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A Theory of Intraperson Games

A wide variety of theories across disciplines posit the existence of multiple inner preferences (selves, drives, or agents) within each person, whose conflicts must be resolved for a person to reach a decision. Despite their strong validity, these theories have not been incorporated into mainstream management science literature because of their qualitative nature. In this article, the author proposes a theory of intraperson games (TIG) to fill this important gap. Building on social welfare literature and standard (multiperson) game theory, the TIG defines two types of intraperson players, and each has a unique strategy set. The first type, the efficiency agent, attempts to maximize the total utility for the entire set of selves that reside in a person's mind. The second type, the equity agent, strives to balance the utilities that each of these selves receives. The TIG states that an individual decision is the outcome of the strategic interaction between the efficiency agent and the equity agent. Thus, standard consumer utility theory is a special case of the TIG if the role of the equity agent is ignored. A mathematical apparatus is provided for the TIG and is defined in a way similar to standard (multiperson) game theory. As a general quantitative theory, the TIG can be applied to many different contexts across disciplines, including, but not limited to, management science. The author demonstrates one such application for variety-seeking behavior and shows that stochastic variety seeking is a mixed-strategy equilibrium in an intraperson game. Key theoretical insights from this applied model are subsequently validated in an empirical study.

"An angel on one shoulder and a devil on the other" is a familiar American folk expression that captures moments of conflict that most people have experienced at one time or another. It recounts the anguish of a person who is pulled in opposite directions by two conflicting preferences (the angel on one shoulder tells him or her to do one thing, and the devil on the other shoulder tells him or her to do the opposite).

This folklore exemplifies a school of thought that underlies a wide variety of theories across disciplines that posit the existence of multiple inner preferences (also called selves, drives, and agents in different literature) within each person, whose conflicts must be resolved for a person to reach a decision. Such thinking begins with Sigmund Freud's (1923) structural theory and also includes Carl Jung's (1959) unconscious and persona theory, Erik Erikson's (1968, 1970) stage concept, Henry Murray's theory of needs (see Shneidman 1981), Charles Brenner's (1982) conflicting-mind theory, Marvin Minsky's (1986) "the society of minds," and the theory of reasoned action (Ajzen and Fishbein 1975, 1980).

Despite their strong validity, these theories are mostly qualitative. To the best of my knowledge, no general quantitative theory models individual decisions as the outcome of the (strategic) interaction of multiple selves. The lack of such a rigorous framework has limited the theories' descriptive and prescriptive power for at least two reasons. First, in general, qualitative theories are not particularly powerful in some complex situations and cannot offer precise insights. Second, they are poorly suited to serve as building blocks for quantitative theories based on individual decision making (e.g., economics, management science). Without a quantitative framework for multiple selves, economics and management science simply assume that people are governed by their singular selves (i.e., utility function).[1]

This article proposes a general quantitative framework to fill this important gap based on the following intuition: The state-of-the-art quantitative approach to modeling strategic interactions among multiple parties uses (multiperson) game theory. If the roles of multiple selves (within each person) can be formalized to characterize them similarly to the ways (e.g., payoff, actions, knowledge, belief) that define each player in a multiperson game, it should be possible to develop a modified version of multiperson game theory to capture individual decision making. Thus, I propose a theory of intraperson games (TIG) to model explicitly the strategic interactions of people's multiple selves.

To demonstrate the utility of this new theory, I implement a TIG model for variety-seeking behavior. Variety seeking refers to "the tendency of individuals to seek diversity in their choices of services or goods" (Kahn 1995, p. 139) and typically appears within the context of switching among options. In the context of multiple selves, the parsimonious TIG model provides a theoretical explanation for stochastic variety seeking as an equilibrium strategy in an intraperson game. It also identifies specific conditions in which a consumer seeks variety and then empirically validates these conditions.

The rest of this article is organized as follows: The relevant literature is first reviewed on multiple selves. Then, the TIG is proposed, followed by an application for variety-

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[1]For exceptions, see the discussion in the next section.

ISSN: 0022-2429 (print), 1547-7185 (electronic)

Journal of Marketing
Vol. 71 (April 2007), 1–11

seeking behavior. Finally, the article concludes with a general discussion and directions for further research.

Relevant Literature

Modeling individual decision making as an intraperson game is meaningful only if existing theoretical and empirical literature supports two premises. First, multiple selves must exist inside a person's mind, and their interactions must lead to observed individual behavior. Second, at least some of these selves must be capable of choosing strategies that improve their own utilities and (possibly) reach equilibrium outcomes. The first premise provides the requisite environment for intraperson games, because by definition, any game requires more than one player. The second premise makes it relevant to study people's behavior in a game theoretical framework because standard game theory has little descriptive or prescriptive utility in situations in which the players are not intelligent enough to formulate long-term beneficial strategies. Therefore, literature that supports these two premises is reviewed.

Multiple Selves and Individual Decision Making

Two streams of literature posit that people's minds consist of multiple selves, each with its unique characteristics. Research in psychology and psychiatry attempts to understand people's decision making and provide descriptive (diagnostic) and prescriptive solutions, whereas research in artificial intelligence (AI) investigates the construction of the human mind to inform its creation of machine intelligence. I highlight the structure theory (Freud 1923) of the first stream and the society of minds (Minsky 1986) of the second to provide a foundation for the TIG.

