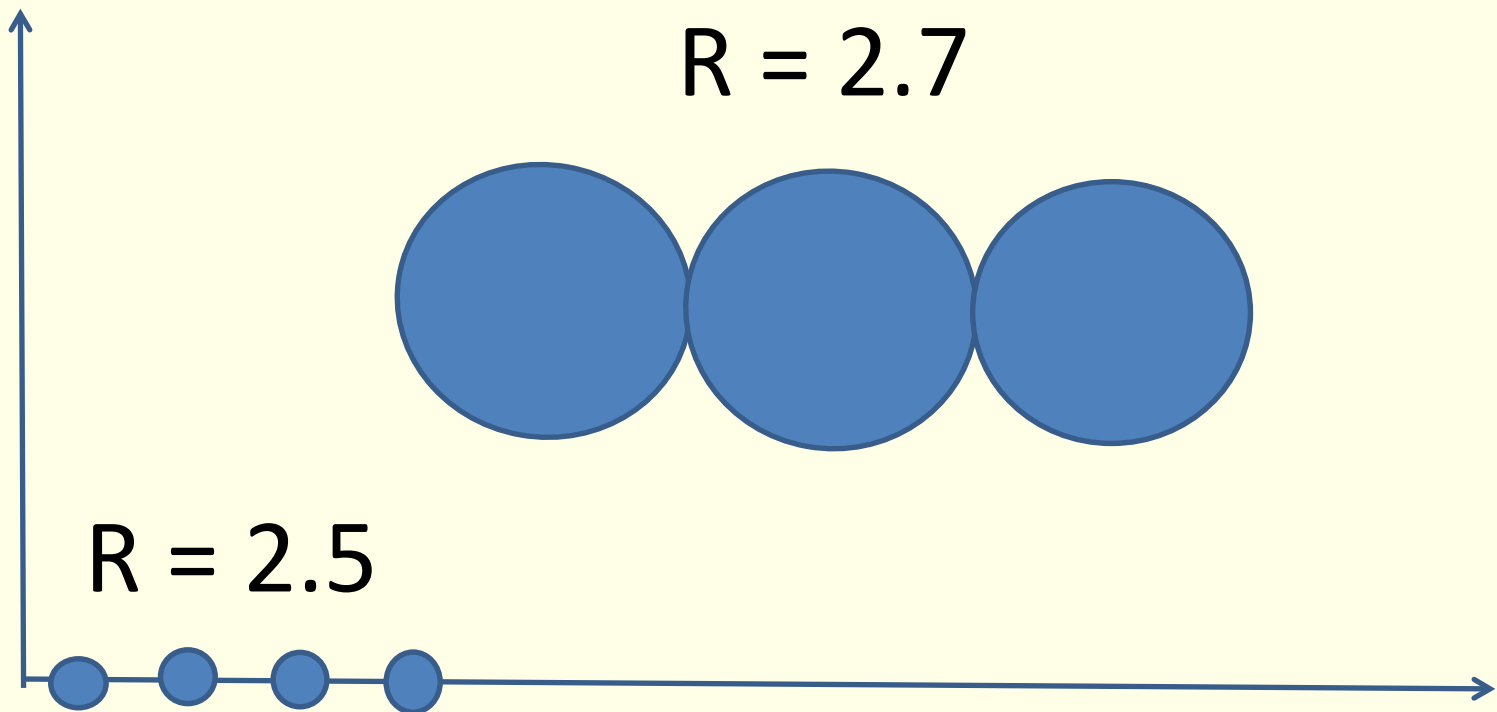
Theoretical Demand for the Stocks

R = 2.7

R = 2.5

Table 1. List of Stocks Available for Forming the Portfolio

Logo	Company Name	Stock Code	R	Mean Familiarity (Std)
	Volkswagen AG St	239	2.5	9.5 (1.033)
	Pfleiderer AG	134	2.7	1.45 (1.545)
	IVG Immobilien AG	532	2.7	1.883 (1.688)
	Deutsche Lufthansa AG	342	2.5	9.067 (1.425)
	Homag Group AG	131	2.7	1.733 (1.821)
	Puma AG	332	2.5	9.117 (1.627)
	Wacker Chemie AG	423	2.5	3.55 (2.837)

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Which has the highest demand?

Observed Demand

Share of High-Familiarity, Low-Return Stocks
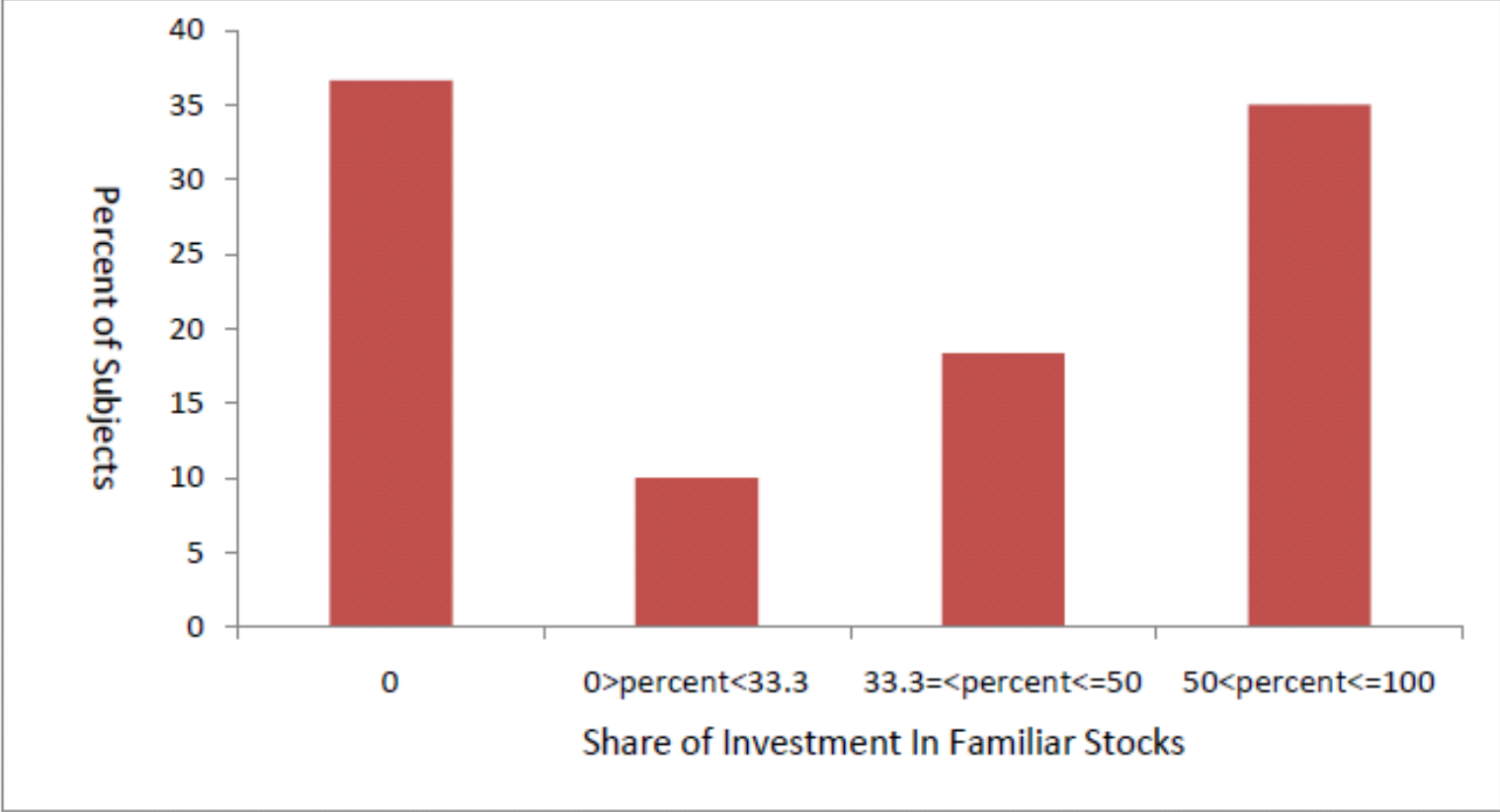
Linking decision theory with choice bias plus some biology and discussion of the role of the (un)conscious

