Curiosity, Information Gaps, and the Utility of Knowledge

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The Desire for, or Desire to Avoid, Information

	Connected to Decision Making	
	Yes	**No**
Motivation	(extrinsic)	(intrinsic)
Valence	A) standard economic account of information	B) motivated attention to (and avoidance of) information
Clarity (addressing an 'information-gap')	D) ambiguity-preference	C) curiosity

Basic Principles

- People have limited awareness
- Knowledge has valence
- Ceteris paribus people prefer to fill in information gaps
- Information affects the focus of attention as well as contributes to knowledge

Limited Awareness

Question	Answer	Belief	
Latent	–	Unawareness	
Activated	Unknown	Uncertainty	↕ information gap
	Known	Certainty	

Utility of Knowledge

- Beliefs enter directly into the utility function
  - Akerlof & Dickens, 1982;
  - Loewenstein, 1987;
  - Geanakoplos et al., 1989;
  - Grant et al., 1998;
  - Caplin & Leahy, 2001;
  - Yariv, 2001;
  - Benabou & Tirole, 2002;
  - Brunnermeier & Parker, 2005;
  - Köszegi, 2006;
  - Köszegi, 2010
- Cannot choose beliefs; choose whether to acquire information

$$\text{Information} \Longrightarrow \text{Beliefs}$$

States of Knowledge

- Set of prizes (material outcomes) X
- Finite set of activated questions $\mathcal{Q} = \{Q_1, \ldots, Q_m\}$
- Possible answers to question Q_i are $\mathcal{A}_i = \{A_i^1, A_i^2, \ldots\}$
- Knowledge state $K \in \mathcal{K}$ consists of:
  - subjective probability measure π over $\alpha = \mathcal{A}_1 \times \cdots \times \mathcal{A}_m \times X$
  - vector of attention weights $\mathbf{w} \in \mathbb{R}_+^m$
- A default knowledge state $[\pi^0, \mathbf{w}^0]$, upon learning answer A_i, is updated to $[\pi^{A_i}, \mathbf{w}^{A_i}]$ with:
  - $\pi^{A_i} = \pi^0(\cdot|A_i)$
  - $\mathbf{w}^{A_i}$ updated due to surprise (described later)

Preferences Over Knowledge States

Independence We assume there is a continuous, complete, and transitive preference relation $\succeq$ on $\Delta(\mathcal{K})$ that satisfies independence, so there exists an expected utility representation u of $\succeq$ (von Neumann and Morganstern 1944).

Denote utility of degenerate distribution on knowledge state K as $u(K)$
The desire for information answering question Q_i is:

$$\sum_{A_i \in \mathcal{A}_i} \pi_i^0(A_i)\, u(\pi^{A_i}, \mathbf{w}^{A_i}) \; - \; u(\pi^0, \mathbf{w}^0)$$

Also assume preferences satisfy **independence across prizes** for any given belief about activated questions

$\Rightarrow$ Belief-dependent expected utility over belief-independent lotteries

Structural Assumptions

Separability of Attention Weights If either $\pi_i = \pi'_i$ or $w_i = w'_i$ for all i, then $u(\pi, \mathbf{w}) \geq u(\pi', \mathbf{w})$ if and only if $u(\pi, \mathbf{w}') \geq u(\pi', \mathbf{w}')$.

Monotonicity with respect to Attention Weights If $w_i = w'_i = w''_i$ for all $i \neq j$ and $w''_j > w'_j > w_j$, then $u(\pi, \mathbf{w}') > u(\pi, \mathbf{w})$ if and only if $u(\pi, \mathbf{w}'') > u(\pi, \mathbf{w}')$ (equality too).

Linearity with respect to Attention Weights When belief about Q_i is independent of other beliefs (i.e., for π'_i and $\pi''_i \in \Delta(\mathcal{A}_i)$, and $\pi_{-i} \in \Delta(\alpha/\mathcal{A}_i)$), we have

$$u(\pi_{-i} * \pi'_i, \mathbf{w}) - u(\pi_{-i} * \pi''_i, \mathbf{w}) = \frac{w_i}{w^*_i} \left(u(\pi_{-i} * \pi'_i, \mathbf{w}^*) - u(\pi_{-i} * \pi''_i, \mathbf{w}^*) \right).$$

Behavioral Assumptions

One-Sided Sure-Thing Principle Let $\mathrm{supp}(\pi)$ denote the support of π. If for all $\delta \in \mathrm{supp}(\pi)$ we have $u(\pi', \mathbf{w}) \geq u(\delta, \mathbf{w})$, then $u(\pi', \mathbf{w}) \geq u(\pi, \mathbf{w})$, with strict inequality whenever there exist $\delta' = (\mathbf{A}', x')$ and $\delta'' = (\mathbf{A}'', x'') \in \mathrm{supp}(\pi)$ such that $\mathbf{A}' \neq \mathbf{A}''$.