Many psychological and psychiatric theories espouse the notion that each person possesses multiple and often conflicting selves (or preferences) and that a decision requires the resolution of these conflicts. Many notable researchers, such as Anna Freud (1936), Fenichel (1941), Hartmann and Kris (1945), Hartmann, Kris, and Loewenstein (1946, 1949), and Brenner (1975, 1982), have extended Sigmund Freud's (1923, 1926) influential structural theory. In "The Ego and the Id," Freud (1923) proposes three major functional centers of the mind. The id represents instinctual drives, is largely biological, and resides in the unconscious, which makes it, by nature, primitive, self-centered, and antisocial. Freud also identifies two id-related drives, erotic and aggressive—though subsequent work suggests that any given person can possess various drive derivatives (Brenner 1982)—that aim toward whatever feels good at a given time, regardless of reality. The superego consists of a group of moral imperatives that enable the person to pass judgment about what is right and wrong and act as an observer or critic. Some refer to the superego as conscience because it represents self-judgment, self-punishment, and ideal aspirations and, in general, functions at an unconscious level. Although the superego is strongly influenced by social standards of the culture in which the person is raised, it is not an internal replication of such standards but rather is individual in nature, in that it represents the internalization of a person's exposure to the ideals and standards of other important people. In general, the demands emanating from the superego conflict with those from the id. Finally, the ego mediates the internal and external environments and reconciles the drives of the id and the ideal aspirations of the superego on the basis of an assessment of realistic consequences (Brenner 1982). Therefore, ego might be viewed as a person's own self; it is learned through interactions with important people, through which it acquires methods to cope with difficult situations. The ego also goes through an endless process of adaptation, reconciliation, and integration, so each person develops his or her own set of compromise rules to respond to inner and external pressures.

Similar thinking also has emerged in the field of AI. Although this field continues to evolve, Minsky (1986), one of the founders of AI, argues in *Society of Minds* that minds are not singular entities but rather are composed of a large number of "miniminds" (which he calls "agents"). Each agent has a specific and limited role, and the interaction of these agents results in the person's observed intelligence. Minsky suggests a hierarchical structure, such that a higher-level agent chooses which lower-level agent the person uses during a given situation. However, Minsky does not differentiate the roles of those agents or indicate how higher-level agents might make choices; he asserts only that they occur in a hierarchical structure. Thus, his theory does not provide a specific framework for constructing quantitative models of intelligent individual decision making.

Although both streams of literature are qualitative, they argue convincingly that multiple selves exist and that interactions among these selves lead to decisions. Thus, although no theories provide a quantitative framework to capture such interactions, existing theories offer the building blocks for intraperson games. Specifically, the proposed TIG incorporates the roles of the three distinctive types of selves (id, ego, and superego) from structure theory and the concept of agents in a hierarchical relationship from Minsky's theory.

Ability to Identify Equilibrium Strategies

The idea of multiple selves within each person is a necessary but not sufficient condition to support a game theoretical approach to modeling individual decision making. That is, the TIG can offer little descriptive or prescriptive utility if the multiple selves cannot formulate strategies to improve the individual selves' utilities and potentially reach equilibrium outcomes. As is theorized in both psychiatry and AI, most selves/agents in isolation possess limited or no intelligence and cannot conduct the sophisticated thinking (e.g., backward induction) that classic game theory requires. However, two alternative research streams indicate that selves may be capable of identifying better strategies and equilibrium outcomes. According to evolutionary theory (Darwin 1859) and its offspring—evolutionary game theory (Maynard Smith 1982) and evolutionary psychology (Buss 1999)—an entity could identify better strategies with essentially no intelligence. In addition, another research stream argues that such strategies can be achieved with learning through even basic intelligence (Fudenberg and Levine 1998).

Evolution theory states that only two elements are necessary for an "optimal" outcome: mutation and selection. Even in the absence of intelligence, random mutation coupled with strong selection pressures leads to seemingly rational evolutionary outcomes. As an extension, evolutionary game theory (Maynard Smith 1982; Weibull 1995) demonstrates that multiperson games require no intelligence (which differs from the often ridiculed superrationality assumption in classic game theory) for the players to identify equilibrium strategies. The same argument might be used for intraperson games because the strategies of different selves vary greatly, and strong selection pressures push for the best possible outcomes of individual decision making. For example, someone who undertakes a suboptimal strategy of giving in to his or her desire for fat intake is unlikely to stay fit or to produce offspring with similar strategies. Similar thinking dominates the development of evolutionary psychology (Buss 1999; Tooby and Cosmides 1992).

According to the learning literature (Fudenberg and Levine 1998), a person's ability to adopt strategies that offer better welfare may occur with simple learning using basic intelligence (e.g., reflex), and therefore people may reach complicated equilibriums in the long run. For example, the simple best-response strategy in the familiar Cournot game (i.e., the player selects a strategy that is the best response to the observed history of previous periods) eventually leads to Nash equilibrium (Fudenberg and Levine 1998). This support is also consistent with psychology theories; for example, structure theory posits that the ego develops and learns through repeated actions over many years.

Therefore, these streams of research argue convincingly that at least some selves are capable of identifying better strategies and, over the long run, possibly even reaching equilibrium outcomes with little (or no) intelligence. In turn, I argue that it is appropriate to model individual decision making as an outcome of intraperson games.

Recently, economists have begun to model individual decisions explicitly by extending their conceptualizations beyond a singular preference structure. Fudenberg and Levine (2006) develop a model of a dual self (see also Bernheim and Rangel 2004), which consists of a long-term, patient self and a short-term, impulsive self. This approach represents a specific implementation of the TIG propose herein.