Lesson from Observed Behavior

- Risk attitude may depend on the source of uncertainty
  - Can relate to underlying ambiguity
  - Can relate to underlying familiarity
- **E**qually likely events in terms of frequentist probability may **still** not be treated the same!

How might we define a
stronger sense of equal likelihood
between events *E* and *E'*
while maintaining the usual
assumptions of *Completeness* and
Transitivity over lotteries?

Definition of Exchangeability

For any pair of non-null and disjoint events $E,E' \in \Omega$, $E \approx E'$ if for any $x,x' \in X$ and $f \in F$,

$$xEx'E'f \sim x'ExE'f.$$

Exchangeability-Based Relative Likelihood

- We posit that two disjoint events are comparable if one includes a subset that is exchangeable with the other

  - Write, $E \succcurlyeq^C E'$ whenever E contains a subevent that can be exchanged with E'
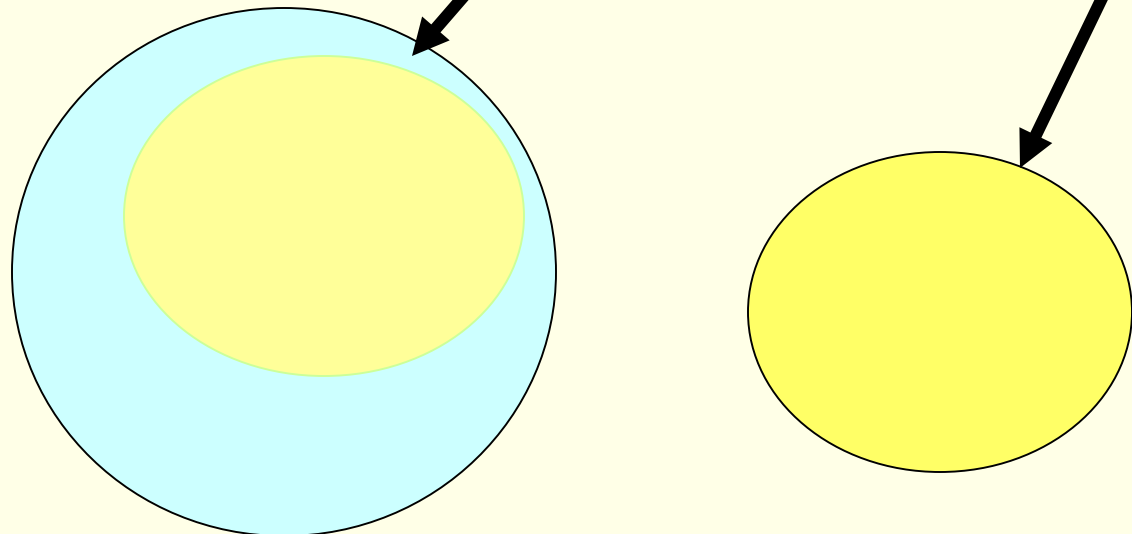
To Complete or Not to Complete?

Axiom C (**Completeness**):

Every pair of events can be compared in terms of an exchangeability-based likelihood.

- Not necessary as demonstrated in some puzzles.

To complete

Besides the usual *Completeness* and *Transitivity*, we introduce

2 axioms on relative likelihood

Event Archimedean & Event Non-Satiation

Axiom A (*Event Archimedean Property—CS06*). Any set $A \subseteq \Sigma$ of non-null, pairwise disjoint events, such that $e \approx e'$ for every $e, e' \in A$, is necessarily finite.

Axiom N (*Event Non-satiation—CS06*). For any pairwise disjoint $E, A, E' \in \Sigma$, if $E \approx E'$ and A is non-null, then no subevent of E' is exchangeable with $E \cup A$.

Complete Likelihood Relation
– *no source preference*

EVENT EXCHANGEABILITY: PROBABILISTIC SOPHISTICATION WITHOUT CONTINUITY OR MONOTONICITY

By Chew Soo Hong and Jacob S. Sagi[1]

Building on the Ramsey–de Finetti idea of event exchangeability, we derive a characterization of probabilistic sophistication without requiring any of the various versions of monotonicity, continuity, or comparative likelihood assumptions imposed by Savage (1954), Machina and Schmeidler (1992), and Grant (1995). Our characterization identifies a unique and finitely-additive subjective probability measure over an algebra of events.

Not to complete

Strengthening Event Non-satiation to Model Source Preference

Axiom A (*Event Archimedean Property—CS06*). Any set $A \subseteq \Sigma$ of non-null, pairwise disjoint events, such that $e \approx e'$ for every $e, e' \in A$, is necessarily finite.

Axiom N' (*Strong event non-satiation*). For any disjoint $E, E', A \in \Sigma$, if $x(E \cup A)x'E'f \sim xEx'(E' \cup A)f$ for every $x, x' \in X$ and $f \in \mathcal{F}$ then A is null.

Incomplete Likelihood Relation
to *model source preference*

Small worlds: Modeling attitudes toward sources of uncertainty

Soo Hong Chew[a], Jacob S. Sagi[b,*]

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Abstract

We introduce the concept of a *conditional small world event domain*—an extension of Savage's [The Foundations of Statistics, Wiley, New York, 1954] notion of a 'small world'—as a self-contained collection of comparable events. Under weak behavioral conditions we demonstrate probabilistic sophistication in any small world event domain without relying on monotonicity or continuity. Probabilistic sophistication within, though not necessarily across, small worlds provides a foundation for modeling a decision maker that has source-dependent risk attitudes. This also helps formalize the idea of source preference and suggests an interpretation of ambiguity aversion, often associated with Ellsberg-type behavior, in terms of comparative risk aversion across small worlds.

Immediate Deliverable:

source-dependent SEU

Complete and transitive source preference using

different *vNM utility functions to model*
distinct *attitudes towards risks from*
different *sources of uncertainty*

User Friendly Example

Consider a CRRA EU form:

$$E(x^r, F^s)$$

where F refers to a probability distribution based on RV defined on a source of uncertainty s.

