Boredom and Flow: A Counterfactual Theory of Attention-Directing Motivational States

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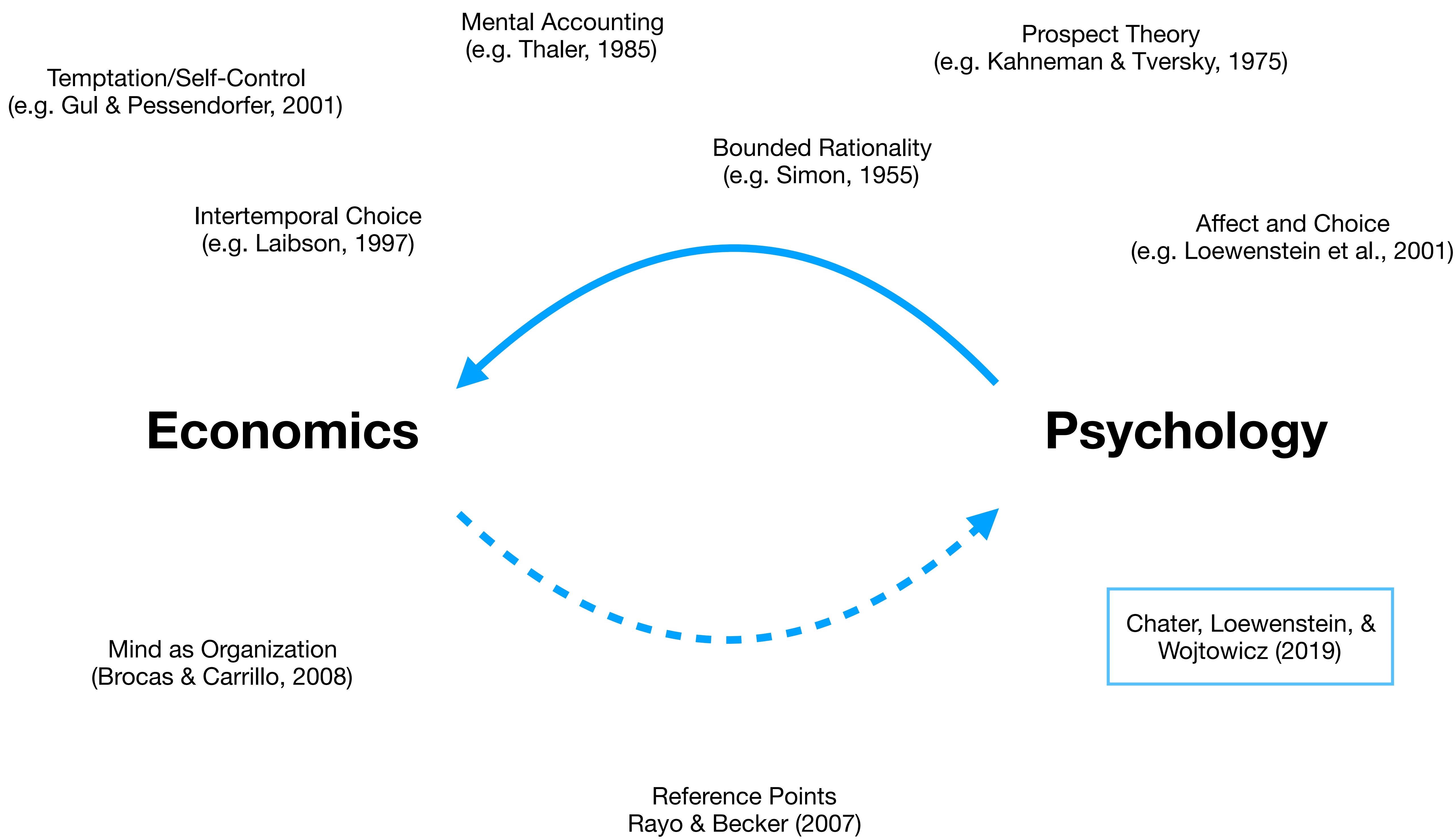
The Big Picture: Reversing Our Approach to Behavioral Economics



