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# Measuring Rationality and Cognitive Debiasing

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*Measuring intelligence has a century old tradition but rationality is perhaps an even more important cognitive ability of efficient thinking. The paper explains the concept of RQ (Rationality Quotient), the cognitive biases that saturate our rational thinking and also the possible methods of cognitive debiasing. This subject has a crucial importance when one works in a field or position where decisions carry larger than average importance and where unusually high risks and uncertainty prevail.*

***Keywords:*** *cognitive bias, cognitive debiasing, rationality, dysrationalia, measuring rationality, RQ, rationality quotient*

Everyone of us has witnessed situations when very smart and intelligent people were doing dumb things or acted irrationally and foolishly. Oftentimes this "smart but acting dumb" phenomenon is persistent, affects serious and important decisions and has long lasting and negative effect on the individual's professional or private life. In order to gain a comprehensive understanding of this phenomenon we are going to examine "intelligence" and "rationality" in a new context. This new context will enable us to provide an explanation of this anomaly. Furthermore, this article will explain the role of cognitive biases in our cognitive processes and will also give an insight into the latest findings of measuring rationality and cognitive debiasing, two crucial areas when dealing with cognitive biases.

## The Broad and the Narrow Theory of Intelligence

In order to fully comprehend the psychological/epistemic construct of "cognitive bias" it seems to be useful to lay down a clear definition of the terms "intelligence" and "rationality" at least for their specific use in this article.

Intelligence comes from the Latin term *intelligentia* and is used since the 14th century. The expression "intelligence" is used heavily today by laypersons as well as professionals in many areas. The definition of the term, however, is far less clear than one would think at first sight. Broad definitions, or rather *broad theories*,[2] include functioning that are also captured in the term when appearing in folk language. These

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2 For example the well-established Cattell–Horn–Carroll theory, Flanagan et al (2014)

functions include "adaptation to the environment", "showing wisdom or creativity", "being knowledgeable" and several others whether or not these functions are actually measured by existing intelligence tests. Laypeople also tend to understand the term "intelligence" in its broad meaning. Narrow theories – in contrast – adopt a practical approach and confine themselves to the set of mental abilities that are actually measured by modern intelligence tests.[3]

It is interesting to examine our "smart but acting dumb" phenomenon in light of the above theories. When applying a broad theory of intelligence the "smart but acting dumb" seems to present a paradox. If we try to define intelligence in a way that it includes as many identifiable cognitive abilities as possible it becomes increasingly difficult to explain why someone would consciously act dumb, and thus create a lot of trouble for him or herself, when he or she seems to possess all the necessary abilities, like wisdom, knowledge, creativity, etc. to avoid acting in that way. On the other hand, there seems to be no contradiction if we apply the narrow theory of intelligence. Experience shows that people scoring high on intelligence tests are no less prone to "acting dumb" than people with average IQ. If we use the narrow theory the "smart but acting dumb" phenomena simply suggests that intelligence, as measured by intelligence tests, may simply not be the only or most important factor in avoiding such unfortunate course of action. American psychologist Keith Stanovich argues convincingly that the ability which plays a major role in acting "smart or dumb" is "rationality".[4]

## Rationality, the Missing Element

The dictionary definitions of "rational" tend to be rather unspecific and diverse ranging from "having reason" through "sensible" to "having sound judgement". In order to understand the role played by "rationality" in our cognitive domain we must find a more specific and solid definition of rationality. Stanovich differentiates two types of rationality.[5] The first is the *instrumental* rationality, which basically means that one behaves in the world so that one gets exactly what he or she wants, given the resources (physical and mental) available to him or her. Instrumental rationality involves optimization of one's goal fulfilment through optimal choice pattern. *Epistemic* rationality shows to what extent one's belief structure of the existing world actually mirrors the factual structure of the world. Deviation from the optimal choice pattern in the case of instrumental rationality and the distance of the epistemic optimum in the case of the epistemic rationality can be considered an inverse measure of rationality as a cognitive ability in humans.

3 Of course, defining intelligence as something that intelligence tests measure, however useful in this present context, is fully circular. There seems to be a consensus that the central cognitive function that intelligence tests tap is cognitive decoupling, the ability to manipulate secondary representations that do not track the world in one-on-one fashion as do primary representations.

