A Dual-Process Model of Economic Rationality: The Symmetric Effect of Hot and Cold Evaluations on Economic Decision Making

We explore the budget waste coming from inconsistent choices triggered by "hot" and "cold" evaluations, as well as the overall budget waste across both types of evaluations. We find that budget waste coming from "hot" and "cold" evaluations is comparable, but the overall waste of budget across the two types of evaluations is significantly higher.

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Introduction

Consumers often go grocery shopping to buy food to consume throughout the week. One of their basic goals is to choose products that maximize their utility given the available budget. However, very often individuals make suboptimal decisions, which can potentially result in a loss of utility (Kahneman 2003; Kahneman and Thaler 2006). Understanding what drives economic rationality of consumers' decisions is essential in order to help them improve the quality of their decisions, and as a result prevent significant losses of utility and enhance welfare (Ratner et al. 2008). The aim of the present research is to obtain more insight in the economic rationality of consumers' decisions.

A lot of research has linked irrationality to behavior triggered by a dual-processing system (Dhar and Gorlin, 2012). According to the literature, human behavior is guided by two types of processes (Kahneman and Frederick 2002), often referred to as a hot system and a cool system. The hot system operates relatively automatically, quickly and effortlessly, whereas the cool system is more deliberate, slow and effortful. The aim of the present research is to explore economic rationality in consumers' choice behavior based on the two different systems, using a direct measure of economic rationality. Relying on the theory of Revealed Preferences, we develop a task that allows us to investigate rationality of behaviors based on the hot system on the one hand and the cold system on the other hand, and also allows us to investigate the overall rationality across the two systems. We do this by capturing the loss of budget resulting from those choice behaviors.

Dual System Theory and Rationality

One of the important assumptions in behavioral science is that decision making is driven by two types of processes (Epstein 1994; Metcalfe and Mischel 1999; Kahneman and Frederick 2002; Loewenstein and O'Donoghue 2004), often referred to as the hot and the cool system. The hot system is quick and heuristic-based, whereas the cool system is deliberate and rule-based. The main features of the hot system are its automatic operation and minimal demands on working memory. The hot system operates mostly through components of associative memory, meaning that different associations emerge spontaneously and influence behavior. The hot system tends to be rapid, unconscious and uncontrollable (Evans and Stanovich 2013). In contrast, the main features of the cool system are its active engagement of working memory and analytical thinking. Cool system processing happens willful, and is effortful most of the time. It tends to be slow, conscious and controllable (Evans and Stanovich 2013).

In an experimental study, Shiv et al. (2005) showed that participants able to use their emotional (hot) system made less advantageous gambling decisions and thus gained less money than participants not able to use their emotional system (due to brain damage) and thus relying on their cool system only for making decisions. Consumer research also provided evidence on the lack of rationality in choices resulting from hot system activation. Pocheptsova et al. (2009) found that consumers relying on their hot system (due to resource depletion) engaged in behaviors that are typically viewed as not rational, such as an increase in reference-dependent choices and the attraction effect. Moreover, studies on resource depletion showed that depleted consumers using their hot system were willing to pay significantly higher amounts of money for products than consumers who were not previously depleted (e.g. Bruyneel et al. 2006).

On the other hand, more recent studies showed that certain features of cool state behavior can potentially lead to decisions being considered as irrational. Relying on cognitive processing during a choice task has been found to lead to less preference consistency than relying on affective processing (Lee et al. 2009; Nordgren and Dijksterhuis 2009). These studies argue that deliberation can hinder systematic processing in decisions as it operates as a form of distraction which pulls individuals' attention away from the most relevant information. Similarly, studies on unconscious thought and decision making show that the more deliberative approach taken by the cool system can lead to less accurate decisions in some situations (Dijksterhuis 2004; Dijksterhuis et al. 2006).

Adopting yet another perspective, some studies suggest that loss of utility does not result from activation of a specific (i.e., the hot or the cool) system, but rather from a potential discrepancy between decision frames and/or decision situations. For instance, Read and Loewenstein (1995) found that when people choose multiple goods simultaneously (for instance during grocery shopping), they choose more variety of products than when they choose these goods sequentially (i.e., known as the "diversification bias"). According to the authors, this discrepancy in desired variety can potentially lead to inconsistent choices and loss of utility over time. Investigating the diversification bias further, Read et al. (1999) concluded that what appears to be desirable locally might not be likeable when adopting a more global perspective.