The TIG

The proposed TIG consists of two components: a new conceptual framework of multiple selves that is amenable to game theoretical modeling and a specific mathematical apparatus that allows the interactions of those selves to be modeled as games. After presenting the theory in this sequence, I offer a brief discussion of potential applications of the TIG in various disciplines.

A Conceptual Framework of Multiple Selves

Many different paradigms of multiple selves have been proposed in the literature, though virtually none of them define the relationships among the selves precisely enough to make the paradigm amenable to quantitative modeling. In response, I propose a new conceptual framework that is general enough to capture the essence of multiple selves without appearing partial to any particular theory; furthermore, it consists of precise characteristics for each self and the relationship among the selves. Thus, the proposed framework provides a general foundation on which different theorists may model individual decision making as intraperson games, consistent with their own paradigms of multiple selves. To provide intuitive links to existing literature, I discuss the TIG's relationship to structure theory and the society-of-minds theory when relevant.

The proposed framework can be summarized as follows: (1) Each unique entity within the mind is an agent, (2) all agents are classified into four different types, (3) agents within each type have the same characteristics, and (4) the nature of interactions among agents is determined by the types of these agents but is not agent specific. Whereas psychiatric theories tend not to treat action as a unique entity inside the mind, AI research considers both preference and action unique entities. Minsky (1986) calls all actions agents; for example, he considers the action of building blocks a build block agent. I follow this latter tradition and define all unique entities as agents in the new framework, which enables me to include all paradigms of multiple selves.

However, Minsky (1986) does not specify any specific relationships among agents, and though psychiatric theories distinguish among the id, ego, and superego, they do not specify precise relationships with regard to their interactions. Therefore, I synthesize existing literature to develop four distinctive types of agents with two different levels. When cast in the game theoretic framework, agents in the higher level are the players, and those in the lower level are the strategies that higher-level agents might use. Table 1 contrasts the various characteristics of these agents.

In the TIG, the two types of lower-level agents are referred to as behavioral and identity agents. Behavior agents are the actions a person might take, and they represent the entities inside the mind that are responsible for implementing specific actions. Psychiatric theory does not model such behavior agents formally but simply treats them as general action. Following the literature, I assert that behavior agents do not have utilities themselves and mirror the actions defined in the standard game theory.

Identity agents consist of the unique preferences of an individual person; in the structure theory paradigm, they would correspond to the drive derivatives of the id and the rules of the superego. Thus, the angel on one shoulder and the devil on the other refer to two contrasting identity agents. Other common folk wisdom, such as "enjoy life as if there were no tomorrow," also refers to a type of identity agent. Each identity agent has its own utility function and acquires utility if it is selected to represent the person's preference. Identity agents are not modeled in standard game theory, which assumes that each individual has a singular identity.

In the TIG, two types of higher-level agents are also defined: efficiency (control behavior) and equity (control identity) agents; this structure is based on literature in social

TABLE 1
Four Types of Agents in the TIG

	Higher-Level Agents		Lower-Level Agents	
	Efficiency Agents	**Equity Agents**	**Behavior Agents**	**Identity Agents**
Examples of agents of each type	Maximize the sum of utility from all identity agents	Choose each identity agent with a certain probability	Eat cake	Enjoy life as if there were no tomorrow
Role in TIG	Players	Players	Strategies/actions	Strategies/actions
Payoff	Overall utility of all identity agents	How utilities are distributed across identity agents	N.A.	Utility of individual identity agent
Strategies	Choose which behavior agents to play	Choose which identity agents to assume	N.A.	N.A.
Corresponding concept in structure theory	Ego	Ego	N.A.	Id and superego
Corresponding concept in society of mind	Higher-level agents	Higher-level agents	Agents	Agents
Corresponding concept in standard game theory	Players	N.A.	Actions	None (singular entity)

Notes: N.A. = not applicable.

welfare, which notes the perpetual trade-off between efficiency and equity. From social planners' point of view, it is not enough to ensure efficient allocation (i.e., maximize social welfare according to the sum of utilities for all members in a society); some equitable division of that welfare must also occur among members of a society. Actual social policies themselves usually result from a compromise between the drive for greater efficiency and the drive for improved equity.[2]

If a person consists of multiple selves, he or she must also confront the trade-off between efficiency and equity to make decisions. That is, although individual decision making attempts to make the person better off overall (efficiency), people also consciously and unconsciously work to ensure that their selves take turns to dominate (equity), even if this means lower overall utility (e.g., a common and successful strategy in weight control is for a person to allow him- or herself to eat junk food one day each week).

In turn, efficiency agents are entities that make conscious choices regarding which behavior agent to use in a given situation and therefore correspond to the coping methods (decision rules) of the ego in structure theory. Because efficiency agents are interested in the overall utility of all identity agents, their objective is to maximize the sum of these utilities. Therefore, in the context of the TIG, efficiency agents represent the players, and behavior agents represent their strategies. Efficiency agents likely exist at the conscious level and are capable of sophisticated thinking, as assumed in standard game theory, which models them as players.

