UNIVERSIDADE DE LISBOA
FACULDADE DE PSICOLOGIA

HEURISTICS: SMART AND FRUGAL BUT ALSO BIASED

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Área de Especialização em Cognição Social Aplicada

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Abstract

When it comes to decision-making under uncertainty, there is a well-known confrontation between two approaches: Kahneman and Tversky's Heuristics and Biases and Gigerenzer's Fast and Frugal Heuristics. Even though both approaches defend that heuristics correspond to intuitive processes, one postulates systematic and characteristic heuristic-based errors that are costly for individuals and the other refers that heuristics mostly lead to accurate judgments. This present work addresses this apparent paradox: "how can human intuition be simultaneously right and wrong?" by putting together in the same study judgment tasks coming from each theorical approach. One hundred and twenty participants responded to problems presenting a conflict between intuitive (heuristic-based) and deliberate answers (CRT, syllogisms and semantic illusions), commonly used by the heuristics and biases approach; and to a pairwise comparisons task, typically used to study the recognition heuristic by the Fast and Frugal approach. Furthermore, we manipulated instructions to be rational versus intuitive, in order to affect participants' reliance on intuition. Results show that rational instructions increased performance to conflict problems (i.e., lead to reduced reliance on heuristic-based intuitions) and increased the use of the recognition heuristic. These results defy the view that all heuristics stem from the same intuitive, largely autonomous processes, and suggest that the recognition heuristic also involves a more deliberate type of processing. Limitations and follow up studies are discussed.

Keywords: Heuristics and biases, Fast and Frugal heuristics, Intuition, CRT, Semantic illusions, Syllogisms, Recognition heuristic.

Resumo alargado

De entre várias abordagens e autores que se dedicaram ao estudo da tomada de decisão em situações de incerteza, existem duas que receberam uma atenção sistemática e consistente: a investigação em Heurísticas e Vieses iniciada por Kanhneman e Tversky (e.g., Gilovich, et al., 2002; Kahneman, et al., 1982; Tversky & Kahneman, 1974) e a investigação em heurísticas rápidas e frugais de Gigerenzer e colaboradores (e.g., Gigerenzer, 1991, 2004; Gigerenzer, et al., 1999; Goldstein & Gigerenzer, 2002). Estas abordagens concordam que o julgamento e tomada de decisão dependem bastante das heurísticas. Ou seja, baseia-se frequentemente em atalhos cognitivos ou formas simplificadas de fazer julgamentos e tomar decisões. Para além disso, concordam que a) as heurísticas não só são formas simplificadas de tomar decisões como também são qualitativamente diferentes dos modelos normativos de julgamento e decisão; b) as heurísticas correspondem à intuição humana, produzindo respostas que surgem na mente sem se ter acesso consciente aos processos psicológicos subjacentes (sendo que o Tversky e Kanhneman (1974) lhes chama "*natural assessments*" enquanto que Gigerenzer lhes chama "*gut feelings*"); c) as heurísticas têm uma natureza não compensatória, ou seja ignoram parte da informação disponível no ambiente; d) as heurísticas funcionam por substituição – veja-se, por exemplo, os casos das heurísticas do reconhecimento (Gigerenzer & Goldstein, 1996; 2002) e da disponibilidade (Tversky & Kanhneman, 1973). no caso da heurística do reconhecimeto, a pergunta "qual das duas cidades tem mais habitantes" é substituída por "qual das cidades é reconhecida", se uma das cidades for reconhecida e a outra não, conclui-se que a primeira é a que tem mais habitantes. No caso da heurística da disponibilidade, a probabilidade ou frequência de ocorrência de exemplares (eventos) de uma determinada categoria é substituída pela facilidade com que se consegue recuperar da memória exemplares dessa categoria; e) finalmente, ambas as abordagens, consideram que as heurísticas são

ecologicamente validas (i.e., exploram de forma eficaz a estrutura do ambiente na qual a tomada de decisão acontece). No entanto, as heurísticas são, por definição, suscetíveis a erros.

As duas abordagens divergem principalmente na importância que dão a estes erros. De acordo com o programa de investigação em heurísticas e vieses, estes erros são comuns e prejudiciais tanto para os indivíduos como para a sociedade. Assim, a sensibilização para a existência destes erros e para o desenvolvimento de estratégias mais deliberadas de julgamento e decisão que permitam reduzir a sua frequência, é vista como crucial por este programa.

De acordo com a abordagem das heurísticas rápidas e frugais, os erros que advêm do uso de heurísticas são mais raros, menos graves e mais ilusórios do que reais, no sentido em que muitas vezes resultam de tarefas de raciocínio criadas propositadamente (pelo programa de investigação em heurísticas e vieses) para levar as pessoas a darem erros, não tendo propriamente ligação com a tomada de decisão do dia-a-dia.

A investigação tem mostrado que os erros decorrentes das heurísticas propostas pelas abordagem de Kanhneman e Tversky ocorrem também nas decisões tomadas no dia-a-dia (e.g., Toplak et al., 2017). No entanto, quando os participantes estão a responder a tarefas mais características da abordagem das heurísticas rápidas e frugais (i.e., Gigerenzer & Goldstein, 1996), as respostas baseadas heurísticas são frequentemente bastante precisas. No caso da heurística do reconhecimento, a validade estimada é de 80% (Czerlinski et al., 1999).