User Friendly Example … Cont'd

Consider a source-dependent CRRA EU form:

$$E(x^{r(s)}, F^s)$$

- Can bound behavior of $r(.)$, e.g.:
  - risk versus ambiguity,
  - strategic uncertainty,
  - familiarity

Familiarity breeds Investment
if you have the right gene

GABRB2 as Candidate Gene

- We hypothesize that individual differences in the effectiveness of the GABAergic systems in coping with anxiety may explain differences in familiarity bias

- *GABRB2* is the β_2 subunit gene forming the $GABA_A$ receptor sitting on chromosome 5

Systems – Gene-Brain-Decision – Hypothesis

Familiarity bias

Decision

H1: genotype → familiarity bias

H3: Amygdala activation → familiarity bias

Amygdala

Gene

Brain

GABRB2

H2: genotype → responsiveness of amygdala activation to unfamiliarity
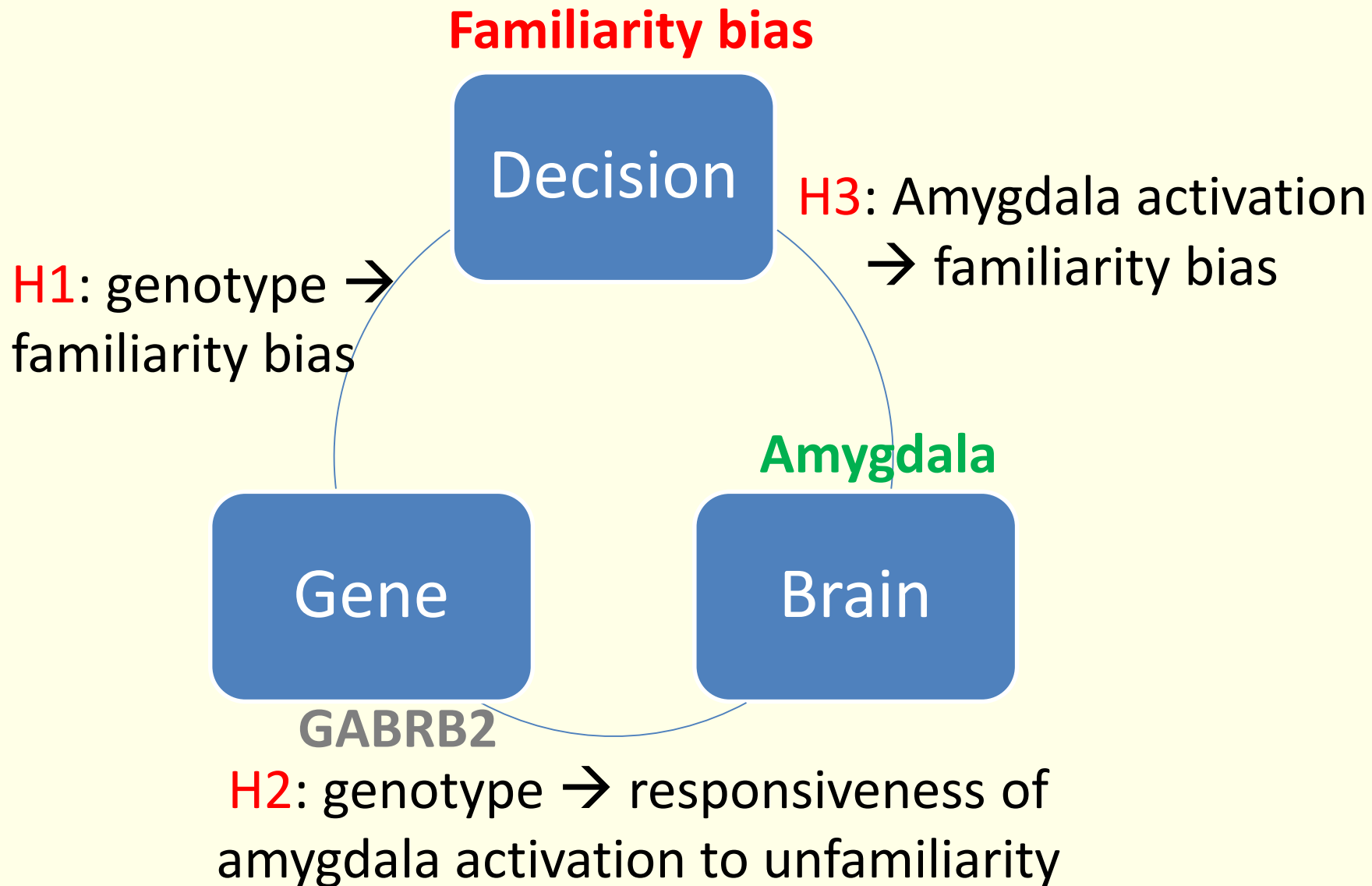
Study 1: Gene-Decision Link

- Part of 325-subject gene-brain-behavior study
- Odd or even of the temperature of a city

Beijing: RMB 11 (40%)   Tokyo: RMB **13 (60%)**
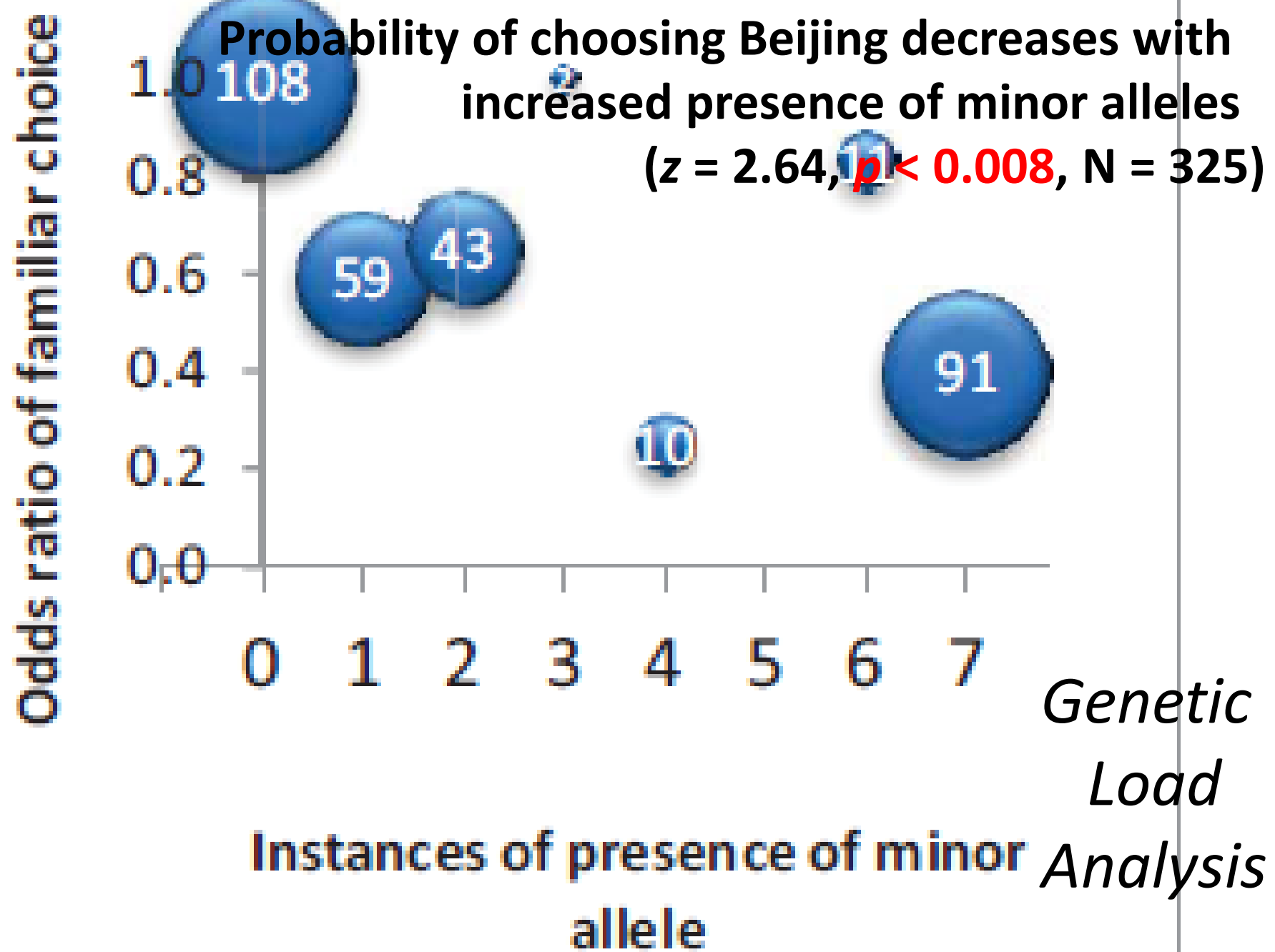
Single-Nucleotide Polymorphism (SNP)