Key Features of Attention

- Attention (of the deliberative sort we consider) is extremely flexible but relatively scarce

- Attention can be put to many uses (and therefore induces opportunity costs)

- Attention is ‘use it or lose it’ — it cannot be stored across time

- Attention can be directed, at least in part, by conscious volition

- Attention used to deliberate about its allocation is not available for the task at hand (Sweller, 1988)

Central Dilemma

- Brain needs to allocate attention without using too much attention

The Solution?

- Dual-systems mental architecture (an *explicit* and *implicit* system)
- Explicit system makes final decisions about attention allocation
- Implicit system - which operates autonomously and without attention - makes associative evaluations of attentional opportunity costs using crude environmental cues
- Boredom and flow are motivational signals that the implicit system uses to influence decisions of explicit system
- These signals are positive or negative momentary hedonic experiences that change the value of maintaining attention

Model: Overview

- Agent starts off with a default attentional focus of known value
- Agent make a choice:
  - 1) Maintain attention
  - 2) Search for a different activity
- Agent estimates opportunity costs of maintaining attention based on an environmental signal
- Need to integrate implicit and explicit system estimates

Model: Setup/Notation

- Agent's objective is to maximize utility: U *(note: this does not include hedonic signals)*

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  1. <u>Maintain</u> attention: receive $\bar{U}$

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- The agent makes a choice:

  1. Maintain attention: receive $\bar{U}$
  2. Search for a different activity: draw $U \sim P(u|S = s)$

Model: Deriving Reference-Dependence

- **Assume the agent has two means of generating forecasts**

$$\underbrace{\mathbb{E}[U|M_e, S=s]}_{\text{Explicit System}} \qquad \underbrace{\mathbb{E}[U|M_i, S=s]}_{\text{Implicit System}}$$

Explicit System:

- Deliberative
- Causal/Consequentialist
- Conscious
- Effortful
- *Requires attention*

Implicit System:

- Heuristic
- Associative
- Non-conscious
- Effortless
- *Requires no attention*

Tversky & Kahneman, 1974
Kahneman, 2003
Frederick, 2005
Kahneman & Frederick, 2002
Toplak et al., 2011
Evans & Stanovich, 2013

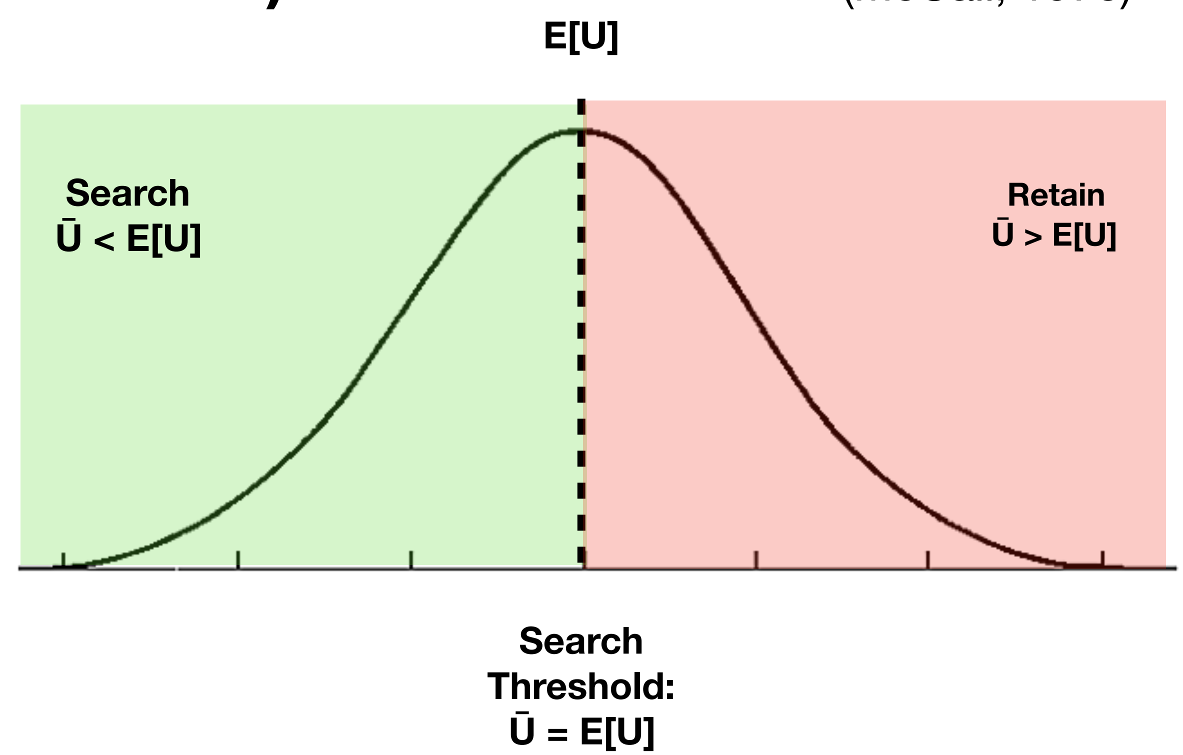
- **Search threshold (according to explicit system alone):**