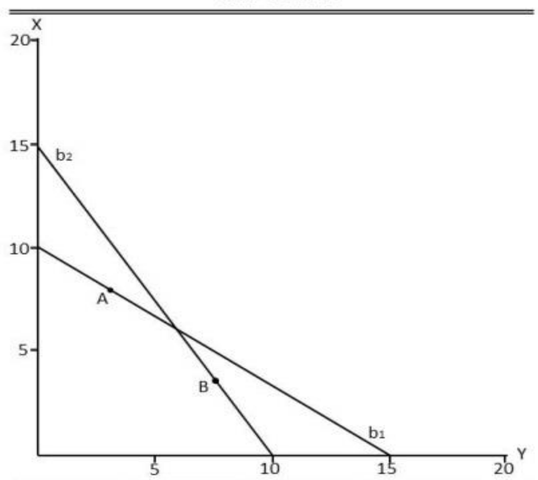
To summarize, findings on the influence of dual-processing on rationality are equivocal. There are studies implying that economic irrationality is driven by the hot system, but there are also studies hinting at the idea that the cool system triggers irrational behavior. Other studies adopt a more neutral position, and suggest that a discrepancy between decision situations (and decision frames or states) may trigger inconsistent decisions, and thus result in an overall loss of utility. However, none of the studies investigating irrationality in decisions has used a direct measure of economic rationality involving conditions with different price regimes and budget restrictions. We believe that an investigation that does this could be very helpful in shedding light on the drivers of economic (ir)rationality. We use the General Axiom of Revealed Preferences (GARP) and Afriat's Index to examine rational choice behavior in terms of efficient budget use. This method also enables us to experimentally isolate and assess the rationalities in hot states and cool states independently (local rationalities), as well as assess the overall rationality across the two states (global rationality) and compare to the local rationalities.

Revealed preferences and Afriat's Index

Varian (1982) formulated the General Axiom of Revealed Preferences (GARP), which makes use of indirect revealed preferences. A chosen bundle of goods x_i is "indirectly revealed preferred" over some other bundle x_t, if and only if there exists a sequence of bundles x_j, x_k ,… , x_s such that x_i is directly preferred over x_j, x_j is directly preferred over x_k, … , and x_s is directly preferred over x_t. According to the GARP, if a bundle x_i is indirectly revealed preferred to x_t, then x_t is not strictly directly revealed preferred to x_i, that is, x_i is not strictly within the budget set when x_t is chosen. Varian proved that GARP is a sufficient and necessary condition for decision-makers' choices to be consistent with the maximization of a concave, weakly monotonic, locally non-satiated and continuous utility function.

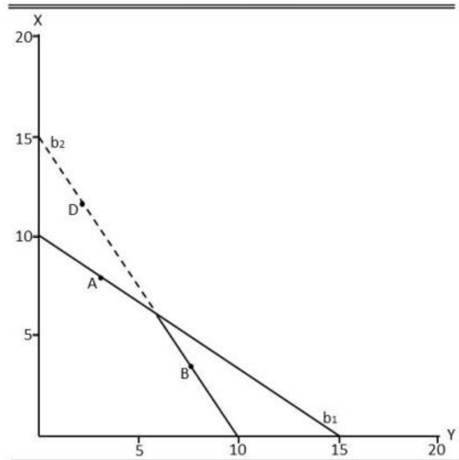
Figure 1 exhibits a GARP violation. Suppose an individual wants to dedicate a budget of 120$ between 2 products X and Y. When the prices are p_1 (X=12, Y=8) the individual can buy all combinations below the budget line b_1. Suppose the individual chooses to buy the combination A(X=8, Y=3). When the prices change to p_2 (X=8,Y=12) all possible combinations that lie in the area below the budget line b_2 can be bought. However, should the individual choose to buy the combination B(X=3, Y=8), this would violate the GARP: bundle A is revealed preferred to bundle B, and bundle B is strictly revealed preferred to bundle A. By choosing combination B the individual actually wastes money as, for the given prices p_2, the revealed preferred bundle A was available at a lower cost (equal to 8*8+3*12=100$) than the chosen bundle B (in which case s/he pays 3*8+8*12=120$). In our example the individual thus failed to maximize the utility of the given budget as s/he chose bundle A over B when B was cheaper, while s/he also chose bundle B over A when bundle A was cheaper. Below we will introduce Afriat's Index as a measure for the efficiency of consumers' choices, which captures exactly this idea of budget waste associated with behavior that violates GARP.