Em suma, as heurísticas referem-se ao julgamento intuitivo humano e este parece ser simultaneamente "bom" e "mau", dependendo da abordagem teórica adotada! Curiosamente, não existe investigação que, num mesmo estudo, inclua tarefas tradicionais de ambas as abordagens e assim permita um teste mais direto desta aparente contradição. A minha tese procura colmatar este lapso na literatura. Para isso, na experiência aqui reportada, cento e vinte participantes responderam a tarefas caraterísticas da abordagem de heurísticas e vieses: CRT (*cognitive reflection test*, Frederick, 2005), ilusões semânticas (e.g., Erickson & Mattson, 1981;

Mata, et al., 2013; Park & Reder, 2004) e silogismos (e.g., De Neys & Franssens, 2009; Evans et al., 1983;). Em todos estes problemas, existe uma resposta intuitiva e psicologicamente apelativa, mas errada (baseada em heurísticas), em oposição a uma resposta mais deliberada que está estatística ou logicamente correta. Ademais, os mesmos participantes realizaram uma tarefa de comparação de pares de cidades em que tinham de escolher, em cada par, qual das cidades era maior (uma tarefa tipicamente usada para estudar a heurística do reconhecimento).

Assumindo que ambas as tarefas (de ambas as abordagens) capturam de forma equivalente a noção de intuição, avançamos uma primeira hipótese: quanto mais os participantes dependerem da sua intuição, pior será o seu desempenho nas tarefas de raciocínio e melhor será o desempenho na tarefa de comparação de objetos. O padrão inverso será de esperar quanto mais os participantes evitarem usar a sua intuição e, em vez disso, responderem com base em raciocínio ou processamento deliberado. Por outro lado, pode ser que os participantes sejam capazes de regular a forma como tomam decisões, o que nos leva a uma segunda hipótese: os participantes baseiam-se na intuição quando esta é uma forma válida de tomar decisões (i.e., baseiam-se na heurística do reconhecimento na tarefa de comparação de pares) e evitam usá-la caso contrário (i.e., inibem as respostas heurísticas nos restantes problemas de raciocínio).

Para melhor explorar estas hipóteses, manipulámos também as instruções. Os participantes foram convidados a pensar de uma forma mais deliberativa ou, pelo contrário, a dar a primeira resposta que lhes ocorria (i.e., resposta intuitiva). De acordo com a primeira hipótese acima referida, as instruções para ser mais racional deveriam reduzir o uso de heurísticas. Ou seja, reduzir os erros dados pelos participantes nos problemas de raciocínio e reduzir o uso do reconhecimento na tarefa de comparação de pares. Em contraste, de acordo com a segunda hipótese, pode ser que as instruções para os participantes serem mais racionais

faça com que estes consigam controlar melhor a sua intuição, não a usando nos problemas de conflito (tarefas de raciocínio) e dependendo dela na tarefa de comparação de pares.

Instruções para deliberar e responder de forma racional levaram a melhor desempenho global comparativamente a instruções para responder com base na intuição. Para além disto, estas instruções levaram a um maior uso da heurística do reconhecimento. Ou seja, parece que participantes induzidos a adotar um "*settting*" mental mais racional controlaram melhor a sua intuição, usando menos as heurísticas na presença de conflito entre intuição e razão (tarefas de raciocínio) e mais na tarefa de comparação de pares.

Os nossos resultados parecem estar alinhados com a posição de Gigerenzer (2008) de acordo com a qual, diferenças de aptidão cognitiva (no nosso caso meramente instruções para usar mais ou menos tais aptidões) estão mais "ligadas à seleção adaptativa da resposta heurística e menos à execução da heurística" (Gigerenzer, 2008, p. 21).

Por outro lado, do ponto de vista das teorias dualistas de julgamento e decisão (e.g., Evans & Stanovich, 2013) os nossos resultados podem ser lidos como sugerindo que a heurística do reconhecimento não se baseia inteiramente em processamento autónomo, Tipo 1, mas envolve também processamento mais deliberado, Tipo 2. Kanhneman e Frederick (2002) já tinham posto esta possibilidade, defendendo que esta heurística, poderia envolver uma componente estratégica deliberada. Com efeito, caso a heurística do reconhecimento funcionasse puramente com base em "*gut-feelings*" instruções para ser racional e inibir as intuições deveriam ter interferido com (e talvez não reforçado) o seu uso.

Palavras Chave: Vieses e Heurísticas, Heurísticas rápidas e frugais, Intuição, CRT, Ilusões Semânticas, Silogismos, Heurística do Reconhecimento

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Introduction

People make choices every day, however, the judgement and decision-making processes underlying these choices are not completely studied or unraveled yet. Among all the different approaches to this problem, two have received consistent and systematic attention: the research program on heuristics and biases initiated by Kahneman and Tversky started in the late 1960's (e.g. Gilovich, et al., 2002; Kahneman, et al., 1982; Tversky & Kahneman, 1974); and the fast and frugal heuristics proposed by Gigerenzer and collaborators in the early 1990's (Gigerenzer, 1991, 2004; Gigerenzer, et al., 1999; Goldstein & Gigerenzer, 2002). Even though they hold quite different and sometimes even opposite views, both approaches start up by agreeing that human judgment and decision making rely heavily on heuristics. That is, cognitive short-cuts or simplified ways to make judgement and decisions. Moreover, both converge in the following points:

a) Heuristics are not only simplified ways to make decisions but also qualitatively different from the normative models of decision making like the one proposed by Keeney and Raiffa (1993). In other words, normative models do not capture the way people make decisions;
b) Heuristics correspond to human intuitions, producing responses that pop to mind without a clear conscious access to the underlying psychological processes. With that in mind, Tversky and Kahneman (1974) called heuristics "natural assessments" whereas Gigerenzer and collaborators called them "gut feelings", both terms eventually capturing the intuitive nature of heuristics;
c) Heuristics have a non-compensatory nature, which means they work by ignoring part of the available information in the decision environment. As a result, heuristic-based responses arise from a limited number of cues (in the simplest of cases, one cue);

d) Heuristics work by substitution. For instance, in the case of the recognition heuristic (Gigerenzer & Goldstein, 1996; 2002), the question "which of two cities have more inhabitants" is replaced by "which of the two cities is recognized?". If one of the cities is recognized and the other not, it is concluded that the former is the one with more inhabitants. Because larger cities are more often recognized than smaller cities, the recognition heuristic often leads to correct judgments. Similarly, in the case of the availability heuristic (Tversky & Kahneman, 1973), the probability or frequency of occurrence of a given event of a given category is replaced by how easily one can retrieve exemplars of that category. So, for example, when questioned: are there more deaths in 2020 due to covid-19 or due to cardiovascular disease? Many people will (wrongly) say the former because covid-19's deaths are much more publicized (easier to retrieve from memory);

e) Finally, both approaches consider that heuristics are ecologically valid (i.e., they successfully explore the structure of the decision environment in which they have emerged). However, heuristics are by definition error prone, and abrupt changes in the decision environments (or its growing complexity, that is, of cues to account for) may dramatically increase heuristic-based biases and errors.

The two approaches seem to diverge on the importance they give to heuristics-based errors. According to the research program on heuristic and biases, these errors are common and costly for individuals and society at large, making the debiasing of human reasoning a crucial goal. For the fast and frugal approach, heuristic errors are much rarer and more illusory than real as they are often the result of, so called, parlor games: reasoning tasks purposefully made to produce errors but with little connection to everyday decision-making.

One way to partially solve this divergence is to assume that both approaches are correct under certain circumstances: when heuristics fail to capture the structure of the decision

environment (which is more likely to happen in the heuristics and biases research program), intuition is likely to be the source of biases; when they successfully explore the structure of the decision environment (which is typically the case in research conducted by the fast and frugal approach) human intuition works well. Such possibility is aligned with the existing research data showing that heuristic based intuitions are the source of biases and errors when people respond to reasoning problems in the tradition of Kahneman and Tversky's approach (which have been shown to have real-world correlates and thus can hardly be described as parlor games; e.g., Toplak, et al., 2017). However, when responding to tasks in the fast and frugal tradition (e.g., Gigerenzer & Goldstein, 1996), heuristic-based intuitions turn out to be quite accurate. In the case of the recognition heuristic, in which participants have to infer which of two given objects is the larger one, the mean recognition validity has been estimated to be 80% (Czerlinski et al., 1999).

To the best of our knowledge, no prior research so far put the above solution to direct empirical test by putting together in the same study reasoning tasks coming from both theorical approaches. To change this state of affairs, in the experiment here reported, participants responded to tasks of the heuristic and biases tradition: Cognitive rationality test (CRT, Frederick, 2005), semantic illusions (e.g., Erickson & Mattson, 1981; Mata, et al., 2013; Park & Reder, 2004) and syllogisms (e.g., De Neys & Franssens, 2009; Evans, et al., 1983). In all of these problems an intuitive and appealing but wrong (heuristic based) response is in opposition to a more deliberate and effortful response. Furthermore, the same participants were presented with a paired comparison task, in which they had to infer which of two cities was the larger one (a task traditionally used by the fast and frugal approach). The main dependent measure was the frequency of choosing the recognized object, that is, reliance on the recognition heuristic.

In sum, our goal is to shed some light on the apparent contradictory results concerning the accuracy of (heuristic based) intuitive judgments by running a crucial experiment that allows us to compare the performance of the same participants across tasks typically used by the heuristic and biases and the fast and frugal approaches.

Next, we begin by briefly reviewing theory and research in both traditions with emphasis on the specific reasoning tasks that are used in the present experimental work. Even though this is an exploratory investigation, based on this revision, we will then identify the main research hypotheses of our work and specify the design used to test these hypotheses.

Kahneman and Tversky's Heuristic and Biases

The first wave of research on judgment and decision making was dominated by a formal approach that used linear and normative models of judgment (Becker & McClintock, 1967; Keeney & Raiffa, 1993; Peterson & Beach, 1967; Slovic & Lichtenstein, 1971) to try to account for lay people judgments, decisions and choices. That is, statistical decision models were applied to human judgment. For example, expected utility theory (Newman & Morgenstern, 1957) and the Bayesian Theorem were used to define and describe what the optimal response should be in a certain situation. A second wave of researchers attempted to correct this first approach by relaxing the strictly rational assumptions of the original normative models and using these models to develop more complex descriptive accounts of human judgment (e.g., Brunswik, 1940; Dawes & Corrigan, 1974; Zeleny, 1976). However, it was the seminal work of Kahneman and Tversky that definitely began to shape the scientific discipline of Judgment and decision making as we know it in our days. Indeed, Kahneman and Tversky's research program on heuristic and biases put forward a revolutionary idea – that Judgment under uncertainty often rests on a limited number of simplified heuristics – qualitatively different from normative models of decision (for a review see, Sherman & Corty, 1984).