In contrast, equity agents select which of the identity agents to use and therefore correspond to other parts of the ego in structure theory. A familiar saying illustrates how equity agents work; namely, people "wear many different hats," and behavior changes depend on which hat (or identity) is being worn at a given time. In the TIG, hats are the identity agents, and equity agents select which identity agent (hat) a person wears in a particular situation, with or without conscious awareness. Unlike efficiency agents, equity agents attend to how utilities get distributed across different identity agents, so their payoff likely corresponds to whether every identity agent receives a fair chance of being selected. Equity agents also are players in the TIG, and their strategies are the identity agents; thus, their objective is to select a specific identity agent to represent the person at a given moment, such that in the long run, all relevant identities have a fair (though not necessarily equal) chance of selection. Although they likely function at both conscious and unconscious levels, equity agents may not be capable of sophisticated thinking. Furthermore, standard

[2]For example, consider family decision making with two parents and multiple children. One parent's objective could be to ensure that the sum of utilities for all children is maximized, even if that means giving one child most of the resources and minimum amounts to the others. Another parent's objective could be to ensure that each child derives a minimum utility from the decision and that the maximum difference among all children does not exceed a ceiling level. Thus, family decisions are the result of discussion and compromise between the two parents.

game theory does not include equity agents; in many cases, people treat their implications simply as irrational behavior.

Formal Specification of Intraperson Games

Building on the preceding conceptual framework, I specify the requisite mathematical apparatus for the TIG to make it amenable to game theoretical analysis. A normal (strategic) form game in standard multiperson game theory includes three elements (Fudenberg and Tirole 1991): a finite set of players, the pure strategy space for each player, and payoff functions for each combination of strategies. A mixed strategy represents a probability distribution over pure strategies and essentially randomizes several pure strategies. In line with classic (multiperson) game theory, intraperson games are defined in the normal form and suggest the corresponding TIG definitions for each element using appropriate mathematical formulations and supported by theoretical arguments. Finally, the equilibrium concept and its existence in TIG are discussed.

Definition 1: There are two types of players in TIG, efficiency agents and equity agents.

The pure strategies for efficiency agents are behavior agents (actions a person could take in a game), just as in standard game theory. The pure strategies for equity agents are the various identity agents from which they might choose, whether consciously or (more likely) unconsciously. In a given TIG, the pure strategy space of equity agents probably involves identity agents from both the superego and the id. (It is also possible that they are drive derivatives of the id.) Bénabou and Tirole (2004) take a similar approach by allowing individual decision makers to choose between a "no-willpower" option and a "willpower-dependent" option, which is equivalent to the equity agent selecting between two identity agents in TIG, though Bénabou and Tirole do not model the role of the efficiency agent explicitly.

Definition 2: The pure strategy for an efficiency agent is $S_b = \{s_b^1, ..., s_b^B\}$, or the set of all relevant behavior agents; the pure strategy for an equity agent is $S_i = \{s_i^1, ..., s_i^I\}$, or the set of all relevant identity agents.

A mixed strategy in multiperson game theory reflects a probability distribution over pure strategies, but in the TIG, the mixed strategy must be considered separately for efficiency and equity agents. For an efficiency agent, the mixed strategy is a straightforward randomized choice among the various possible pure strategies, just as it is in multiperson game theory. For an equity agent, mixed strategy means that an equity agent's choice of identity agents at a given time is not deterministic. Freud's (1923) original work (see Gay 1989), as well as more recent work (e.g., Brenner 1982), supports this assertion. Psychoanalytic theory states that the id and superego compete in any given decision-making situation, such that the drive derivatives of the id win on some occasions and the rules of the superego win on others. If a person always listens to his or her id drive derivatives, the anxiety and/or depressive effect from the superego becomes salient and diminishes the chances he or she will continue to listen to the id the next time. Conversely, if a person consistently listens to his or her superego, the displeasure from the id becomes salient and diminishes the chances of following the superego. Therefore, the selection of an identity agent on a given occasion is rarely deterministic; rather, the balance between defense (superego) and drive gratification (id) remains mobile (Brenner 1982). Note that there are exceptions to this statement; always succumbing to drive derivatives is the definition of clinical illness, and people who always follow their superego become rigid, obsessive, and/or compulsive. However, most people fall somewhere in between.

Definition 3: The mixed strategy for an efficiency agent is $\Sigma_b = \{\sigma_b^1, ..., \sigma_b^B\}$, a probability distribution over S_b; the mixed strategy for an equity agent is $\Sigma_i = \{\sigma_i^1, ..., \sigma_i^I\}$, a probability distribution over S_i.

The payoff for an efficiency agent parallels the Von Neumann–Morgenstern utility in its familiar form, whereas the payoff for an equity agent is more complex. As social welfare literature demonstrates, it is easy to define efficiency, but there is no consensus regarding what equity really implies. Therefore, instead of constraining the TIG by a specific formulation of equity agents, the payoff for an equity agent is loosely defined as a function of the utilities of each identity agent and the probabilities of each outcome. Applications of TIG can specify a specific formulation that is consistent with the problem at hand (as is done in the next section for variety-seeking behavior).

Definition 4: The payoffs for the four types of agents are as follows:

a. Behavior agents do not have a payoff.

b. The payoff for an identity agent m is 0 if the equity agent does not select it and $u^m(s_b^n)$ if the equity agent selects it and the efficiency agent's strategy is s_b^n.

c. The payoff for an efficiency agent is the sum of utilities of all identity agents, $u_b(\Sigma_b, \Sigma_i, u^m[s_b^n]) = \Sigma_{m=1}^{I} \Sigma_{n=1}^{B} \sigma_i^m \sigma_b^n u^m(s_b^n)$.

d. The payoff for an equity agent is a function of the payoffs for each identity agent and the probabilities that each outcome will be realized, $u_i(\Sigma_b, \Sigma_i, u^m[s_b^n]) = f(\Sigma_b, \Sigma_i, u^1[s_b^1], u^1[s_b^2], ..., u^1[s_b^B], u^2[s_b^1], ..., u^I[s_b^B])$.