- DNA comprises lots of pairs of genetic letters
  - AG and CT
- Allele
  - Minor allele (m) < 50% prevalence
  - Major allele (M) > 50% prevalence
- Genotype
  - Homozygous minor (mm)
 - Heterozygous (mM)
  - Homozygous major (MM)

10 GABA SNPs

dbSNP ID	Variation (M/m)	Minor allele frequency (%)	Genotype Call rate	Genotype Association z-scores	p-values
	T/C	19.25	322	2.80	0.005
	T/C [B]	40.40	323	2.47	0.014
	C/A	19.00	321	2.44	0.015
	T/C	16.40	317	2.40	0.016
	A/G	27.19	320	2.31	0.021
	G/C	16.41	323	2.30	0.022
	G/T	15.69	325	2.27	0.023
	G/C	8.33	324	0.43	0.668
	G/A	13.08	325	-0.23	0.815
	C/T	13.35	322	-0.05	0.958

Probability of choosing Beijing decreases with increased presence of minor alleles ($z = 2.64$, $p < 0.008$, N = 325)

Study 2: Gene-Brain-Decision Links

- 37 subjects selected from the 325 subjects using most balanced SNP
  - Matched genotype
    - **CC or CT: 22   (minor)**
    - **TT: 15   (major)**
  - The minor allele C is under positive selection and has functionality as agonist
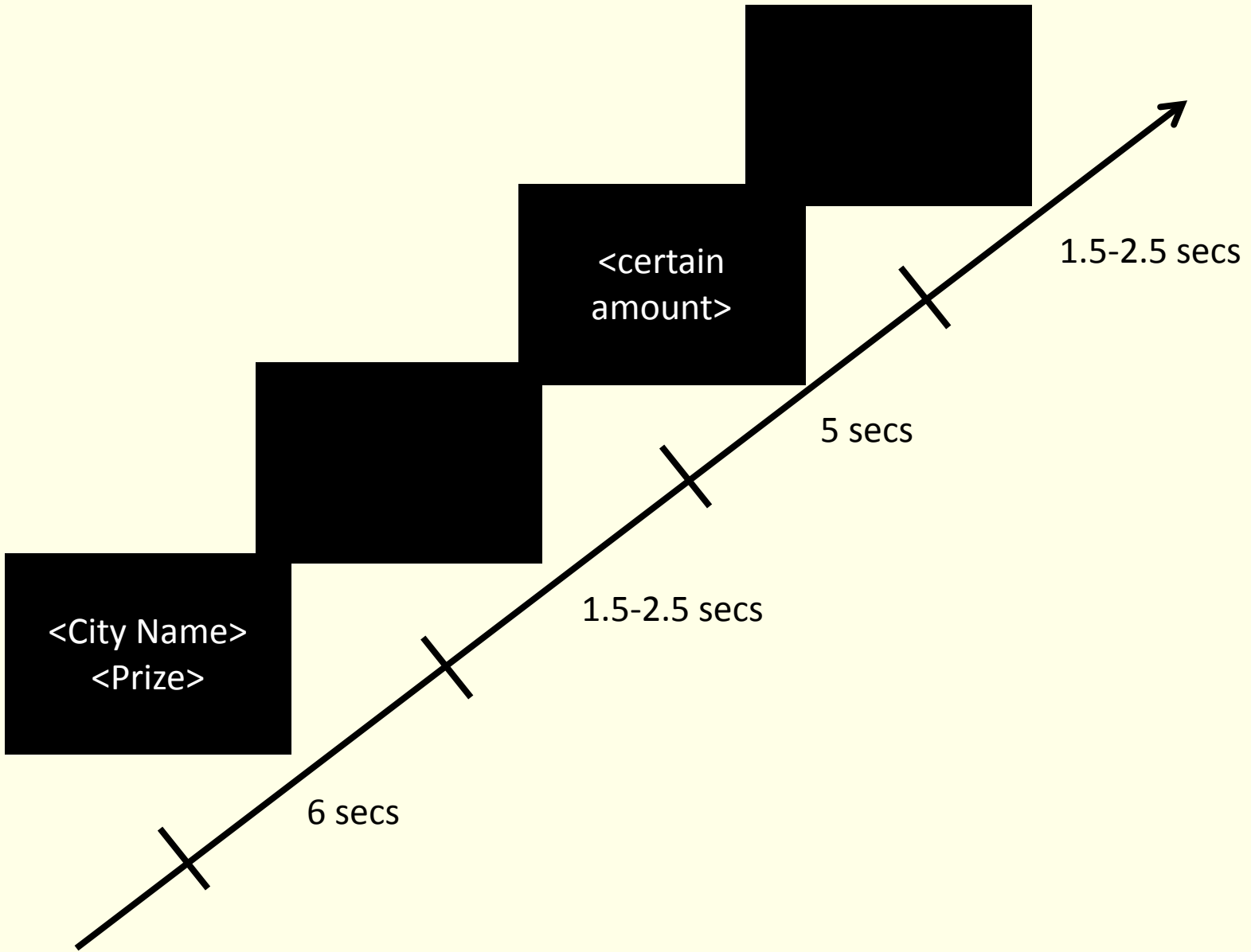
City	In Chinese	Average Familiarity (s.d.)
Shanghai	上海	1.93 (2.45)
Hangzhou	杭州	1.78 (2.41)
Tianjin	天津	1.73 (2.66)
Wuhan	武汉	1.49 (2.90)
Chengdu	成都	1.34 (2.81)
Guangzhou	广州	1.17 (2.68)
Shenzhen	深圳	1.07 (2.80)
Harbin	哈尔滨	0.93 (2.63)
Sanya	三亚	0.85 (2.38)
Kunming	昆明	0.20 (2.72)
Baotou	包头	-0.63 (3.23)
Liuzhou	柳州	-0.98 (3.09)
Yibin	宜宾	-1.27 (3.20)
Wuhu	芜湖	-1.54 (3.25)
Jining	济宁	-1.71 (3.00)
Changde	常德	-1.76 (3.26)
Golmud	格尔木	-2.12 (3.28)
Jinzhou	锦州	-2.22 (3.07)
Yingtan	鹰潭	-3.17 (2.96)
Tongchuan	铜川	-3.44 (2.72)

Post Scanning Familiarity Rating

Study 2 establishes G-B-D link with imaging

- During scanning, Ss makes 80 choices matched to 20 Chinese cities
  - Each City Bet pays x if temperature is odd and matched to 4 sure amounts, one above and 3 below.
- After scanning, we elicit familiarity ratings f for each city.
- To estimable possible familiarity-dependent risk attitude, use

$$E(x^{r(f)}, F^f) = x^{r(f)}/2$$

where $r(f) = r_0 + r_1 f$.

