Deep Uncertainty, Ambiguity, and Risk: how ignorance of lottery elements shapes decisions

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Workshop *Unforeseen Contingencies*
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Correlations between risk elicitation tasks

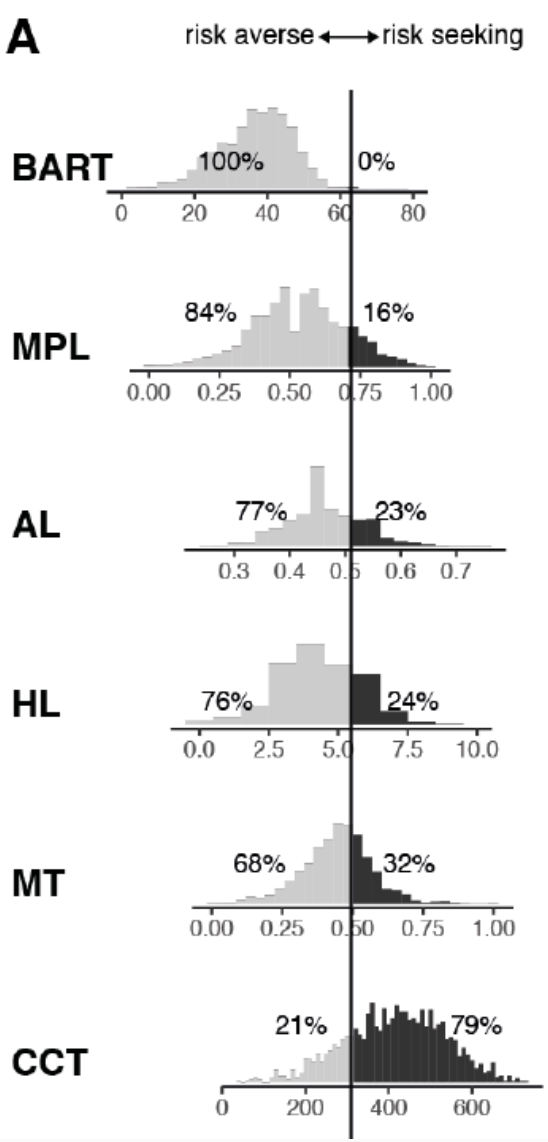
Slovic, 1962

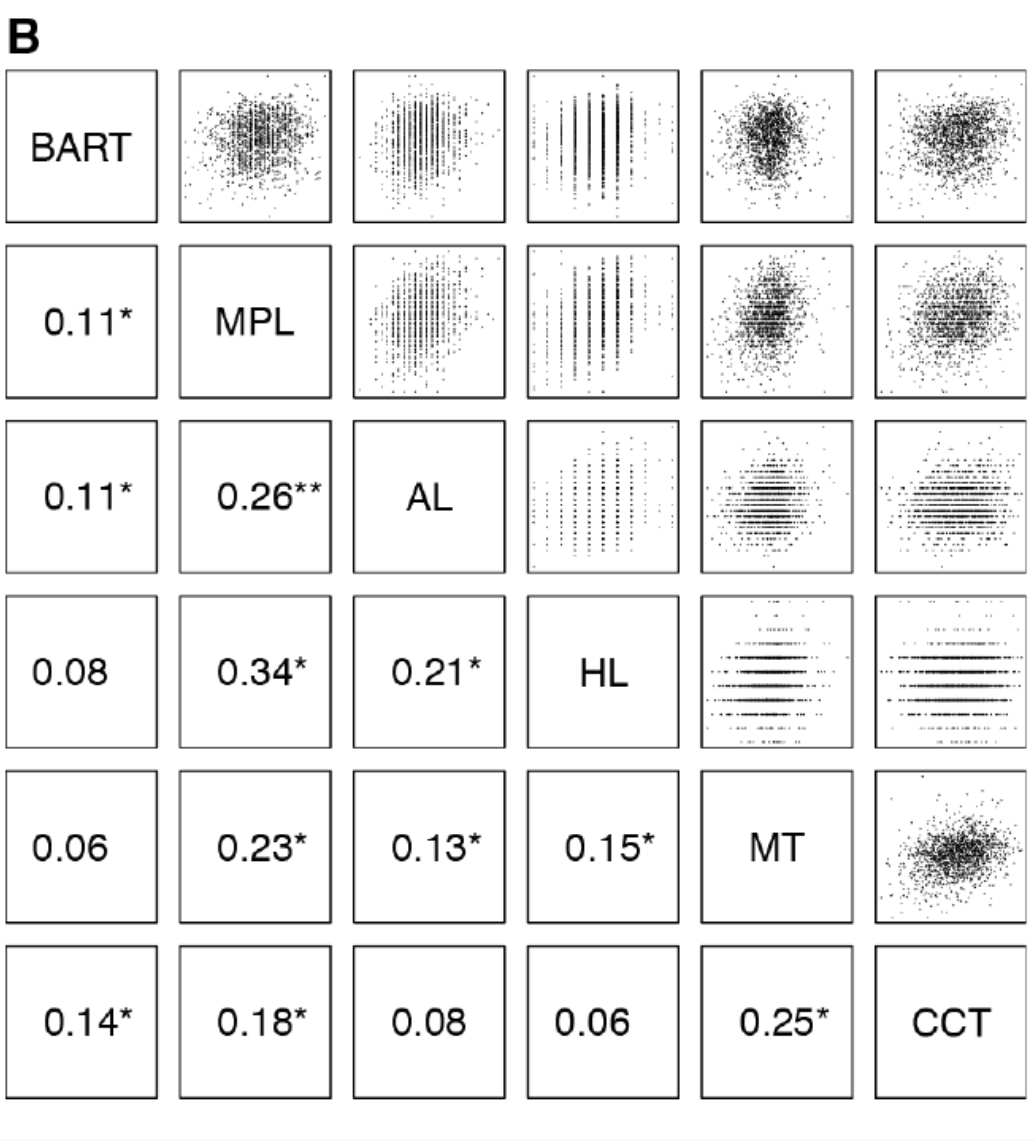
TABLE 1

INTERCORRELATIONS AMONG RISK TAKING MEASURES
($N = 82$)

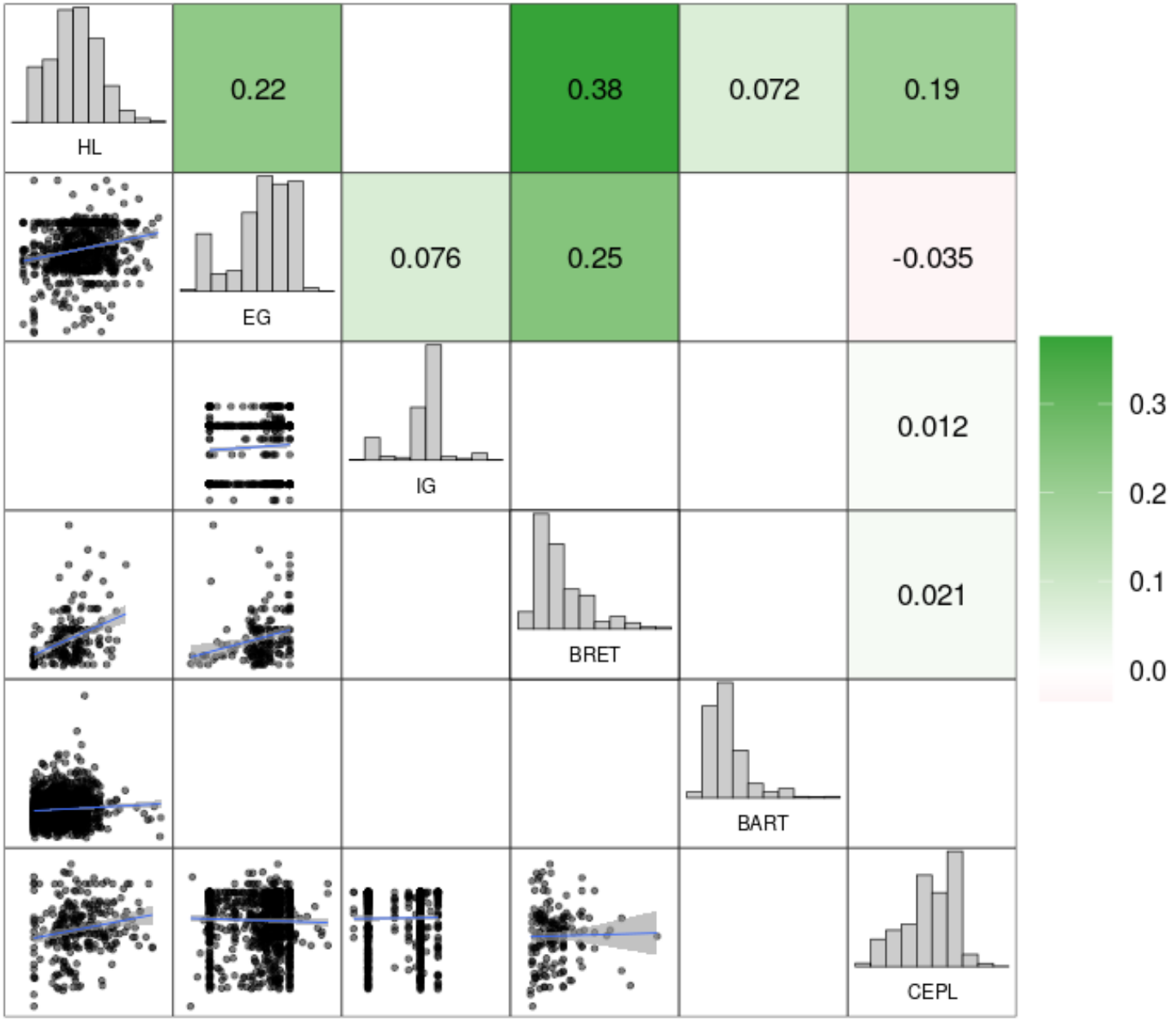
Variable	1	2	3	4	5	6	7	8
Response sets								
1 Dot Estimation								
2 Word Meanings	−.17							
3 Test Risk	.16	.05						
Questionnaires								
4 Life Experience Inventory	.05	.27**	−.04					
5 Job Preference Inventory[a]	.07	−.14	−.19	−.06				
Gambling preferences								
6 Self-Crediting Test	−.08	.19*	−.24*	.05	.09			
7 Variance preferences	.32**	.03	−.07	.23*	.07	.04		
8 Probability preferences	.16	−.03	−.07	−.03	−.35*	−.20	−.17	
Ratings								
9 Risk rating	.05	.00	−.24*	.34**	.10	−.02	.02	.18[a]

Pedroni et al, 2017





Crosetto et al, 2025



Correlations between risk elicitation tasks suck

This is called the Risk Elicitation Puzzle

The Risk Elicitation Puzzle

Risk preferences primitive of most economic decisions

They are assumed to be an *innate* and *stable* construct. But:

- **Temporal instability:** different choices in sit & resit.
- **Lack of convergent validity:** across tasks, within tasks across participants, ...
- **Poor external validity:** Low correlation, if any, with naturally-occurring decisions.
- **Rabin's paradox:** risk aversion measured in the lab implies absurdly high risk aversion over large stakes
- ...

A set of potential solutions

Small improvements

- IID measurement **error** (Crosetto & al, wip)
- Task-specific **bias** (Crosetto & Filippin, 2015)
- **Richer** models (e.g. Prospect Theory, Narrow bracketing...)

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Drastic alternatives

- Cognitive **imprecision** $\rightarrow$ Risk aversion **is not**! (Oprea 2025)
- Risk **perception** $\neq$ mean/variance (Holzmeister & al 2019)
- Inconsistent **representation** of what risk **is**

This paper:
what if risk representations matter,
in particular for external validity?

Have we got the right representation of risk?

In the lab: "risk"

- known probabilities
- known set of outcomes
- no surprises
- learn by description
- small stakes
- no losses

Out of the lab: "risk"

- fuzzy probabilities
- fuzzy set of outcomes
- surprises
- learn by experience
- high stakes
- losses

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Quite the gap to mind – and bridge

Two research questions: synopsis

1. In the lab:

How does ignorance of the elements of choice shape risk taking? Do subjects act more conservative in absence of information? How much? How do risk perception and risk taking react to a task spanning risk, ambiguity, deep uncertainty?

2. Across lab and the outside world:

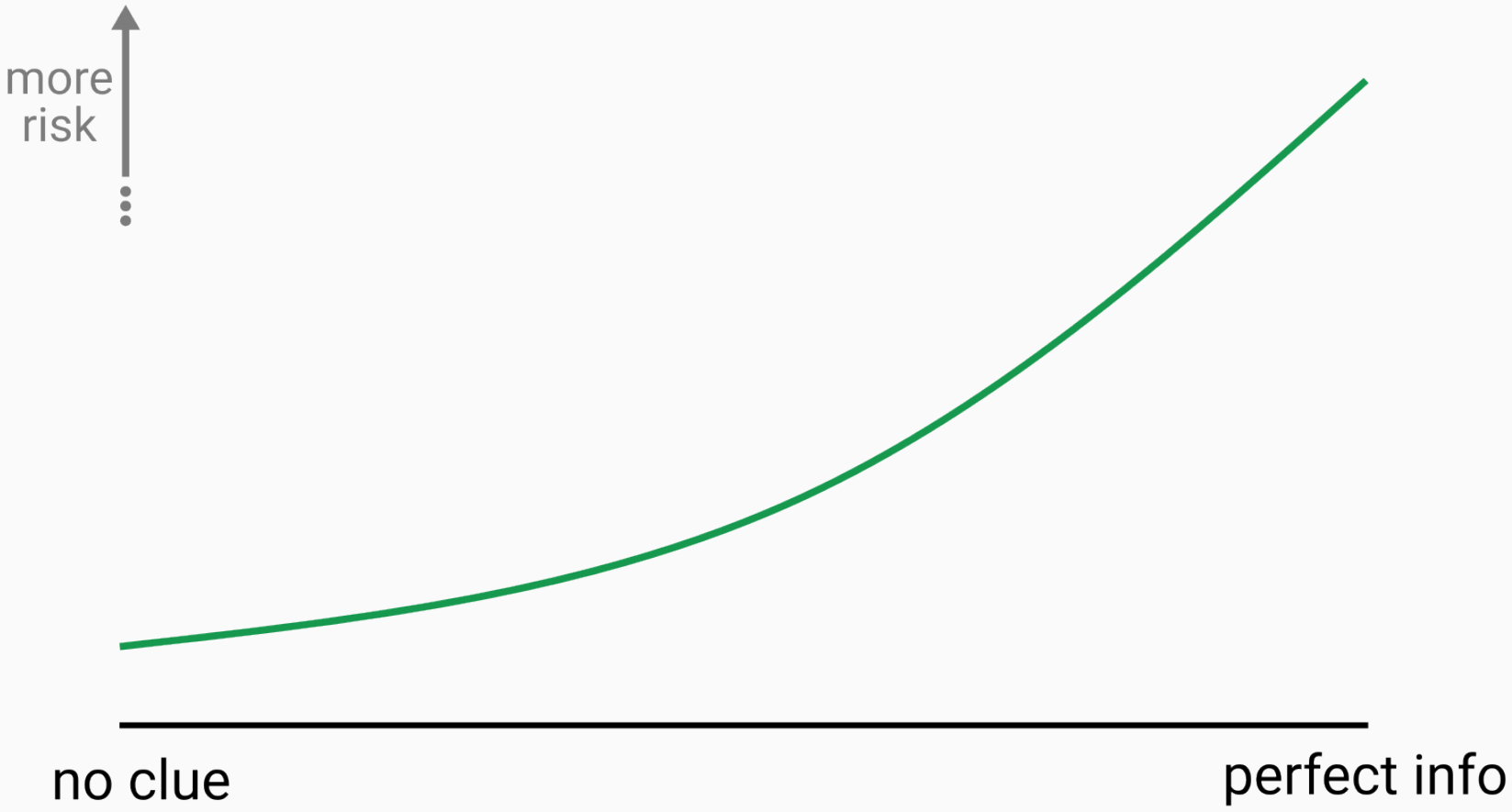
Does the external validity of the measures of risk taking improve when considering more layers of ignorance? What correlates more with naturally occurring behaviour – a choice under risk, ambiguity, or deep uncertainty?

