

THE COGNITIVE REFLECTION TEST AND THE PROPENSITY TO USE HEURISTICS IN DECISION MAKING

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Abstract

The dual processes and dual system theories distinguish the two self's, the intuitive and the rational one. These theories claim that our decisions are shaped by these systems and their quality depends on the fact which system prevails. We tried to find dependence between the intensity of usage of these systems and the propensity to use basic heuristics in decision making. We measured the intensity of usage with a simple three-item test for cognitive abilities - Cognitive Reflection Test (CRT) of Frederick (2005). The research results prove the general influence of heuristics on the decision making. At the same time they partially show the link between the reached CRT score and the tendency to use heuristics, this relation is manifested utmost by the representativeness heuristics, to a lesser extent by the anchoring heuristics and did not confirm by the availability heuristics.

Introduction

Recent research in cognitive sciences suggests that people use two different systems, respectively processes in their decision making, one of which is intuitive and the other one rational. Their utilization rate affects the quality of decisions. Frederick (2005) compiled the Cognitive Reflection Test (CRT), which detects the prevailing system that determines the decisions. This article seeks answers to the research question: Is there a relationship between the CRT score and the tendency to use specific types of heuristics in the decision making?

1. Dual Process and System Theories

Dual process and system theories are object of extensive research within the cognitive and social sciences. They are based on the distinction between the two systems that reside in the human mind (Evans & Stanovich, 2013). The first system (usually referred to as System 1) is considered to be fast and subconscious. It is responsible for decisions that are automatic, instinctive, and correct at the first sight. The decisions generated by the system 1 are often

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Suggested citation: GAL, P., MRVA, M. and GAJDOSOVA, Z. (2014) The cognitive reflection test and the propensity to use heuristics in decision making. *Comenius Management Review*. (8) 2. p.29-40.

associated with the concept of heuristics, which was introduced by Kahneman and Tversky (1974). Heuristics serve as mental shortcuts that help us to simplify, structure and quickly process information in our decision making. Their usage might be quite useful in some cases, while in others it might lead to severe and systematic errors, based on significant deviations from the fundamental principles of statistics, probability and sound judgment (Gal et al. 2013). The second system, known as System 2, is slower, but it is considered to be more rational and based on the logic. The decisions originating from this system are conscious, controlled and based on the rules. Researches of Stanovich & West, Smith & DeCoster and Kahneman provide a deeper insight into dual processes and systems.

1.1 System 1 and System 2

The research of Stanovich and West (2000) focused on the irrationality of human thinking. One of the possible ways how to explain the errors in human judgment are dual processes. They distinguish between the System 1 and System 2 in their research. The System 1 is regarded to be automatic and its task is to generate ideas to match our intentions. The aims of it are the fast interaction steps, which are based on the stated goals. The System 2 presents controlled processes. The main difference of these systems lies in the perception of the situation and decisions. The System 1 creates decisions that are perceived in a broader context, they are personal and socially oriented. It processes also the so called heuristic processes that lead to frequent errors and mistakes.

The System 2, conversely, is trying to depersonalize from decisions and see them in a narrower context. It is a controlled process that involves rules and basic principles. It tries to omit the social content from the judgments. Both systems engage also the intelligence in the decisions. The System 1 uses so called interaction intelligence (formed by mechanisms that are based on the relation of intention - activity). The analytical intelligence linked to the computational mechanisms is bound to the System 2. The differences between these two systems and processes that are associated with them are described in the following Table 1.

Table 1: Clusters of Attributes Frequently Associated With Dual-Process and Dual-System Theories of Higher Cognition

Type 1 process (intuitive)	Type 2 process (reflective)
Defining features	
Does not require working memory	Requires working memory
Autonomous	Cognitive decoupling; mental simulation
Typical correlates	
Fast	Slow
High capacity	Capacity limited
Parallel	Serial
Nonconscious	Conscious
Biased responses	Normative responses
Contextualized	Abstract
Automatic	Controlled
Associative	Rule-based
Experience-based decision making	Consequential decision making
Independent of cognitive ability	Correlated with cognitive ability