Kahneman and Tversky (1972)'s approach focused on judgements in terms of general principles of information processing and it involved identifying and analyzing typical judgmental biases and errors. The idea was that judgment errors and biases were not random and unsystematic (e.g., due to fatigue or lack of attention) but hallmarks of the underlying reasoning processes: the heuristics. That is, they did not only want to study what decisions were made but how those decisions came to be (Kahneman & Tversky, 1972,1973; Tversky & Kahneman, 1973). From the consistency between error and bias, they were able to describe a set of heuristics that often seemed to underlie judgment and decision making.

Tversky and Kahneman (1974) defined three major heuristics: availability, representativeness and anchoring and adjustment. According to the availability heuristic, people often rely on the ease of retrieval of exemplars of a category to estimate its frequency of occurrence. This is a useful heuristic because frequency of occurrence tends to increase psychological fluence and thus ease of retrieval from memory. However, several factors not related to frequency of occurrence may affect ease of retrieval. For example, after seeing several news on shark attacks, people tend to overestimate these events, because such come to mind quickly and easily.

According to the representativeness heuristic, "a person evaluates the probability of an uncertain event, or a sample, by the degree to which- it is (i) similar in essential properties to its parent population and (ii) reflects the salient features of the process by which it is generated" (Kahneman & Tversky, 1972, p. 431). In other words, judgments of probability that an object A belongs to a class B or an event A results from process B are replaced by judgments of the similarity between A and B.

Representativeness is a useful heuristic whenever probability and similarity are correlated. However, in other cases it may lead to errors and biases. One classic demonstration of this is the famous Linda problem (Kahneman & Tversky, 1983, p.11):

"Linda 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."

Linda is a bank teller.

Linda is a bank teller and is active in the feminist movement."

Basically, Linda is described in such a way that you can't help but think that she must be a feminist, because Linda's description is stereotypical of feminists. So, when asked if Linda is more likely to be a bank teller or a feminist bank teller, most people say the latter, even though this violates the conjunction rule of probability [P(A) >= P(A and B)].

Finally, according to the anchoring and adjustment heuristic, when faced with estimates of unknown quantities, one starts with information one knows or information that is salient in the decision environment (the anchor) and then adjusts until an acceptable value is reached. When the anchor is higher than the class of acceptable values, one's estimates tend to be higher than when the anchor is lower than this class – for the simple reason that the adjustment tends to end when the first acceptable valued is reached (Tversky & Kahneman,1974).

Kahneman and Tversky's research program on heuristics and biases (Kahneman, et al., 1982; Gilovich, et al., 2002) slowly evolved over the years from the initial proposition of a limited set of heuristics able to account for judgment under uncertainty to the realization that reasoning and judgment could not be accounted for by heuristics alone. Indeed, people can go beyond their initial heuristic-based intuitions, inhibiting them and eventually replacing them by more deliberate and effortful reasoned answers (Kahneman & Frederick, 2002; Stanovich & West, 1999).

Such dual-process approach considers the need of a second type of judgment process (T2) and downplays the initial research interest on distinguishing the different heuristics, which started to be seen as different manifestations of, so-called, Type 1 processes (T1). T1 are

defined as autonomous processes that once triggered tend to run to completion with little deliberation or effort. T2 refer to more deliberate and effortful reasoning that rely on working memory and executive functions such as inhibition, stimulus control and mental simulations (Evans & Stanovich, 2013). So, initial T1 intuitive responses may be monitored, inhibited and eventually replaced by T2 processing.

In this thesis we used problems frequently used by research on dual-process theories of reasoning and judgment. These problems typically present a conflict between T1 and T2 and can thus be used to investigate when T1 (heuristic) intuitions dominate and when T2 is capable of inhibit and replace T1 based responses. Specifically, we used the CRT, Syllogisms and Semantic Illusions.

The CRT is a known test where the first answer that comes to mind is the wrong one. For example, "A bat and a ball cost $1.10. The bat costs $1.00 more than the ball. How much does the ball cost? __cents", the first answer that comes to mind is that the ball costs 10cents, but because the difference between $1 and 10cents is 90cents, the correct answer is actually 5cents. The syllogisms (composed of two premises and one conclusion) have been shown to also elicit an intuitive answer (based on our knowledge of the world) that is often wrong. For example, consider the following syllogism: "flowers need water. Roses need water. Therefore, roses are flowers." Is the syllogism logically valid? Participants' knowledge that roses are flowers often lead them to respond affirmatively interfering with the fact that such conclusion (roses are flowers) does not logically follow from the two abovementioned premises (to see this go back to the syllogism and replace "roses" by, for instance, "dogs"). In the case of the semantic illusions, the sentence is made just so that the first thought that comes to mind is intuitively compelling but wrong. One example of this would be: "Water freezes when the thermostat is at zero Celsius degrees. Is this sentence true or false?". Well, water does freeze

when it gets to zero Celsius degrees, but you can check that using the thermometer and not the thermostat, however most people accept the sentence as truth.

In sum, in all of these problems, there is a more intuitive answer (T1) that comes quickly to mind but is wrong, and a more rational answer (T2) that takes time and effort but is normatively correct.

Gigerenzer's Fast and Frugal Approach

An approach that has heavily criticized Kahneman's and Tversky's Heuristic and Biases research program was Gigerenzer et al's (Gigerenzer, 1991, 2008; Gigerenzer, et al., 1999; Goldstein & Gigerenzer, 1996, 1999, 2002; Gigerenzer & Selten, 2001) proposal of Fast and Frugal heuristics.