Two research questions: graphically

1. Ignorance and risk taking

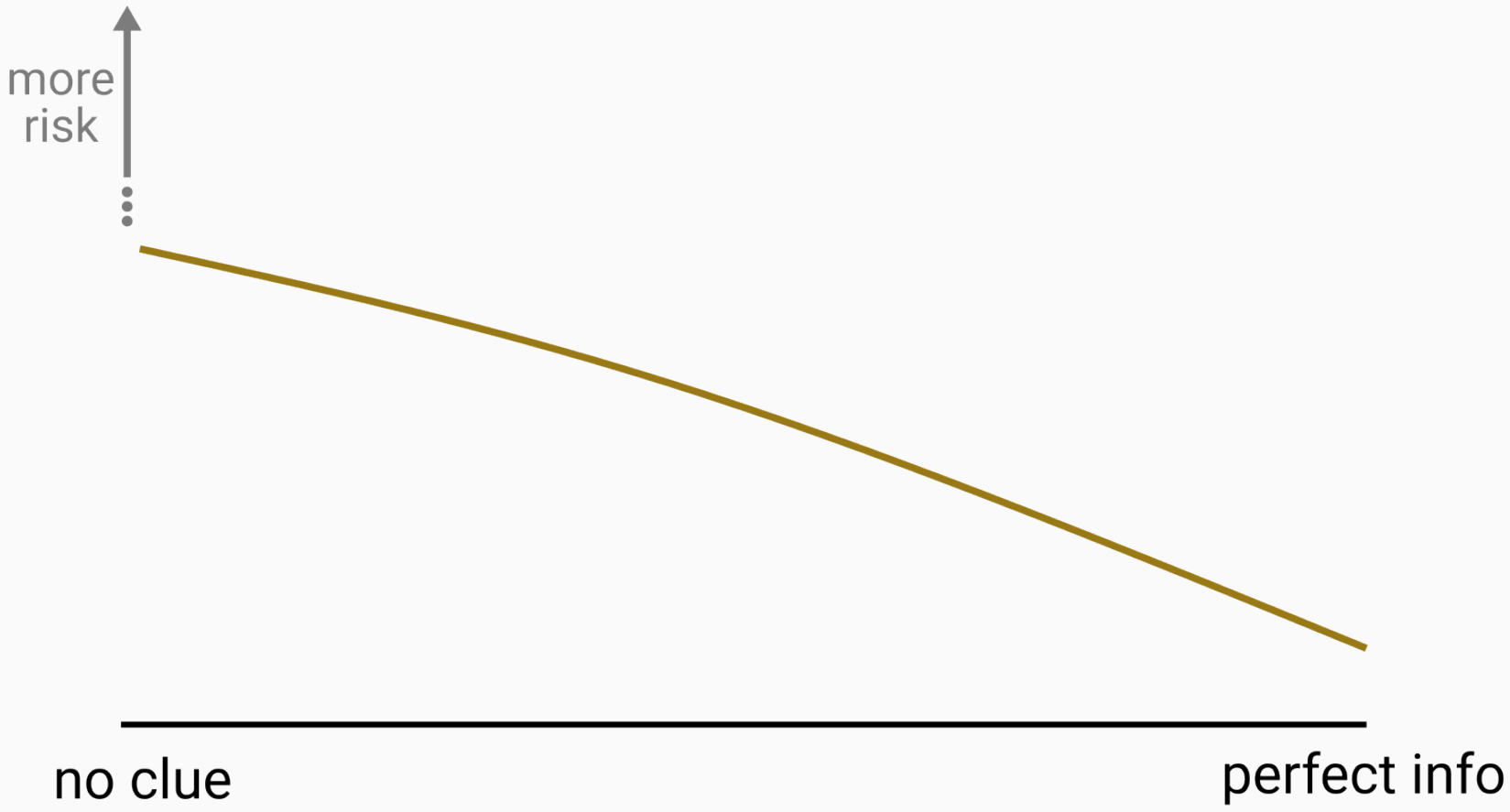
Two research questions: graphically

1. Ignorance and risk taking: a pessimist learner



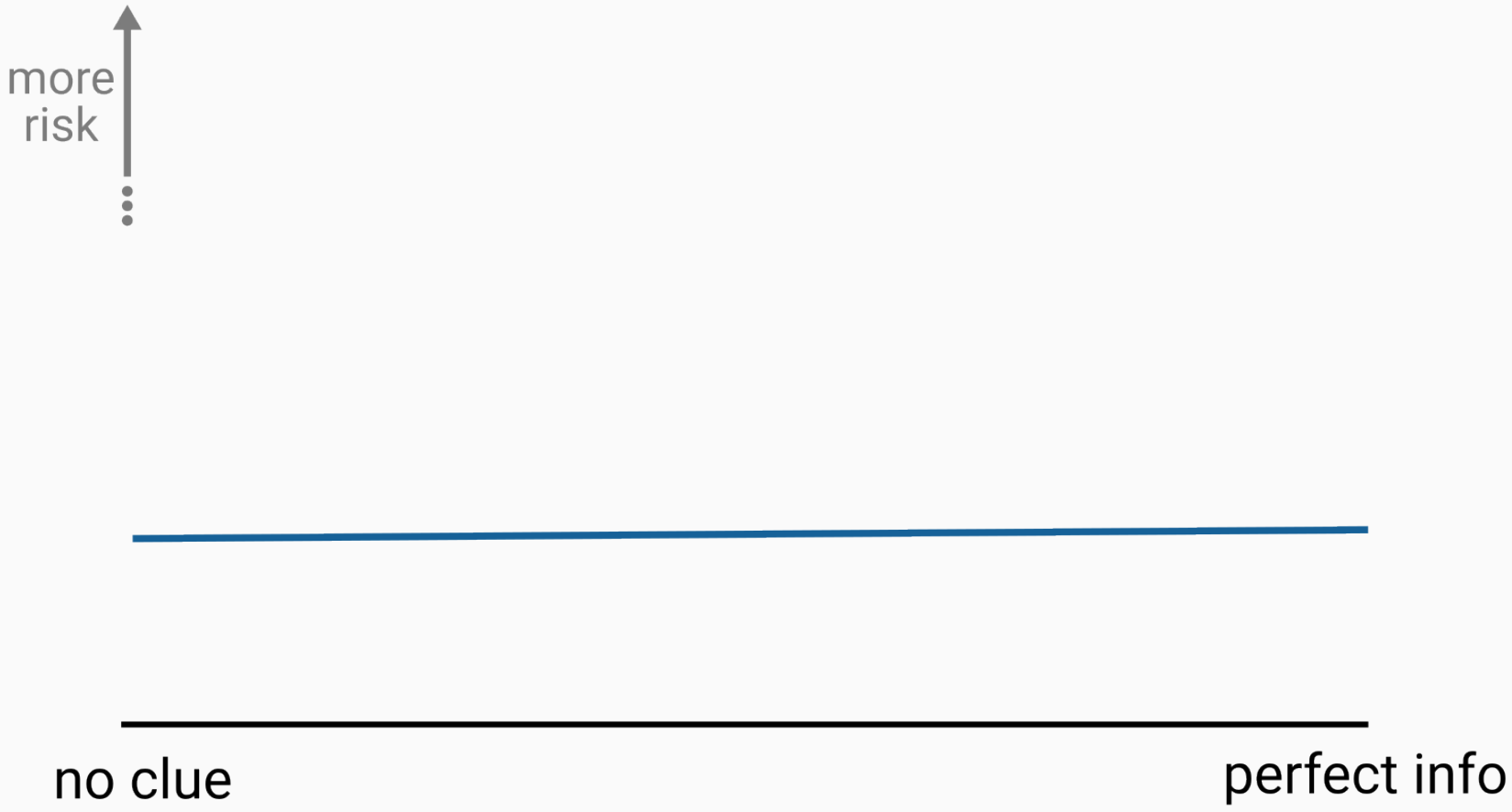
Two research questions: graphically

1. Ignorance and risk taking: an optimist learner



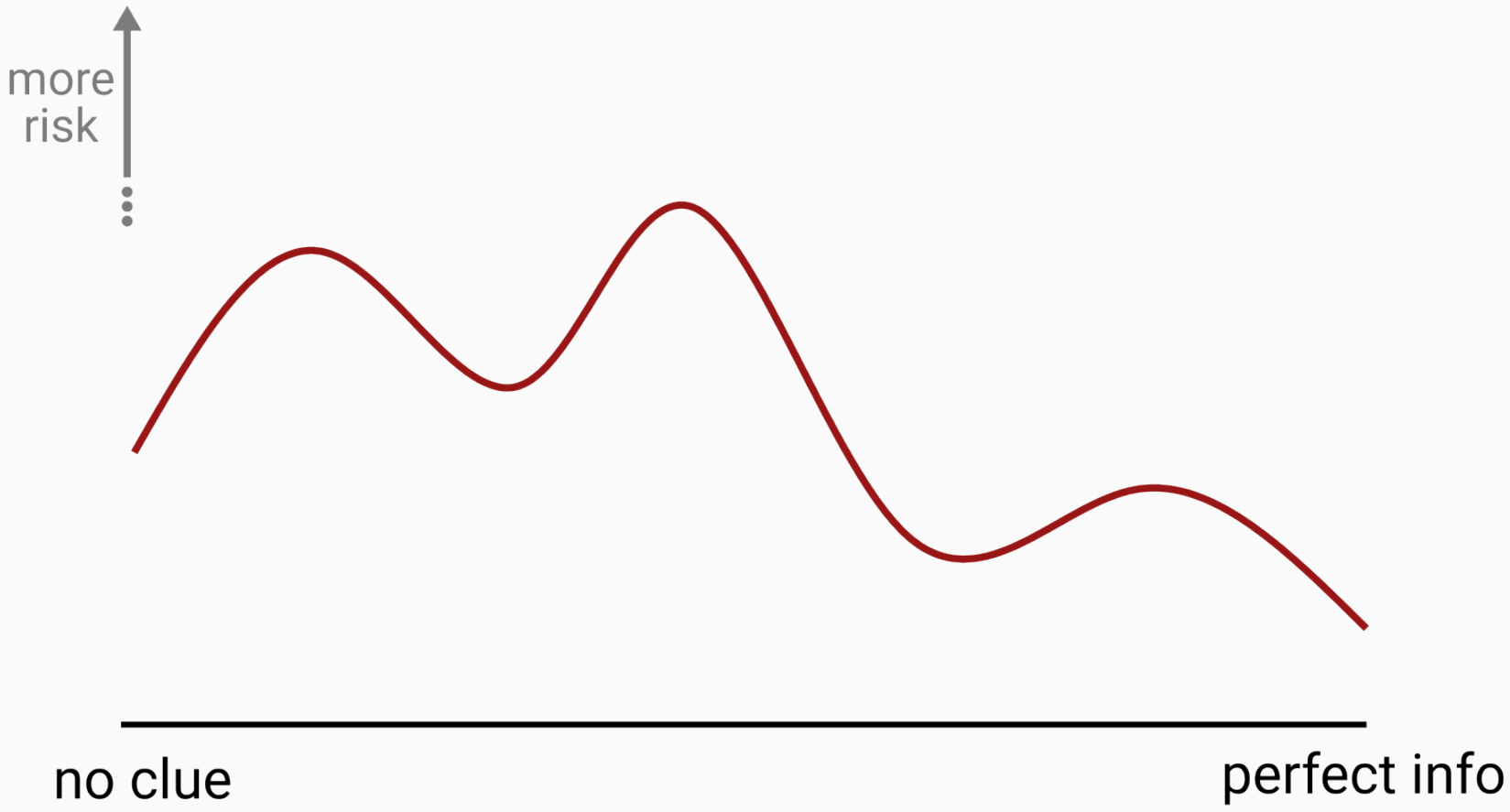
Two research questions: graphically

1. Ignorance and risk taking: impervious to information



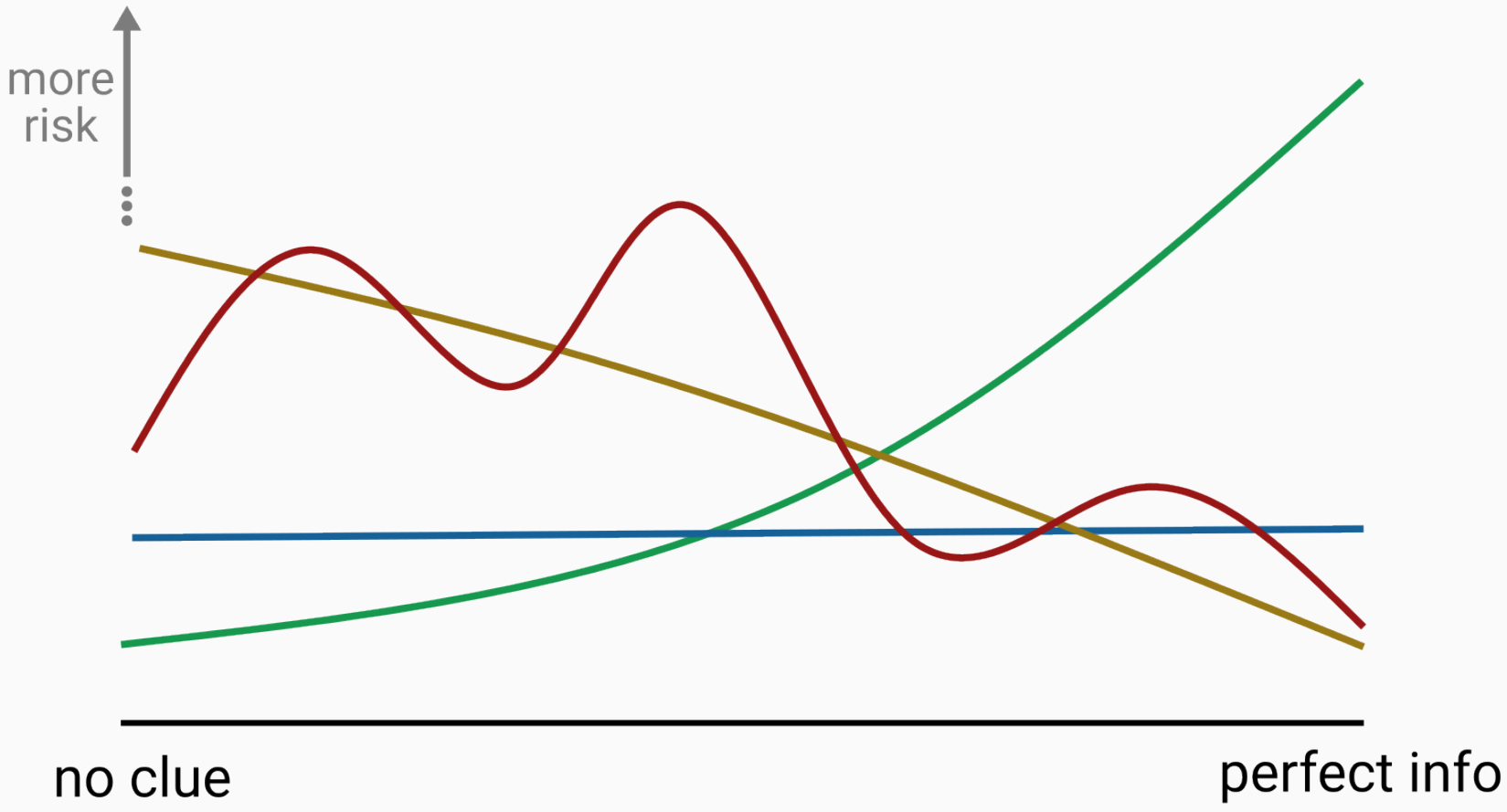
Two research questions: graphically

1. Ignorance and risk taking: an overreacter



Two research questions: graphically