Figure 1
GARP Violation



The essence of Revealed Preference theory and GARP lies in the concept of indifference curves. Indifference curves show the different bundles of goods between which a decision maker is indifferent. In other words, indifference curves show the quantity of product X an individual is willing to sacrifice to get a certain quantity of product Y. A utility maximizing individual always wants to move to higher indifference curves as s/he gets better bundles of products, meaning that s/he can combine the same quantity of X with larger quantities of Y and vice versa. An individual who (given the chance) fails to move to higher indifference curves is considered to be irrational. In the case of the example, a rational choice that maximizes the utility of the available budget at prices p_2, given the fact that the individual chose the combination A (X=8, Y=3) at prices p1, would be combinations placed on the dotted section of the budget line b_2, for example the combination D (X=12, Y=2). Choosing these combinations would allow the individual to move to higher indifferences curves and end up with bundles containing larger quantities of products. Choosing combination B (X=3, Y = 8) however would not (see figure 2).

Figure 2
Rational Choice



Afriat (1973) has introduced an efficiency index which can be used to measure the severity of the GARP violations. This measure has been developed in the context of budget waste. As explained above, a violation of GARP can be interpreted as a waste of money. The index can take values between 0 and 1. A value of 1 means that there are no GARP violations (and no budget is wasted), whereas a value below 1 reveals that GARP is violated (with corresponding budget waste). Generally, lower index values indicate that a larger fraction of the budget is wasted. We use GARP and Afriat's index to assess the local rationality of choice behaviors based on the hot and the cool system separately, and the global rationality across states. We do so in two studies.

Study 1

Participants were 139 students from a large university (43.9% women, average age 20.43 years, SD=2.01). They were invited to come to the lab to complete a task gauging economic rationality in exchange for money or course credit. To be able to calculate Afriat's Index we created a choice task to assess participants' revealed preferences (table 1). Our task was similar to the one used in studies of Harbaugh et al. (2001) and Bruyneel et al. (2012). It included 12 sequential choice problems, with each choice problem consisting of four products: two vice, relative tasty but not so healthy (chocolate bar and Dorito chips) products, and two virtue, relative healthy but not so tasty (baby carrots and raisins) products. The prices of the products differed for every choice problem. Participants were asked to indicate the quantities they wanted from each product given the different price regimes and their budget (10 tokens). For every choice problem participants had to spend their entire budget and had the option to choose non-integer quantities.

We used a mixed design consisting of three between-subjects conditions: An experimental condition in which the hot and cool systems were sequentially activated during two choice-making episodes, and two control conditions in which only one of the two systems was activated (cool or hot). As a manipulation of hot and cool system activation we varied the visceral state hunger. Similar to the design of Nordgren et al. (2007), in the hungry state participants were instructed to not eat for at least four hours prior to the study. In the satiated state, participants were instructed to eat a full meal within an hour prior to the study. In the experimental condition, participants completed the choice task once hungry (hot) and once satiated (cool). The order of the tasks was counterbalanced and separated by one week. In the cool control condition participants were asked to come to the lab satiated (eat a full meal within an hour prior to the study) both times, whereas in the hot control condition participants were asked to come to the lab hungry both times. The purpose of the control conditions was to increase confidence that potential differences in rationality between states in the experimental condition could be attributed to differences between the two systems, rather than to noise driven by the one week time lag between experimental sessions.

For every condition, we measured the relative virtue and vice consumption in each state, as well as the Afriat's Index for each state (system) separately, and the aggregated Afriat's Index across both states (systems).