A measure of the uncertainty in a belief is its entropy:

$$H(\pi_i) = -\sum_{A \in \mathcal{A}_i} \pi_i(A) \log \pi_i(A)$$

Uncertainty Aversion Suppose $\{\delta\}$ is a set of degenerate distributions such that for all δ' and $\delta'' \in \{\delta\}$, $u(\delta', \mathbf{w}) = u(\delta'', \mathbf{w})$. For subjective probability measures π and π' with support restricted to $\{\delta\}$, we assume that $u(\pi, \mathbf{w}) > u(\pi', \mathbf{w})$ if and only if $\sum_i w_i H(\pi_i) < \sum_i w_i H(\pi'_i)$.

An Example Utility Function

We need not specify the precise form of the utility function, but we illustrate with an example with separable utility:

$$u(\pi, \mathbf{w}) = \sum_{x \in X} \pi_X(x) U_X(x) + \sum_{i=1}^{m} w_i \left(\sum_{A_i \in \mathcal{A}_i} \pi_i(A_i) U_i(A_i) \; - H(\pi_i) \right)$$

Factors Influencing Attention

Attention weight is strictly increasing and supermodular on:

- *Salience*
  - Factors like framing and epistemic vs. aleatory uncertainty
  - Surprise at new information (Baldi, 2002):

$$s_i(\pi_i^{A_j} || \pi_i^0) = \sum_{A_i \in \mathcal{A}_i} \pi_i^{A_j}(A_i) \log \frac{\pi_i^{A_j}(A_i)}{\pi_i^0(A_i)}.$$

- *Importance*: how much is at stake depending on the answer

$$\gamma_i = \phi\left(\left\langle \pi_i^0(A_i),\, u\left(\pi^{A_i}, \mathbf{w}^0\right) \right\rangle_{A_i \in \mathrm{supp}\left(\pi_i^0\right)} \right)$$

with ϕ satisfying:

1. invariance under constant shifts in utility
2. a $<$ ordering that respects second-order stochastic dominance when expected utility is equal

Temporal Effects

Acquiring information has

- an immediate, but temporary, effect on salience, through surprise
- a delayed, but permanent, effect on importance

e.g., learning an answer with certainty generates a short-term boost in attention (due to surprise), but a decline in attention after the person adapts (because certainty makes the question no longer important)

Short-run effect dominates decision making; long-run effect relevant for satisfaction

We assume the short-term increase in attention weight due to surprise is independent of baseline salience

Curiosity

Curiosity – the desire to fill an information gap (answer an activated question)

Depends on

- *Importance* of the question
- *Salience* of the question
- Potential for *epiphany*

Desire vs. satisfaction

The Ostrich Effect

People seek out information about issues they like to think about and avoid information about issues they do not like

- Most people enjoy opening a gift
- Most people do not enjoy seeing a doctor for a diagnosis

The *ostrich effect* – more people look up the value of their investment portfolios when markets are up than when they are down

Attentional effects reverse over time (with adaptation), so we would expect exceptions to this pattern to be associated with foresight (and thus be correlated with low time discounting)

A Tradeoff when it comes to Negative Beliefs

Information would

- reduce expected entropy, improve clarity, increase utility
- increase attention weight on negative beliefs, decrease utility

Novel testable prediction: a preference to avoid information may reverse itself as a question becomes more salient

- e.g., obtaining costless medical tests vs. asking about the results when seeing the doctor who conducted the tests

Ambiguity Aversion

Our view:

- An information gap that cannot be addressed is a source of discomfort
- Making a decision in the absence of relevant information exacerbates that discomfort

Very different from an account with supermodular subjective probability weights or imprecise, set-valued probabilities and pessimism

Ellsberg Paradox

Bet on Urn I: unknown composition OR Urn II: 50-50 composition?

Activated questions:

Q1 Which color will be drawn from Urn I?

Q2 Which color will be drawn from Urn II?

Q3 What is the composition of Urn I?

Q4 What is the composition of Urn II?

- All answers have neutral valence, but because uncertainty (entropy) is aversive, questions Q1-Q3 induce negative beliefs
- Betting on Urn I makes Q1 and Q3 more important; betting on Urn II makes Q2 more important
- Increasing the importance (attention weight) of these negative beliefs decreases utility
- Preference is for betting on the known urn despite equivalent subjective chances of winning

Comparative Ignorance Effect

- Presenting the two urns in comparison makes salient the difference in their composition
- Pricing a bet on just one of the urns in isolation makes the composition less salient
- Ambiguity aversion should lessen when pricing bets on isolated urns instead of urns that can be compared

Documented by Fox and Tversky (1995)

Source Preference

People prefer to bet on an uncertain event before rather than after an outcome is realized (Strickland et al., 1966; Chow & Sarin, 2002)

- Epistemic uncertainty more salient than aleatory uncertainty
- The same increase in importance would generate relatively more attention weight for a question of epistemic uncertainty
- Preference is for bets on questions with aleatory uncertainty

People actually prefer to bet on uncertain events in domains of expertise rather than on chance events (Heath & Tversky, 1991)

- Such bets increase the importance of questions with positive beliefs.
- Increasing attention weight on positive beliefs increases utility.

The Search for Knowledge and Insight

Expertise for its own sake

- discriminating taste for wine
- ability to identify flora and fauna

"It is better to be a human being dissatisfied than a pig satisfied; better to be Socrates dissatisfied than a fool satisfied."

– John Stuart Mill