Disrupting Dual Systems: A Dynamic Decision-Making Framework for Human Behavior

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Abstract

Human decision making is often characterized as a competition between a deliberative, "cognitive" system and an irrational, impulsive, "emotional" system, a view conventionally aligned with dual process theories. We challenge this prevailing dual systems narrative using evidence from a growing body of behavioral and neuroscience studies and propose a new dynamic decision-making framework for understanding human behavior. Rather than follow the intuitive conventional wisdom that processing is binary, our framework argues that decisions are the outcome of a cascade of processes that range a continuum or gradient of cognitive effort from fast/automatic to slow/deliberative and unfold as decisions are constructed. Critically, there is a regulatory or adaptive control process that modulates or guides this cascade of processes to select a response that is suitable for the current context. Finally, these processes are deeply influenced by the goals, prior associations and experiences stored in memory, and bodily sensations that combine with those associations to create emotions. We discuss the implications of this framework for managerial insights and strategies.

Key words: adaptive processing, consumer decisions, decision strategies, emotions, cognition, neurophysiological methods.

Introduction

Since Daniel Kahneman won the Nobel Prize in Economics in 2002 and published *Thinking Fast and* Slow in 2012 (Kahneman, 2011), there has been an explosion of interest in System 1 versus System 2 thinking and its applications to research, marketing, and public policy. This idea though has a much longer history in cognitive and social psychology where it has been more generally known as the Dual Process Theory (DPT) (Chaiken & Trope, 1999). In fact, that decision making reflects the balance between two competing systems – one cognitive and more rational, one emotional/motivational and less rational – is a compelling idea with references in both scientific and literary writing from James and Freud to Dante and Aristotle

(Dante, 1935; Freud, 1964; James, 1884; Press, 2015). In the current form, System 1 is thought to be intuitive, autonomous, and requires no working memory, whereas System 2 is reflective or deliberative, and affords cognitive decoupling, mental simulation, requiring working memory (Evans & Stanovich, 2013).

Kahneman popularized a version of the theory called default interventionist DPT that argues that, when making a decision, people will first rely on the more automatic System 1 (the default), then only sometimes switch to the more deliberative System 2 (intervening on the default response). This approach has spawned a wide array of myths and misconceptions in marketing and public policy about the primacy of automatic processing, emotions, and confusion about the relevance and utility of various research methods, including surveys and neuroscience methods. At its most extreme, the presumption among some business and public policy decision makers is that consumer decisions are dominated by a cluster of conflated processes that includes System 1 and emotions, all presumed to be non-conscious in nature.

Over the years, several researchers have criticized DPT pointing to variability in dual-processing accounts, the vagueness of definition, lack of coherence and consistency in the cluster of attributes for each “system” (Keren & Schul, 2009; Kruglanski & Gigerenzer, 2011). Similarly, recent developments in judgement and decision making, cognitive neuroscience and developmental psychology have challenged the core evidentiary basis of DPT (Frank, Cohen, & Sanfey, 2009; Houde & Tzourio-Mazoyer, 2003). While Dual Process Theory is easy to understand and compelling, it does not accurately represent the complex and adaptive nature of the decision-making process. A fundamental paradigm shift is necessary in marketing and consumer behavior to keep pace lest we miss out on important and valuable insights. We focus on some of the key insights that form the foundation of this shift and propose a new dynamic framework that provides a more complete picture of decision-making processes and strategies.

DPT in Marketing: Misuse and Myths

The past decade has seen a tremendous increase in the adoption (and misuse) of DPT within marketing, particularly in the area of market research and behavioral science. However, several of these are erroneous applications or extensions of the DPT. For example, despite Kahneman’s own statement that these systems are “fictitious characters” and not physiological systems (Kahneman, 2011), System 1 and System 2 are often treated as separate independent systems that have specific representations in the brain. These systems are almost always invoked sequentially, with System 1 dominating as the default response (some even arguing that as much as 95% of our decisions are made without any deliberate thought (Zaltman, 2003)) and System 2 stepping in to override in only a small number of cases. The presumption is that default and implicit nature of System 1 means that there is no conflict or executive control involved when making System 1 decisions. Finally, falling into the trap of essentialism (Barrett, 2017) the binary nature of these systems lends to a faulty association with several other "dualities" in psychology – conscious vs. non-conscious, emotional vs. rational/cognitive, impulsive vs. planned, though these other dimensions have vastly different implications and are often non-overlapping. There is a pervasive essentialist fallacy in marketing (as well as in other domains) that System 1 represents emotional and biased thoughts, and System 2 represents rational, cognitive thought. These beliefs have been precipitated further by the framing of neurophysiological methods like skin conductance, heart rate monitoring, eye tracking and pupil dilation, and EEG as "System 1 tools" and self-report and behavioral measures only providing access to "System 2" responses. We address several of these myths in the following section and provide an alternative decision-making framework that helps clarify the role of these different processes and methods in adaptive decision making.

Countering Dual Process Theory: Behavioral Evidence

Over the years, the results of a number of studies have challenged the prevailing DPT narrative. First is challenging the notion the two systems engage sequentially (System 1 and then System 2) and that the automatic System 1 responses lack any form of regulatory control and detection of conflict. Let's take the example of the classic Cognitive Reflection Test question known as the bat and ball problem (Frederick, 2005). In this problem, a bat and a ball together cost $1.10 and the bat costs $1 more than the ball. Research participants are given this problem and asked to report the cost of the ball. The common (incorrect) response of $0.10 is often used to illustrate the default interventionist idea as the biased, automatic "System 1" response. Implicit in this assumption is the implication that participants are ignoring key aspects of the problem in providing a fast response.