System 1 – (old mind)	System 2 – (new mind)
Evolved early	Evolved late
Type 1 process (intuitive)	Type 2 process (reflective)
Typical correlates	
Similar to animal cognition	Distinctively human
Implicit knowledge	Explicit knowledge
Basic emotions	Complex emotions

source: Evans & Stanovich, 2013

1.2 Associative Processing and Rule-Based Processing

The research of Smith & DeCoster (2000) on dual processes is based on the two processing modes and two memory systems with different characteristics. The memory system is defined as a set of acquisition, retention and retrieval mechanisms that follows certain rules of operations (Sherry & Schacter, 1987). These two memory systems operate under different operating rules, as well as they are storing different types of information (e.g. visual and verbal). The contradictory requirements for their performance are the reason for the existence of these two memory systems (McClelland et al., 1995). The first demand is to record the information in a slow and incremental manner so that the total configuration in memory reflects a large sample of experiences. This is the slow-learning memory system (Fiske & Taylor, 1991). The second demand is in contrary the fast learning of new information, thus we can acquire new experience after a single time. This ability requires a fast learning storage system that can put the acquired information into context. For the proper functioning of this memory is necessary the retention ability of episodic records about the details including the context (Smith & DeCoster, 2000).

These systems do not operate as two separate entities, but they cooperate and interact. The most important process, which involves both the systems is a process of consolidation, during which a new commemoration recurring impression is quickly transferred from the slow to the fast learning system in the mind. Within the behavioral patterns they distinguish the associative way of behavior and behavior based on rules (Table 2).

Table 2: Summary of Theoretical Properties of Two Processing Modes

Associative Processing	Rule-Based Processing
Draws on associations	Draws on symbolically represented rules
That are structured by similarity and contiguity	That are structured by language and logic
And are learned over many experiences	And can be learned in just one or a few experiences
Occurs automatically	Occurs optionally when capacity and motivation are present
And precociously, with awareness of the result of processing	And often with conscious awareness of steps of processing

source: Smith & DeCoster, 2000

1.3 System 1 and System 2

Kahneman (2012), summarizing the previously stated theories, focused on the exploration of the dual process theory. He recognizes two modes of thought - two different "I" each person has in itself, referred to as the System 1 and System 2. The basic difference between these two systems lies in the control and attention. The System 1 could be described as our "automatic I", which is characterized by fast responses while spending a minimal or no effort in expressing the judgment or conclusion. We don't have conscious control over these reactions. System 2, our "rational I", in turn requires focus, attention and control. These are conscious reactions that require thought and effort in formulating conclusions that this system could arrange in a logical way. It is responsible for our decisions, opinions, and actions. System 2 is superior to System 1, but nevertheless they work in close cooperation and one without the other could not exist. The System 1 delivers continuously stimuli to the System 2, which decides on further action. The basic differences between these systems describes the following Table 3.

Table 3: The Differences between the System 1 and System 2

System 1	System 2
Automatic and fast mental activity	Conscious and slower mental activity
It creates impressions, feelings and inclinations to certain activities	Forms opinions, attitudes, intentions and decisions
Works well in known, simple and repetitive situations	It is activated at the moment when the System 1 cannot react in a given situation
It is susceptible to systematic biases under certain circumstances	It works as a control mechanism
Operates continuously	Operates continuously

source: Kahneman, 2011

1.4 The Two Systems and The Cognitive Reflection Test

The Cognitive Reflection Test (Frederick, 2005) tries to answer the question whether there is a way we can distinguish, whether the intuitive or the rational system is at the forefront of our subconscious. He explains the cognitive reflection as the ability or tendency to resist the answer that we first think of. The Cognitive Reflection Test (CRT) is a very simple test consisting of the three following questions:

- „A bat and ball cost \$1.10. The bat costs one dollar more than the ball. How much does the ball cost?“ (The subconscious answer: \$0.10; the right answer: \$0.05).
- „If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?“ (The subconscious answer: 100 minutes, the right answer: 5 minutes).
- „In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?“ (The subconscious answer: 24 days, the right answer: 47 days)

Frederick classified respondents into three groups based on the number of correct answers. In the first group with no right answer prevails the System 1. The second group with

three right answers, has at the forefront the System 2. According to him it is not possible to accurately determine which one of the systems prevails in the group with one or two right answers. Frederick originally researched both the time and risk preferences within the CRT framework.