1. **Ignorance and risk taking: join the choir!**



Two research questions: graphically

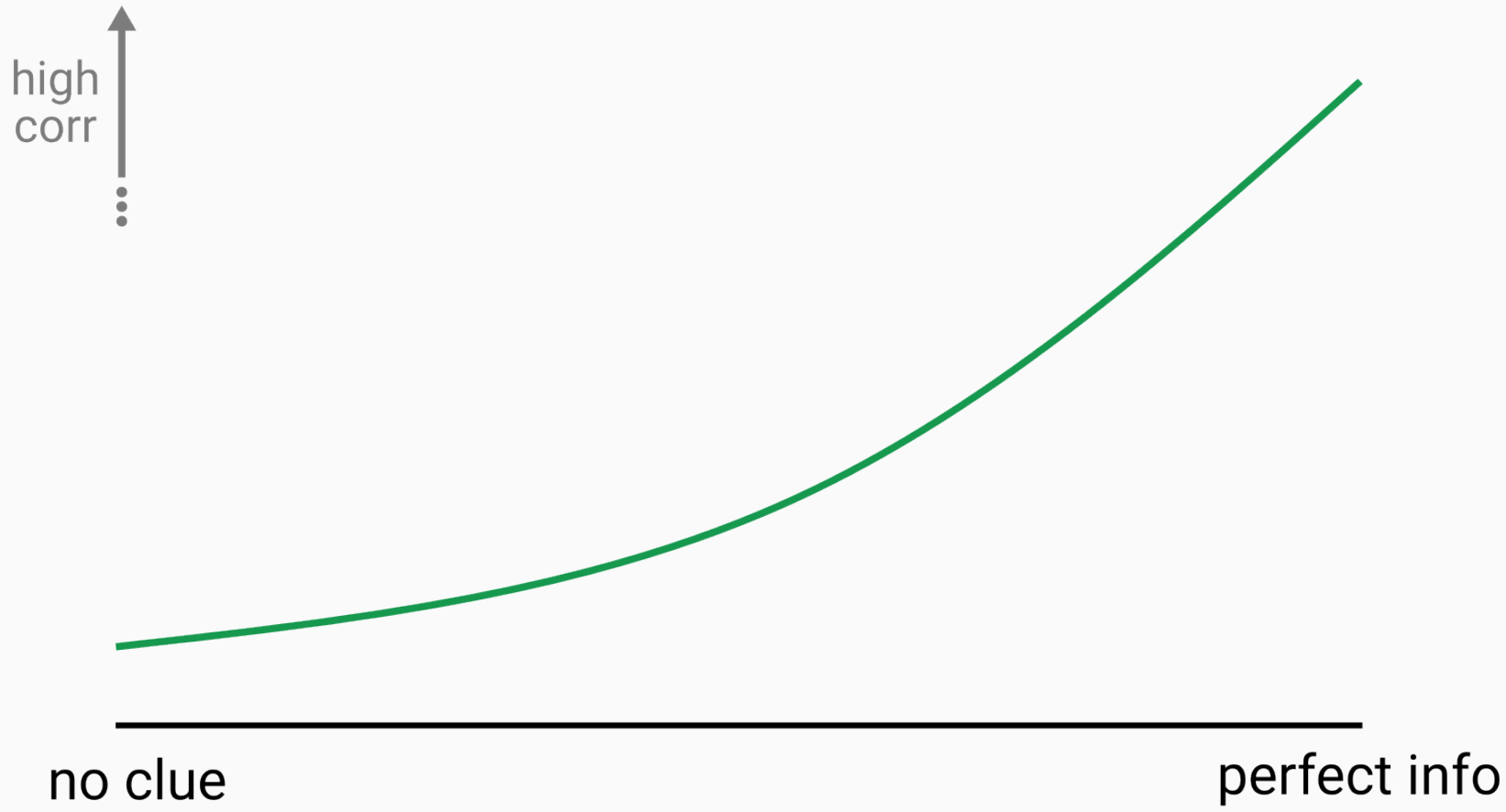
2. Ignorance & external validity:

no clue

perfect info

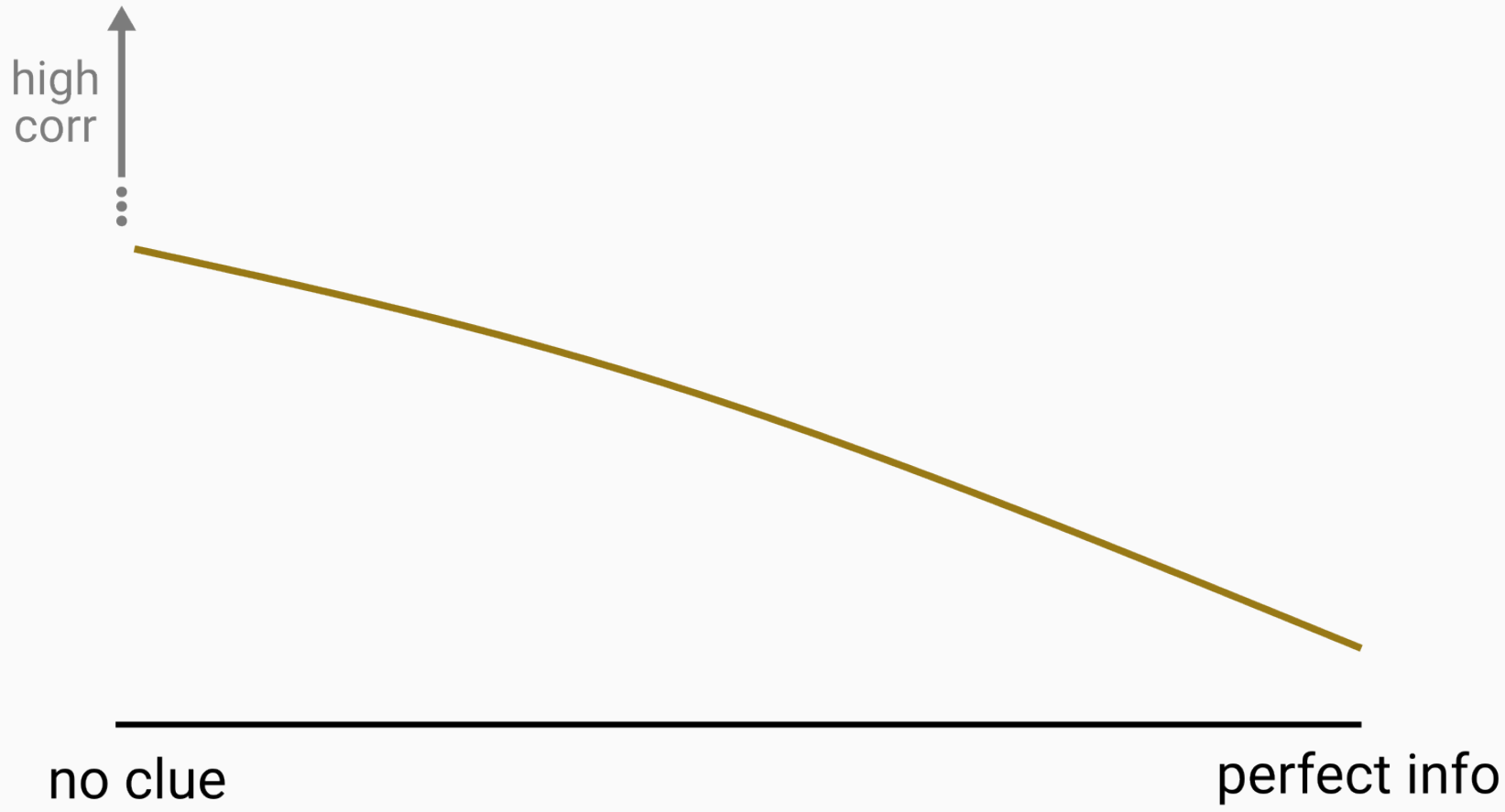
Two research questions: graphically

2. Ignorance & external validity: risk represents best



Two research questions: graphically

2. Ignorance & external validity: ignorance represents best



Two research questions: graphically

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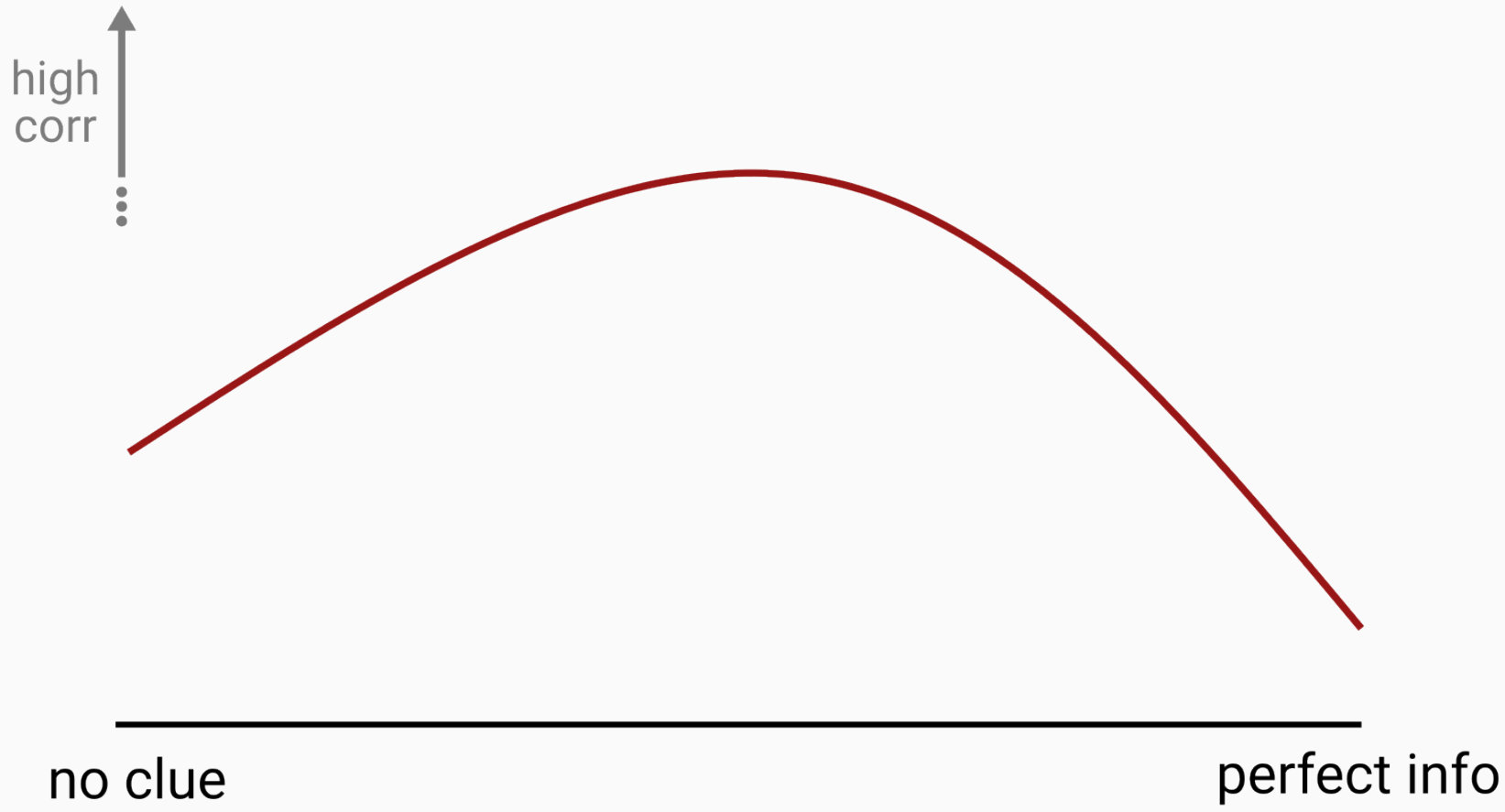
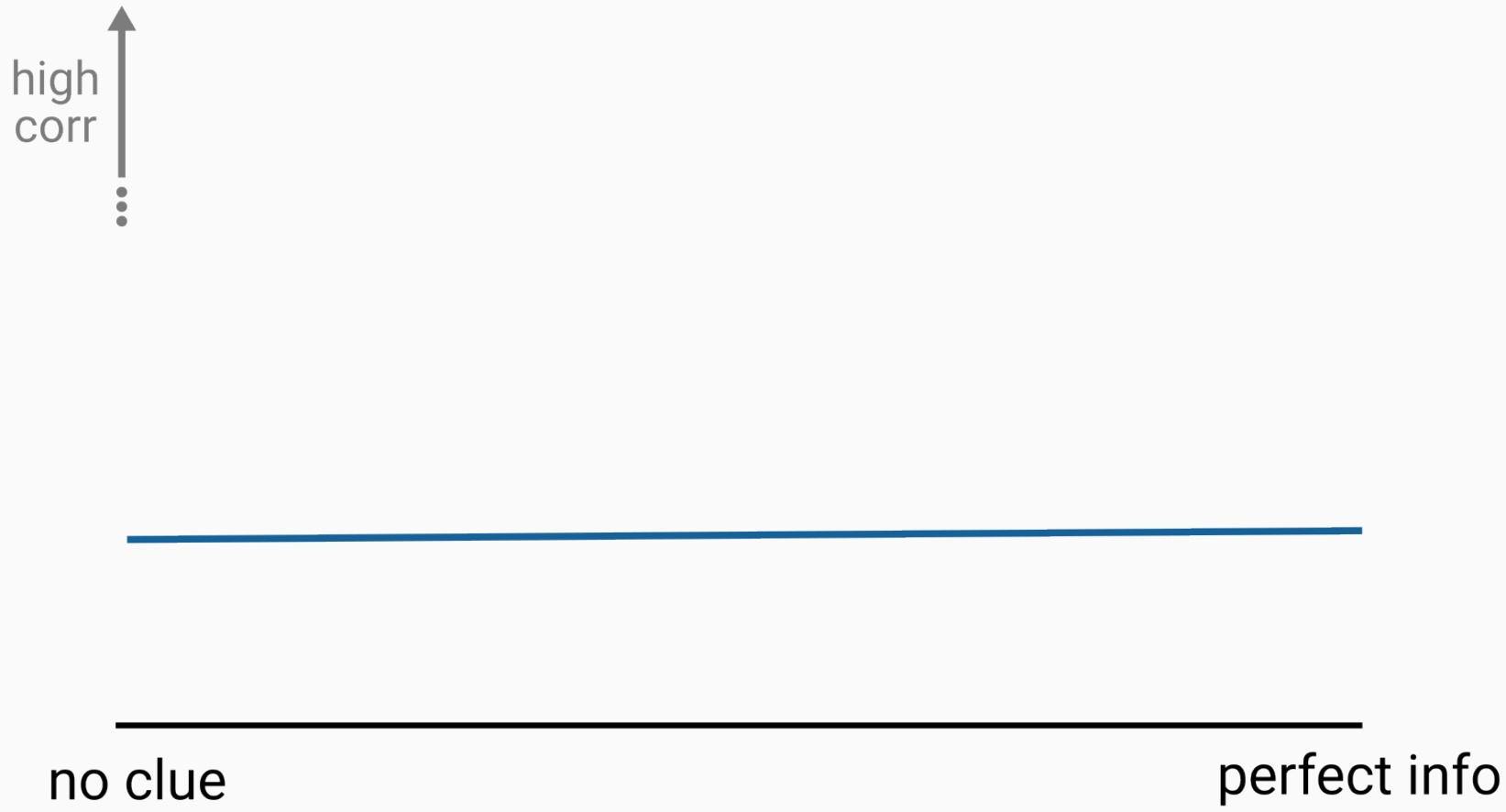