Results and Discussion

To check the hunger manipulation, we ran two repeated measures ANOVAs, one for vice consumption and one for virtue consumption, with condition as between-subjects variable (experimental, cool control and hot control) and with session/state as within-subjects variable. We found no main effects for condition, but we found the expected interaction between session/state and condition for vice as well as virtue consumption (table 1). A paired samples test showed that in the experimental condition respondents chose more grams of vice products when hungry (M_{hungry}=211.99, SD=72,81) than when satiated ($M_{satiated}$=177,87, SD=82.20; t(66)=3.90, p<0.001), whereas they chose fewer grams of virtue products when hungry (M_{hungry}=119.87, SD=70.38) than when satiated ($M_{satiated}$=149,52, SD=79,20; t(66)=3.49, p=0.001). In the control conditions none of these differences were significant (table 1).

A Wilcoxon signed rank test on the Afriat's indices of the two states in the experimental condition showed that the difference in the rationalities was insignificant (M_{hungry}=0.972, SD=0.081, $M_{satiated}$=0.966, SD=0.054, Z=-0.826, p=0.409). The results indicate that respondents' choices were equally (ir)rational in both decision frames. The means of the Afriat's indices indicate that individuals wasted on average approximately 3% of their budget due to suboptimal choices. We also calculated overall rationality across the two states in the experimental condition in a way that allowed us to directly compare it with the individual rationalities for the two states separately. To meaningfully compare the three indices we constructed an overall Afriat's index with components that were identical to the ones of the individual indices. Specifically, we randomly picked six observations from each time frame dataset for each respondent to neutralize the fact that Afriat's index is sensitive to the number of observations. We avoided picking the same price regime twice to ensure that the price regime variation in the global rationality assessment was identical with that of the within-frame tests. This yielded a dataset consisting of 12 observations per individual that allowed us to calculate an overall, cross-frames Afriat's index that was directly comparable to the local indices. We repeated the same procedure 200 times and calculated the average of the overall Afriat's index for every respondent. The overall rationality was significantly lower ($M_{overall}$=0.93, SD=0.077) than the rationality of the individual states (Z=-3.836, p<0.001 for the hungry state, Z=-3.169, p=0.002 for the satiated state). The use of budget inconsistent with GARP was 2.8% for the hungry state and 3.3% for the satiated state, whereas overall it was 7%.

We repeated the same procedure to study differences between the three indices in the cool and hot control conditions, respectively, and found that these differences were all insignificant (table 1). Taken together, the findings of our first experiment suggest that choices of individuals in hot and cool decision states are equally rational. However, the overall rationally across the different states is lower. Thus, though choice behaviors relying on different systems seem equally rational at a local level, conflicting preferences revealed by these systems can have a negative impact on rationality at a more global level. Ours findings show that the difference in preferences resulting from the two systems leads people to irrational behaviors and waste of money.

Study 2

Participants were 118 students from a large university (60% women, average age 21.18 years, SD=3.62). They were invited to come to the lab to complete a task assessing economic rationality (see Study 1) in exchange for money or course credit. We again made use of a mixed design including three between-subjects conditions, completed in two sessions (48 hours difference). Specifically, in the experimental condition a different system was activated in every session, whereas in the two control conditions the same system was activated (either cool or hot) in every session. A cognitive load task was used as a manipulation of the hot versus cool system. That is, participants were asked to keep in mind a difficult sequence of 8 different consonants (e.g. GTPWLZKN) or an easy sequence of 8 identical consonants (BBBBBBBB), respectively (Kruger 1999). Cognitive load prevents individuals from deliberating and makes them use their hot system more (Shiv and Fedorikhin, 1999). In the experimental condition, participants executed the decision task while keeping in mind the difficult sequence in one of the two sessions, and while keeping in mind the easy sequence in the other session. In the cool control condition participants were asked to keep in mind the easy sequence while making their decisions in both of the sessions, whereas in the hot control condition participants had to keep in mind the difficult sequence while making decisions in both of the sessions. To motivate participants to make utility-maximizing choices, we raised the budget to 20 tokens and told participants that they would be entitled to one of their choices at the end of each session.