To complete the specification of TIG, I address the equilibrium and process of reaching equilibrium. Many different equilibrium concepts (e.g., Nash, evolutionarily stable strategy) exist in the standard game theory, but I do not attempt to take a stand on which is most appropriate for the TIG. For the purposes of this article, I simply use the Nash equilibrium and derive the following claim from Nash's (1950) theorem, which states that any finite games expressed in normal form have at least one equilibrium (including mixed strategies):

Claim 1: There is at least one Nash equilibrium, which may involve mixed strategies, for the TIG.

The two types of players in the TIG, efficiency agents and equity agents, do not operate in similar ways. At the conscious level, the efficiency agents likely conduct sophisticated thinking and anticipate other players' strategies. In other words, they behave in a rational way that is consistent with standard game theory. At the unconscious level (for the most part), equity agents possess far less ability to think strategically. Without imposing a specific structure, I simply state that equity agents identify a better strategy through one of three mechanisms discussed in the literature.

Claim 2:

(a) An efficiency agent identifies its optimal strategy using strategic thinking, as assumed in standard game theory.

(b) An equity agent identities a better strategy following one of three mechanisms:

(i) Strategic thinking, as assumed in standard game theory;

(ii) Simple heuristics, as assumed in the learning theory of games; or

(iii) Mutation and selection, as assumed in evolutionary game theory.

Applications of the TIG

Many disciplines could benefit from the TIG, including, but not limited to, psychology, medicine, AI, economics, and marketing. Table 2 provides a few examples within each discipline that might profit readily from the TIG. In marketing, for example, almost without exception, consumers are assumed to have a singular utility function and an objective of maximizing this utility. Instead, the TIG argues that the outcomes of individual decisions reflect compromises between efficiency agents (the only thing modeled in extant marketing literature) and equity agents (absent from extant marketing literature). This new perspective can shed light on how consumers make decisions about new product adoption; for example, a consumer may purchase a new product to satisfy one of his or her identity agents, even though the overall utility for this consumer decreases. It also can inform advertisers how to design their advertisements to target the interactions between efficiency and equity agents and thus influence consumers' acceptance of an advertising message. To illustrate the utility of the TIG, in the next section, I develop a parsimonious model for variety-seeking behavior, a familiar topic in marketing.

TABLE 2
Potential Applications of the TIG

Discipline	Examples of Potential Applications
Marketing	Variety seeking, new product adoption, advertising acceptance, pricing strategy, negotiation
Psychology	Cognitive psychology, personality psychology, developmental psychology
Medicine	Bipolar syndrome, placebo effect, phobia, suicide, weight loss, addiction
Economics	Consumer preference, choice theory
AI	Machine intelligence

An Application of the TIG

Variety-seeking behavior, an important topic with a long tradition in marketing (e.g., Bass 1974; Bass, Pessemier, and Lehmann 1972; McAlister and Pessemier 1982; Ratner, Kahn, and Kahneman 1999), is driven by intrapersonal factors and uncertainty about preferences. Existing literature considers three types of intrapersonal factors: satiation (Coombs and Avrunin 1977; Lattin and McAlister 1985; McAlister 1982), stimulation (Berlyne 1970; Faison 1977), and hedging (Farquhar and Rao 1976; Huber and Reibstein 1979). Empirical observations also show that variety-seeking behavior often is stochastic in nature (Trivedi, Bass, and Rao 1994).

I illustrate the utilities of the TIG with a parsimonious TIG model developed for variety-seeking behavior and show that the model provides accurate predictions about whether an individual consumer will seek variety. The resultant theoretical insights offer guidelines to managers regarding what actions they can take to encourage or discourage variety seeking. I also discuss an empirical study designed to test the validity of the theoretical model.

Theoretical Model

To develop a specific TIG model for variety seeking, I make a few assumptions about aspects that the general TIG does not specify, based on existing knowledge about variety seeking, specifically in terms of (1) the numbers of players and the number of strategies for each player, (2) the payoff for each player, (3) how an equity agent identifies a better strategy, and (4) the dynamic structure of the game and the sequence of moves. Variety-seeking behaviors are characterized by alternating choices between two or more options, such as the choice of a lunch entrée (tasty burger or healthy salad) or a drink (coffee, juice, or water). Although existing variety-seeking literature often includes many options, to obtain a precise test of the TIG, I focus on a choice situation with only two options. In most such cases, a person experiences conflict between two identity agents; for example, in the lunch choice, the consumer must choose between the desire for fat (Identity Agent A) and the desire for health (Identity Agent B).

Assumption 1: An efficiency agent has two pure strategies $S_b = \{s_b^1, s_b^2\}$, and an equity agent has two pure strategies $S_i = \{s_i^1, s_i^2\}$. The mixed strategy of the efficiency agent is $\{\sigma_b, 1 - \sigma_b\}$, and the mixed strategy of the equity agent is $\{\sigma_i, 1 - \sigma_i\}$.

The payoffs for identity and efficiency agents are as they are defined in the general TIG, though it only defines the equity agent's payoff broadly. Therefore, I make a specific assumption about the payoff for equity agents in a variety-seeking context.