Unconditional Familiarity Bias
Not Observed

Estimation using STATA to estimate a **Smithian model of familiarity bias**

$$r(f) = r_0 + r_1 f$$

$r_0 = .7426$

$r_1 = -.001808 \qquad (p > .4)$

You exhibit familiarity bias if your have the right gene

Incorporating knowledge of Ss' genotypes …

$$r(f) = r_0 + r_{0,G} + (r_1 + r_{1,G})f$$

where

$G = 0$, if minor allele (CC or CT)

$G = 1$, if major allele (TT)

$r_0 \quad = .7560$

$r_{0,G} = -.03597 \quad (p > 0.3)$

$r_1 \quad = -.006471 \quad (p > 0.1)$

$r_{1,G} = .01072 \quad (p < 0.05)$

Dual System Processing

- Each city represents lottery outcomes (**conscious processing – System 2**)
- Level of familiarity (**unconscious processing – System 1**)
- Observes joint role of conscious and unconscious beyond revealed choice
  - Limited capacity of conscious thought vs. unlimited for unconsciousness
  - Linked to influence of limitation in attention

Reassuring Finding – Reward

- **$EV = x/2$ correlates positively with activity in the ventral striatum**

  - Reward prediction (e.g., Breiter et al. 2001; Hsu et al. 2005; Knutson et al. 2003; Tom et al. 2007)

- **Decision utility (utility of chosen option) correlates positively with activity in the striatum**

Activation in bilateral striatum correlates positively with utility of chosen option at **decision epoch** (*p* < 0.001, uncorrected; *k* ≥ 10).

<City Name>
<Prize>

6 secs

1.5-2.5 secs

<certain amount>

5 secs

1.5-2.5 secs

Y = 12
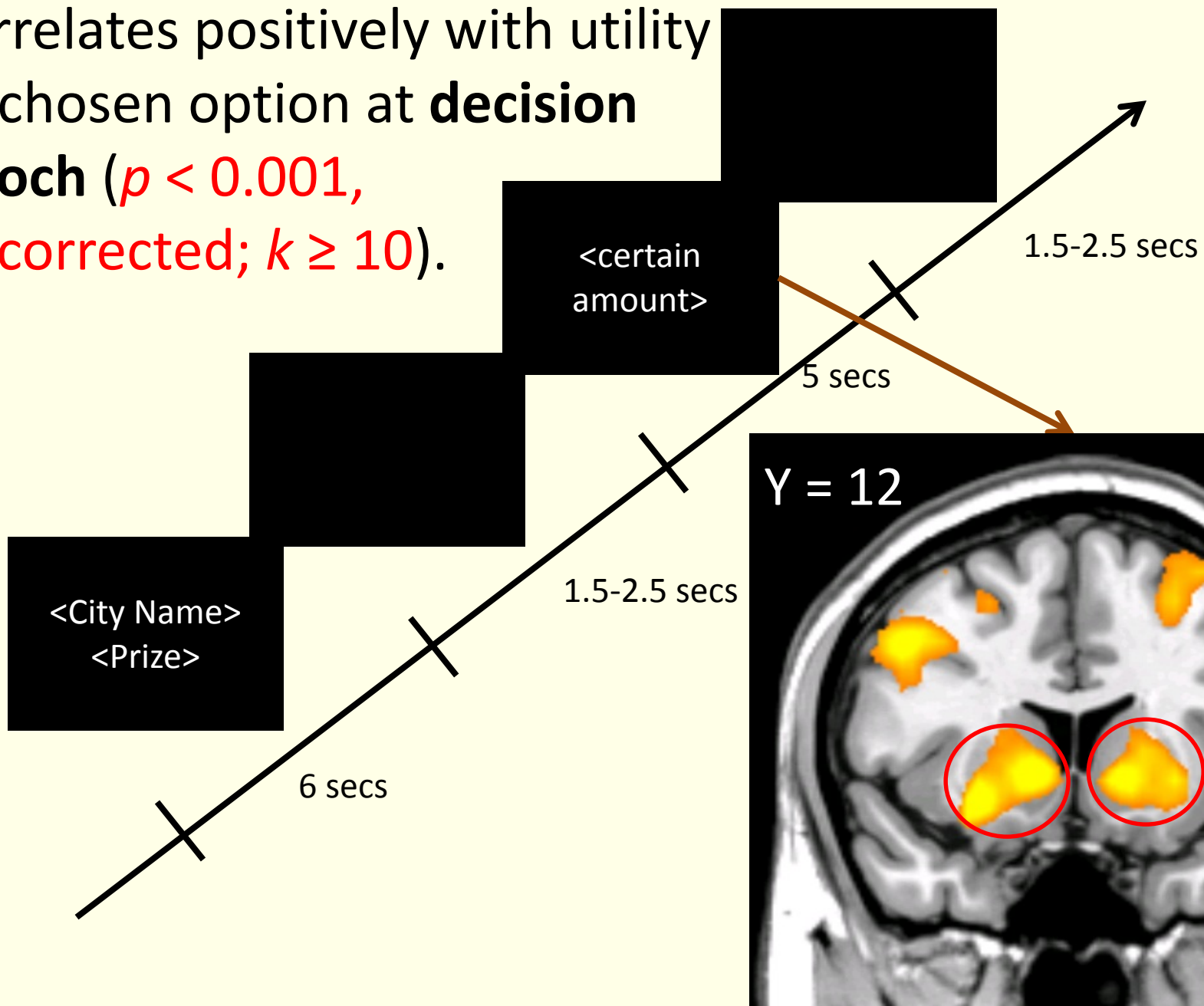
Novel Finding – Amygdala

- Amygdala activation
  - **Predicts degree of familiarity bias**
  - **Predicted by genotypes**