Two research questions: graphically

2. Ignorance & external validity: we're just wrong



I lied! there's sort of a third research question

1.5 In between: risk perception

We assume that risk perception plays the crucial pivot role between ignorance and choice – and hence also in the external validity of the elicited risk attitudes.

We expect perception to strongly anti-correlate with choice.

. . . summarising

We study ignorance $\Rightarrow$ risky choices $\Rightarrow$ external validity

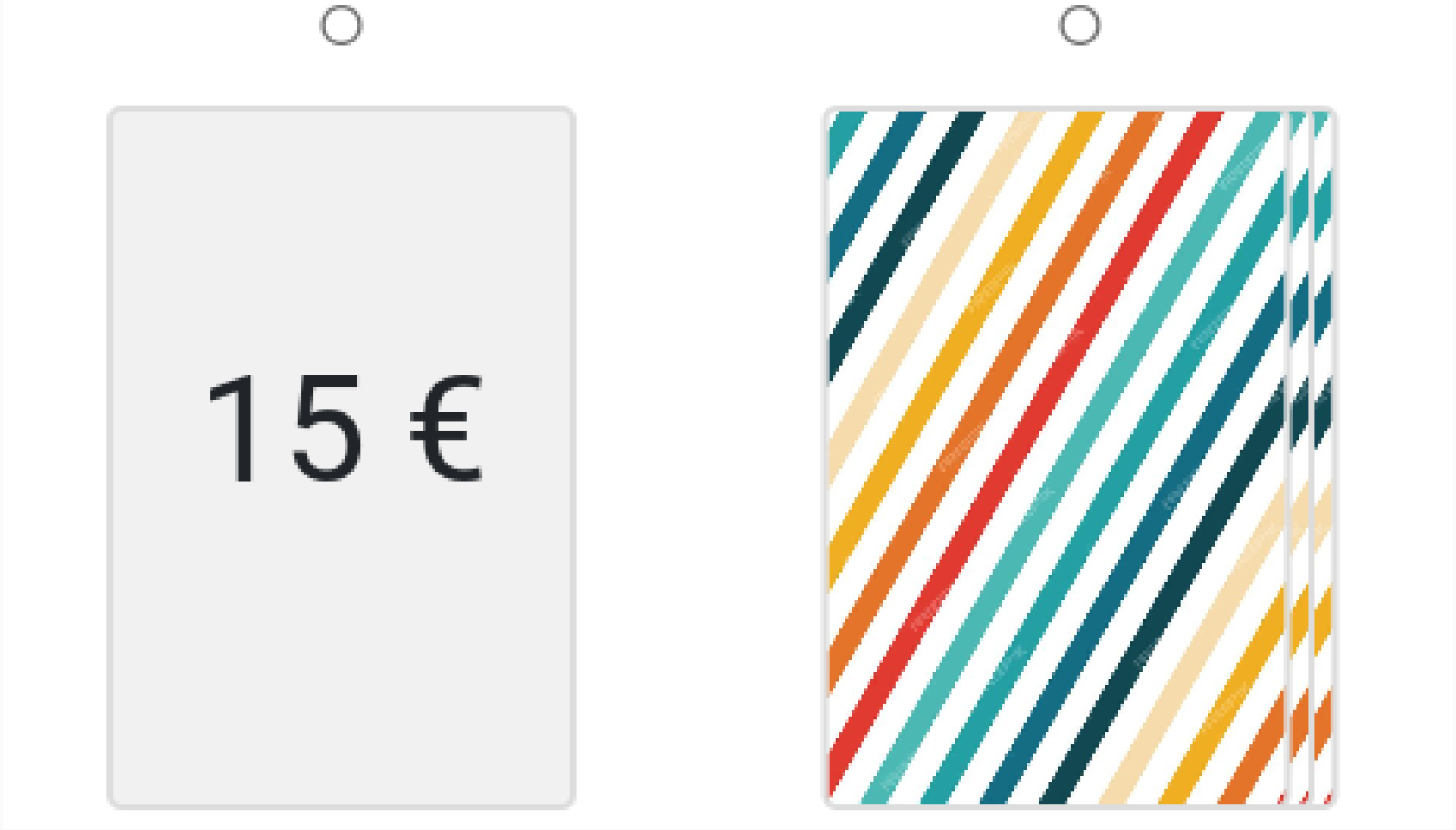
- Experimentally
- Without being backed by strong theory
- Still believing in the construct of risk (aversion)

Main Goal: bridging a gap between

- Risk as represented by economists & used in tasks
- Risk as perceived by subjects & fundamental for life

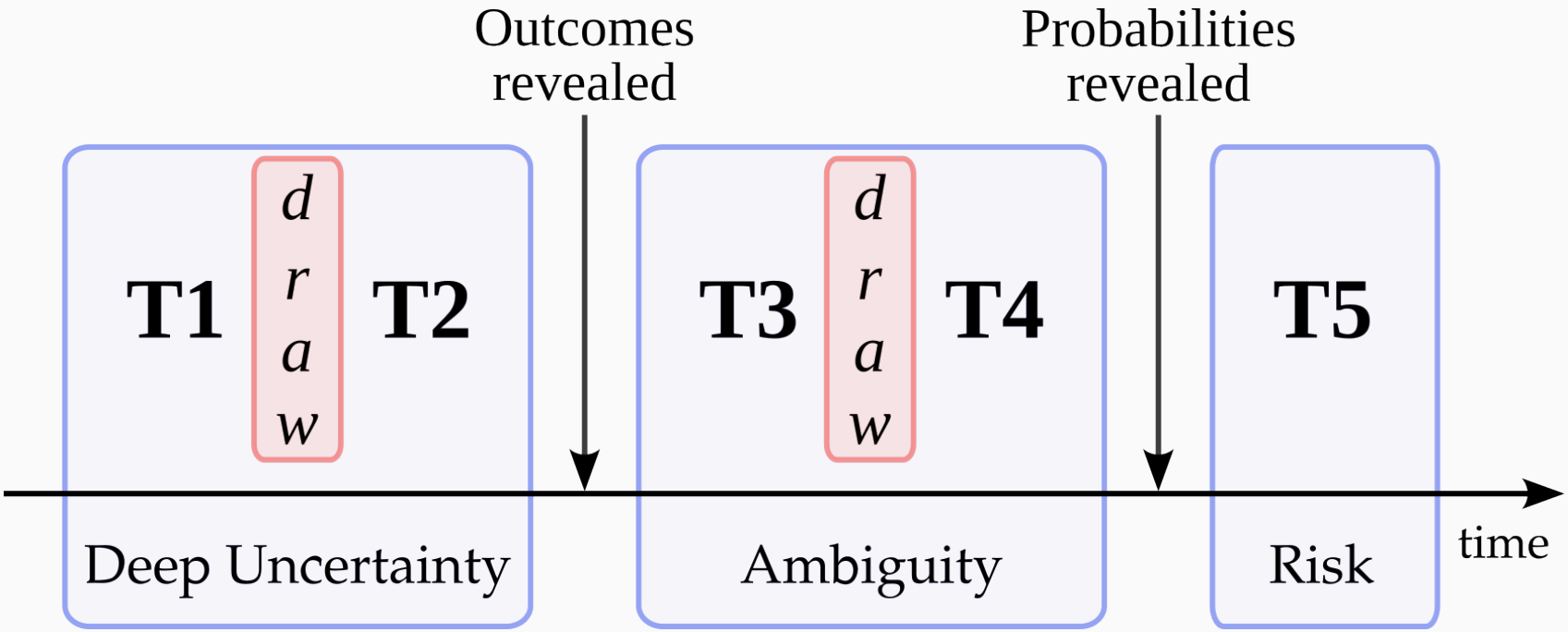
Experimental design: risk taking

The simplest possible task: binary choice, safe *vs* risky



"*deck contains up to 6 different positive or negative values*"

Repeated choices: more information (sampling + description)



Deep U: probabilities & outcomes *unknown*

Ambiguity: probabilities *unkown*, outcomes *known*

Risk: probabilities & outcomes *known*

The experiment: exploring different risky decks

- 60 cards (divisible by 2, 3, 4, 5, 6)
- EV = 20€ (assume risk averters)
- Varies in:
  - presence of losses [yes/no];
  - probability and amount of loss;
  - variance;
  - skewness [sym; skew low; skew high];
  - number of outcomes [2,3,4].
- Sample: draw 6 cards (with replacement)

17 different decks: overview

	p1	v1	p2	v2	p3	v3	p4	v4	Type
1	*0.50*	0	*0.50*	40					baseline
2	*0.50*	10	*0.50*	30					low variance
3	*0.25*	0	*0.50*	20	*0.25*	40			3 outcomes
4	*0.25*	0	*0.25*	10	*0.25*	30	*0.25*	40	4 outcomes
5	*0.33*	0	*0.67*	30					lean good
6	*0.50*	10	*0.25*	20	*0.25*	40			lean bad 3
7	*0.75*	0	*0.25*	80					lean bad
8	*0.50*	-10	*0.50*	50					base + loss
9	*0.25*	-10	*0.50*	20	*0.25*	50			3 + loss
10	*0.33*	-5	*0.33*	25	*0.33*	40			3 + loss
11	*0.25*	-10	*0.25*	0	*0.25*	40	*0.25*	50	4 + loss
12	*0.25*	-10	*0.75*	30					lean good + loss
13	*0.50*	-10	*0.25*	40	*0.25*	60			lean bad + loss
14	*0.67*	-5	*0.33*	70					lean bad + loss
15	*0.25*	5	*0.50*	20	*0.25*	35			3 outcomes
16	*0.50*	-5	*0.50*	20	*0.25*	45			3 outcomes + loss
17	*0.50*	20	*0.50*	20					Monotonicity check

Experimental design: external validity

Our external validity setup

The Daily Reconstruction Method

*Anonymized, self-reported list of daily active decisions under risk, irrespective if the risk was taken or avoided, filled at home every evening over **14** days.*

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For each activity:

- **Domain**: health, safety, recreation, drive, financial, ethics, social
- **Perception**: of the risk avoided or taken (-10..0..10)
- **Outcomes**: positive (0..10) and negative (0..-10) consequences
- **Probabilities**: positive and negative consequences (0..100%)

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External judges

- 4 “judges” hired to rate the overall risk taking by subjects
- For each activity, they fill the same questions as subjects

Experimental details

Sample.	General population, France 252 'new' subjects + 104 subjects for whom we have the DRM
Payment.	15€ show-up fee + 1 choice paid (EV: 15-20€)
Choices.	17 decks in Random Order
Duration.	About 1h
Lab.	Grenoble INP
Pre-reg.	of course, it's 2025

Exclusion criteria

Monotonicity check

we exclude all subjects for which

$$15 \succ \{100\% : 20\}$$

whenever the necessary information is available (T3, T4, T5)

69 out of 356 fail (mostly those who go always safe)

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Monotonicity check

we exclude all subjects for which

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69 out of 356 fail (mostly those who go always safe)