2. Methodology

The research was carried out at the Faculty of Management Comenius University in Bratislava in year 2014. Its participants were 223 full-time first year master course students. The questionnaire consisted of questions focused on specific types of heuristics (representativeness, availability, and anchoring) and the three CRT questions. The students were divided into two groups of approximately equal size. They received points for course credits for their participation. The questionnaire was distributed electronically and was completed online by students during the seminar with lecturer. The respondents were not allowed to use Internet or to discuss the answers on the questions. The survey questions are inspired or similar to the questions used in similar researches about heuristics in decision making. We tried to find a link between the CRT score and a tendency to use heuristics as mental shortcuts in the research. Our premise was that respondents with a lower score of CRT have a higher tendency to use heuristics and vice versa, respondents with higher CRT scores would not use them. The results were calculated with the software MS Excel and SPSS.

3. The Results and Discussion

For the purposes of this research respondents were divided into two groups based on the number of correct answers to the CRT. The same division used Oechssler et al. (2008). The System 1 (S1) group consists of respondents with a low CRT score: they answered 0-1 questions correctly. The System 2 (S2) group consists of respondents with a high CRT score, they answered 2-3 questions correctly. Out of the total number of 223 respondents - 104 (46,64%) ranked in the Group S1 and 119 (53,36%) in the Group S2 (Table 4).

Table 4: Distribution of the respondents into S1 and S2 groups according to the CRT score

The System Correct answers to the CRT (#)	System 1 (S1)				System 2 (S2)			
	0		1		2		3	
Answers (#,%)	N	%	N	%	N	%	N	%
Group A	28	23.14%	29	23.97%	35	28.92%	29	23.97%
Group B	19	18.63%	28	27.45%	27	26.47%	28	27.45%
Total	47	21.08%	57	25.56%	62	27.80%	57	25.56%

source: own elaboration

The following questions (No. 1, 2) are focused on the relationship between the prevalent usage of the Systems 1 / 2 and the anchoring heuristics. Anchors in the form of numbers were presented only to one group. The second group members reported their number

estimates based on their best deliberation. The extreme values, which could negatively affect the survey results were deleted from the answers.

3.1 Question No.1 - Anchoring

Group A:

- *"What is the length of the River Thames in km? Try to estimate it numerically."*

Group B:

- *What is the length of the River Thames in km? Is it more than 600 km? Try to estimate it numerically.*

We observed only a minimal difference in the responses of the Group A (without the anchor) and Group B (with the anchor). The estimated average length of the River Thames is between 680 and 690 km in both Groups A and B. The standard deviation of the Group B is almost half the value of the Group A. The answers of the Group B are much more concentrated around the average; this can be attributed to the impact of the anchor.

In terms of the responses frequency, the most common answer in Group B with anchor is 400 km (9 respondents), which is closer to the actual length of the river. The majority of the Group B responses was around the offered anchor (600 km) and ranged from 346 km to 700 km. The Group A (without the anchor) estimates were on the contrary in the range from 100 km to 500 km in the largest extent (Table 5).

Table 5: Results for the Question No.1 – the length of the River Thames

Question 1.: The Thames River	Group A		Group B	
Count	100		101	
Mean value	680		690	
Maximal value	3 000		2 000	
Minimum value	100		100	
Standard deviation	689		339	
Median	400		610	
Modus	500		400	
The group with the anchor:	B	The correct answer - the River Thames length:		346 km

source: own elaboration

We compared the CRT score with the influence of heuristics on the Group B (with anchor) estimates. The Group S1 favoring its "intuitive I" was more influenced by the provided anchor of 600 km. Its average estimated value was 649 kilometers. The most numerous response was 1,000 km, which is quite remote from the average, as well as from the correct answer.

The Group S2, which is expected to be more rational, stated the most frequent answer of 400 km, the respondents neared more closely to the actual length in comparison with the Group S1 results. The average value of this group (724 km) is more remote from the anchor in comparison with the Group 1 (649 km). These results indicate a greater impact of anchor on the group S1 respondents (Table 6).

Table 6: Results for the Question No.1 – the length of the River Thames by CRT groups

Question 1.: CRT (Group B)	Group S1	Group S2
Count	46	55
Mean value	649	724
Maximal value	1.500	2.000
Minimum value	100	250
Standard deviation	312	357
Median	588	650
Modus	1.000	400

source: own elaboration

3.2 Question No.2 - Anchoring

Group A:

- *"What is the height of the highest peak of Alps - Mont Blanc? Is it more or less than 3,500 meters above the sea level? Try to numerically estimate it."*

Group B:

- *"What is the height of the highest peak of Alps - Mont Blanc? Try to numerically estimate it."*

The next question focused on the impact of the anchor in Group A. We observe more significant differences between the groups' responses, particularly in the mean value and standard deviation. The average estimate for the Group A (4,389 m) is closer to the actual height of Mont Blanc than to the offered anchor of 3,500 m, that might be caused by the modus, because 15 respondents stated the value of 4,800 m. This fact speaks for the good knowledge of its height by the respondents. Concerning the standard deviation, the answers of the Group A were significantly more concentrated around the average in comparison with the Group B. The impact of anchors in the Group A is also confirmed by the frequency of individual responses. Most of the students stated the height of Mont Blanc from 3,000 m to 4,810 meters above the sea level. For Group B, it was the interval from 4,000 m to 4,810 meters above the sea level (Table 7).