What happens if we create an easy version of the bat and the ball problem, where participants are just told that both cost $1.10 and the bat costs $1 (rather than "the bat costs $1 *more* than the ball")? The default response of $0.10 is now the correct response. Critically, do participants process the two problems similarly? According to prevailing DPT narrative, participants should engage identical processes in both versions of this problem when providing the $0.10 response. However, across a range of studies from different labs using a variety of problems similar to the one above, research shows that people answering the original version take longer (Pennycook, Trippas, Handley, & Thompson, 2014), fixate their eyes on the "harder" parts of the problem like the comparison prompts (De Neys & Glumicic, 2008), recall the hard parts better (De Neys & Franssens, 2009), express less confidence in the response (De Neys, Rossi, & Houde, 2013), exhibit more autonomic nervous system response in the form of increased skin conductance (De Neys, Moyens, & Vansteenwegen, 2010), and show more activation in the areas of the brain associated with conflict detection and executive control (Bago & De Neys, 2017; De Neys & Pennycook, 2019; De Neys, Vartanian, & Goel, 2008). Together, these findings challenge some fundamental premises of DPT, both in terms of the sequential "System 1, then System 2" argument, as well as the engagement of regulatory processes in System 1 response. On the other hand, these problems suggest that people detect conflict and recruit additional processes even when engaging in biased automatic reasoning and fast automatic responses.

A second implication of DPT is that there is often a single biased and default System 1 response to any given problem within a particular context, which could get overridden by a deliberative System 2 response. However, across experiments, findings suggest that people are able to get the correct (unbiased, System 2-like) response ($0.05 in the hard bat and ball problem above) very quickly, a response referred to as "logical intuition" (Thompson, Pennycook, Trippas, & Evans, 2018). For example, in some studies, participants were asked to provide a fast response first and a second more deliberative response after a delay. Traditional DPT argues that majority of responses during the early stage should be incorrect ($0.10 in the case of bat and ball problem above), which then shift to the correct response ($0.05) after some deliberation. However, a significant proportion of people arrive at the correct response even without deliberation, through either some logical intuition or due to prior knowledge about similar problems. These effects persist even when System 2 processing resources are "knocked out" by engaging people in a demanding secondary working memory task (e.g., remembering spatial patterns presented on the screen) (Bago & De Neys, 2017). Therefore, it is impossible to classify a response ($0.10 in this case) as a System 1 or System 2 response without adequate insights into the decision processes.

In general, these studies suggest that multiple threads of processing (e.g., biased heuristic, logical intuition, deliberative) are often activated in parallel (Thompson & Newman, 2018) and regulatory control processes are engaged fairly early in the decision processing pipeline, presenting serious challenges to default interventionist DPT. This is also consistent with the broader research on adaptive decision making, which argues that individuals have access to a broad repertoire of strategies to any given decision problem (Gigerenzer & Goldstein, 1996; Payne, Bettman, & Johnson, 1993). Humans are often faced with complex decisions that involve acquiring and integrating information across different input variables. Importantly, they often employ a variety of strategies, often in parallel, to simplify the representation of these problems (Gigerenzer & Goldstein, 1996; Payne, Bettman, Coupey, & Johnson, 1992; Payne, Bettman, & Johnson, 1988a; Tversky & Kahneman, 1974). Some of these strategies may be heuristics that involve the use of only a subset of information available to them, while others may involve integrating across all available information. The ability to adapt to subtle changes in decision context involves the dynamic selection of decision strategies based on goals and available cognitive resources (Simonson & Tversky, 1992; Tversky & Simonson, 1993). More importantly, this requires the ability to exert cognitive control and monitoring of the task environment to help switch between these strategies according to demands of the current decision environment.

Countering Dual Process Theory: Neuroscience Evidence

Another common misconception associated with DPT is that the distinction between System 1 and System 2 represents differences between emotion and cognition respectively, with emotion almost entirely driven by System 1. Along similar lines, a central dogma in much of the early work in decision neuroscience argued that **rational and irrational behaviors result from the activation of distinct and independent systems for cognition and emotion, respectively**. Many of the early highest-impact papers in the neuroscience of decision making reflect this viewpoint; e.g., *moral decision making* (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001); *ultimatum game* (Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003); *intertemporal choice* (McClure, Laibson, Loewenstein, & Cohen, 2004); and *framing effects* (De Martino, Kumaran, Seymour, & Dolan, 2006). However, subsequent papers started challenging this dogma (Frank et al., 2009), with evidence in favor of a more distributed and integrated processing across emotional and cognitive regions in the context of intertemporal choice (Kable & Glimcher, 2007); loss aversion (Tom, Fox, Trepel, & Poldrack, 2007); and risk strategies (Venkatraman, Payne, Bettman, Luce, & Huettel, 2009). Similar findings also began to emerge in the developmental literature challenging the view that logical reasoning and mathematical cognition were distinct and independent (Houde & Tzourio-Mazoyer, 2003). Instead, the ability of humans to detect conflict, inhibit responses, and shape behavior in a flexible manner was attributed to the adaptive use of cognitive control (Koechlin, Ody, & Kouneiher, 2003).