4 Stanovich (2009) 8.

5 Stanovich (2009) 16.

Another important term introduced by Stanovich is *dysrationalia*.[6] Dysrationalia is the inability to think and behave rationally despite adequate intelligence. It is a general term that refers to a heterogeneous group of disorder manifested by significant difficulties in belief formation, in the assessment of belief consistency, and/or in the determination of action to achieve one's goals.

A remarkable point is that rational thinking skill seems to show only small-to-medium correlation with intelligence test performance. When people (laypersons and psychologists alike) use the word intelligence they often talk as if the concept of intelligence encompassed rationality (adaptive decision making which is the quintessence of rationality), but the items used to assess intelligence on widely accepted tests bear no resemblance to measures of rational decision making. Intelligence, as conventionally measured, leaves out many critical cognitive domains.

Measuring intelligence has a tradition of roughly a hundred years and is widely accepted by society. Intelligence tests are regularly used at various institutional entry points in the field of education and also in professional employment. The IQ test represents a quantified, easily and quickly applicable selection tool.

The concept of intelligence is not only firmly established but also highly valued by modern Western societies. Intelligence is a coveted trait, a rather valuable ability. Scoring high in IQ tests seems like almost an indication of personal worth. People would rather have a high IQ than almost any other physical or mental quality.

In contrast, the concept rationality is neither well understood nor established in society. Properly measuring and quantifying rationality is difficult and has no significant tradition. Naturally, measuring rationality is not a standard selection tool and extremely rarely used in any selection process. It seems that intelligence is significantly overvalued, while rationality is notably undervalued by society.

## The Cognitive Bias

Cognitive bias refers to systematic and recurring patterns of deviation from epistemological rationality in judgment; in other words, it is systematic and recurring erroneous thinking. The term was introduced by Nobel Laureates Daniel Kahnemann and Amos Tversky in 1972. There are several dozens of vastly different cognitive biases and they show a surprising variety in nature. Cognitive bias is a very common phenomenon to all human beings and while, naturally, none of us produce the full list of thinking errors, all of us seem to have some of them whether we are aware of it or not.

The more cognitive bias one has, the more he or she diverges from rational thinking. More cognitive biases mean higher dysrationalia, thus more erroneous thinking, regardless of the level of intelligence. Cognitive biases are widespread because humans seem to have a dual process thinking system which operates in a way that opens a ground for such irrational thinking.

6 Stanovich (2009) 18.

## Dual Process Thinking

To understand the roots of cognitive biases we must have a deeper evolutionary understanding of human thinking. In our present knowledge human thinking is a *dual process system*.[7] The first process, *System 1* thinking, is a fast, automatic, emotional, stereotypical, heuristic, intuitive and mostly subconscious thinking. A good example of System 1 thinking is face recognition or depth perception, both happening quickly, subconsciously and based on previous experience. Because of its computational ease System 1 thinking is a common processing default in our thinking. System 1 thinking also allows parallel operation, so that many System 1 processes can happen at the same time. *System 2* thinking is relatively slow, computationally expensive, serial and involves conscious problem solving. We use System 2 thinking when our situation requires focused, often step-by-step, methodical approach. Engaging in a challenging math problem is a good example of System 2 thinking. Also, System 2 thinking is serial because the intense focus and systematic nature of cognitive efforts in System 2 usually leaves no room for significant parallel processes.

*Table 1 The comparison of System 1 thinking and System 2 thinking*

| System 1 thinking | System 2 thinking |
|---|---|
| fast | slow |
| automatic | controlled |
| low effort | high effort |
| associative | rule based |
| non-verbal | language based |
| default process | inhibitory |
| non logical | logical |
| evolutionary old | evolutionary recent |
| parallel | serial |

System 1 and System 2 processing have a very clear distribution of labour firmly based in evolutionary development. System 1 is our old default system which does a respectable job in our everyday life. With its rapid, low effort, parallel and approximative operation System 1 can process a lot of information, far more than our slow and serial System 2 thinking would be capable of. Simply being here gives and convincing evidence

7 Kahnemann (2011) 28.

that throughout our evolutionary history System 1 thinking was able to provide output sufficient to our survival.

