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

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The Big Picture: Reversing Our Approach to Behavioral Economics

- Mental Accounting (e.g. Thaler, 1985)
- Prospect Theory (e.g. Kahneman & Tversky, 1975)
- Bounded Rationality (e.g. Simon, 1955)
- Intertemporal Choice (e.g. Laibson, 1997)
- Affect and Choice (e.g. Loewenstein et al., 2001)
- Temptation/Self-Control (e.g. Gul & Pessendorfer, 2001)
- Mind as Organization (Brocas & Carrillo, 2008)
- Reference Points (Rayo & Becker, 2007)

Chater, Loewenstein, & Wojtowicz (2019)
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: $U$ \textit{(note: this does not include hedonic signals)}
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- Agent observes a signal which comprises sensory cues about the environment: $S$
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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

\[ \mathbb{E}[U | M_e, S = s] \quad \text{Explicit System} \]
\[ \mathbb{E}[U | M_i, S = s] \quad \text{Implicit System} \]

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

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

- Search threshold (according to explicit system alone):

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

- Search threshold (with hedonic signal):

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

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

(McCall, 1970)
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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 the agent acts according to optimal indifference point rule...

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

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

(because weights sum to one)

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

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

\[ \tilde{U} + \frac{w_i}{w_e} \left( \tilde{U} - \mathbb{E}[U|M_i] \right) = \mathbb{E}[U|M_e] \]

...do algebra...

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

Remember, we were looking for \( h \)...

\[ \tilde{U} + h = \mathbb{E}[U|M_e, S = s] \]
Model: Our Specification

Total Utility = Direct Utility + Hedonic Signal

\[ U(\bar{x}|S = s) = \bar{U} + \frac{w_i}{w_e} \left( \bar{U} - \mathbb{E}[U|M_i, S = s] \right) \]

- 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

\[ U(\bar{x}|S = s) = \bar{U} + \frac{w_i}{w_e} \left( \bar{U} - \mathbb{E}[U|M_i, S = s] \right) \]

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
Implications of The Model

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?