The Fast and Frugal approach defends that the benchmark of good judgment and decision-making does not rely on a normative account of rationality (e.g., a "good" response is defined by normative decision models) but on an ecological account of rationality (e.g., a "good" response is defined by accurately exploring the structure of the decision environment). Furthermore, Gigerenzer, et al. (1999), criticized the heuristics proposed by Tversky and Kahneman (1974) as being mere labels that could be used to loosely describe judgment after the fact, but that could hardly make clear predictions. In contrast, they proposed a new set of heuristics, which make precise predictions and that could be more precisely tested (e.g., using computer simulations).

The Fast and Frugal heuristics underlying framework is the so-called "adaptive toolbox". A Darwinian-inspired metaphor of the human judgment and decision processes that conceives the mind as a modular system in which heuristics are composed of building blocks (usually a search rule, a stopping rule and a decision rule) that explore evolved capacities (e.g., recognition memory) (Gigerenzer, 2008). Fast and Frugal heuristics tend to be ecologically

valid because evolved capacities, shaped by long periods of evolution, allow them to successfully explore the structure of the decision environments.

The Recognition Heuristic

Perhaps the simplest heuristic studied by this approach is the recognition heuristic. According to the recognition heuristic, when "one of two objects is recognized and the other is not, it is inferred that the recognized object has the higher value with respect to a criterion" (Goldstein & Gigerenzer, 2002, p.76). Thus, the recognition heuristic exploits the basic psychological capacity for recognition (an evolved capacity) in order to make inferences, and when it is used no further information is needed or searched for.

As is the case for all fast and frugal heuristics, the recognition heuristic is domain specific; it only works in environments in which recognition correlates with the criteria being predicted. Formally speaking, the recognition heuristic is considered to be useful (e.g., it has ecological validity) in decision environments where there is a substantial correlation between recognition and the criterion (>.05). Interestingly people seem to have some understanding of this since they do not follow the heuristic blindly. Rather, the percentage of inferences in accordance with the recognition cue is dependent on the recognition ecological validity in a given situation (Newell & Shanks, 2004; Oppenheimer, 2003; Pohl, 2006).

In the initial studies of the recognition heuristic, Gigerenzer and Hoffrage (1995) asked about a dozen Americans and Germans "which city has a larger population: San Diego or San Antonio?" and around two thirds of the Americans answered correctly. Surprisingly, 100% of the German students answered correctly, despite the lack of knowledge they had about these cities. Ayton and Önkal (1997) cited by Goldstein and Gigerenzer (2002), were able to replicate these results using 50 Turkish students and 54 English students, asking them to make forecasts for all 32 English F. A. Cup third round soccer matches. Again, Turkish students who had less

interest and knowledge of English soccer teams, gave more accurate answers than English students. Both these studies are usually presented as demonstrations of the "less is more" effect. In other words, under certain conditions, the recognition heuristic leads to answers that may be more accurate than predictions based on more knowledge or other (contradicting) decision cues (Goldstein & Gigerenzer, 2002).

Summing up, the recognition heuristic has been studied using pairwise choice tasks, in which participants are asked to indicate which of two objects is the larger one in a given criterion. Three cases are possible in these paired comparisons: (1) Both objects are recognized, (2) one is recognized and the other is not, and (3) neither is recognized. Obviously, the recognition heuristic can only be applied in the second case.

Goldstein and Gigerenzer (2002), defined the recognition validity (α) as "the proportion of times a recognized object has higher criterion value than an unrecognized object in a reference class". That is, the probability of scoring a correct answer when one object is recognized and the other is not. When neither object is recognized, the probability of a correct answer is 50% which means basically that participants take a guess. There is still the correlation to knowledge that Goldstein and Gigerenzer (2002) defined as knowledge validity (ß). This last one is the probability of getting a correct answer when both objects are recognized and some other cues (knowledge) are used (so the "less is more" effect is only bound to happen when the recognition validity is larger than the knowledge validity).

Extant research (Newell & Shanks, 2004; Pohl, 2006) appears to show that a) the recognition heuristic predicts the inferences of a substantial proportion of individuals consistently, b) reliance on the heuristic increases with larger recognition validity and decreases in situations where the validity is low or indeterminable (Gigerenzer & Goldstein, 2011).

In order to study this, Pohl (2006) conducted a set of experiments using the dichotomic task (Gigerenzer & Hoffrage, 1995). In the first experiment Pohl (2006) tried to understand if there would be a difference between a condition in which participants were asked, which city was the most populous (a case where the ecological validity of the heuristics is high), and a condition where they were asked, which city was closer to a third one (a case where the ecological validity is low). Their results indicate that participants systematically relied in the recognition heuristic in the population condition but not in the distance condition, where participants' choice were close to random. This provided evidence to the claim that the recognition heuristic is domain-specific and that participants seem to possess some knowledge concerning the domains where the heuristic "works" and does not "work" (Goldstein & Gigerenzer, 1999, 2002; Pohl, 2006).

In our thesis we explore the recognition heuristic as it is one of the most representative and studied heuristic of the fast and frugal approach. For this, we rely on a dichotomic choice task as proposed by Gigerenzer and Hoffrage (1995). Specifically, we pre-tested a set of cities in terms of percentage of recognition by Portuguese participants and selected 8 Spanish cities (4 with high recognition and 4 with low recognition).