Empirical literature on variety seeking demonstrates that the decision depends on how often each option has been chosen in the past and suggests a U-shaped relationship (Ratner, Kahn, and Kahneman 1999). Therefore, equity agents change their strategy on the basis of how often each identity agent has been chosen, probably not on how much utility each identity agent would achieve if selected, similar to psychiatric theories pertaining to conflict management. In his influential book *The Mind in Conflict*, Brenner (1982) claims that whether a drive derivative or a superego rule dominates at a given time depends on how often each has been satisfied previously. Thus, I propose the following utility formulation for equity agents in a variety-seeking context:

Assumption 2: Payoffs in the variety-seeking context are as follows:

a. The payoff for an identity agent m is 0 if the equity agent does not selected it and $u^m(s_b^n)$ (hereinafter abbreviated as u^{mn}) if the equity agent selects it and the efficiency agent's strategy is s_b^n.

b. The payoff for an efficiency agent is the sum of expected utilities of the two identity agents,

$$(1)\quad u_b(\sigma_b, \sigma_i, u^{11}, u^{12}, u^{21}, u^{22}) = \sigma_b\sigma_i u^{11} + \sigma_b(1-\sigma_i)u^{21} + (1-\sigma_b)\sigma_i u^{12} + (1-\sigma_b)(1-\sigma_i)u^{22}.$$

c. The payoff for an equity agent is

$$u_i(\sigma_b, \sigma_i) = f(\sigma_b, \sigma_i) \text{ and } \frac{\partial^2 u_i(\sigma_b, \sigma_i)}{\partial \sigma_i^2} < 0.$$

Specifically, a quadratic formulation is assumed[3]:

$$(2)\quad u_i(\sigma_b, \sigma_i) = -(\sigma_i - q\sigma_b - p)^2 + c.$$

Quadratic formulation has a long tradition of being used in marketing literature (Lilien, Kotler, and Moorthy 1992). The foregoing quadratic formulation allows an equity agent to have an interior optimal mixed strategy (σ_i between 0 and 1), but it does not eliminate the boundary solution (σ_i equals either 0 or 1). In this specific case, "interior optimal" means that the equity agent prefers that both identity agents gain some utility. Parameters p and q are coefficients associated with a quadratic formulation, and c is a constant independent of σ_i. In this specific case, p is related to the base utility an equity agent will receive if the same identity agent and behavioral agent are always selected ($\sigma_i = 0$, and $\sigma_b = 0$), and q is related to the magnitude of the effect that the efficiency agent's strategy (σ_b) will have on the equity agent's utility.

The general TIG suggests three possible mechanisms that an equity agent could adopt to identify a better strategy. Given the specific context of variety seeking, the equity agent is likely to use heuristics (i.e., learning theory) to determine its strategy. Specifically, I propose that the equity agent will use the best-response heuristic, one of three widely used dynamic adjustment processes in the learning literature pertaining to game theory (Fudenberg and Levine 1998), in which a player selects a strategy (action) that represents the best response to the observed history of previous periods. The best-response adjustment dynamics are particularly suitable to model the equity agent in the variety-seeking context for two reasons: First, it captures the notion that variety seeking is mostly a non-zero-order process, and it allows history to affect the current-stage decision in the model.[4] Second, it reflects the notion that the choice of identity agents in variety-seeking contexts is not likely to be highly involved, and the equity agent may not be able to anticipate the efficiency agent's strategy.

Assumption 3: The equity agent determines its strategy on the basis of the best-response adjustment.

Because variety seeking, by definition, refers to choice behavior that begins in youth and repeats until a person dies, it is logical to study the problem in a finitely repeated game framework. Thus:

Assumption 4: The efficiency agent and the equity agent move simultaneously in each stage, and the game is repeated over a finite horizon.

The subgame perfect outcome for a finitely repeated game coincides with the equilibrium in its stage game if the stage game equilibrium is unique, as is the case for this game. The key theoretical result is presented as Theorem 1:

Theorem 1: A consumer seeks variety between two behavior agents if and only if p is bounded between B_1 and B_2; the probability of selecting Behavior Agent 1 is

$$(3)\quad \sigma_b^* = \frac{u^{22} - u^{21} + q(u^{22} - u^{12}) - p\Delta}{2q\Delta},$$

where

$$\Delta = u^{11} - u^{21} - u^{12} + u^{22},$$

$$B_1 = \left(\frac{u^{22} - u^{12}}{\Delta} - 2\right)q + \frac{u^{22} - u^{21}}{\Delta},$$

and

$$B_2 = \left(\frac{u^{22} - u^{12}}{\Delta}\right)q + \frac{u^{22} - u^{21}}{\Delta}.$$

The probability of selecting Identity Agent 1 is

$$(4)\quad \sigma_i^* = p + q\sigma_b',$$

where σ_b' is the observed probability of selecting Behavior Agent 1 in the previous history, where history is defined as the previous n periods that the agents remember (or about which they care). Thus, $\sigma_b' \rightarrow \sigma_b^*$ as the number of repetitions approaches n (note that n is likely to be individual specific). (For a proof, see the Appendix.)

[3]Other specific formulations are possible; the purpose here is to propose a parsimonious model that can capture variety-seeking dynamics.

[4]I thank an anonymous reviewer for pointing out this important aspect of variety seeking.

The intuition behind the equilibrium for the variety-seeking game is as follows: Although the equity agent follows the best-response adjustment (Equation 4), the efficiency agent anticipates this strategy. If the efficiency agent consistently plays its equilibrium strategy (Equation 3), regardless of the equity agent's actions, the game converges to equilibrium quickly after some repetitions (as $\sigma_b' \to \sigma_b^*$).