Notwithstanding of the above one of the most critical function of System 2 processing is to override System 1 processing from time to time. This is often necessary because System 1 processing is quick and approximative and while in most of the cases this proves to be sufficient there are a number of situations when System 1 outputs are highly inadequate and sometimes devastatingly poor. Also, System 1 heuristic processing depends on *benign* environments, in *hostile* environments, as it is explained later, it can be quite costly.

Overriding, however, is difficult. Humans tend to be *cognitive misers* so that they incline to spend, unconsciously, as little time and effort on mental processing as possible. System 1 thinking with its quick, approximate, simplifying process fits this criteria. This is because, according to the logic of our evolutionary development, we try to spend as little energy as possible on any given task and thus conserve as much energy as we can for survival. Accordingly, most of the times humans tend to simplify things, tend to engage in attribute substitution, the substitution of an easy-to-evaluate characteristics for a harder one even if the easier one is less accurate.

Most of our cognitive biases are results of our inability to override our heuristic System 1 thinking with the more sophisticated System 2 in particular contexts which require more analytic mental processing. Another part of the cognitive biases arise when we lack the proper "mindware" to process the information available.

## Example 1: Bad Syllogism

A syllogism is a kind of logical argument that applies deductive reasoning to arrive at a conclusion based on two or more propositions that are assumed to be true. For example:

| | |
|---|---|
| All humans are mortal and I am a human | (propositions) |
| therefore | |
| I am mortal | (conclusion) |

Now, let's examine the following syllogism:

| | |
|---|---|
| All Greeks are warriors and Socrates is a warrior | (propositions) |
| therefore | |
| Socrates is Greek | (conclusion) |

The majority of us do not recognize at first that the second example is a bad and invalid syllogism. The example resembles a valid syllogism and our System 1 thinking, quickly processing the information, fails to recognize the erroneous reasoning. Let's see the second syllogism in a different setup:

All Greeks are warriors and Napoleon is a warrior (propositions)
therefore
Napoleon is Greek (conclusion)

In this second example it seems to be easier to override our System 1 thinking because Napoleon is a famous historical figure and we all know that he is, in fact, not Greek. However, the structure of the second and the third example is very much the same and the second example shows us how easy it is to arrive at an invalid conclusion without overriding System 1 thinking.

## Example 2: Conjunction Fallacy

There are some cases when the inability to override System 1 thinking is possibly paired with inadequate mindware. Let's examine the following example:

> *Lidia is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.*

Which is more likely?

1. Lidia is a bank teller.
2. Lidia is a bank teller and is active in the feminist movement.

85% of those asked chose option (2), but the correct answer is Option (1). This is because the probability of two events occurring together (in "conjunction") is always less than or equal to the probability of either one occurring alone.

$$p(A) \geq p(A+B)$$

accordingly,

$$p(\text{bank teller}) \geq p(\text{bank teller} + \text{active in the feminist movement})$$

That is, the probability that Lydia is a bank teller has to be at least as great as the probability that she is a bank teller and a feminist. Most people get this problem wrong because they use the representativeness heuristic to make this kind of judgment: Option (2) seems more "representative" of Lidia based on the description of her, even though it is clearly mathematically less likely.

## Example 3: Lycanthropy[8] test

Suppose you are a doctor in the Victorian era and you are screening a set of citizens in the city Ledenham,[9] England for a disease called Lycanthropy. You know from past population studies that around 20% of the citizens will have Lycanthropy in that unholy city.