In the study next described, participants not only solved the aforementioned reasoning problems (CRT, syllogisms, semantic illusions) but also made 56 pairwise choices, indicating which city (of each presented pair) was the most populous.

Back to the Problem

One of the biggest disagreements between the two aforementioned approaches is related to the accuracy of heuristic answers. The heuristic and biases approach defends that by ignoring information, heuristics lead to biases and errors. The fast and frugal approach, however,

dictates that by ignoring some information, heuristics end up leading, in general, to good and accurate answers (sometimes even better than deciding based on more clues/information).

That being said, the problem consists on that both approaches consider that heuristics (see table 1) correspond to the human intuition. Which leads to a paradox, when studied by the first approach intuitive judgments lead mostly to errors, though when studied by the second they lead mostly to accurate answers.

Table1

Definition of heuristics contrasting Tversky and Kahneman's Heuristic and Biases approach (K&T) and Gigerenzer's Fast and Frugal approach(F&F)

Definition of Heuristics	
K&T	**F&F**
Simplified/non compensatory	Simplified/non compensatory
Work by substitution	Work by substitution
Ecologically valid	Ecologically valid
Biases and errors are defined by normative models of rationality	Biases and errors are defined by ecological rationality
"Natural assessments" (based on generic principles such as accessibility, similarity, affect)	Intuitive "rules of thumb" (based on evolved capacities (e.g. recognition) and tailored to solve specific classes of problems.

This debate has been occurring mostly at a theorical or meta-theorical level, with both approaches and respective scholars being closed to their own experimental investigations, ignoring each other's advances (Frankish & Evans, 2009).

Bearing this in mind, the objective of the present study is to contribute to unveil this apparent contradiction by presenting to the same participants in the same experimental study, tasks that are typical of the heuristics and biases approach and tasks that are typical of the Fast and Frugal approach.

Although exploratory, this study may begin testing some hypotheses. Assuming that both tasks (form both approaches) capture and equivalent notion of intuition, the more

participants rely on their intuitions, the worse is going to be their performance in the reasoning problems and the better their performance in the pairwise choice task (and vice-versa – the more they inhibit their intuitions and make use of more information/deliberation, the better is going to be their performance in the reasoning problems and the worse their performance in the pairwise choice task). On the other hand, it could be the case that participants are able to regulate their decision behavior, relying on their intuitions when it is appropriate to do so (pairwise choice task) and more often second-guess (and replace) their intuitive responses to the reasoning problems.

Summing up, this Study will involve tasks in which intuition leads to errors like the Cognitive Reflection Test (CRT, Frederick, 2005), syllogisms (De Neys & Franssens, 2009; Evans et al., 1983) and semantic illusions (Erickson & Mattson, 1981) and a recognition heuristic task in which the intuition leads to better or more accurate answers. Moreover, in this study we will be manipulating the instructions in order to lead participants to think in a more deliberative way, or to give the first answer that comes to their minds (e.g., to be more intuitive). It could be the case that the instructions to be more deliberate reduce participants' reliance on heuristics, in which case, the errors on the first type of tasks (reasoning problems) is expected to diminish as well as the accuracy on the second task that is dependent on the use of the recognition heuristic. In contrast, it could be the case that more deliberate participants manage better their gut-feelings, refraining from using them when in conflict with better (reasoned) responses (as it happens in the problems here used) but also more often relying on them in the pairwise decision task (where there are less systematic conflict with other decision cues).

Method

Participants. One hundred and twenty participants (74 males and 46 females; M_{age} = 22.91, SD_{age} = 2.66) were recruited online using the Prolific platform (www.prolific.co) [July, 2020]. They were randomly assigned to one of three conditions, namely the rational condition (N = 41), the intuition condition (N = 39), and the control condition (N = 40).

Materials. The materials included 12 reasoning problems. Four questions adapted from the Cognitive Reflection Test (CRT, Frederick, 2005) (see Appendix II); Four syllogisms adapted from De Neys and Franssens (2009) and Evans et al. (1983), consisting of two premises and a stated conclusion (see Appendix III); and four semantic illusions adapted from Erickson and Mattson (1981) (see Appendix IV). In each of these sets of four items, there were three conflict problems (i.e., that create a conflict between an intuitive response that immediately comes to mind, and a more deliberate response that is advised by careful reasoning) and one no-conflict problem (i.e., where the intuitive and deliberate responses converge in the same response option).

The materials also included eight Spanish cities that were used in the recognition heuristic task (see Appendix V). These cities were selected based on a pilot study with an independent sample of 97 participants (21 males and 76 females; M_{age} = 26.04, SD_{age} = 8.28). Participants were asked to indicate from a list of 20 Spanish cities (the 10 largest and 10 smallest cities in terms of population) which cities they recognized. From the 8 cities selected, participants in the pilot study recognized a mean of 4.25 cities ($M_{recognition}$ = 4.25, $SD_{recognition}$ = 0.98), and that recognition was positively related to the city's population size (r =0.77, p = .024).

A questionnaire was constructed for the current experiment with four CRT questions, four syllogisms, four semantic illusions and all 56 possible pairs of the 8 cities in random order in a recognition task (if one of the objects, in this case, cities, is recognized and the other is not people usually infer the recognized object has the higher value, much alike an inference task).

Procedure. Participants first received a recognition test where they were asked to mark, for each of the Spanish cities, whether they recognized the city's name or not.