Results

We again ran two repeated measures Anovas, one for vice consumption and one for virtue consumption, with condition as between-subjects variable (experimental condition, control cool, and control hot) and with session/state as within-subjects variable to check the state manipulation. We found no main effects for condition, but neither did we find the expected interaction between session/state and condition for vice as well as virtue consumption (table 1). The pattern of results however confirms our expectations. A paired samples test showed that respondents in the experimental condition chose more grams of vice products when under cognitive load (M_{load}=390.72, SD=151.07) than when not under load ($M_{nonload}$=363.34 (SD=168.36); t(62)=-2.645, p<0.010), whereas they chose fewer grams of virtue products when under load (M_{load}=257.64, SD=144.74) than when not ($M_{nonload}$=278.57, SD=160.65; t(62)= 2.097, p=0.040). None of the differences in the control conditions was significant (see table1).

For the experimental condition, the difference in Afriat's index between the two states (M_{load}=0.937, SD=0.108, $M_{nonload}$=0.941, SD=0.106) was again insignificant (Z=-0.077, p=0.939). After a similar processing of the data as in Study 1, we calculated overall rationality and compared it with the separate rationality indices. The overall rationality was significantly lower ($M_{overall}$=0.913, SD=0.112) than the rationality of the individual states (Z=--2.144, p<0.032 for load condition, Z=-2.362, p=0.018 for non-load condition). Again none of the differences between any of the indices in the control conditions was significant (see table 1).

The findings indicate, in line with study 1, that locally, rationality of choice behaviors relying on the hot or cool system is high and not significantly different between systems. However, once more we noticed a significant decrease in rationality when calculated across behaviors resulting from both systems. These results confirm that a significant loss of utility is the result of conflicting behaviors triggered by the different systems.

General Discussion

We conducted two studies to assess rationality of choice behaviors relying on a hot and cool decision system. Results of the two studies indicate that the choice behavior resulting from both systems is equally rational, despite the fact that the product preferences were different. We conclude that both systems are equally appropriate to make economic decisions. However, a further analysis revealed that the discrepancy between the choices under the influence of the two systems had a negative impact on the overall rationality of the choices. This drop in overall rationality shows that the discrepancy between the preferences revealed by the different decision systems is responsible for a significant loss of decision utility.

Our findings provide an answer to the question as to which system leads to more economically rational choices. We show that when it comes to economic decisions, both systems can be equally rational. Our study is the first to include realistic economic conditions, such as budget constraints and price variance, which presumably contributes to the discrepancy between previous findings and ours. The symmetry in our findings suggests that the decision making rules followed by the two systems in economic contexts involving price regimes and budget constraints might not be all that different. This is consistent with recent proposals suggesting that deliberative and intuitive judgment, as based on the cool and the hot system respectively, can be based on common principles in certain environments (Kruglanski and Gigerenzer 2011).

We contribute to the literature on economic rationality by showing that loss of utility due to irrational choices is not a result of the decisions driven by one specific system directly, but of the conflicting choices driven by these two systems separately instead. Our findings suggest that, although the levels of rationality resulting from activation of the two systems is not different, the discrepancy between choices resulting from activation of both systems can lead to suboptimal choices and loss of utility from an overall perspective. Last, our findings show that dual-system processing prevents consumers from forming global judgments about trade-offs between various products, and as a result prevents them from reaching indifference levels that would allow them to make the most optimal decisions. This finding can be related to literature on affective forecasting errors and hot-cold (and vice versa) empathy gaps (e.g. Fisher and Rangel 2014), as it is in line with the idea that difficulty of one system to appropriately “forecast” the preferences activated by the other system leads to a waste of budget.