(failed) Reverse monotonicity check

we *should* also have excluded subjects for which

$$15 \prec \{100\% : 10\}$$

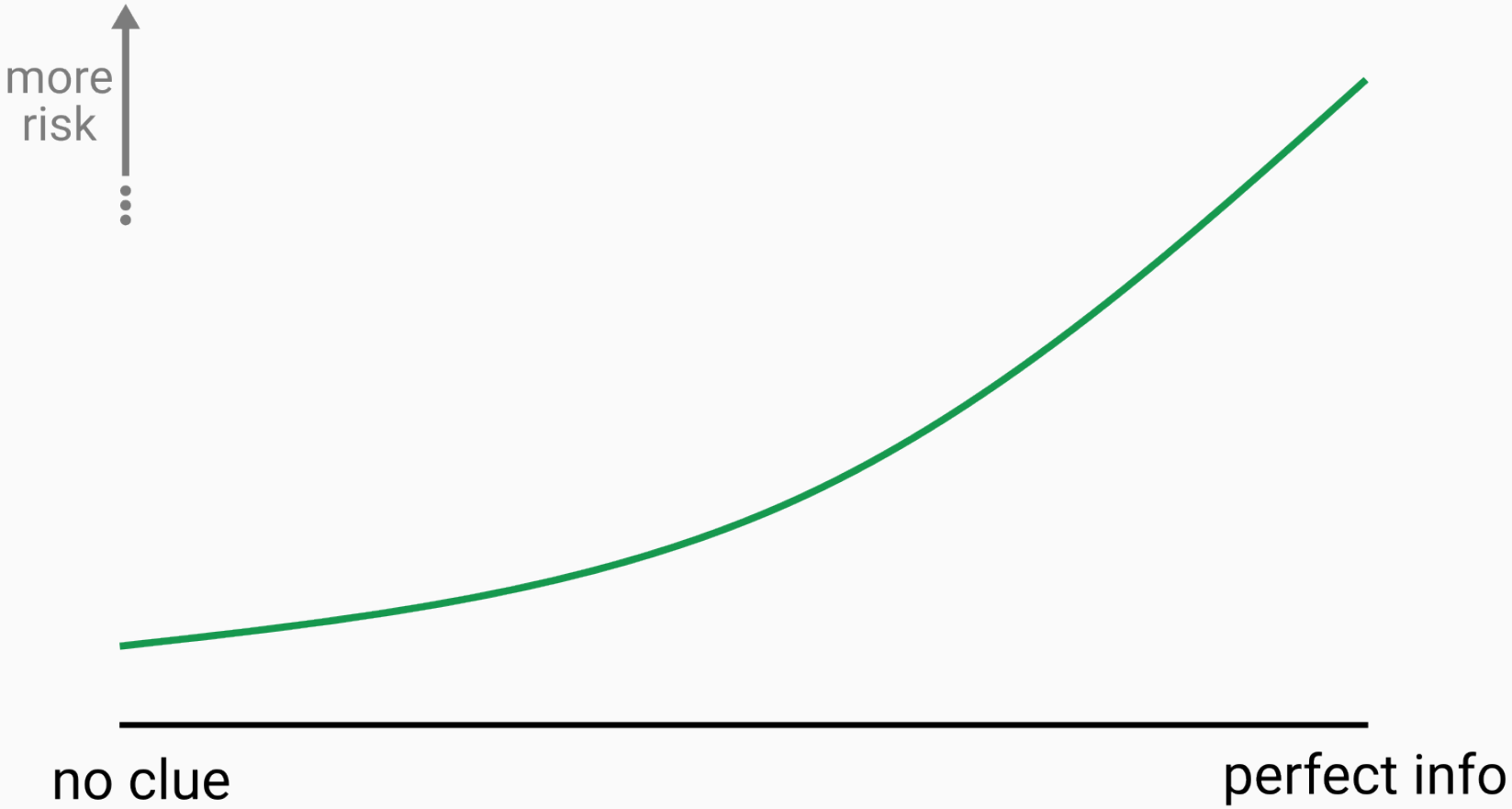
but we didn't expect this *unforeseen contingency*.

36 out of 356 fail (all of these go always risky)

Expected results

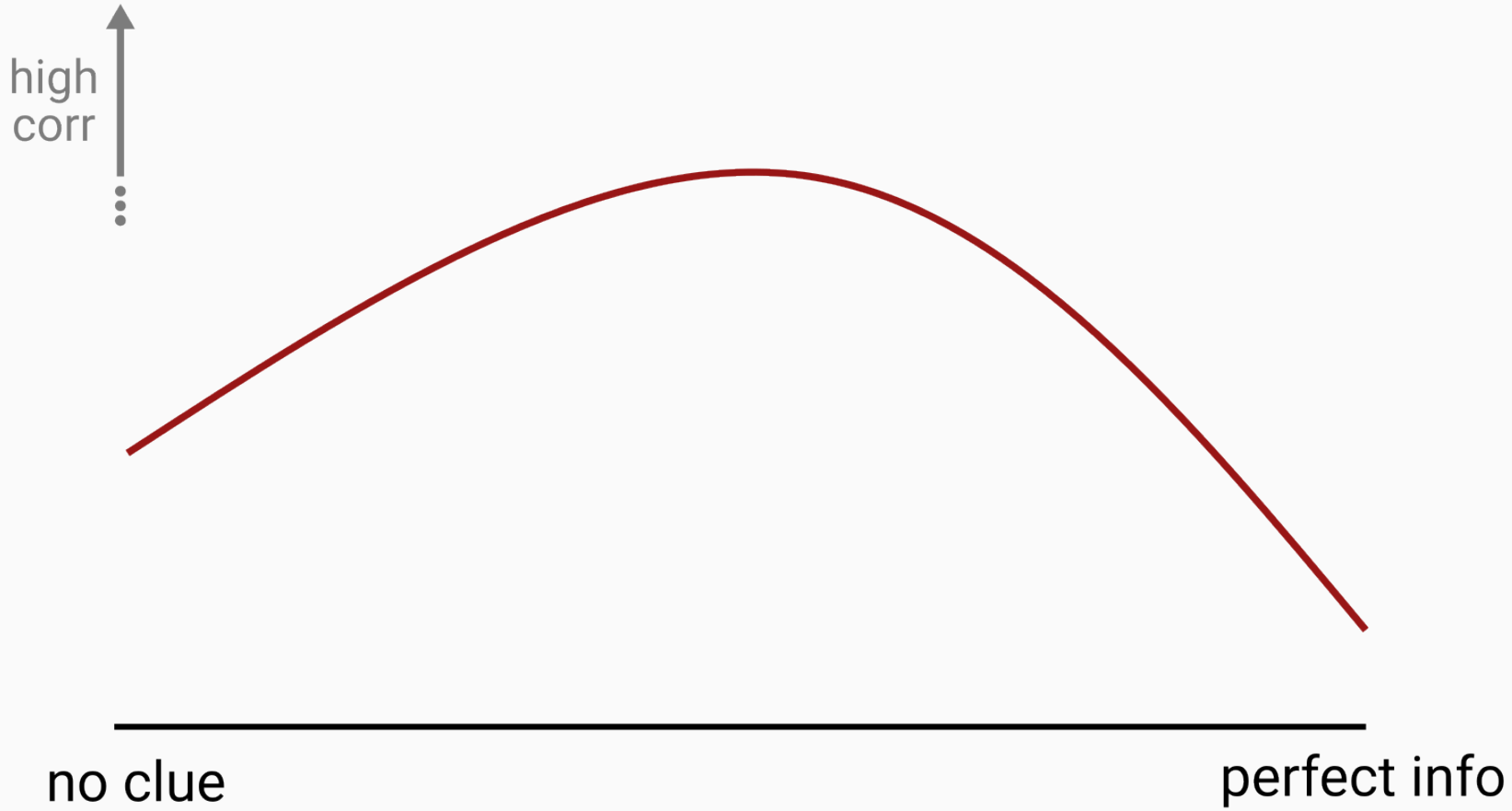
Ignorance will translate into apparent risk aversion

More info → more risk taken



Ambiguous situations will be closer to external behavior

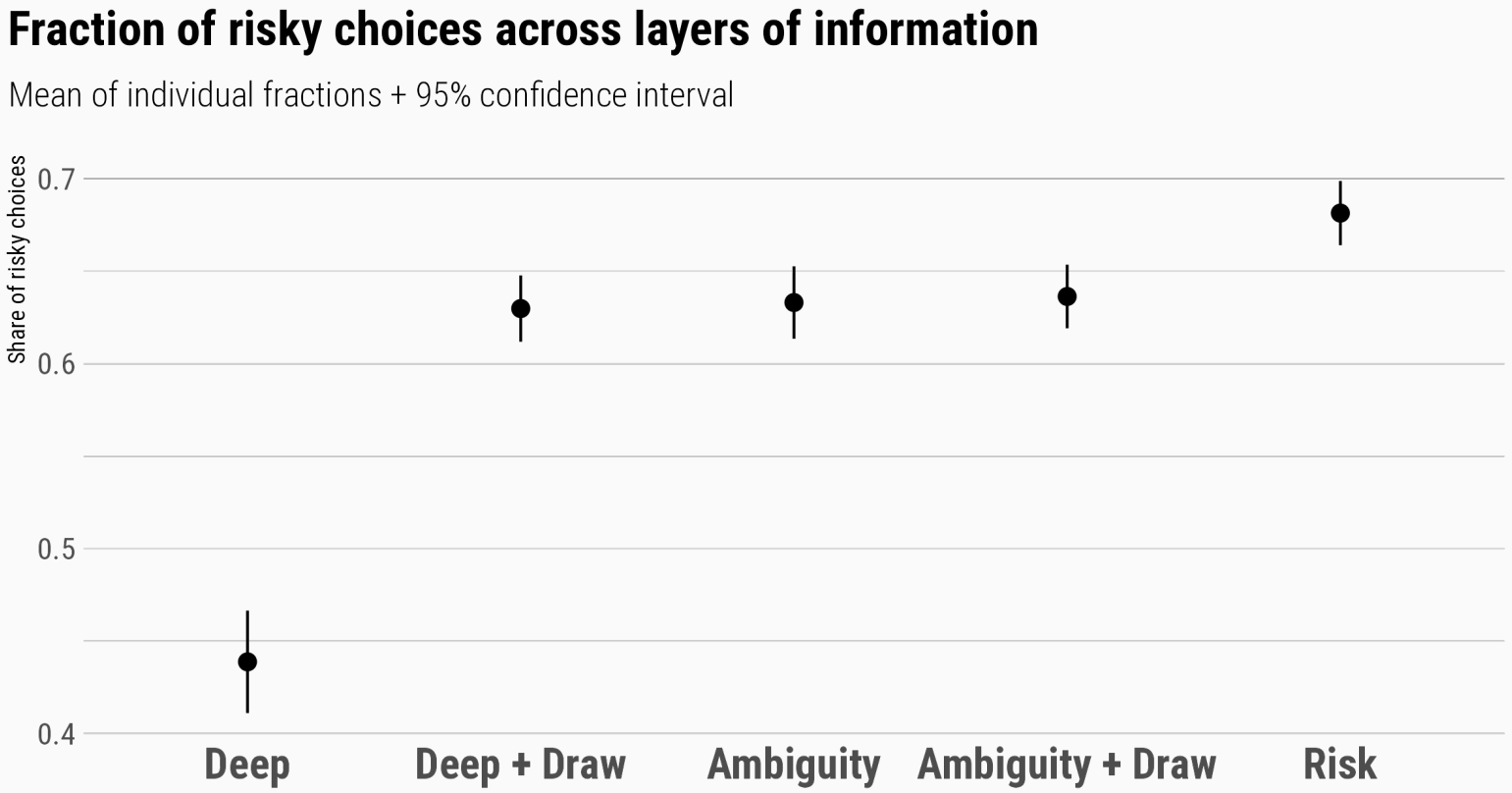
More info → inverse-U correlation with behavior



Actual results /1

Ignorance and risky choice

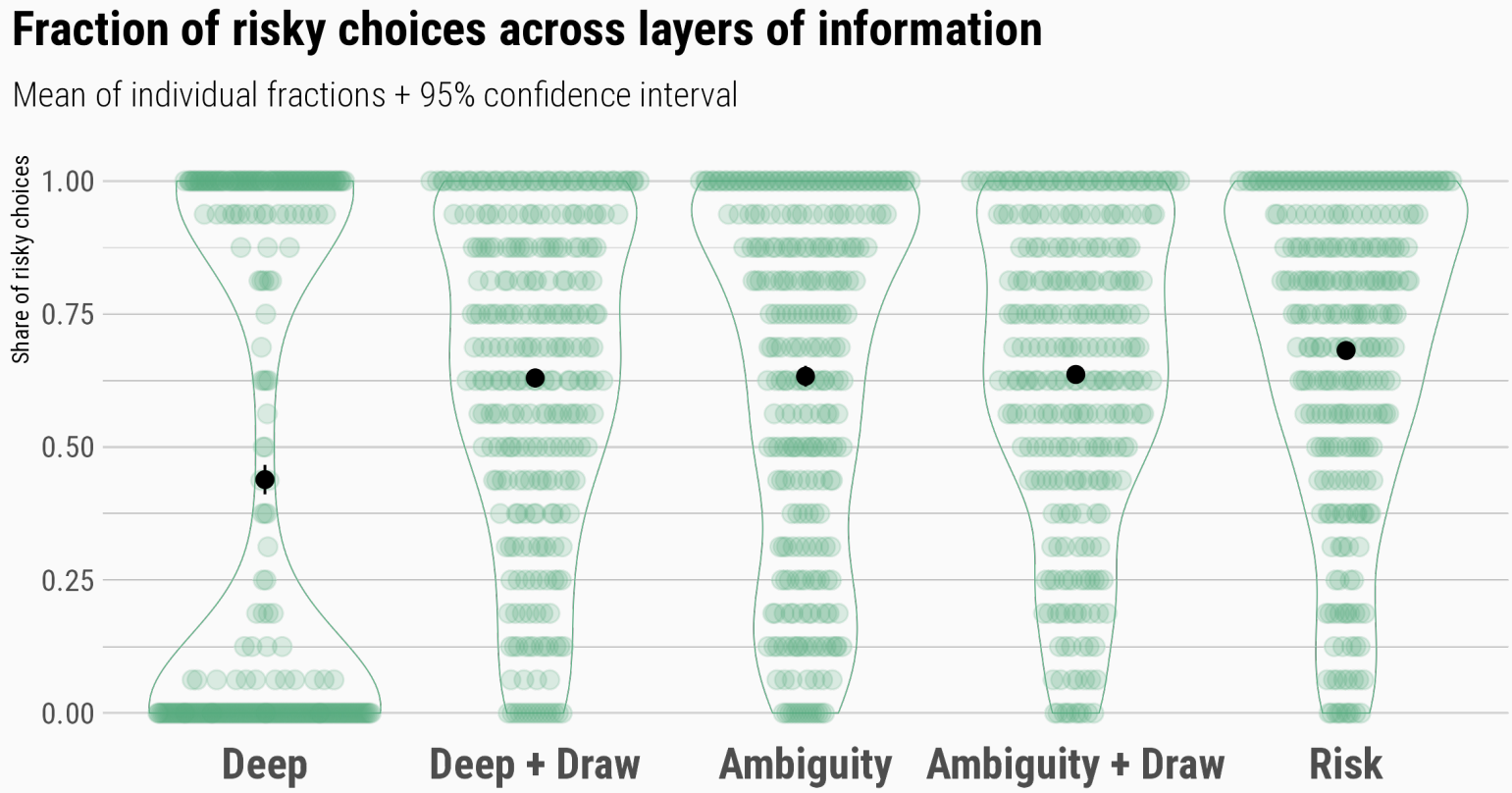
Revealing information increases risk taking