Afterwards they were randomly assigned to one of three conditions (see Appendix I) that manipulated the instructions showed to participants. In the control condition participants were presented with neutral instructions introducing them to the judgment tasks (CRT questions, syllogisms, semantic illusions and recognition task) and requesting them to respond to the questions presented. In addition to these neutral instructions, in the rational condition participants were told that these was a study about their reasoning abilities, were warned, before each task, that the first answer that comes to mind is not always the correct answer and were encouraged to think carefully before answering. In the intuition condition, participants were told that these was a study about their intuitions and encouraged, before each task, to give the first answer that came to mind.

Subsequently, participants were presented with the three judgment tasks (CRT questions, Syllogisms and semantic illusions). Each of these tasks included 4 problems (3 conflict problems and 1 no-conflict problem) presented in a random order.

Next, participants completed the recognition task where they had to compare pairs of the 8 Spanish cities with respect to their population size.

Results

Descriptive data. Two participants recognized all the cities; hence they were withdrawn from the sample since they could never rely on the recognition heuristic. From the 8 Spanish cities used in the experiment, an average of 4,62 cities were recognized. Furthermore, recognition and city's population size were significantly correlated, $r = 0.76$, p=.028.

Main analysis. When it comes to the recognition heuristic, we calculated the recognition validity (α) according to Goldstein and Gigerenzer (2002):

$$\alpha = R/(R+W)$$

In which, as explained by the authors, "R is the number of correct (right) inferences the recognition heuristic would achieve, computed across all pairs in which one object is recognized and the other is not, and W is the number of incorrect (wrong) inferences under the same circumstances." (Goldstein & Gigerenzer, 2002, p.78). We also calculated the knowledge validity (β), which corresponds to the proportion of correct responses across all pairs in which participants recognized both cities. Our results showed an α =. 95 and a β = .92.

A 3x4 ANOVA was computed with Instructions (neutral, rational, intuitive) as between-subjects factor and Response Type (CRT, semantic illusions, syllogisms, pairwise comparisons) as a within-subjects factor. The dependent variable was participants performance (proportion of correct answers). This ANOVA showed a main effect of Instructions, $F(3,117) = 3,73$, p= .027, $\eta_p^2 = 0.06$, such that, participants who were told to be more rational answered more accurately ($M_{rational\ condition} = 0.59$, $SD_{rational\ condition} = 0.02$), than participants under neutral instructions ($M_{neutral\ condition} = 0.54$, $SD_{neutral\ condition} = 0.02$) and more accurately than those under intuitive instructions ($M_{intuitive\ condition} = 0.51$, $SD_{intuitive\ condition} = 0.02$). There was also a main effect of Response Type, $F(3,351) = 127,98$; $p < .001$, $\eta_p^2 = 0.52$, indicating difference in performance between tasks (see Table 2 for mean performance across tasks).

Table 2

Mean results (and SD) per condition

	Neutral Condition	Intuitive Condition	Rational Condition
CRTPROP[a]	0.13 (0.03)	0.15 (0.03)	0.19 (0.03)
SyllogismsPROP[b]	0.67 (0.06)	0.59 (0.06)	0.70 (0.06)
SemIlusionsPROP[c]	0.59 (0.04)	0.58 (0.04)	0.68 (0.04)
Performance Pair Wise[d]	0.77 (0.02)	0.72 (0.02)	0.78 (0.02)

[a]*CRTPROP: proportion of right answers on CRT*
[b]*SyllogismsPROP: proportion of right answers on syllogisms*
[c]*SemIllusionsPROP: porportion of right answers on semantic illusion*
[d]*Performance Pair Wise: right answers on the recognition heuristic task*

There was no interaction, $F>1$ (see fig. 1).