Dynamic Decision-Making Framework

The term *cognitive control* broadly describes the ability to shape behavior in an adaptive manner, as a function of current goals and constraints (Taren, Venkatraman, & Huettel, 2011; Venkatraman, Rosati, Taren, & Huettel, 2009). Different theoretical models and definitions have emphasized different aspects of control in the past. These include (i) the ability of the human cognitive system to configure itself for the performance of specific tasks (Botvinick, Braver, Barch, Carter, & Cohen, 2001); (ii) the ability to coordinate thoughts or actions in relation with internal goals (Koechlin et al., 2003); (iii) the acquisition and implementation of the behavioral rules needed to achieve a given goal in a given situation (Miller & Cohen, 2001) or (iv) the support of flexible behavior by selecting actions that are consistent with our goals and appropriate for our environment (Badre, 2008). The diversity in conceptual models follows from the remarkable progress made in understanding cognitive control and flexible selection of behavior over the past couple of decades.

Nearly all models of cognitive control posit an important role for regions within the prefrontal cortex (Miller & Cohen, 2001), which in turn shapes processing in other cortical and subcortical brain regions. In recent years, there has been substantial interest in the dorsomedial prefrontal cortex (dmPFC) – which includes the dorsal anterior cingulate cortex (ACC) - as playing a key role in assessing and/or shaping behavior adaptively based on context (Mevel et al., 2019; Taren et al., 2011). Specifically, dmPFC activation is evoked by task contexts that involve conflict between competing response tendencies or choosing between decision options that are evenly matched (Pochon, Riis, Sanfey, Nystrom, & Cohen, 2008). The dmPFC also plays a key role in coordinating activation in other regions (Kerns et al., 2004). For example, deviations from preferred strategies were associated with increased activity in the dmPFC and differential functional connectivity with regions in the brain associated with implementing these strategies (Venkatraman, Payne, et al., 2009).

In parallel, research in developmental decision neuroscience has also demonstrated the central role of executive control, and more specifically, inhibitory control in the adaptive response to decision making, a fundamental problem in the developmental trajectory that presents a challenge for the design of successful education programs (Borst, Poirel, Pineau, Cassotti, & Houde, 2013; Houdé & Moutier, 1996; Houdé et al., 2000). Evidence of the importance of inhibitory control in decision making has given rise to a proposition that these processes are of equal importance along with intuitive processing and more deliberative processing, because it allows the decision maker to respond to changes in context in an adaptive manner (Houde, 2019).

Dynamic Decision-Making Framework

Therefore, we propose an alternative decision-making framework which makes three important advances over the prevailing DPT by integrating the core idea of adaptive processing.

1. When individuals are confronted with a decision, **multiple processes/strategies** are launched and operate in parallel. These threads unfold, cross-feed, are abandoned, resumed, and iterated across the course of time - from milliseconds to days, depending on the context and the need for action.
2. These cognitive processes cannot be discretely classified as automatic or deliberative, but rather fall along a continuum or **gradient of cognitive effort** from fast/automatic to slow/deliberative.
3. There is a regulatory or **adaptive control process** that modulates or guides this cascade of processes and strategies to form a response, that is adapted to the needs and constraints of the current context.

In the next section, we discuss the role of context and how it influences the adaptive control process.

Contextual Factors in Adaptive Processing

Rationality often assumes that individuals have stable well-defined preferences that pervade across all contexts. Under this view, each option or choice is associated with a fixed subjective utility that depends entirely on the option and the ability of the individual to compute it. Yet, the limitations of human processing often lead to bounded rationality, where preferences are often constructed in making a decision, and not merely revealed (Bettman, Luce, & Payne, 1998; Lichtenstein & Slovic, 2006). An important implication of constructed preference is that preferences are not always merely pulled from a list of options in memory but are constructed on the spot contingent on a variety of factors characterizing the decision environment – decision context, task framing, goals, knowledge, attitudes, and states.

Therefore, the current view argues that irrationality and biases do not necessarily reflect a failure of brain systems for cognitive control; instead, control systems may potentiate distinct choices adaptively depending on context. **In other words, the level and relative impact of deliberative versus automatic processing is an adaptive function of cognitive control and executive processing.** We discuss the role of these contextual factors in shaping decision strategies and processing in greater detail below.

Memory and Knowledge

Memory plays an important role in shaping preferences. Though individuals have some well-formed and stable preferences, especially in cases where they are familiar with the choice options or have made similar decisions in the past (Wright, 1975), the bounded and finite nature of memory makes it impossible to have such refined preferences for every option we are likely to encounter. Therefore, in most cases preferences are constructed based on the information available and the decision context (see below). One specific consequence of limited memory resources is that individuals have to rely on relative values for attributes and options when making decisions. These subjective valuations are shaped by the context in which the options are presented, and past experience or lack of with similar alternatives and attributes.