Theorem 1 also specifies the conditions in which a person will seek variety; such an insight is not possible with existing qualitative theories. It further provides a coherent theoretical explanation for variety seeking due to intraperson factors.[5]

An Empirical Study

To test the validity of this model and, more important, to offer empirical support for the TIG, I conducted a small empirical study to determine whether the conditions specified in Theorem 1 are robust for predicting whether a person actually seeks variety, which differs from prior research that has attempted to predict variety-seeking choice on the basis of choice history. A good predictive performance supports the notion that variety seeking may be explained by the interactions of multiple selves within each person.

Two variety-seeking cases were selected on the basis of interviews with students at a major U.S. university; two identity agents exist in each case, and the decisions normally involve a choice between two types of behavior. The first case is what to eat for lunch, which appears to consist of two identity agents (eating something healthy versus something that tastes good) and two major behavior agents (salad versus burger). The second case pertains to the choice of a video to watch, in which case two key identity agents (have fun and relax versus be emotionally uplifting and rewarding) and two behavior agents (comedy/action videos versus emotionally involving videos) again inform the choice.

For each case, the participants were asked to respond to seven questions. The first six questions are used to obtain the six parameters that specify the variety-seeking condition in Theorem 1. The four different payoffs (u^{mn}) are obtained by direct rating questions (e.g., "Rate your enjoyment of having salad when you are in the mood of giving your body healthy food"). The parameters p and q are obtained on the basis of the optimal strategy of the equity agent (Equation 4). Participants were asked to indicate for a given observed σ_b (e.g., "if you had been eating salad 6 out of 7 times during the last week") how likely (σ_i) they would be in a given mood (e.g., "in the mood to give your body healthy food"). Each participant was asked twice, for different values of σ_b. Note that these questions are purely hypothetical and ask participants how likely it is that they would be in a specific mood, not whether they would make a certain choice. Their answers do not indicate their actual behavioral one way or the other.[6] Finally, the two pairs of (σ_b, σ_i) are substituted into Equation 4, which is solved for p and q.

In the final question, on the basis of their real-life behavior during the previous three months, participants were asked whether they always stuck to the same option (i.e., non–variety seeking) or sometimes picked one option and, at other times, picked the other (variety seeking). The responses to this question were used to represent actual behavior, against which the model's predictions were compared. The objective was to test how well this stated real-life behavior could be predicted using the six parameters and Theorem 1.

For each case, each respondent was evaluated for whether his or her parameter values indicated that he or she satisfied the variety-seeking conditions in Theorem 1. These predicted behaviors were then compared with respondents' self-stated, real-life behaviors. The 61 valid responses for food and 57 for videos appear in Table 3, Panels A and B, respectively. For food choice, 39 participants indicated that they sought variety; the model predicted that 42 participants would, and 32 of these were participants who indeed sought variety (chi-square test, $p = .003$). For video choice, 36 participants indicated that they sought variety; the model predicted that 30 participants would, and 22 of these were participants who indeed sought variety (chi-square test, $p = .093$).

Managerial Implications

These empirical results provide some evidence that the parsimonious TIG model is robust and captures the dynamics of variety-seeking behavior. This new understanding has several important managerial implications. A firm launching a new product into a market (or a firm with a small market share) might want to encourage more variety-seeking behavior, whereas a dominant firm would probably want to discourage it. Firms also may want to turn variety-seeking consumers into loyal consumers if possible.

With the new framework based on the TIG, which indicates which individual consumers are likely to seek variety, managers have more specific guidelines regarding how to influence consumers' choice behavior. According to Theorem 1, these firms should examine the six parameters (u^{mn}, p, and q) and design specific marketing tools to influence one or more of these parameters, such that more (fewer) consumers in the target segment fall within (outside) the variety-seeking region specified in Theorem 1.

Summary and Discussion

This article presents a quantitative framework (the TIG) for studying individual decision making that builds on qualitative theories used across disciplines, all of which posit that

[5]A more extensive analysis of Theorem 1 reveals that it can provide theoretical explanations for the three mechanisms suggested in behavioral literature for intrapersonal variety seeking—namely, satiation, stimulation, and hedging. This analysis is available on request.

[6]This response does not necessarily indicate variety seeking. Almost all participants stated that their probabilities are other than 0 or 1 (with the exception of one participant in the food-choice task and two participants in the video task). Nevertheless, only 64% and 63% of participants stated that they sought variety in food and video during the previous three months, respectively.

TABLE 3
Predicting Variety Seeking

A. Food Choice

		Predicted by Theorem 1		
		Variety Seeking	**Non–Variety Seeking**	**Total**
Stated by participant	Variety seeking	32	7	39
	Non–variety seeking	10	12	22
	Total	42	19	61

B. Video Choice

		Predicted by Theorem 1		
		Variety Seeking	**Non–Variety Seeking**	**Total**
Stated by participant	Variety seeking	22	14	36
	Non–variety seeking	8	13	21
	Total	30	27	57

(1) there are multiple selves within each person and (2) individual decisions are the result of the interaction among these various selves. The new TIG has two components. The first is a conceptual framework of multiple selves, which is categorized into four different agent types. All identified agent types have well-defined characteristics and are amenable to quantitative modeling. The second component is a specific mathematical apparatus, based on the conceptual framework, that makes it possible to build models for intraperson games.

The advantages of the TIG lie in its ability to capture individual decision-making processes in a more realistic framework with a rigorous apparatus. It also enables researchers to study decision problems that previously have been studied only in conceptual frameworks and qualitative theories. Therefore, the quantitative nature of this theory makes it feasible to investigate complex problems and provide precise insights.