*You are testing for Lycanthropy using a colour-changing tongue depressor, which usually turns black if the citizen has Lycanthropy.*

- *Among patients with Lycanthropy, 90% turn the tongue depressor black.*
- *However, the tongue depressor is not perfect, and also turns black 30% of the time for healthy citizens.*

*Your beloved mistress comes into the office, takes the test, and turns the tongue depressor black. What is the probability that she has Lycanthropy?*

Most people are unable to give even an educated guess about the probability of the mistress having Lycanthrophy. Some people will give a quick "gut" estimation but they will almost certainly be mistaken. A lot of people will succeed in overriding their System 1 thinking but will be unable to use their System 2 process because they lack the necessary knowledge in probability theory that is required to answer this question.[10]

## Why are Cognitive Biases Important?

There are several dozens of different cognitive biases. Some of the relatively well known are:

- Confirmation bias – the tendency to search for, interpret, favour, and recall information in a way that confirms one's pre-existing beliefs or hypotheses, while giving disproportionately less consideration to alternative possibilities;
- Anchoring bias – the tendency to rely too heavily on the first piece of information offered (the "anchor") when making decisions. During decision making, anchoring occurs when individuals use an initial piece of information to make subsequent judgments;
- Hindsight bias – the inclination, after an event has occurred, to see the event as having been predictable, despite there having been little or no objective basis for predicting it;
- Gambler's bias – is the mistaken belief that, if something happens more frequently than normal during some period, it will happen less frequently in the

8 Lycanthropy is an imaginary infectious disease that that causes a human to transform into a werewolf.
9 Ledenham is an imaginary English town in the novels of Susan Pleydell.
10 This a conditional probability problem which can be solved either graphically or by using Bayes rule. The answer is 43 (forty-three) % which seems quite counterintuitive and most people estimate a far larger probability of having the disease.

future, or that, if something happens less frequently than normal during some period, it will happen more frequently in the future (presumably as a means of balancing nature);
- Status quo bias – a preference for the current state of affairs. The current baseline (or status quo) is taken as a reference point, and any change from that baseline is perceived as a loss;
- In-group bias – is a pattern of favouring members of one's in-group over out-group members;
- Out-group homogeneity bias – is one's perception of out-group members as more similar to one another than are in-group members, e.g. "they are alike; we are diverse";
- Bias blind spot – is the cognitive bias of recognizing the impact of biases on the judgement of others, while failing to see the impact of biases on one's own judgment.

Cognitive biases are highly important because they can ruin our mental performance to a remarkable extent. High IQ and extensive knowledge are universally valued characteristics of our cognitive domain but if our cognitive processes are saturated by erroneous patterns the output will be inevitably saturated. Cognitive biases play a decisive role in hindering rational thinking and thus are the primary cause of dysrationalia.

Cognitive biases can deteriorate one's thinking and actions but this effect is multiplied when it happens in the professional area. Certain industries operate in high-stake, high-risk, high-security, high-hazard, highly liquid or highly sensitive environments. These enterprises include state organizations like intelligence and law enforcement agencies, military, public service providers like medical institutions and private companies like financial, insurance, security, energy, etc. firms and also companies running large and complex industrial, environmental etc. projects. Decisions of operative management in these areas have robust and direct operational implications on the enterprises employing them and often long lasting and serious social and economic impacts on their broader institutional scope and environment. In these areas the importance of rational thinking cannot be overemphasised.

Another important observation here is that our environment cannot really be considered "benign" anymore. This is because of two reasons. First, in modern society the amount of available information cannot be compared to the amount that was available throughout the very long period through which our brain and cognitive abilities evolutionary developed. Biological evolution is a much slower process than social evolution and our brain sometimes struggles to process the enormous quantity and complexity of information we face.

Secondly, our social environment is far from being "neutral". In modern society a lot of agents work to take advantage of our cognitive biases. For example, the whole modern marketing industry, let it be commercial or political, operates on the assumption that, in most cases, we are unable to approach information in a rational way and thus

exploiting our cognitive weaknesses. This does not mean that these agents are inherently evil but it does mean that they work against rational decision making.

## Cognitive Debiasing

Cognitive debiasing is a cognitive, motivational and/or procedural process through which a certain cognitive bias can be recognized, made be aware and transparent of and possibly removed from one's or a group's cognitive thinking patterns. As a consequence, judgements and decisions will be less saturated by cognitive biases, by erroneous assumptions, by false convictions. Judgements and decision making will be based on facts, evidence and logical reasoning, in other words they will be more rational.

Cognitive debiasing in a person or in a group is a process and not necessarily an easy and quick one. Cognitive biases tend to have different roots, backgrounds and characteristics while, according to our present knowledge, there is no universal solution or cure for them. Cognitive biases proved to be remarkably persistent, even with the best techniques based on the latest research on the area the debiasing process requires remarkable focus, conscious efforts and continuous practice from the participants of the process.