Table 1: Results

Study 1							
Repeated Measures Anova							
		Vice			Virtue		
Condition		F=0.673	p=0.512		F=0.570	p=0.567	
Condition*Session/State		F=6.140	p=0.014		F=4.781	p=0.010	
Experimental Condition							
Product Choices							
	Products	Difference		Products	Difference		
	Vice	t(66)	P	Virtue	t(66)	p	
Hungry	211.99 (SD=72.81)			119.87 (SD=70.38)			
Satiated	177,87 (SD=82,20)	3.90	<0.001	149.52 (SD=79.20)	3.49	0.001	
Rationalities							
Sessions	Afriat's Index	Differences					
		Hungry-Satiated		Hungry-Overall		Satiated-Overall	
		Z	P	Z	p	Z	p
Hungry	0.972 (SD=0.081)						
Satiated	0.966 (SD=0.054)	-0.261	0.794				
Overall	0.93 (SD=0.077)			-3.836	<0.001	-3.169	0.002
Control Condition (satiated-satiated)							
Product Choices							
Sessions	Products	Difference		Products	Difference		
	Vice	t(30)	p	Virtue	t(30)	p	
Session 1	186.89 (SD=92.57)			132.55 (SD=92.88)			
Session2	184.14 (SD=85.38)	0.575	0.569	135.58 (SD=82.52)	-0.554	0.584	
Rationalities							
Sessions	Afriat's Index	Differences					
		Session 1-Session 2		Session1-Overall		Session2-Overall	
		Z	p	Z	p	Z	p
Session 1	0.954 (SD=0.091)						
Session 2	0.950 (SD=0.119)	-0.568	0.570				
Overall	0.944 (SD=0.106)			-0.597	0.550	-1.232	0.218
Control Condition (Hungry-Hungry)							
Product Choices							
Sessions	Products	Difference		Products	Difference		
	Vice	t(40)	p	Virtue	t(40)	p	
Session 1	177.14 (SD=80.48)			149.25(SD=73.38)			
Session 2	177.59 (SD=84.26)	-0.083	0.934	149.17 (SD=78.85)	0.15	0.988	

Rationalities

Sessions	Afriat’s Index	Differences					
		Session 1-Session 2		Session1-Overall		Session2-Overall	
		Z	p	Z	P	Z	p
Session1	0.960 (SD=0.077)						
Session2	0.956 (SD=0.087)	-0.261	0.794				
Overall	0.952 (SD=0.070)			-1.130	0.258	-1.029	0.304

Study 2

Repeated Measures Anova

	Vice		Virtue	
Condition	F=1.094	p=0.338	F=0.961	p=0.385
Condition*Session/State	F=1.906	p=0.153	F=1.188	p=0.309

Experimental Condition

Product Choices

Sessions	Products	Difference		Products	Difference		
	Vice	t(63)	p	Virtue	t(63)	p	
Cognitive load	390.72 (SD=151.07)			257.64 (SD=144.74)			
Non-load	363.34 (SD=168.36)	-2.645	0.010	278.57(SD=160.65)	2.097	0.040	

Rationalities

Sessions	Afriat’s Index	Differences					
		Cognitive load-Non-load		Cognitive load-Overall		Non-load-Overall	
		Z	p	Z	p	Z	p
Cognitive load	0.937 (SD=0.108)						
Non-load	0.941 (SD=0.106)	-0.077	0.939				
Overall	0.913 (SD=0.112)			-2.144	0.032	-2.362	0.018

Control Condition (Non-load – Non-load)

Product Choices

Sessions	Products	Difference	Products	Difference			
	Vice	t(25)	p	Virtue	t(25)	p	
Session 1	333.37 (SD=146.85)			308.86 (SD=141.34)			
Session 2	338.93 (SD=148.25)	-0.365	0.718	304.10 (SD=139.40)	0.329	0.745	

Rationalities

Session 1	Afriat’s Index	Differences					
		Session 1-Session 2		Session1-Overall		Session2-Overall	
		Z	p	Z	p	Z	p
Session 1	0.943 (SD=0.093)						
Session 2	0.934 (SD=0.123)	-0.063	0.950				
Overall	0.931 (SD=0.100)			-0.795	0.427	-0.511	0.609

Control Condition (Cognitive load – Cognitive Load)

Product Choices

Sessions	Products	Difference		Products	Difference		
	Vice	t(27)	p	Virtue	t(27)	p	
Session 1	394.28 (SD=119.50)			255.51 (SD=121.26)			
Session 2	388.26 (SD=128.29)	-0.336	0.740	260.43 (SD=125.29)	0.417	0.680	
Rationalities							
States	Afriat's Index	Differences					
		Session 1-Session 2		Session1-Overall		Session2-Overall	
		Z	p	Z	p	Z	p
Session 1	0.946 (SD=0.110)						
Session 2	0.945 (SD=0.113)	-0.051	0.959				
Overall	0.939 (SD=0.105)			-0.621	0.535	-0.672	0.501

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