(McCall, 1970)

$$\bar{U} = \mathbb{E}[U|M_e, S=s]$$

- **Search threshold (with hedonic signal):**

$$\bar{U} + h = \mathbb{E}[U|M_e, S=s]$$



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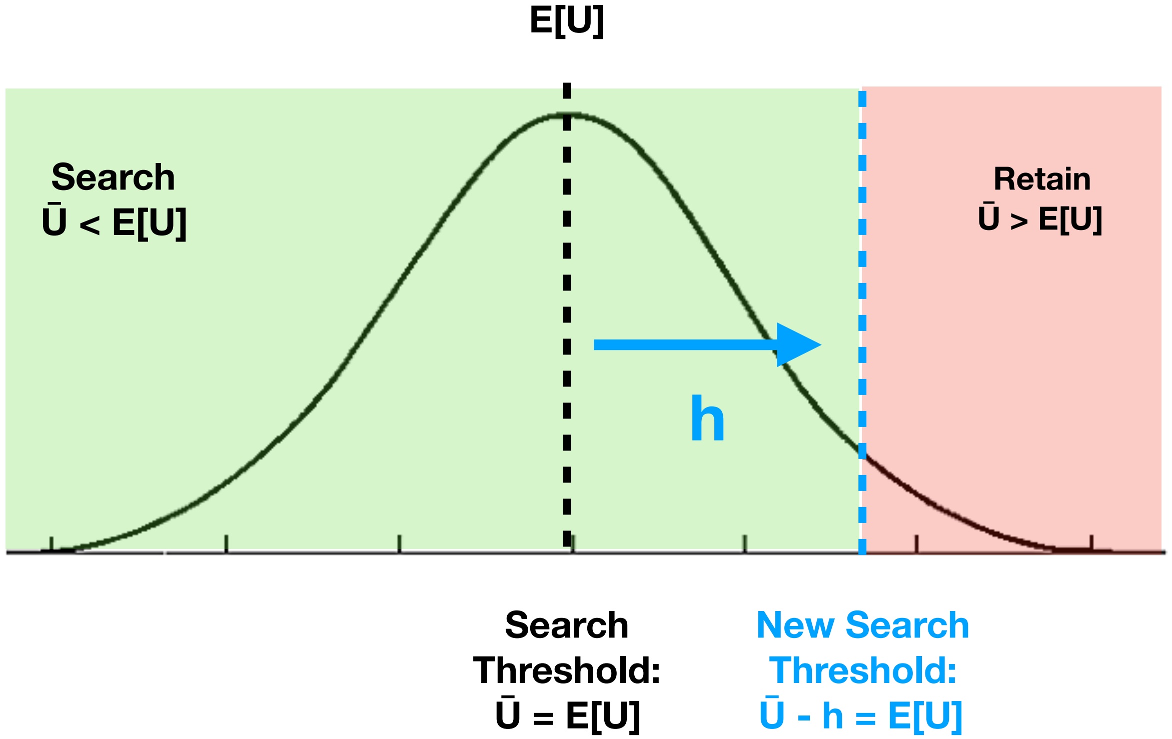