Eliminating some cognitive biases (See: Example 1: Bad Syllogism) require only the ability of our System 2 thinking to override our System 1 thinking. Most of us are cognitively well equipped to process syllogisms and we execute this process quite frequently in our everyday life. Ironically, this relative ease and prevalence are the reasons why we automatically and unconsciously assign this problem to our System 1 thinking, which is very good at quickly processing syllogisms. The problem arises when, at first sight, the case looks like a valid syllogism but, in reality, it is not. Our System 1 thinking is often too quick and superficial to point out bad logical reasoning. We fail to recognize the bad syllogism and process it as a valid logical reasoning and thus, we arrive at a false conclusion.

Debiasing other cognitive biases (See: Example 2: Conjunction Fallacy) also requires a conscious switch from System 1 thinking to System 2 thinking but also requires some additional knowledge, in this case in the field of probability theory. In Example 2 most people are quickly inclined to choose Option 2 because of the reasons explained. It is, of course, very important that we recognize the need to switch to System 2 thinking but we also must be in possession of the necessary knowledge in probability theory (in this case it means understanding the $p(A) \geq p(A+B)$ rule) if not explicitly than at least implicitly. If we do not possess this knowledge then switching from System 1 to System 2 is not going to be sufficient to make the right choice.

A few situations require deeper understanding of probability theory (See: Example: Lycanthrophy test). Most of the people will realize that this is a complicated issue and will automatically try to switch from System 1 to System 2 thinking. However, probably only a few of them will possess the necessary knowledge to solve this problem. Others, when realizing that they are unable to process an exact calculation, will try to give an approximate answer that, in this case, will be reasonably far from the actual value.

A large number of cognitive biases are of course less quantifiable than those explained above, nonetheless, they represent erroneous thinking patterns. Confirmation bias, for example, is not easy to quantify but surely is a wrong thinking pattern to follow. It is important to understand that there is no magic bullet in the field of cognitive debiasing. Although understanding the concepts of System 1 and System 2 thinking, overriding, dysrationalia, cognitive biases, etc. provides an excellent, and also indispensable, starting ground, the actual debiasing process is likely to progress slowly and from one bias to another.

## Recent Findings in Measuring Rationality

Unlike intelligence, measuring rationality is difficult and has only been recently researched. Keith Stanovich laid down the theoretical foundation of the RQ (Rationality Quotient) in its book "What Intelligence Tests Miss – The Psychology of Rational Thought" in the early 2000's. In his most recent book "The Rationality Quotient (RQ) – Toward a Test of Rational Thinking" Stanovich explains the components of rational thought including probabilistic and scientific reasoning, the avoidance of miserly information processing and the knowledge structures needed for rational thinking. Also the book presents the first prototype for an assessment of rational thinking analogous to the IQ test: the CART (Comprehensive Assessment of Rational Thinking).[11]

The RQ research program is a firmly progressing one but, naturally, there is still lot of work to do. For example, the measurement of RQ needs more confirmation in terms of both validity and reliability. Nevertheless, there is a good chance that this research program will provide an essential and presently missing cognitive metrics system. Beside its function as a general evaluation and selection tool it is likely that with a comprehensive test of rationality we will be able to identify cognitive biases and thus to provide a *diagnosis* for a possible targeted cognitive debiasing.

## Recent Findings in Cognitive Debiasing

Cognitive Debiasing has become an increasingly researched area recently. One of the most interesting studies in this field was carried out by Leidos Inc. in the framework of a US Air Force research program in cooperation with the Air Force Research Laboratory in 2014. The appearance of a branch of the most advanced military in World among the sponsors of research programs in this area is far from being a coincidence. Experience shows that that cognitive biases among the personnel in the military intelligence community seriously affect the quality of analyses being produced. Intelligence analysis, by its nature, already incorporates a significant level of uncertainty. This uncertainty is of course a risk accounted for in the process of intelligence analysis but if the process is further saturated by other unknown and incalculable factors like cognitive biases then the end result may be entirely misleading. Participating in such research projects

11 Stanovich et al. (2016) 75.

is a proof that there is an awareness and sensibility of the military decision makers concerning this subject.