Human memory can be broadly classified into two types – declarative and non-declarative (Squire & Dede, 2015). Declarative memory can be further classified into semantic (memory for facts and general knowledge) and episodic (memory for events) memory (Tulving, 1972). Non-declarative memory, on the other hand, refers to implicit memory, or memory that occurs without a conscious awareness of learning (Squire & Zola-Morgan, 1988). These include priming, skill learning or even the formation of implicit associations. Critically, these two memory systems are independent and mediated by different regions in the brain (Lee, Duman, & Pittenger, 2008; Poldrack & Foerde, 2008), and learning can switch from declarative to non-declarative over time (e.g., learning to drive a car). Therefore, these distinctions are important when making decisions, because our past knowledge and memory influences how we interpret and value the stimulus in front of us when making decisions.

For example, Kahneman makes the distinction about benign versus hostile decision environments (Kahneman, 2011). A benign environment is a familiar environment that one has encountered several times in the past and has developed sufficient cues and knowledge through feedback and learning. A hostile environment, on the other hand, is novel and one that has not been encountered before, and hence no cues are available for System 1 to exploit. Kahneman argues that an attribute-substituting System 1 and a lazy System 2 can combine to yield sufficiently rational behavior in benign environments but can yield seriously suboptimal behavior in hostile environments. Critically, these distinctions between benign and hostile environments often depend on memory (both implicit and explicit) and degree of recognition and familiarity for the individual. A hostile environment also shifts to a benign environment over time.

Dynamic Decision-Making Framework

In summary, we argue that past knowledge or schemas influence the degree of processing and control associated with different choice scenarios and it is not entirely about benign or hostile environments. For example, we might be familiar with the face of someone in a large gathering but have no recollection of their name or occupation. However, when this person starts to approach us for a conversation, we may expend more resources to search for appropriate retrieval cues to convert this familiarity into recognition. It does not mean that the task environment suddenly became hostile, but that the motivation behind the decision changed as below discussed in the section on goals motivation. This is also true with how we construct value for attributes in a decision process – the amount of attention and effort we expend as well as how we appraise emotions from the past (see discussion below on emotions) could lead to differences in the subjective value associated with that attribute and option. Additionally, individual differences in attitudes and capabilities also play a key role in influencing the degree of effort, salience of goals and framing of input information (Stanovich & West, 2008). Here, a critical distinction is often made between cognitive abilities and thinking disposition (Baron, 1985). While variation in cognitive ability refers to factors like working memory, perceptual speed, and discrimination accuracy, thinking disposition index individual's goals and epistemic values (e.g., disposition to spend time on a problem or weigh other's opinions more over self) and are more malleable than cognitive abilities (Stanovich & West, 1998). Integrating these effectively into the decision model is therefore critical for understanding the decision process.

Context and Task Framing

Context plays a critical role in decision making by influencing how individuals perceive and process the choice options. As discussed above, individuals often tend to assign relative rather than absolute subjective values for each of the options in a choice set (Dhar & Gorlin, 2013). As a result, the choice context can have a great influence on how these relative values are generated and choices made. For example, the same option (e.g., dictionary with 10,000 words in brand new condition vs. dictionary with 20,000 words that has a torn cover) may be evaluated differently based on whether it is presented in isolation or in the presence of the other alternatives within the choice set (Hsee & Leclerc, 1998; Hsee, Loewenstein, Blount, & Bazerman, 1999). This is because when presented in isolation, the focus of attention is on the attribute that is easier to evaluate (whether it is in torn condition or new) because people have little idea about the actual number of words in a dictionary. However, when presented together, the attention shifts to the number of words because it is now easier to compare the two numbers on an important attribute. Critically, these findings do not necessarily represent intuitive processing, but a shifting consideration of attributes that go into the decision process based on prior knowledge and memory as discussed above, and its relevance to the decision maker. Similarly, preferences are also influenced by how the question is framed – strategically equivalent methods for eliciting preferences (e.g., do you like an item versus how much will you pay for an item) can lead to systematically different decisions (O'Donnell & Evers, 2019).

Another classic example is the attraction effect or asymmetric dominance (Huber, Payne, & Puto, 1982), where the inclusion of an irrelevant and dominated “decoy” option (print only subscription to Economist at $129) influences the relative preference between two other choice alternatives (online subscription for $69 versus a combined online and print subscription for $129). In these studies, 68% of the people prefer the $69 online-only subscription in the absence of decoy, but only 16% prefer this option in the presence of the decoy (Ariely, 2008). A common explanation for the attraction effect is based on the notion of intuitive processing – the presence of a dominant option makes the decision feel easier and leads to the choice of that option. Studies have also found that people are more likely to choose the dominant option when they are placed under cognitive load (Pocheptsova, Amir, Dhar, & Baumeister, 2009), arguing in favor of these options being based on intuitive System 1 than deliberative System 2. Yet, others have also argued that it is based on justification-based processes that are deliberate and effortful. For instance, do people choose the dominant option because of the attractiveness of the option, or are they now aware that they are getting the print option for only $60 rather than $129 earlier? Therefore, we contend that it is important to not label individual options as deliberative or intuitive, but focus more on the actual decision process to categorize them as intuitive or deliberative.