Model: Deriving Reference-Dependence

- Bayesian Model Averaging (Bates & Granger, 1969; Hoeting et al. 1999)

$$p(Y|X) = \sum_k p(Y|X, M_k)p(M_k)$$

- Optimal forecast is then a linear combination of implicit and explicit forecasts

$$\mathbb{E}[U|M_{i+e}, S = s] = w_i\mathbb{E}[U|M_i, S = s] + w_e\mathbb{E}[U|M_e, S = s]$$

Weights (which add to 1) will depend on relative strength of each model

Model: Deriving Reference-Dependence

Start by assuming that agent acts according to optimal indifference point rule…

$$\bar{U} = \mathbb{E}[U|M_{i+e}]$$

$$\bar{U} = w_i\mathbb{E}[U|M_i] + w_e\mathbb{E}[U|M_e]$$

(because weights sum to one)

$$w_e\bar{U} + w_i\bar{U} = w_i\mathbb{E}[U|M_i] + w_e\mathbb{E}[U|M_e]$$

…do algebra…

$$w_e\bar{U} + w_i\bar{U} - w_i\mathbb{E}[U|M_i] = w_e\mathbb{E}[U|M_e]$$

$$\bar{U} + \frac{w_i}{w_e}\Big(\bar{U} - \mathbb{E}[U|M_i]\Big) = \mathbb{E}[U|M_e]$$

… implicit system's optimal hedonic signal is reference-dependent!

Remember, we were looking for h…

$$\bar{U} + h = \mathbb{E}[U|M_e, S = s]$$

Model: Our Specification

Total Utility = Direct Utility + Hedonic Signal

$$\mathcal{U}(\bar{x}|S=s) = \bar{U} + \underbrace{\frac{w_i}{w_e}\left(\bar{U} - \mathbb{E}[U|M_i, S=s]\right)}_{\text{Boredom/Flow}}$$

- **Boredom/Flow correspond to positive / negative signals**
- **Hedonic signals reflect deviations from implicit system's estimates of opportunity costs**
- **Strength of each signal is determined by ratio of model weights**
- **Self-control requires the explicit system to override the implicit system**

Implications of The Model

$$\mathcal{U}(\bar{x}|S=s) = \bar{U} + \underbrace{\frac{w_i}{w_e}\Big(\bar{U} - \mathbb{E}[U|M_i, S=s]\Big)}_{\text{Boredom/Flow}}$$

New Predictions

- Improving alternatives can reduce experienced utility
- Agents will be subject to dynamic inconsistencies
    - Impossible to 'reverse engineer' the dependence of implicit reference points on environmental cues
- Boredom & flow introduce two types of self-control problems
- Behavioral constraints have hedonic consequences

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Existing Evidence

- Behavioral constraints increase boredom (Fisher, 1987)
  - Not only do these maintain focus on an undesirable activity, they also perpetuate exposure to environmental cues
- Workplaces are more boring if coworkers are present (Fisher, 1993, 1987)
- Sub-perceptual cues indicating the presence of alternative activities increase boredom (Damrad-Fyre and Laird, 1989)
- Reports of quantitative underload i.e. “having nothing to do”… often follow periods of high engagement, or take place in environments typically characterized by high engagement (Fisher, 1993)

Questions?