Deep significantly lower than all others ($p < 0.001$)

Risk significantly higher than all others ($p < 0.001$)

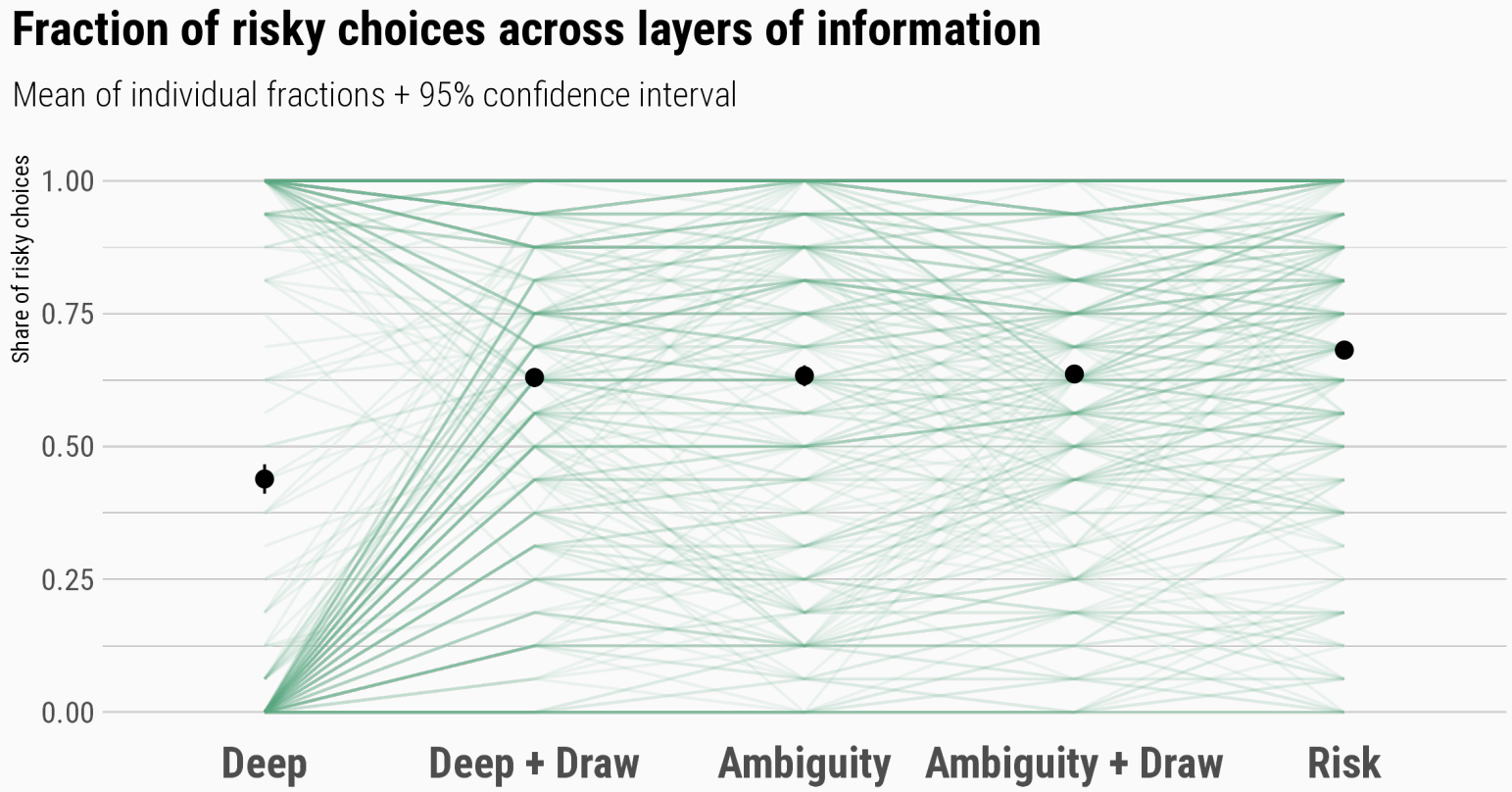
This hides significant heterogeneity across subjects



Deep mainly composition effect of separate groups

Shift more continuous than it seems

This hides significant heterogeneity across subjects



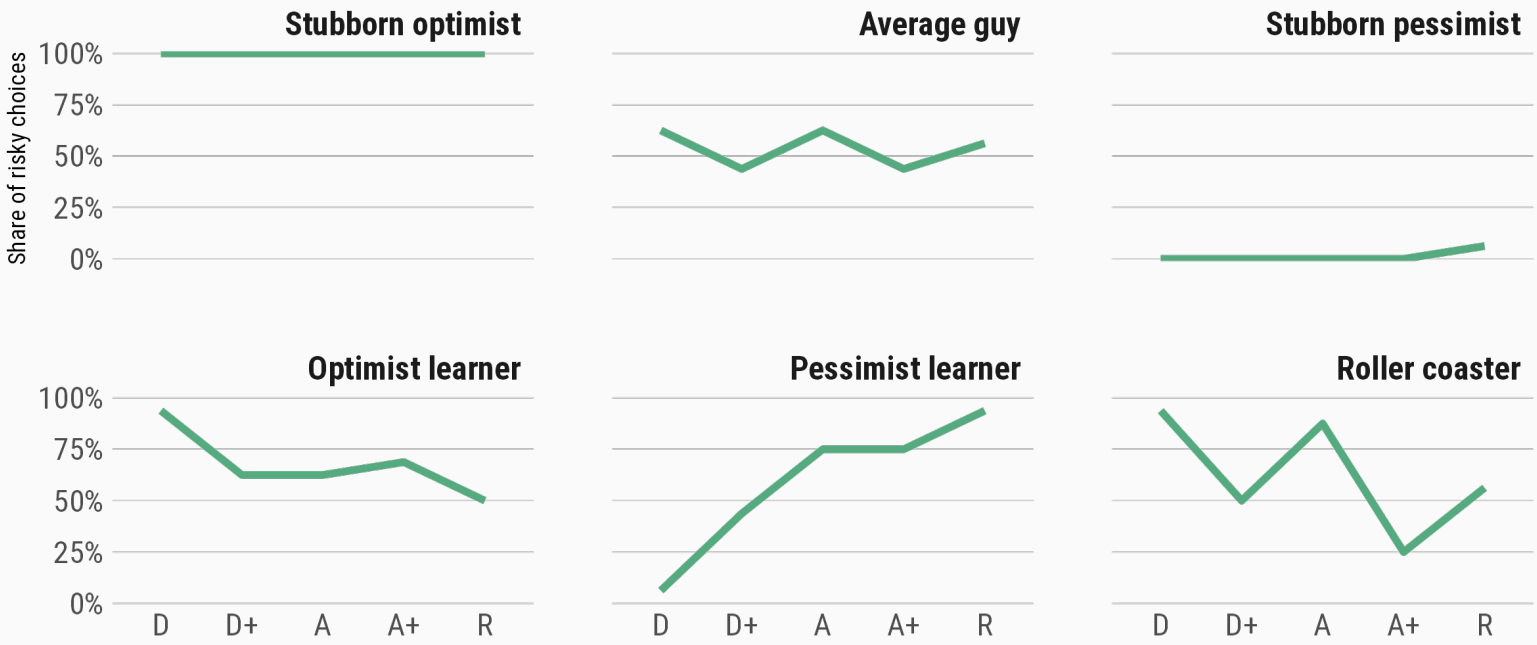
People show markedly different patterns

Shifts are mostly upwards – hence the general trend

This hides significant heterogeneity across subjects

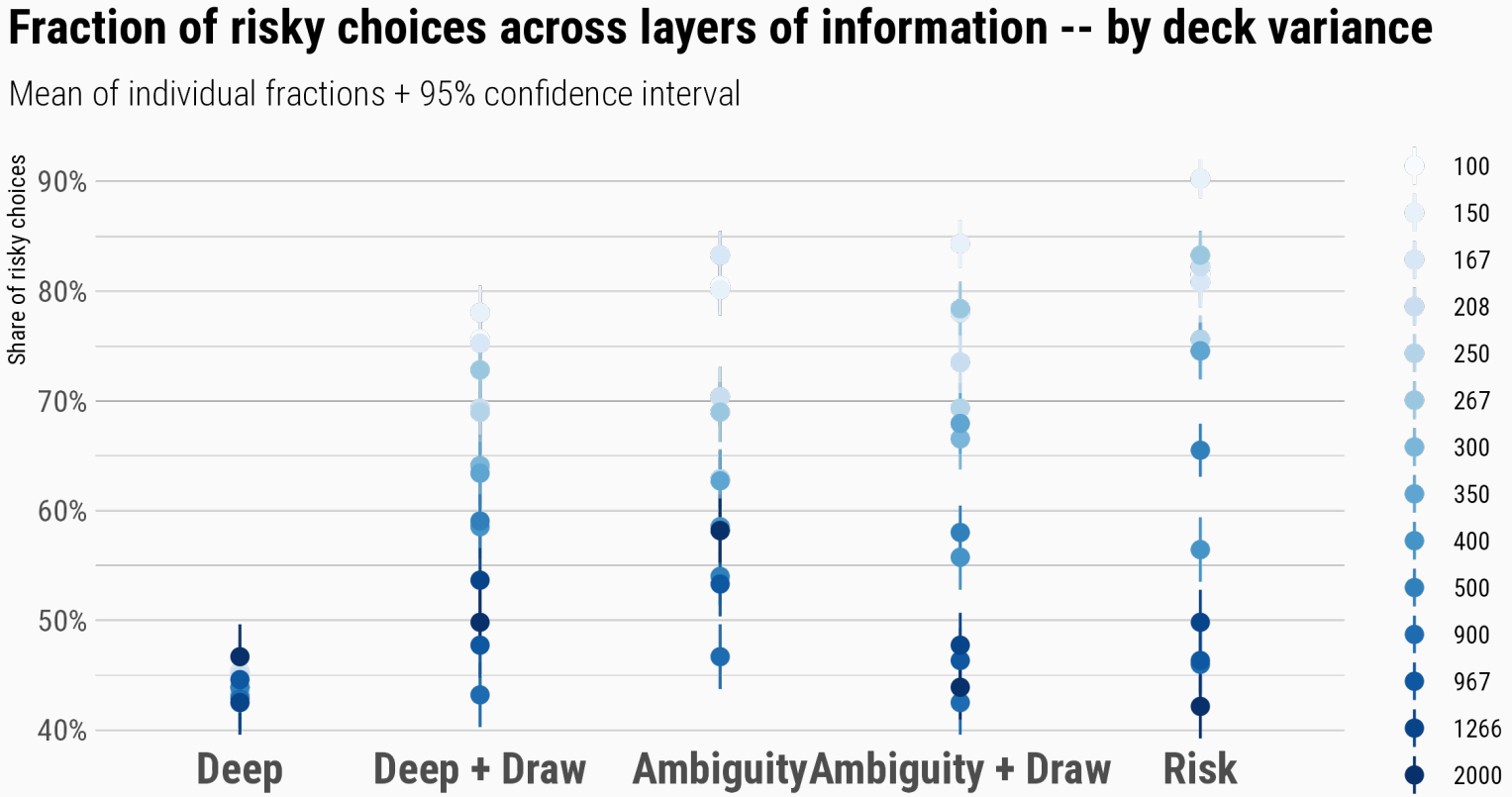
Fraction of risky choices across layers of information

Selection of individual patterns



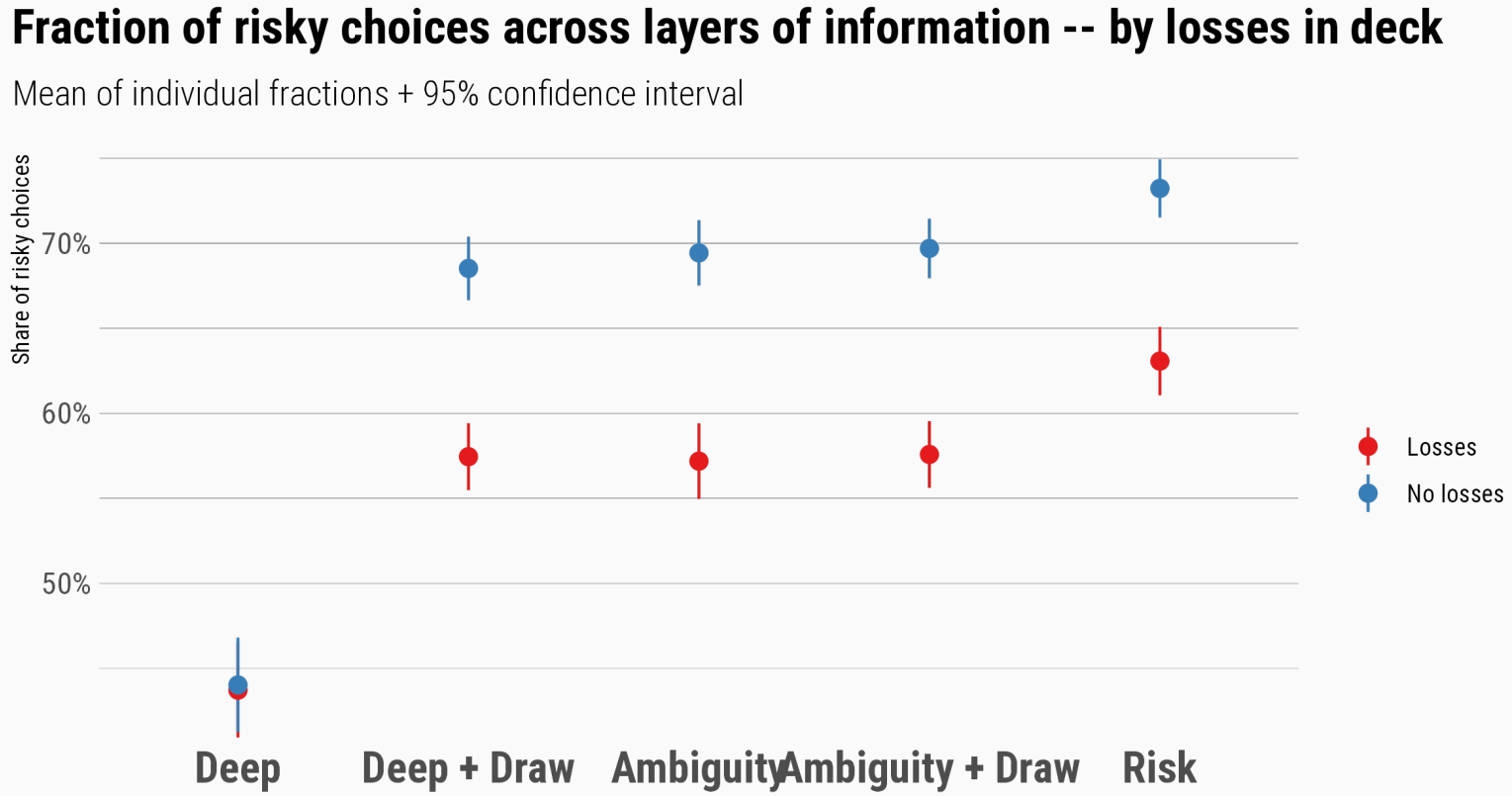
Types clearly emerge from individual analysis