Goals and Motivation

Preferences also depend critically on the goals of the decision maker (Bettman, 1979)**.** These goals often represent a state of affairs that is desirable to the decision maker. In most decisions, they could be related to minimizing the effort needed to complete the task, maximizing the accuracy of the decision, maximizing the ease of justifying their choice, minimizing the possibility of regret associated with the decision, or a combination of these. Though goals are often assumed to represent some form of top-down conscious deliberation (e.g., maximizing accuracy when appearing for an interview or examination), goals are also invoked in a bottom-up manner from the stimuli in the environment (e.g., an advertisement for a product that primes certain desirable characteristics). It is also important to appreciate and acknowledge that individuals may have multiple goals, and these can fluctuate dynamically and even compete during the course of a decision (Kruglanski et al., 2002). For instance, one might visit the supermarket with a specific goal of purchasing items from a list. But when faced with an offer on an alternative item, the goal might shift to minimizing cost or purchasing other impulsive items.

Goals are important in the decision process because they can directly influence the attention paid to stimuli, making some information more salient than others (Kahneman, 1973). Goals can also influence the interpretation and meaning associated with the input information, particularly through the explicit integration of prior knowledge and experience (Russo, Medvec, & Meloy, 1996). Goals also influence the degree of control and effort, leading to differences in the processing strategies and behavioral outcomes (Bettman et al., 1998; Payne, Bettman, & Johnson, 1988b). Interestingly, additional goals can also be activated or switched adaptively based on the degree of processing and salience of input information, similar to the supermarket example above.

Another orthogonal but critical aspect of goals is an individual's motivation to succeed in a social environment. Social cognitive factors refer to "how people make sense of other people and themselves in order to coordinate with their social world" (Fiske & Taylor, 2017). In the context of decision making, individuals may use social information to understand the costs and benefits of various choice options (e.g., reading online reviews), to maintain positive relationships (e.g., when deciding based on spouse's preferences) or to maintain self-identity (e.g., identifying with certain groups) (Wood & Hayes, 2012). Social influence can be triggered by social stimuli (e.g., another person) or the social context, it can queue social associations in memory, and the emotional displays of other people can deeply affect our own bodily states and emotional experience (see below) and hence have a deep influence on decision-making processes.

In summary, goals play an important role in the extent of cognitive processing during any decision process. In some cases, goals can lead to more deliberation as individuals seek and integrate information to make goal-consistent choices. In other cases, consumers may stop additional search and information when they feel a particular goal has been attained. For instance, the ease of justification and positive affect may lead people to abandon any additional processing and choose the dominant option in the case of asymmetric dominance above. Critically, goals can also be easily manipulated (e.g., priming purchase-relevant goals through advertising and design).

Emotions and Bodily Sensation

Everyone agrees that emotions play a key role in shaping decisions. Yet, there is considerable variability in how the term is defined and its interaction with cognition. In the words of Herbert Simon (Simon, 1983), "*In order to have anything like a complete theory of rationality, we have to understand what role emotion plays in it".* Historically, emotion-based decisions have been portrayed as non-adaptive as opposed to reasoned ones. In other words, emotions and cognition have been portrayed as two independent processes, with emotions often preceding cognition (Zajonc, 1980). This is also true in the framing of DPT, where emotions have often been associated with a fast, System 1 response. One influential framework for explaining the role of emotions on decision making is the *Somatic Marker Hypothesis* formulated by Antonio Damasio and his associates, which proposes that emotional processes guide (or bias) behavior (Damasio, 1996). "Somatic markers" are feelings in the body that lead to automatic physiological changes (e.g., pupil dilation, skin conductance, heart rate, facial expressions etc.). These changes are then associated with specific emotions, which in turn influence the decision process. According to the hypothesis, these somatic markers are generated either by past associations with the stimuli (e.g., seeing a snake triggers a fight-or-flight response due to its association with fear) or by anticipating future outcomes (cognitive representations of the emotion can be activated in the absence of a stimulus). The somatic marker hypothesis and new data on the interdependence of affect and cognition in the production of emotion has been instrumental in the evolution of appraisal (Scherer & Moors, 2019) and constructionist models of emotion (Barrett, 2017). And more specifically, recent decision neuroscience research reveals a more complex interplay between emotion and cognition in shaping decision preferences (Kassam, Markey, Cherkassky, Loewenstein, & Just, 2013; Phelps, 2005; Phelps, Lempert, & Sokol-Hessner, 2014).

In our revised decision-making framework, we argue for a broader influence of emotions on decision making. Borrowing from Lerner, we first classify emotions into three categories (Lerner, Li, Valdesolo, & Kassam, 2015):

1. *Ambient or incidental emotions* that are not directly related to the decision. While incidental emotions can be triggered by one situation, those emotions can impact the decision made in a next situation even if that situation is unrelated to the previous one. This carryover effect of incidental emotions occurs without awareness. Mood is an example of incidental emotions.

2. *Task-integral emotions* arise from the nature of the decision itself and deeply shape the decision-making processes over time. These effects can occur with or without awareness. The outcome of these decisions can adaptively influence processing strategies when faced with similar decisions in the future.
3. *Affective reactions* that occur in relation to the outcome, similar to Somatic Marker Hypothesis above. These can be both *experienced outcomes* as well as *anticipated outcome*. Experienced outcomes can also have a great impact on the generation of body states and somatic markers in the future.