Genotype predicts Amygdala Sensitivity to Familiarity
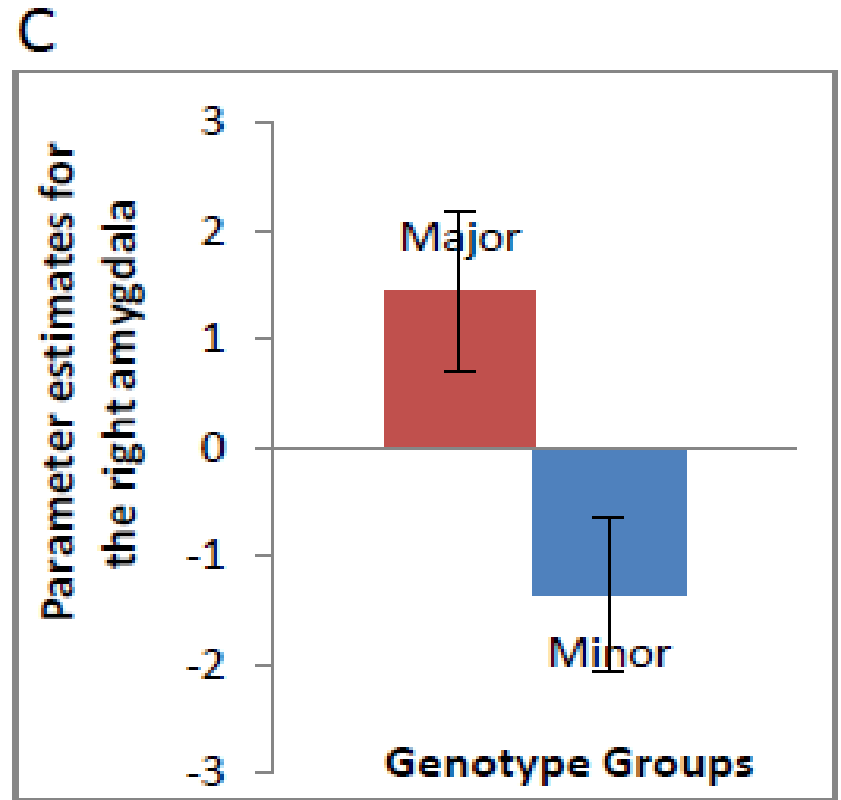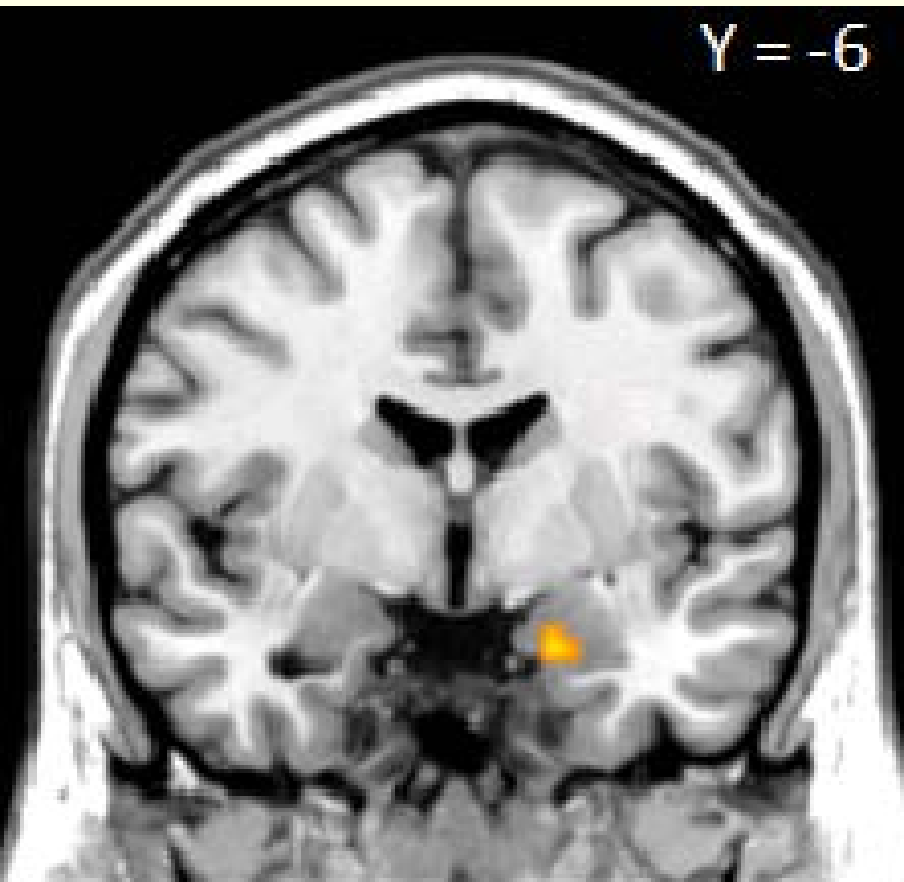
Left: Correlate with degree of familiarity bias.
Right. TT group exhibits higher amygdala response to unfamiliarity than non-TT group (*p* < 0.02).

Some Remarks

- **Gene-Brain-Decision** hypothesis supported.
  - Specific minor allele is under **positive selection** and acts as **agonist** for $GABA_A$
  - Candidate **cause** for choice anomaly
  - Natural **pharmacological intervention** follow up
- **Market implication**: Between 'home' and 'foreign', the amygdala 'GABAergic circuits' may **nudge** one to choose the familiar over the less familiar to ameliorate **anxiety**
- Points to **Conscious-Unconscious Duality** in Decision Making
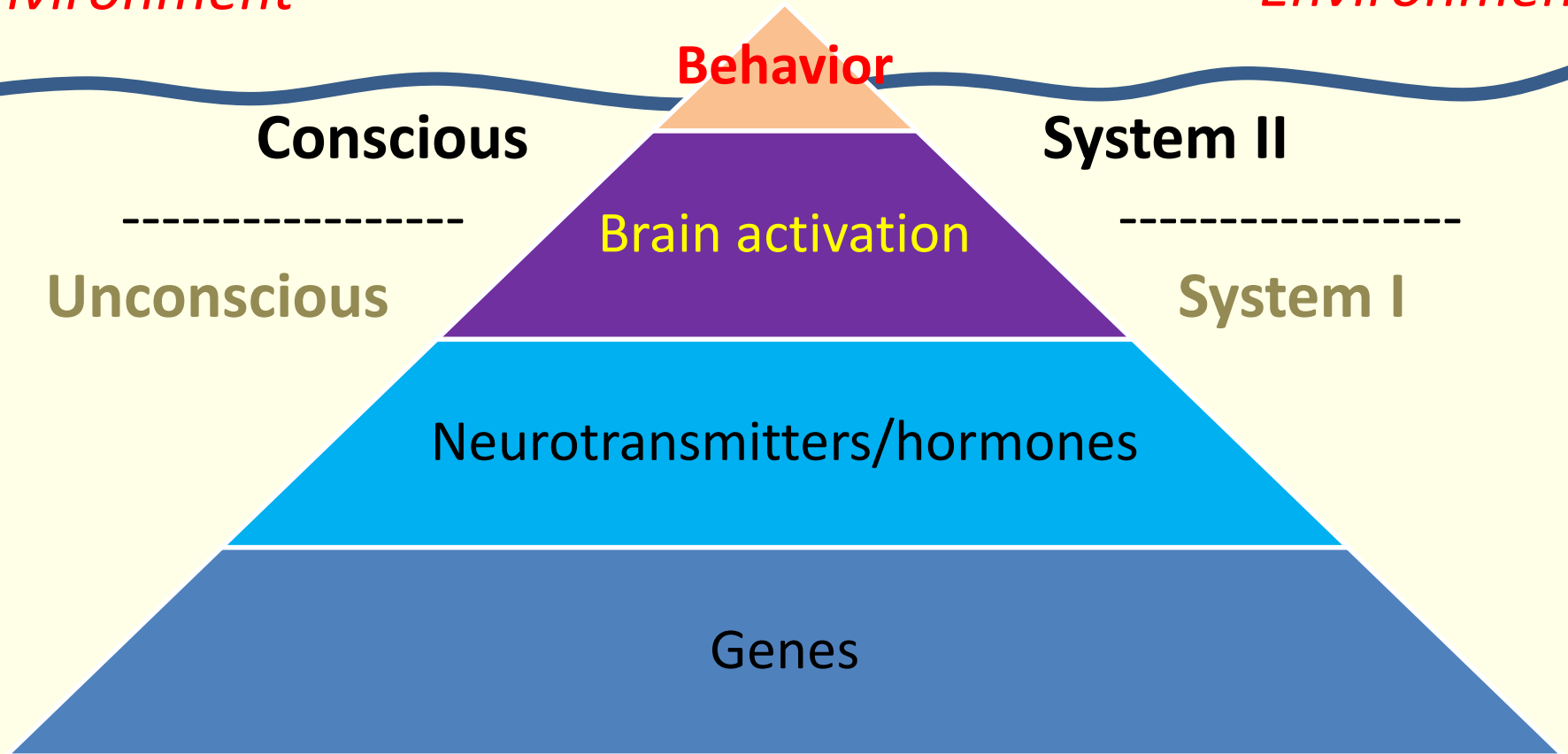
Further remarks re
*Role of the **unconscious***
building on
"What is Life?"
Schrodinger