This hides significant heterogeneity across decks



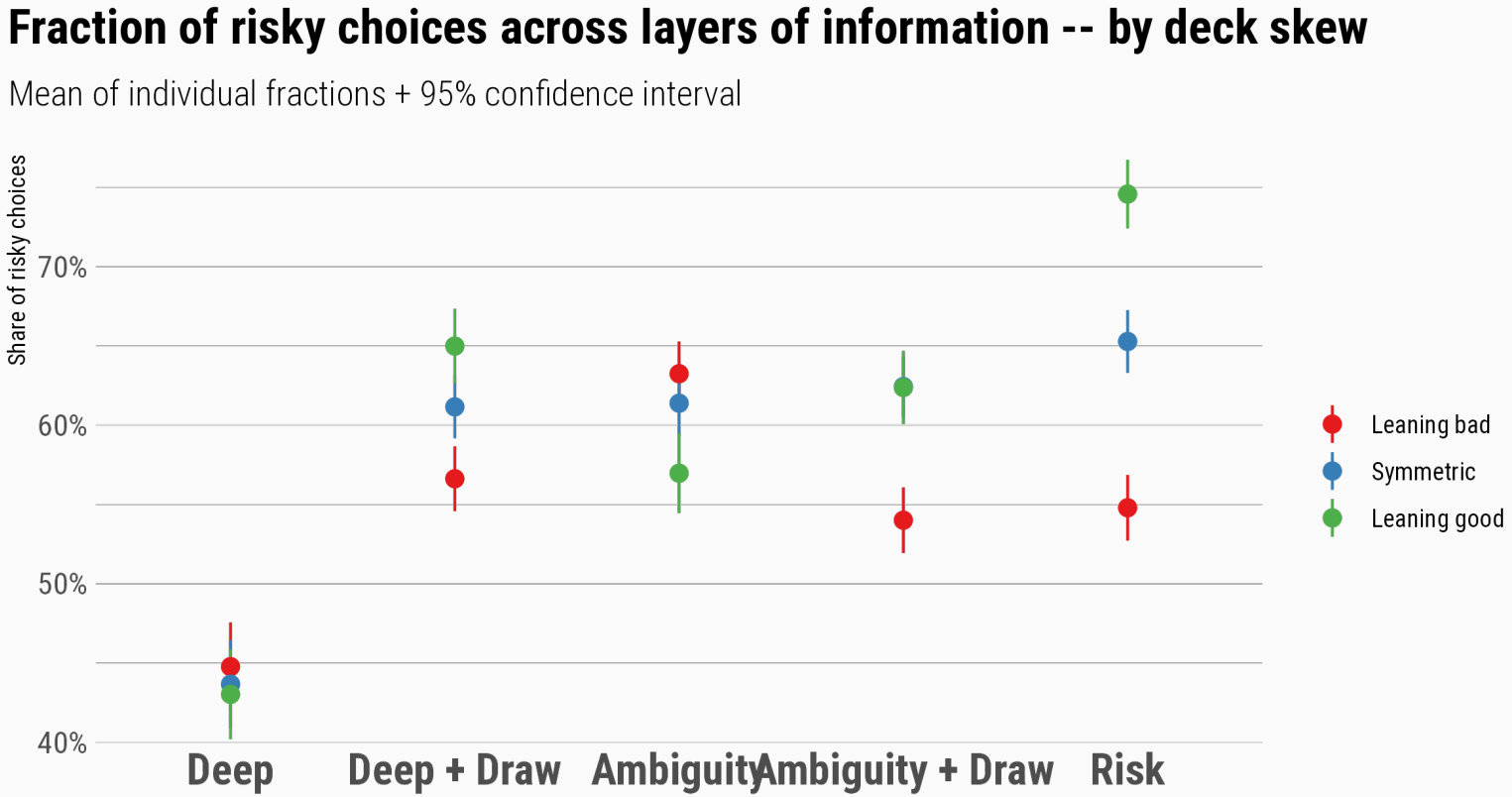
Variance in a deck clear predictor of safer choices

This hides significant heterogeneity across decks



Losses in a deck clear predictor of safer choices

This hides significant heterogeneity across decks



Skew impacts choices and impacts expectations

Any sign of long-term learning – carryover effects?

We deal with a dynamic panel, with **two** time dimensions:

1. Subsequent choices within each deck
2. Across decks, subjects may learn that $EV = 20$ or form expectations on the range of outcomes . . . there wouldn't be much Deep Uncertainty left at the end!

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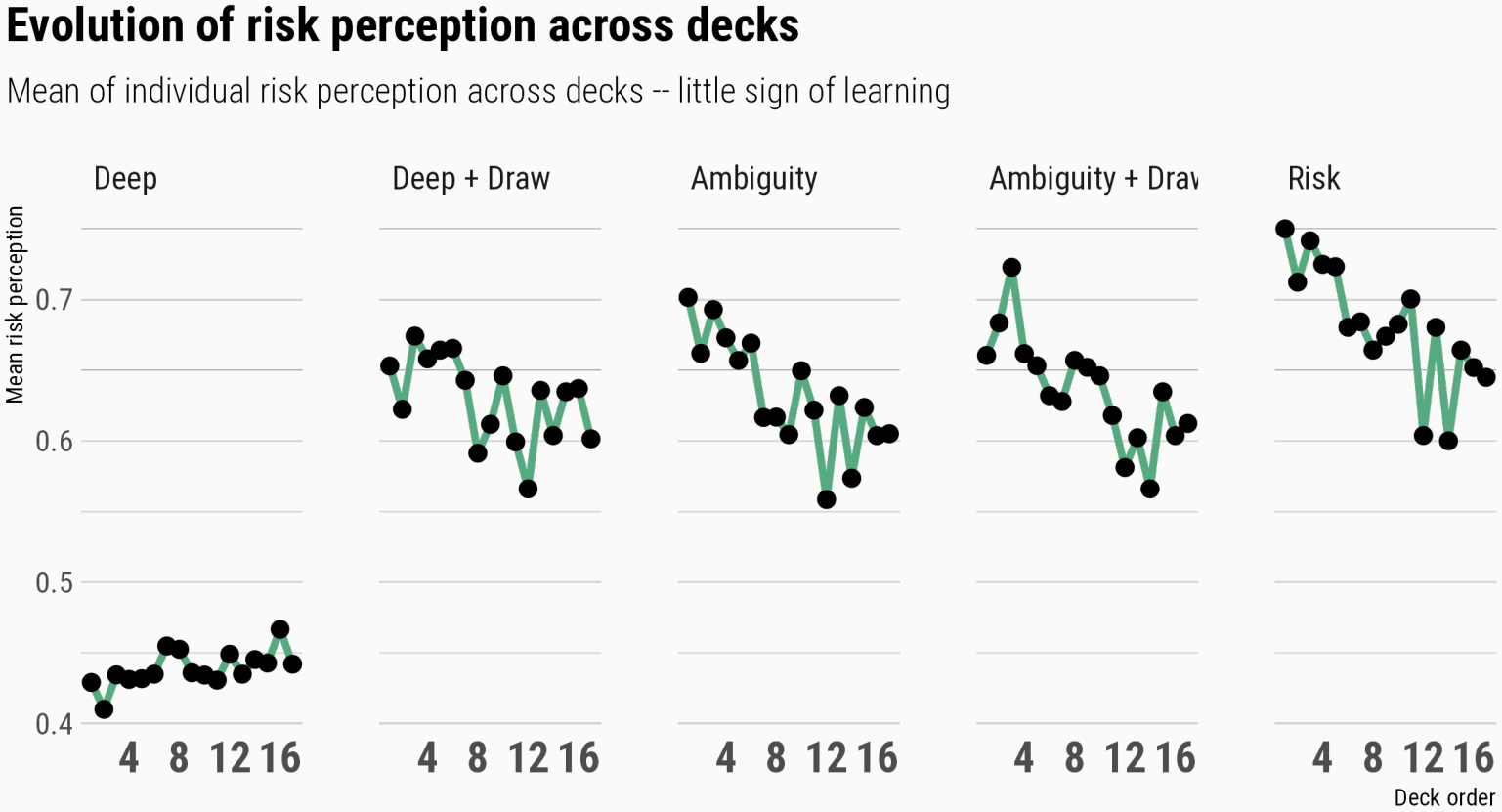
No evidence of learning across decks:

- *very* weak time trend in T1 (.0012 with $p \approx .02$)
- Adding controls it becomes negative (!) but very small

$\rightarrow$ Relevant time dimension is within decks
$\rightarrow$ Either blasé or goldfish subjects

Some trends appear when more information is available (???)



Negative trend in higher information stages (why?)

Multivariate Analysis

	Risky choice	
	LPM	Probit
Deep + Draw	0.220***	1.159***
Ambiguity	0.218***	1.154***
Ambiguity + Draw	0.221***	1.143***
Risk	0.282***	1.447***
Expected value of draws	0.016***	0.086***
Variance	-0.000***	-0.001***
Probability of a loss	0.009	0.274
Value of loss	-0.011***	-0.068***
Period	-0.008***	-0.043***
Period^2	0.000*	0.001*
Constant	0.426***	-0.253*
N	18648	18648

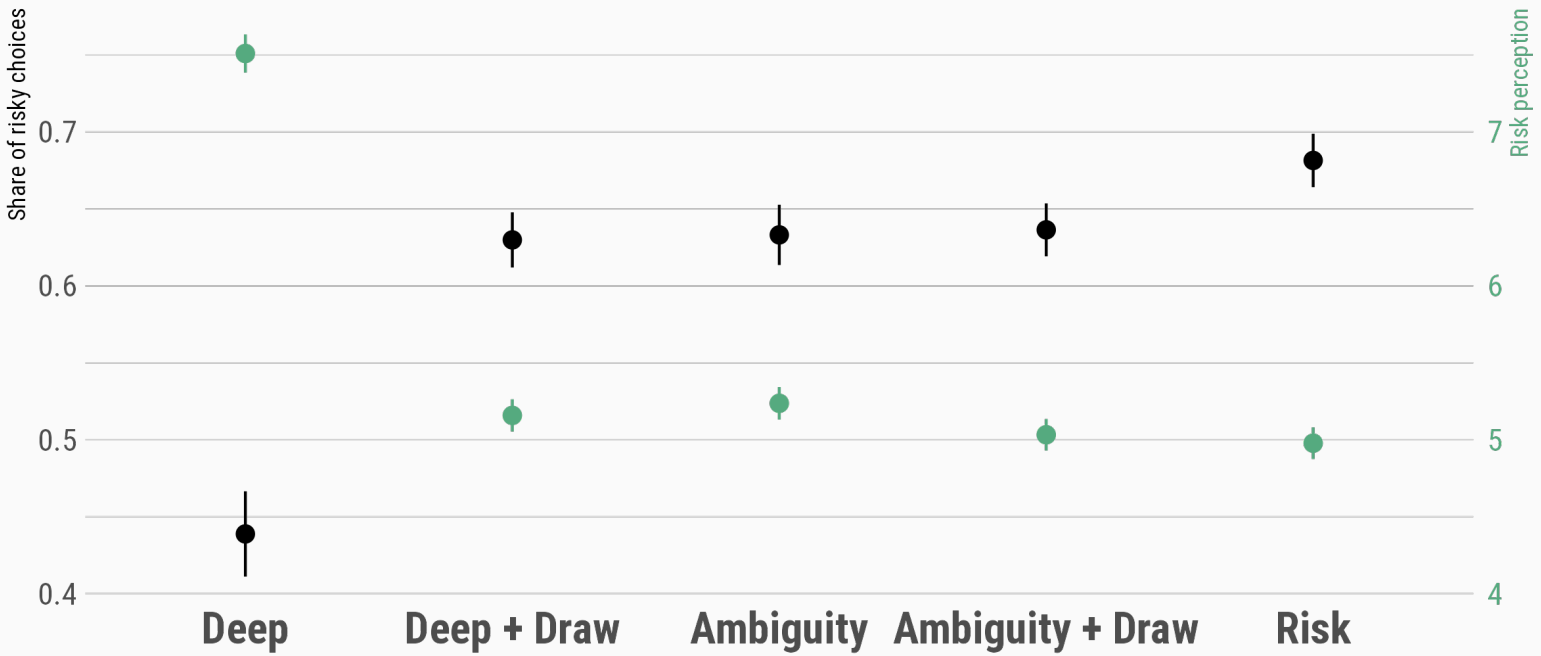
Results **survive** survives controlling for decks & draws

Actual results /1.5
Ignorance and risk perception

Risk perception and risky choices

Fraction of risky choices and risk perception across layers of information

Mean of individual fractions and risk perception + 95% confidence interval



'How risky do you find the deck as compared to the safe amount?' (Likert 0-10)

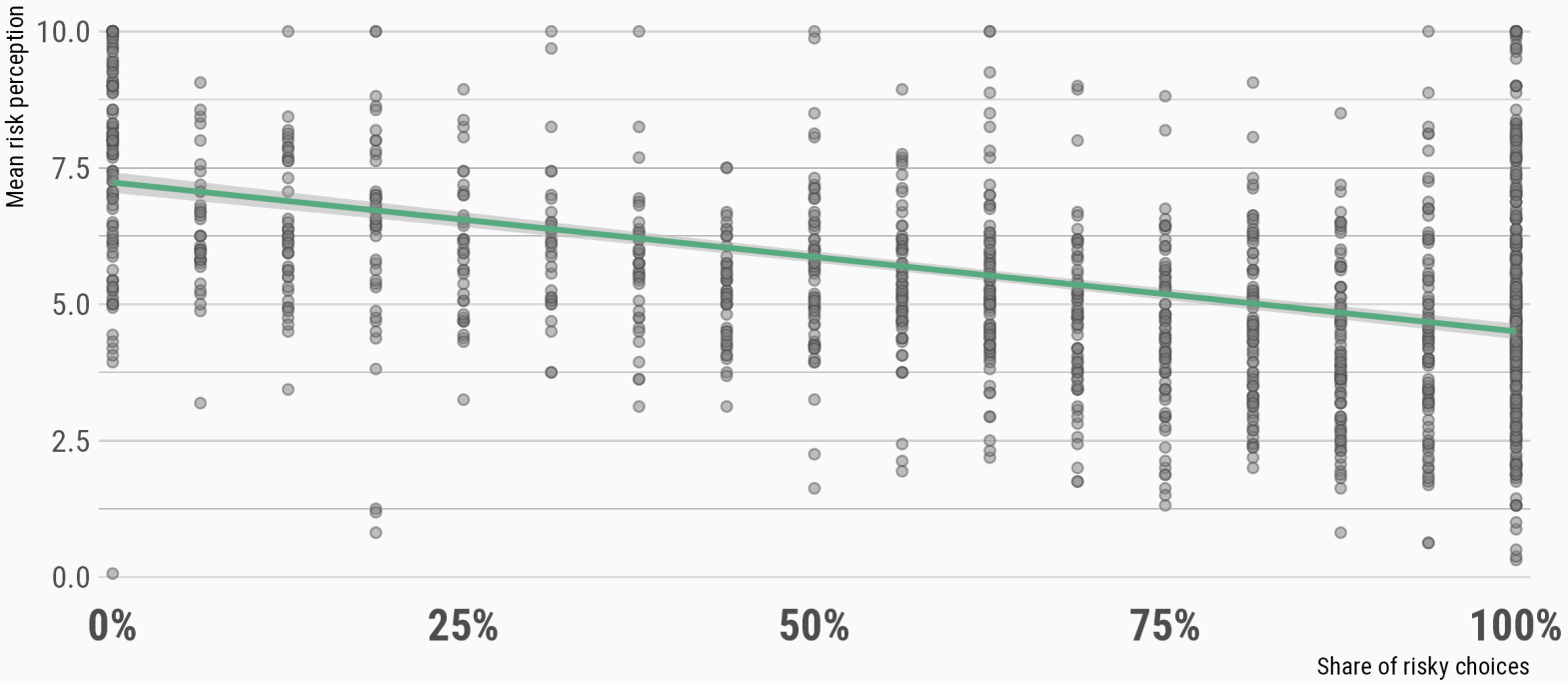
Deep mainly composition effect of separate groups