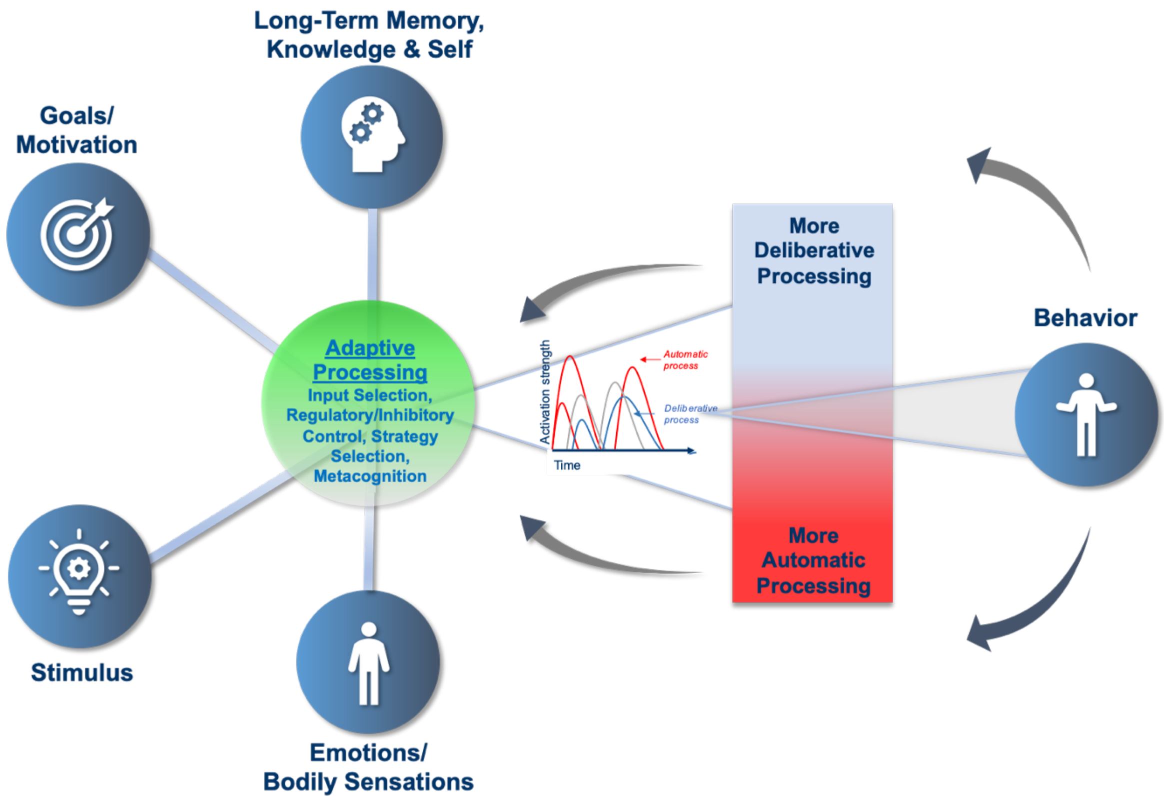

Figure 1: A Dynamic Decision-making Framework.

These different emotions can then influence core processing strategies (Lerner et al., 2015). For example, certain incidental emotions like fear and sadness increase the amount of vigilance and attention, leading to more deliberative decision strategies (Schwarz, 1990; Schwarz & Bless, 1991). Similarly, some decisions like choosing a car seat for the first child are inherently more emotional than others like choosing clothes, and lead to differences in degree of effort and processing (Luce, Payne, & Bettman, 1999). Emotions can also influence goals and motivations. For example, given that anxiety is characterized by the appraisal theme of facing uncertain existential threats (Lazarus, 1991), it is often associated with the motivation to reduce uncertainty (Raghunathan & Pham, 1999). Sadness, by contrast, is characterized by the appraisal theme of experiencing irrevocable loss (Lazarus, 1991) and motivates one to change the current circumstances, perhaps by seeking rewards (Lerner, Small, & Loewenstein, 2004). Finally, one of the most profound ways emotion can affect decision making is via counterfactual thinking (Byrne, 2016). Research in this area has demonstrated that a possible expectation of regret often triggers the kind of inhibitory control that supports more deliberative processing during decision making (Habib et al., 2012).

A Dynamic Decision-Making Framework

We extend our adaptive decision-making framework earlier by integrating context, preference construction, long-term memory and knowledge, and emotions to build a more comprehensive dynamic decision-making model (Figure 1). In this model:

- Stimulus context, goals/motivation, long-term memory/knowledge/self, and body states all influence the nature of adaptive processing and cognitive control, leading to engagement of different strategies that lie along the continuum of automatic and deliberative processing.
- These different factors also interact and influence each other (e.g., specific goals can be influenced by long-term memory and lead to different body sensations). Goals in turn can shape the degree of attention and effort paid to different stimuli and their attributes, and how their values are constructed.
- These factors are also updated based on the outcome of decisions and may have differential influence on similar decisions in the future.

The following example illustrates the proposed decision-making framework in action, although it is not meant to be exhaustive to account for all the links and relationships. Imagine someone has finished shopping at a grocery store and confronted by a candy display when waiting to check-out. The primary goal of this shopper was to buy a set of items from a list. While waiting in the line to check out, they are exposed to a variety of visual stimuli in the environment – the person in front of the line checking out, the cashier, the length of the line in other counters, the efficiency of the cashiers, the number of items in the basket/cart for customers and so on. These are stimuli that may or may not receive any additional processing based on the current goal. Suddenly, the person's eyes fixate on a different stimulus – a piece of candy wrapped in a bright wrapper on a display shelf by the checkout counter. The bright wrapper captures the shopper's attention (bottom-up input selection).