To demonstrate the utility of the TIG, a parsimonious TIG model for variety-seeking behavior was developed, and it was shown that stochastic variety-seeking behavior can be explained as a mixed-strategy equilibrium in the TIG. The model provides precise conditions in which an individual consumer will seek variety. When this insight was tested with an empirical study of two variety-seeking cases (lunch choice and video choice), the empirical results supported the notion that the parsimonious TIG model captures the dynamics behind variety-seeking behavior and offers useful guidelines to managers who are interested in changing the scope of variety-seeking behavior among their target consumers.

Many promising areas for further research remain. A fruitful direction pertains to the equilibrium in TIG. It would be helpful to investigate which equilibrium concepts are most appropriate for the TIG and, if necessary, to develop a new equilibrium concept that is most appropriate for single-person decision making. In addition, research should explore cooperative games within the TIG. Whereas a noncooperative game framework is adopted here, it would be worthwhile to study the TIG from a cooperative game theoretical perspective. This approach may require some additional assumptions about how different agents reach an equilibrium (related to Claim 2), but otherwise, the current TIG would remain relevant. I also hope that this new theory will lend itself to various marketing-relevant applications that can shed new light on consumer decision making.

Appendix
Proofs

Lemma A1

The efficiency agent's expected utility in Stage Game G is strictly convex over σ_b if $q\Delta > 0$ and is strictly concave if $q\Delta < 0$, and the extreme value point is located at

$$\text{(A1)} \qquad \sigma_b'' = \frac{u^{22} - u^{21} + q(u^{22} - u^{12}) - p\Delta}{2q\Delta}.$$

The function is monotonic if $q\Delta = 0$, where

$$\text{(A2)} \qquad \Delta = u^{11} - u^{21} - u^{12} + u^{22}.$$

Proof

The equity agent's utility is defined in Equation 2. Because it follows best-response dynamics and bases its strategy on the efficiency agent's aggregate actions in previous stages, the equity agent's optimal strategy is simply (setting the first derivative to 0):

$$\text{(A3)} \qquad \sigma_i^* = p + q\sigma_b.$$

The efficient agent's utility is

$$\text{(A4)} \qquad u_b(\sigma_b, \sigma_i, u^{11}, u^{12}, u^{21}, u^{22}) = \sigma_b\sigma_i u^{11} + \sigma_b(1 - \sigma_i)u^{21} + (1 - \sigma_b)\sigma_i u^{12} + (1 - \sigma_b)(1 - \sigma_i)u^{22},$$

and its objective is $\max_{\sigma_b} u_b$. Because the efficiency agent is capable of anticipating the equity agent's behavior, the equity agent's optimal strategy can be substituted into the efficiency agent's utility, and derivatives can be taken:

$$\frac{\partial u_b}{\partial \sigma_b} = -u^{22} + u^{21} - q(u^{22} - u^{12}) + (p + 2q\sigma_b)\Delta, \text{ and}$$

$$\frac{\partial^2 u_b}{\partial {\sigma_b}^2} = 2q\Delta,$$

such that

$$\frac{\partial u_b}{\partial \sigma_b''} = 0 \text{ implies that } \sigma_b'' = \frac{u^{22} - u^{21} + q(u^{22} - u^{12}) - p\Delta}{2q\Delta}.$$

If $q\Delta > 0$, the utility is strictly convex, and there is no interior optimal and, thus, no variety seeking. If $q\Delta = 0$, the utility is monotonic, and again, there is no interior optimal. Thus, I focus on the case of $q\Delta < 0$, for which there could be an interior optimal (and variety seeking). Q.E.D.

Theorem A1 (Theorem 1) Proof

Following Lemma A1, if $q\Delta < 0$, the objective function is concave, and it is necessary to check where the extreme value point is located. It should be clear that $\sigma_b^* = \sigma_b''$ if $\sigma_b'' \in (0, 1)$. In this case, Options 1 and 2 are chosen on the basis of the optimal probability σ_b'' (mixed strategy). When $\sigma_b^* = 0$, if $\sigma_b'' \leq 0$, Option 2 is always selected. When $\sigma_b^* = 1$, if $\sigma_b'' \geq 1$, Option 1 is always selected. Because the equilibrium is unique in the stage game in all conditions, the equilibrium is the unique subgame perfect outcome for the entire (finitely repeated) game. It can also be shown that

$$\text{(A5)} \qquad \sigma_b'' = 0 \text{ is equivalent to } p = \frac{u^{22} - u^{12}}{\Delta} q + \frac{u^{22} - u^{21}}{\Delta}$$

and

$$\text{(A6)} \qquad \sigma_b'' = 1 \text{ is equivalent to } p = \left(\frac{u^{22} - u^{12}}{\Delta} - 2\right) q + \frac{u^{22} - u^{21}}{\Delta}.$$

When the optimal strategy for the efficiency agent is a mixed strategy, the equity agent responds with $\sigma_i^* = p + q\sigma_b'$, where σ_b' is the observed probability of the efficiency agent selecting Behavior Agent 1 in the previous history. Because the efficiency agent is capable of anticipating the equity agent's strategy, the efficiency agent can ensure that the game quickly converges to equilibrium by consistently playing its equilibrium strategy, which in turn leads the equity agent to converge to its own equilibrium strategy $\sigma_i^* = p + q\sigma_b^*$. Q.E.D.

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