No other contrast significant

Risk perception and risky choices

Correlation of risk perception and risky choice

Mean of individual risk perception and individual risky choice across decks and stages

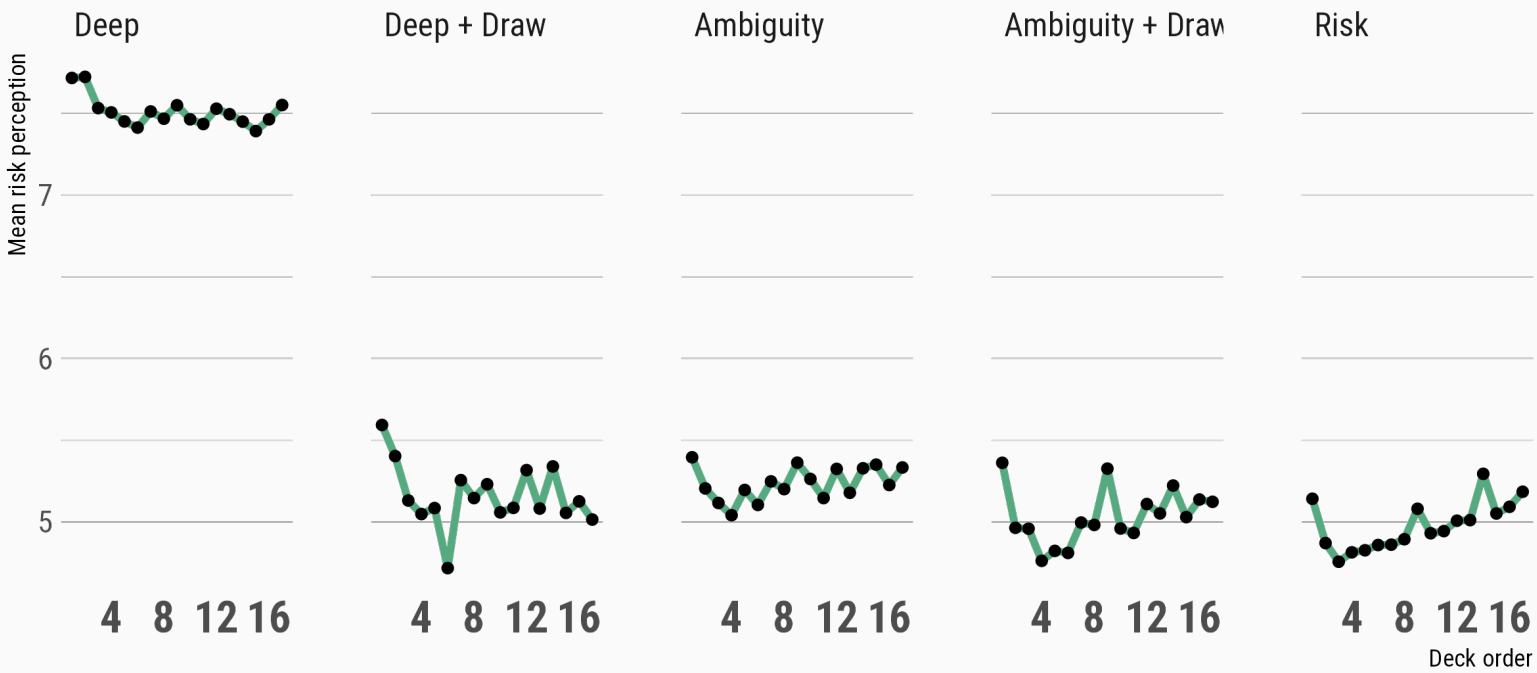


Negative correlation $\rho = -.344$; $p < 0.001$

. . . and again, goldfish or blasé subjects don't seem to learn

Evolution of risk perception across decks

Mean of individual risk perception across decks -- little sign of learning



Nearly no learning across decks in terms of risk perception

Actual results /2

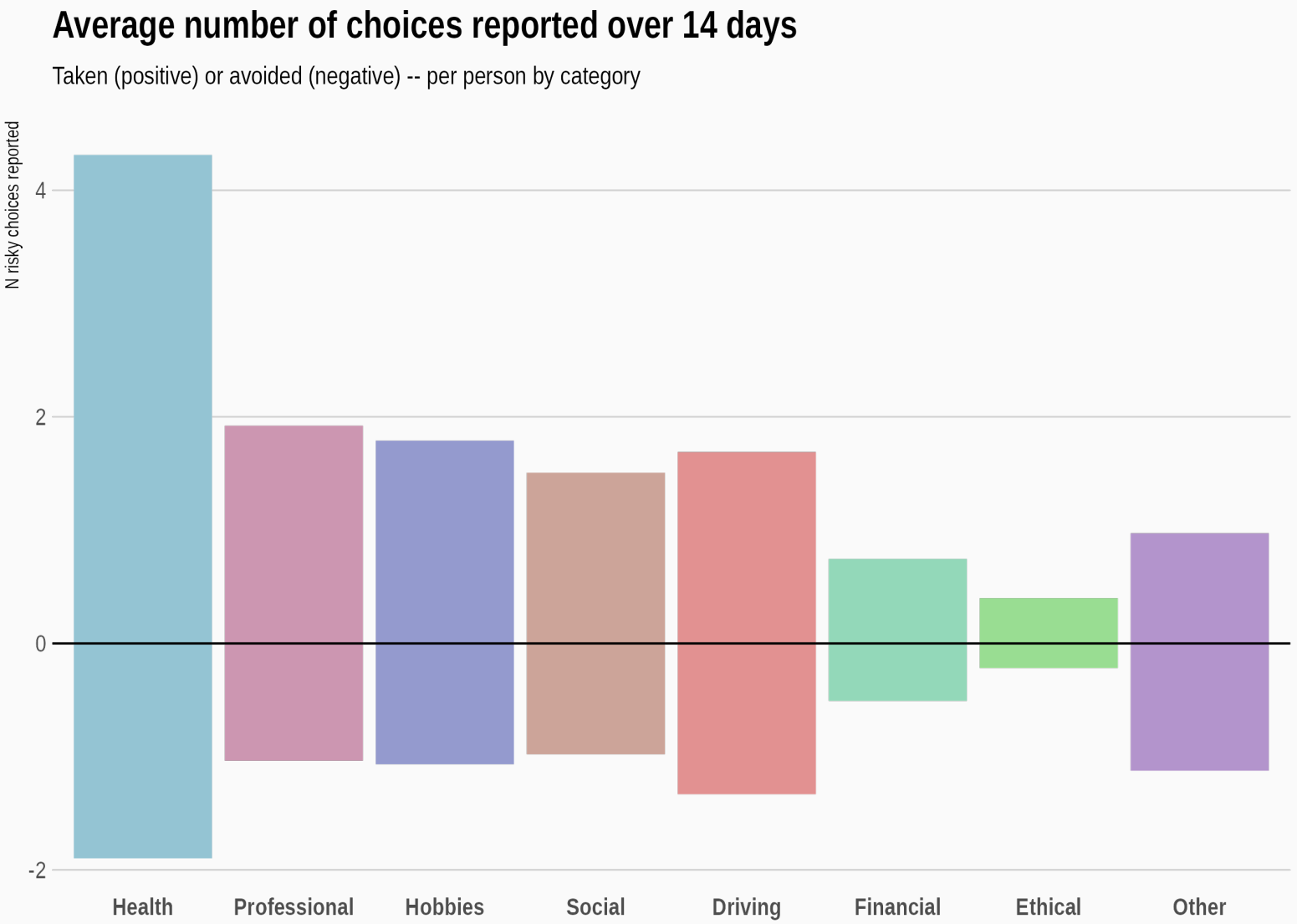
Ignorance and external validity

Analysis plan

We correlate:

1. Individual risk taking in the experiment as captured by the fraction of risky choices in each of the 5 stages
2. Self-reported naturally occurring behavior over 14 days:
    - DRM score, as self-reported by subjects
    - DRM score, as evaluated by judges

Some basic DRM statistics: risky activites over categories



DRM example

"I had some yoghurt well beyond the due date on the fridge, but I was hungry and I ate it anyway"

Subject perspective

Health risk · Taken · risk level of **+7** (on a -10…10 scale)

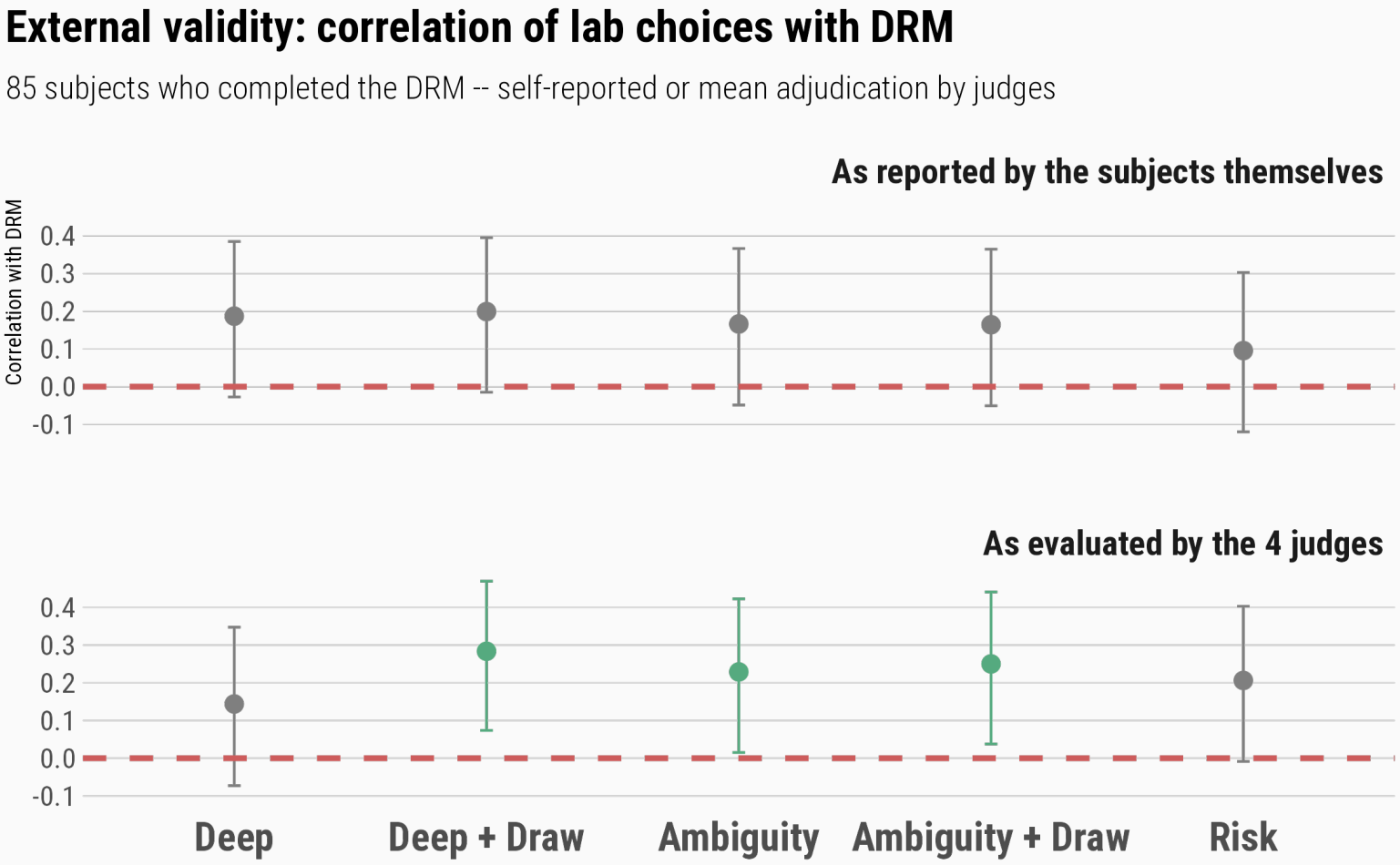
Judge 1 perspective

Health risk · Taken · risk level of **+3** (on a -10…10 scale)

Judge 2 perspective

No actual risk · – · –

Correlations task <> DRM



Peak around ambiguity, but probably underpowered

Judges reach higher correlations (why??)

Multivariate analysis

	DRM (self)	DRM (judges)
Deep	0.894	-0.331
	(0.502)	(0.569)
Deep + Draw	4.290	2.511
	(0.285)	(0.157)
Ambiguity	-1.060	-0.397
	(0.761)	(0.794)
Ambiguity + Draw	0.094	0.234
	(0.983)	(0.904)
Risk	-2.813	-0.572
	(0.400)	(0.698)
Constant	1.243	1.902***
	(0.242)	(0.000)
N	85	85

Deep + Draw largest positive coefficient

Risk far from displaying a positive correlation

Summing up

What do we learn?

1. Ignorance of lottery elements matters:
    - Deep Uncertainty $\Rightarrow$ high risk perception & avoidance
    - Sampling $\Rightarrow$ enough to change perceptions & behavior
    - Additional partial information $\Rightarrow$ no significant impact
    - Ful knowledge $\Rightarrow$ further increase in risk taking

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   - Deep Uncertainty $\Rightarrow$ high risk perception & avoidance
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Economists' representation of risk (σ^2, full knowledge) seems too narrow a construct

Thank you!