Dynamic Decision-Making Framework

As the line clears and it is the shopper's turn to check out, they impulsively reach for the candy and place it with other items in the shopping cart without any further **regulatory processing**. This would represent a canonical System 1 response according to DPT, especially if this happens to be a favorite candy of the shopper (as retrieved by past conceptual knowledge and associations) and it instinctively triggers a positive bodily emotional response.

Alternatively, the shopper might choose to process the items on the candy shelf more (increased **input stimulus processing** and **selection**), especially if the initial candy does not trigger a strong positive association. Alternatively, this may also trigger a choice conflict if there is more than one candy that the person prefers. Additional goals are also activated meanwhile – the **joys** of eating a candy, possible regret from not eating the other candies, the health consequences, and the cost involved. This triggers conflict and activates additional executive processing and deliberation. Multiple strategies for decision making are now in play simultaneously along the spectrum from automatic to deliberative, and the decision depends on the degree of **executive control** and the dominance of **certain goals** and **bodily states** based on past experience. For example,

- The shopper simply follows their impulse and picks up the candy.
- The shopper chooses not to buy anything after considering all options and goals and balancing them.
- The shopper chooses to pick up the first candy after considering all options and goals and balancing them and deciding that joy of eating the candy outweighs other concerns.
- The shopper decides to choose a more healthy-seeming granola bar.

Critically, the same choice (buying the first candy that captured their attention) can result from a fast and automatic response, a completely deliberative processing response, or a response in the middle (when alternative candies and goals are considered briefly but ignored in favor of enjoying the candy). The same response may also be associated with different levels of enjoyment of the candy, and differential updating of schemas for future decisions. We contend that it would be a mistake to attribute the choice of the initial candy to System 1 and term it as an impulsive gut-level response without insights into the decision process, as highlighted in the proposed decision-making framework. We discuss this and the other managerial implications in the following section.

Measurement and Insights into Decision Processes

In the past decade, there has been a burgeoning use of neurophysiological methods to understand decision making and consumer behavior. A new industry, called Neuromarketing or Consumer Neuroscience, has also been built around the use of tools like eye-tracking, galvanic skin response, heart rate, facial affective response (i.e., facial coding), and EEG, based on the increasing accessibility and the decreased administration costs of these methods (Plassmann, Ramsoy, & Milosavljevic, 2012; Venkatraman et al., 2015). We argue that each of these tools can provide valuable and complementary insights into the various stages of the decision process outlined in our decision-making framework (Figure 2). And because they are complementary, using multiple methods will result in more comprehensive insights.

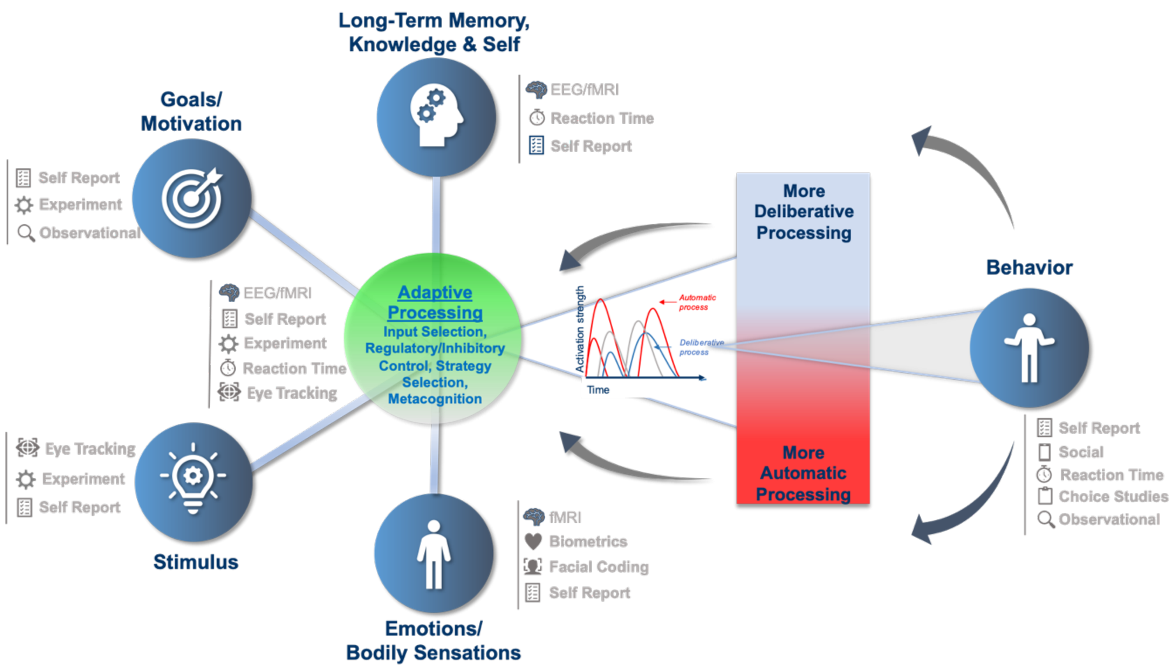

Figure 2: Tools for measuring various aspects of the decision process as defined in the dynamic decision-making framework.