Recent history of how **Schrodinger** (contemporary of **Einstein**, **Freud**, **Knight, Planck, Ramsey, Schoepenhauer**) applied **quantum mechanics** thinking to shed light on the nature of the **genom**, inspiring **Watson** and **Crick's** eventual uncovering of the **DNA** …

Early 1900s were a miraculous time for science, Einstein, Freud, Keynes, Planck, Ramsey, Schopenhauer, Schrodinger were contemporaries …

In "**What's Life**?",

Schrodinger posed the question –

"**Why are atoms so small and organisms so large?**"

Imagine how chaotic, unstable, unpredictable and turbulent life of nano-organisms would be if they are sensitive to a single atom.

What connects our quantum and macro worlds?

- Schrödinger conjectured an 'aperiodic crystal' called '**genom**' as the bridge
  - String of atoms within each living being exposed to atomic and molecular events through (random) **mutations**.
  - A quantum level **code** for producing a macro level organism.
  - Leap-like molecular events can play a role in our lives from **quantum jumps** in the molecular structures of genes
- "While we feel at home in a fairly predictable world and may learn from previous experiences, but **a dislocation of only one (or just a few) atoms may nonetheless suffice to bring about well-defined, visible change** on the macro-level of microbial or organismal life."
- Bringing together physics to and biology and deliver a **quantum theory of biology**

In 1946, "What is life?" changed modern biology through Watson and Crick

- Undecided about what to do as an undergraduate at Chicago, Watson read the book and became "*polarized towards finding out the secret of the gene ...*"

  - "As a student I had liked Schrödinger's contributions to quantum physics [and] I was attracted by Schrödinger's thinking in *What is life?* because he linked the extremely important biological idea of a gene with the rather strange world of electrons moving in crystals ... The main impact of Schrödinger's book was that it set me in motion"

- "A major factor in [Crick's] leaving physics and developing an interest in biology had been his reading of this book which propounded the belief that genes were the key components of living cells and that, to understand what life is, we must know how genes act".

- A **short pop-sci book by a physicist** thus catalysed the development of a great direction of research and **changed biology**.

Why is consciousness so 'big' and the unconscious so 'small'?

At least in economics ☺

- Is this so in economic decision making?
  - Investing and saving, managing risk, producing, …
- Not-so-economic decision making?
  - recreational risk taking and gambling
  - social preference such as altruism, trust, reciprocity, …
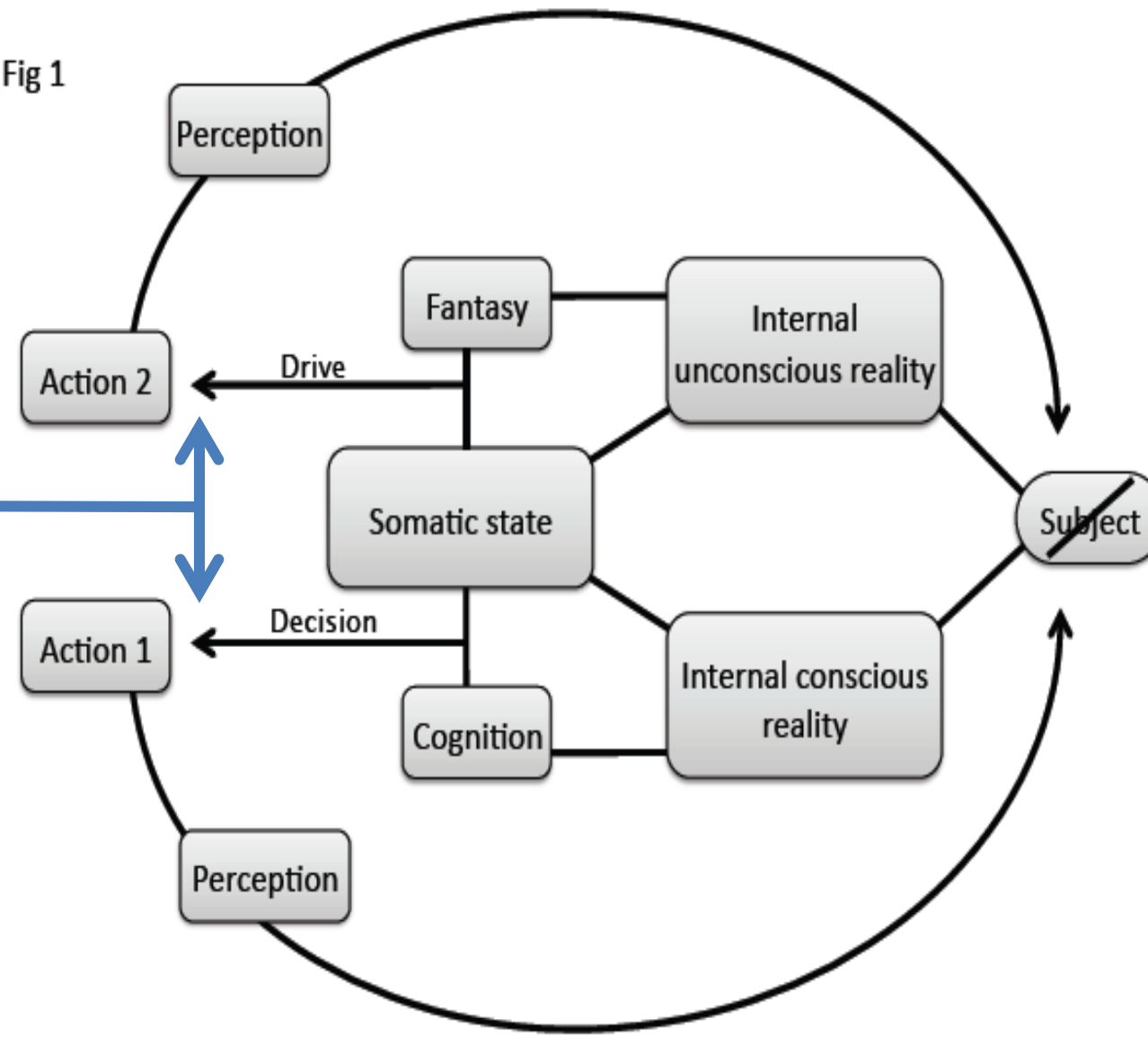
Ansermet-Magistretti Decision Making Schematic

Ansermet-Magistretti's
Neuroplasticity-based Theory of the Unconscious

- Neuroplasticity (Hebb, 1948) →
  - Constantly changing brain versus a constant mind/heart
  - Patterns of synaptic level changes → Representations
  - Unique, not reason-based, discontinuous
  - Trace as somatic parallel to perception/experience,
  - Incompletely authentic, e.g., dreams
  - Directed/motivated unconscious
  - Functionality? Creativity?