Table 7: Results for the Question No. 2 - the height of the Mont Blanc peak

Question 2.: The Mont Blanc	Group A		Group B
Count	114		101
Mean value	4.389		5.170
Maximal value	7.550		10.000
Minimum value	2.475		1.500
Standard deviation	801		1.739
Median	4.375		4.800
Modus	4.800		4.500
The group with the anchor:	A	The correct answer - the Mont Blanc height:	4 810 m

source: own elaboration

From the correlation investigation between the CRT results and the anchoring heuristics impact it was confirmed the greater susceptibility of people using the System 1 to adjust their estimates to the provided anchor. The mean value of the Group S1 is closer to the anchor in comparison with the Group S2, even though we can't talk about a significant difference. More interesting is the observation of modes. The "rational" group S2 respondents most often reported the value of 4,800 m, that is rounded the actual height of the highest peak of the Alps. We can infer from this, that they favored the knowledge and didn't let themselves be fooled by the anchor. On the contrary, the "intuitive" Group S1 members most often reported the value of 4,000 m, which is much closer to the anchor of 3,500 meters above the sea level (Table 8).

Table 8: Results for the Question No. 2 - the height of the Mont Blanc peak by the CRT groups

Question 2.: CRT (Group A)	Group S1	Group S2
Count	54	60
Mean value	4.228	4.534
Maximal value	6.500	7.550
Minimum value	2.475	3.300
Standard deviation	790	783
Median	4.040	4.556
Modus	4.000	4.800

source: own elaboration

The first part of the research focused on the relationship between the prevailing usage of the System 1 and System 2 and the anchoring heuristics. The results show that the provided anchors influenced in a larger extent the "intuitive" group S1, however the differences among the groups were not that significant. Both groups S1 and S2 were caught in the anchoring trap, but the lower CRT respondents to a larger extent. Opposite view on this presents the research undertaken by Oechssler et al. (2008). It shows, that the group with higher CRT scores was more prone to the anchoring heuristics.

3.3 Question No.3 - Representativeness heuristics

Both Groups (A and B)

"A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50 percent of all babies are boys. However, the exact percentage varies from day to day. Sometimes it may be higher than 50 percent, sometimes lower. For a period of 1 year, each hospital recorded the days on which more than 60 percent of the babies born were boys. Which hospital do you think recorded more such days?"

- A. *The smaller hospital*
- B. *The larger hospital*
- C. *About the same"*

This research question is focused on “the law of small numbers” and comes from the research of Tversky & Kahneman (1974). Both Groups (A and B) answered the same question. Option A – smaller hospital is the right answer. According to the research results only 24% of respondents answered this question correctly (Table 9). The majority considered as the right answer– both hospitals about the same (C). It should be noticed, that our sample of respondents reached statistically very similar results, as in the original research of Tversky & Kahneman (1974).

Table 9: Results for the Question No. 3 – The Hospitals

Question No.3 - The Hospitals (both groups)	Group A		Group B		TOTAL	
	N	%	N	%	N	%
The smaller hospital	25	11.21%	28	12.56%	53	23.77%
The larger hospital	23	10.31%	22	9.87%	45	20.18%
About the same	73	32.73%	52	23.32%	125	56.05%
The correct answer:			The smaller hospital			

source: own elaboration

The results according to the CRT show significant differences in the answers of the S1 and S2 groups (Table 10). Despite the fact, that the majority of respondents from both groups indicated the incorrect answer, the correct answer was more often reported by the “rational” Group S2 than by the “intuitive” Group S1 (28% vs. 19%).