First, carefully framed self-report measures combined with other behavioral measures like response times can provide significant insights into almost all aspects of the framework, even in the absence of sophisticated neuroscience tools. These measures can be extended to include other newer process tracing methods like mouse tracking and Mouselab (Schulte-Mecklenbeck, Kuehberger, & Johnson, 2019), which also provide insights into the temporal evolution of the decision process. That these measures can support both fast/automatic responses as well as slow/deliberative responses is in sharp contrast to the commonly held belief that neurophysiological tools are required to obtain insights into emotions, and self-report measures only measure deliberative responses. For example, we can measure how fast do consumers choose their preferred brand when deciding between two alternatives, and how is their speed of response affected when additional attributes about the brand (i.e., price) are presented during the decision process. These responses could illustrate the degree of conflict experienced by the consumer in making their choice, and their curiosity/regret about the alternative options. These data may in turn predict the likelihood of the participant switching away from their preferred brand in the future.

Second, the framework emphasizes and key role for effective experimental designs in isolating the key variables of interest. For example, researchers can explicitly control or manipulate the goals (emphasizing speed vs. accuracy of response) of the respondent and measure its impact. Similarly, the framing and presentation of the decision problem can be varied across trials to identify preference beyond simple context effects. Finally, one can also experimentally vary the emotional states of the respondent (e.g., use of background music or other design aesthetics) to elicit systematic changes in behavior.

Finally, neuroscience tools can extend these insights by providing a more nuanced view of the underlying processes. Moreover, they can produce better information about the time course of consumer response to marketing stimuli or experiences, providing clear diagnostic insights about how or why these marketing instruments succeed or fail. For example, we can use measures like EEG and fMRI to directly measure and quantify the degree of conflict and control required in making a decision. Eye-tracking provides valuable insights into the aspects of the stimuli that are processed. Eye-tracking also provides insights into the temporal sequence of information acquisition which in turn indicates the adaptive and dynamic nature of the decision process. Lastly, one can use measures like facial coding, skin conductance, heart rate and pupil dilation to quantify the role of emotions and bodily states in the decision process. The high temporal resolution of several of these measures, together with self-report measures, also help quantify the timing the precise moment when emotions influence the decision process – whether they are incidental to the task or related the information being processed by the respondent or related to the anticipation of the potential outcomes.

In summary, each method provides unique insights into the different aspects of the proposed framework. However, each of these methods also have their own limitations (Plassmann et al., 2012). Therefore, it is important to identify the right combination of methods to obtain complementary insights into the current decision problem or scenario.

Conclusions and Implications

Human decision making is governed by a much more complex and nuanced process than a simple binary switch between two modes of thinking. We are flexible and dynamic in the way our decision processes unfold such that we can adapt our behaviors and outcomes to fit the environment or context we are in. Multiple processes ranging from more mindless and automatic to more mindful and controlled cascade in any given problem or focal choice situation. And all of this is influenced by our context, goals, sensations, emotions and prior experience and memory.

Our proposed decision-making framework seems sufficiently complex to apply for almost any decision made by individuals across a wide array of contexts. Therefore, naturally questions arise about how it can be applied and interpreted in each of these different decisions and contexts? While the framework is broad, the components that are more influential will vary from scenario to scenario and not all components of the model have to be explicitly involved in each and every scenario. At the same time, it is also important to appreciate the limitations based on the constraints of the current scenario and measurement tools, and temper expectations and inferences accordingly. For example, it is important for one to consider the goals and motivation of a respondent when taking an online survey vs. answering the same questions for a job interview. Similarly, it is important to consider when the questions are posed – whether they are at the beginning of a long survey or towards the end. Neglecting these differences when analyzing the responses can lead to faulty and unreliable inferences.

What does this mean for managers seeking to influence consumer choice or policymakers, governments or cultural leaders looking to influence human behavior? The marketing and public policy zeitgeist of the past 15 years has been dominated by a fascination with processes that are thought to be automatic and unconscious and not under human control. The latest research summarized by our new framework shows that human decision making is adaptive in nature. Likewise, the strategies and methods used by marketers and policy makers to influence humans must also be adaptive. Sometimes the goal is to reinforce existing behaviors and facilitate automatic responding. In other instances, marketers may want to disrupt current thinking and spark a change in behavior and then implement approaches that will help sustain that behavior, perhaps even making it more and more automatic over time. Managing the structure of the decision process or choice architecture can be helpful in this endeavor, but a more effective approach to influencing human decisions and behavior will look to the broader array of factors including the person's goals, personal and social motivations, emotions, and knowledge and memory of prior experiences, and how all these forces are balanced by adaptive or executive control. Marketing, government and other public policy strategies should therefore be based on the context and desired outcomes, seeking in some instances to speed mindless non-adaptive processing to support already automated decisions/behaviors, but in other instances to trigger inhibitory control by activating goals, motivations, emotions or associations that will bring to the fore a more mindful, deliberative and adaptive process.

Second, to be most effective, applied research on human decision making and response to marketing and policy actions must use multiple methods to more fully account for the complexity of the various psychological systems and social influences involved. Various neurophysiological tools can provide highly granular insight into how people are experiencing the flow of experience, and that insight will be more accurate when multiple methods are used. But ultimately, the goals and motivations that frame human experience and decision making and the meaning that people make of that experience is more readily accessible using methods such as self-report, experiments, and other observational tools such as tracking digital behavior and social media communications and signaling.

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