Leidos Inc. developed a serious video game[12] for the mitigation of cognitive biases called "Missing".[13] Missing combines the rich, immersive qualities of entertainment software with a host of training activities on cognitive bias recognition and mitigation incorporated into game play. In this experiment three cognitive biases came into focus:

- Confirmation bias – defined as the tendency to seek out or focus on information that confirms a hypothesis while overlooking or discounting evidence that might disconfirm that hypothesis;
- Fundamental attribution error – assuming that another person's behaviour must stem from personal characteristics while overlooking the potential impact of situational influences;
- Bias blind spot – the tendency to recognize bias in others but not in oneself.

The story develops over the course of three episodes, during which the player completes a series of tasks and interactions with game characters, all in pursuit of resolving the mystery at the centre of the story. After each episode is played, there is an After Action Review (AAR) that teaches about specific biases, offers feedback on game performance and reinforces the point with a story.

The results of the experiment with Missing turned out to be very encouraging. There were four groups in the experiment, two college student groups (N=54 in the test group and N=58 in the control group) and two intelligence analyst groups (N=29 in the test group and N=30 in the control group). The two test groups played the Missing serious game in a way described above. The two control groups watched a professionally produced, engaging video that taught recognition and mitigation of the examined biases. Thus, the video might be considered an active control (i.e., the current standard of practice for providing education about cognitive biases).

Missing achieved a 37% improvement in *knowledge* of biases for the student sample and a 44% improvement for the analyst sample. As for the immediate bias *mitigation* effect the results were 25% and 27% respectively. After an 8-week period the effect was still a significant 25% in case of the students and 26% in case of the analysts. These robust results suggest that the knowledge gained by playing the game Missing was internalized and retained.

## Practical Applications

Measuring rationality is a progressing research program. It seems almost inevitable that Rationality Quotient (RQ) will be a cognitive metrics of paramount importance in any staff selection processes. RQ will be a natural and crucial supplement to Intelligence Quotient (IQ) which is has been widely used for a long time. Measuring rationality will allow us to tap decisive cognitive abilities which remained unaccounted for by existing tests and thus will facilitate a more balanced cognitive evaluation process.

12 Simborsky et al. (2014)
13 Creative Technologies Inc.

Cognitive debiasing is a tool that can dramatically increase efficiency of existing staff especially of personnel operating in high-stake, high-risk, highly hazardous, highly liquid and/or highly sensitive environments. When considering a cognitive debiasing training project there are two options to follow. In the first approach ("staff focused") the starting point is to evaluate the RQ and the existing cognitive biases of the participants by a CART (Comprehensive Assessment of Rational Thinking) test. The CART test will help to obtain a map of the existing biases and the debiasing training can be structured accordingly. The second option ("industry focused") starts with the evaluation of the industry and the specific jobs where the cognitive debiasing is planned. Analysing the industry and job specific characteristics (risks, decision making processes, etc.) will help to identify the cognitive biases that can have the most deteriorating effects in the given area.[14] After the identification of relevant biases in the industry and job the debiasing training can be compiled accordingly.

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14 Yudkowsky

## ABSZTRAKT

***A racionalitás mérése és a kognitív torzítások csökkentése***

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*Az intelligencia mérésének évszázados hagyománya van, ám emellett a racionális gondolkodás képessége is kritikus fontosságú elem a gondolkodás hatékonyságában. A tanulmány az RQ (Rationality Quotient) fogalmával, a racionális gondolkodás képességét alapvetően befolyásoló kognitív torzításokkal és ezek korrigálásának legújabb módszereivel foglalkozik. Ez a téma különösen olyan foglalkozások és munkakörök esetében döntő jelentőségű, ahol a szokásosnál jelentősen nagyobb súlyú döntésekkel, kockázatokkal és bizonytalanságokkal kell számolni.*

***Kulcsszavak:*** *kognitív torzítás, kognitív torzítások csökkentése, racionalitás, diszracionália, racionalitás mérése, RQ, racionalitáshányados*