Table 10. Results for the Question No. 3 - The Hospitals by the CRT groups

Question No.3 - The Hospitals (CRT groups)	S1		S2	
	N	%	N	%
The smaller hospital	20	19.23%	33	27.73%
The larger hospital	33	31.73%	12	10.08%
About the same	51	49.04%	74	62.19%

source: own elaboration

3.4 Question No.4 – Availability heuristics

Group A:

- *Recently, a new infection disease started to spread around the world. It is a bacterial infection, than can be easily treated by antibiotics. Most often you can get infected through a direct contact with sick people. It is estimated that throughout the year the disease affects a fifth of the population. The basic symptoms of the disease include: insomnia, lack of energy and general malaise, respiratory problems, hyperhidrosis and anorexia. Imagine the following symptoms and try to estimate how likely during the following year you would get sick from this disease (in %):*

Group B:

- *Recently, a new infection disease started to spread around the world. It is a bacterial infection, than can be easily treated by antibiotics. Most often you can get infected through a direct contact with sick people. It is estimated that throughout the year the*

disease affects a fifth of the population. The basic symptoms of the disease include: sleeplessness, fatigue, cough, excessive sweating and loss of appetite. Imagine the following symptoms and try to estimate how likely during the following year you would get sick from this disease (in %):

The last question inspired by Sherman et al. (1982) focused on the availability heuristics, which was presented through a difference in formulation of the infection disease symptoms. The symptoms of the disease were identical for both groups, but for the group A they were formulated in a more tangled way, through medical terms. For the group B, they were formulated simply and colloquially. The group B with easily imaginable symptoms estimated a higher probability of falling ill, but the difference against the group A was quite small, only 3%. Members of both groups most often appointed 20% probability of falling ill. It should be noted, that the estimates of students were quite close, but above the presented number of 20%, which might indicate also the influence of the anchoring and representatives heuristics. The respondents didn't take into account, that 20% is the base rate for the whole population (including small children and elderly people) and presumably healthy young students would fall ill less likely. On the other hand, the presented symptoms are so common, that almost everybody experiences them more or less frequently. We can conclude that our judgments might be often influenced by a combination of several heuristics that can work together (Table 11).

Table 11: Results for the Question No. 4 – The Disease

Question No.4 - The Disease	Group A	Group B
Count	118	101
Mean value	24.03%	27.05%
Maximal value	100%	100%
Minimum value	0%	0%
Standard deviation	0.23	0.24
Median	20%	20%
Modus	20%	20%
The group with the heuristics in question:	Both A and B	

source: own elaboration

There aren't significant differences between the groups S1 and S2 according to CRT score. Totally and in the case the symptoms were described in a more complicated way, the S2 group members felt less endangered by the infection than the S1 group members. On the contrary it was the case when the symptoms have been described in an easier way, but the differences are in all the three cases minimal. The most frequent answer was in both groups the 20% chance of being infected (Table 12).

Table 12: Results for the Question No. 4 – The Disease by both CRT groups

Question No.4 - The Disease (CRT both groups)	S1	S2
Count	102	117
Mean value	26.87%	25.04%
Maximal value	100%	100%
Minimum value	0%	0%
Standard deviation	0.23	0.24
Median	20%	20%
Modus	20%	20%

source: own elaboration

Conclusion

The theories of dual processes describe the two systems, which can be found in the mind of every one of us. Each of these systems is responsible for a different type of decisions. The System 1 (S1) could be considered as our "intuitive I", which makes rapid and automated decisions. On the contrary, the System 2 (S2) is our "rational I."

In the framework of our research, we tried to find a link between the more intense usage of one of the two systems (measured by the CRT score) and affection of the decisions by heuristics. We assumed that people, who reach a lower CRT score, are more prone to be infected by the heuristics in their decision making and vice versa, people, who reach a higher CRT score, are more immune to them.

Concerning the anchoring heuristics we found out, that both groups S1 and S2 were caught in the anchoring trap. Answers to the questions with anchor show, that respondents using the System 1 are more susceptible to this heuristic. The relationship of the low CRT score and higher tendency to succumb to the anchoring heuristics was confirmed.

Answers to the question addressing the representativeness heuristic confirmed the positive relationship between the use of the System 1 and this mental shortcut. Answering this question, both groups have succumbed to the law of small numbers, but the "rational" group S2 to a lesser extent.

The last question focused on the availability heuristics did not confirm the relationship of the low CRT score and the usage of this heuristic in larger extent.

Our research results prove the influence of heuristics on the decision making. At the same time they partially show the link between the reached CRT score and the tendency to use heuristics, this relation manifested utmost by the representativeness heuristics, to a lesser extent by the anchoring heuristics and did not show in the availability heuristics.

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