Accessing System I – Unconscious?

- **Dreams, fantasies, delusions, …**
- **Mindfulness** (正念禅修) – intentional, accepting and non-judgmental focus of one's attention on the emotions, thoughts and sensations occurring in the present moment",[1] can be trained by meditational practices[1] derived from Buddhist *anapanasati*.[2]
  - Alleviate a variety of mental and physical conditions, including obsessive-compulsive disorder, anxiety
  - Prevent relapse in depression and drug addiction.[4]
- Vipassana – next slide (*due to Alain*)

Vipassana – see things as they really are. Among India's most ancient techniques of meditation. Rediscovered by Gotama Buddha more than 2500 years ago, taught as a universal remedy for universal ills.

Aumann's (2005) musing re Consciousness

- Ability to **experience**

- **Completely subjective,** distinct from other scientific phenomena.

- One can only observes one's own consciousness **and with certainty** but not anybody else.

- Delusions, dreams, and ravings are **experiences**, thus part of consciousness.

- **This is the last great frontier of science**.

(Un)Consciousness ☺

Homo (Socio)Economicus

	Unbounded	Bounded
Consciousness • **Attention** • **Encoding** • **Storage** • **Recall**	**Full**	**Limited** • **Admits possibility of fantasy & delusion**
Computational Ability	**Unbounded**	**Bounded**
Preference-Choice Coherence	**Complete** • Only conscious choice	**Limited** • Admits influence of the unconscious
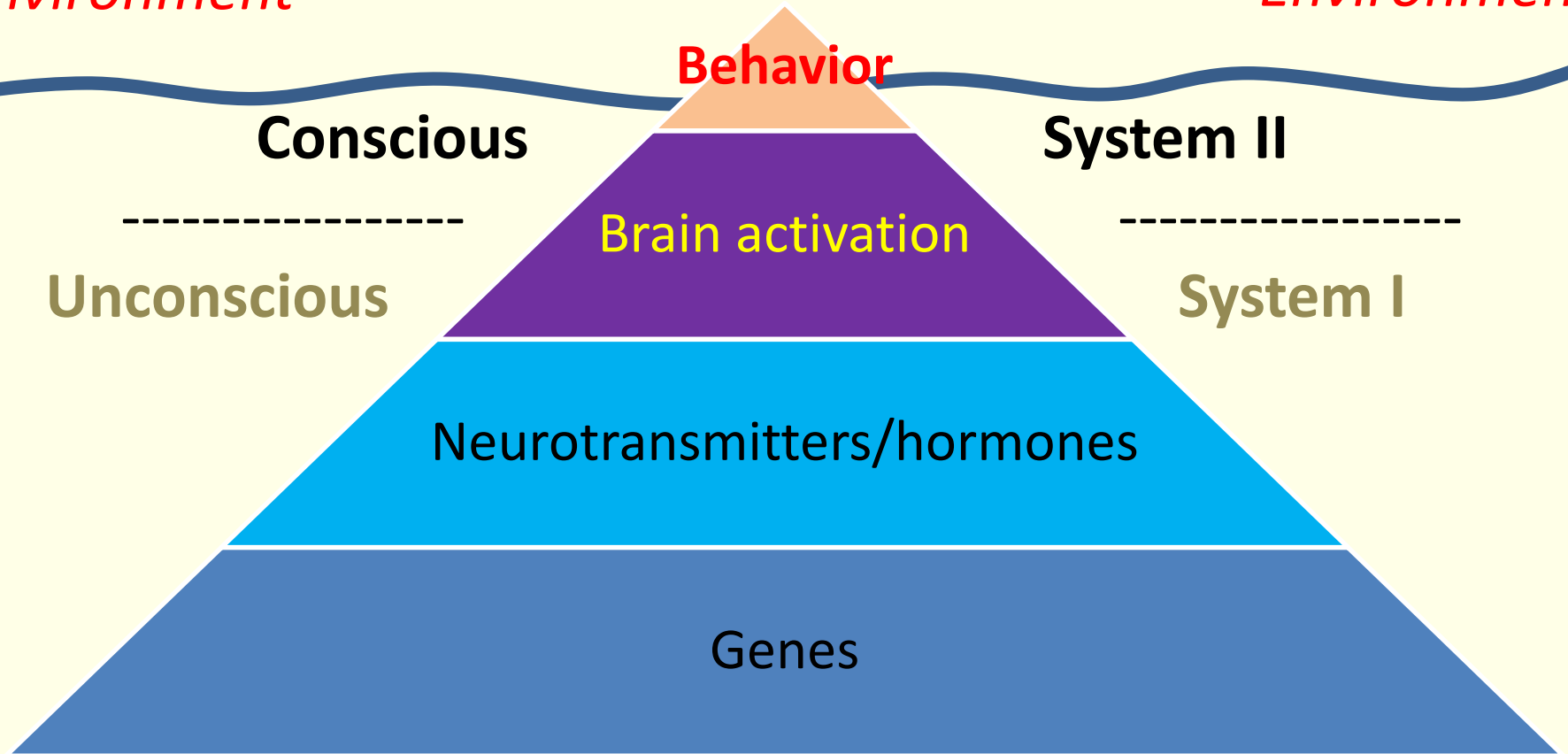
Conversation with a friend at UCI

- Before giving a version of this talk
- A friend asked about my talk, so I posed a question …

Conversation with a friend …

Guess whether the trailing digit of a market index at closing the next business day is **odd** or **even**.

A: Reward: USD33

B: Reward: USD30

Which bet would you choose?

Conversation with a friend ... Cont'd

- After saying that odd or even is a one-one event, she said, "I am sorry Chew. $3 is not a big sum, but I know NYC better ..."

- At some point, I mentioned that my talk has something to do with benzodiazepine ... like Valium.

- Then she decided to share discreetly, "I am familiar with these drugs since I am depressive."

FAMILIARITY BIAS OF HIGH-NET WORTH INDIVIDUALS IN SHANGHAI

Shanghai versus Dow Jones
with High-Net Worth Individuals

Guess whether the trailing digit of a market index at closing the next business day is **odd** or **even**.
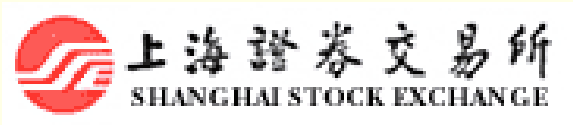
A:

Reward: RMB260

B:

Reward: RMB280

Which bet would you choose?

Dow Jones-Shanghai Study
with High-Net Worth Individuals

A:

B:

Reward: RMB260
(18)

Reward: RMB280
(7)

Dow Jones-Shanghai Study
with High-Net Worth Individuals

Guess whether a specific market index would be **up** or **down** at closing next business day?

A: Reward: RMB260

B: Reward: RMB280

Which bet would you choose?

Dow Jones-Shanghai Study
with High-Net Worth Individuals

	Shanghai Stock Exchange	DOW JONES
	RMB260	RMB 280
odd-even	**18**	**7**
up-down	**21**	**4**