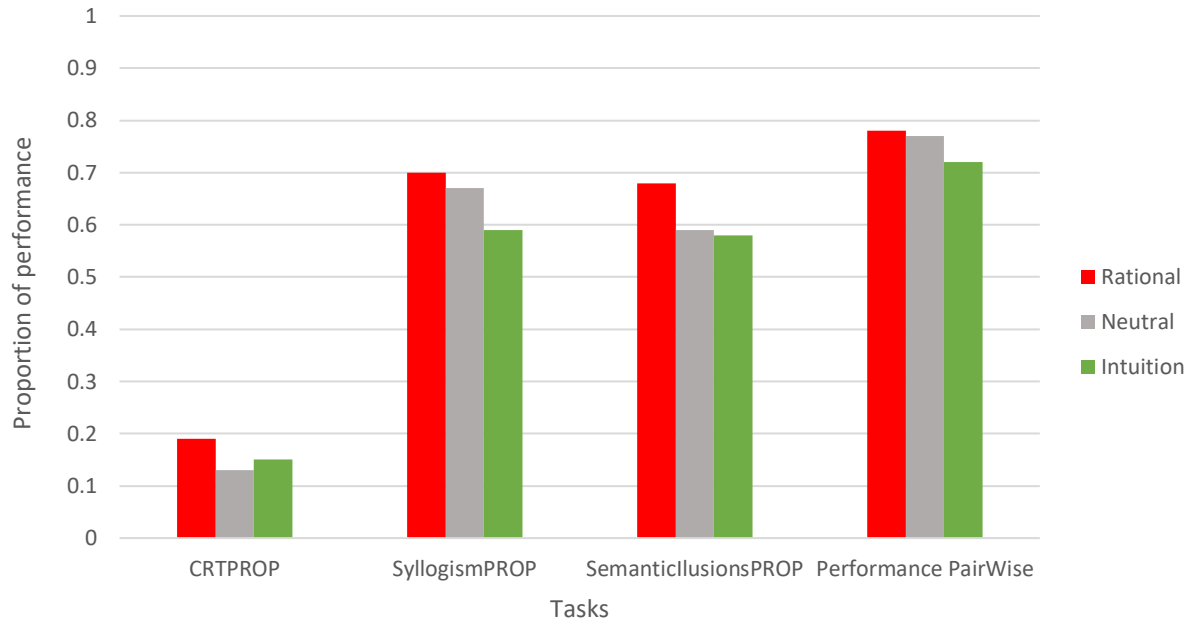

Figure 1: Mean Proportions of correct responses in the CRT, Syllogisms, semantic illusions, and pairwise comparison tasks for neutral, intuition and rational instructions.

To directly test our hypothesis, we further used a univariate test of significance for planned contrasts to compare the performance between intuition and rational instructions.

We compared the effect of rational versus intuitive instructions on the reasoning tasks (CRT, syllogisms and semantic illusions) and found that participants in the rational instructions condition had a better performance ($M_{rational\ condition}$ = 0.52, $SD_{rational\ condition}$ = 0.03) than participants in the intuitive instructions condition ($M_{intuitive\ condition}$ = 0.44, $SD_{intuitive\ condition}$ = 0.03), $F(1,116) = 4{,}80$; $p = .030$.

When looking into the recognition heuristic we also got a significant contrast $F(1, 116) = 3{,}95$; $p = .049$, showing that participants in the rational instructions condition used more often this heuristic to respond in the pairwise task than participants in the intuitive instructions condition. When looking into performance when both cities were recognized (β), we also found a significant difference between rational and intuitive instructions, $F(1,116) = 5{,}08$; $p = .026$, – participants in the rational instructions condition had a better performance on trials where they recognized both cities than participants in the intuitive instructions condition. Finally, the effect of rational versus intuitive instructions in the general performance on the pairwise comparison task showed a marginally significant difference, $F(1,116) = 3.80$; $p = .054$. Once more, pointing to a better performance under rational compared to intuitive instructions (see Table 2).

Although rational instructions (versus intuitive instructions) led to better performance in the reasoning problems and increased the use of the recognition heuristic, there is no correlation between a composite score of performance in the reasoning problems and reliance on the recognition heuristic (r= 0.08, $p = .384$). There is, however a positive and significant correlation between performance in the reasoning tasks and the β ($r = 0.19$, $p = .043$, see table 3, see also Appendix VI for a more exhaustive Table of correlations). In other words, better performance in the reasoning tasks is associated with a better use of knowledge in the pairwise

decision task (e.g., more accurate decisions in the pairwise task, when both cities are recognized).

Table 3

Correlations between heuristics, beta and composite problems

	HRec_PROP	β	CompositProp
HRec_PROP[a]	1.00	0.11	0.08
β		1.00	0.19*
CompositProp[b]			1.00

*Note: *p<.05; **p<.01; ***p<.001*

[a]Hrec_PROP: mean proportion of times in which participants picked the recognized the city on trials 2 (trials in which there's a recognized city and a not recognized city) independently of the answer being correct or wrong

[b]CompositProp: mean proportion of correct answers to the reasoning problems (CRT, syllogisms, semantic illusions)

In sum, instructions to think carefully before answering, in comparison to instructions to give the first answer that came to mind, led to a) a decreased reliance on intuitive (heuristic-based) responses to the reasoning problems of the heuristics and biases tradition; and simultaneously to b) an increased reliance on the recognition heuristic on the pairwise choice task. Furthermore, it also led to better performance on the same task when both cities of the pairwise choices were known. It thus appears that more deliberate participants more often second guess and inhibit intuitive responses to classic reasoning problems, more often rely on the recognition heuristic and overall make a better use of their knowledge (about the pairs of recognized cities) than more intuitive participants.

Discussion

Among all the different approaches to decision making under uncertainty, two have received consistent and systematic attention: the research program on heuristics and biases initiated by Kahneman and Tversky in the late 1960's (e.g., Gilovich, et al., 2002; Kahneman, Slovic & Tversky 1982; Tversky & Kahneman, 1974); and the fast and frugal heuristics proposed by Gigerenzer and collaborators in the early 1990's (e.g., Gigerenzer, 1991, 2004; Gigerenzer, et al., 1999; Goldstein & Gigerenzer, 2002). Even though both approaches agree that human judgment and decision making rely heavily on heuristics, they seem to diverge on the importance they give to heuristics-based errors. According to the first approach, these errors are common and costly for individuals. For the fast and frugal approach, heuristic errors are much rarer and more illusory than real as they are often the result of, so called, parlor games.

That being said, both approaches consider that the heuristics they proposed correspond to people's intuition, which leads to a paradox concerning the validity of human intuition: when studied by the first approach intuitive judgments lead mostly to errors and when studied by the second approach they lead mostly to accurate answers. The main objective of the present work was to empirically evaluate this issue.

Our study suggests that instructions to be rational, in comparison to instructions to go with one's intuition, improved performance across all judgment tasks.

Aligned with previous research (e.g., Ferreira, et al., 2006; Ferreira, et al., 2016), rational instructions reduced heuristic-based errors in reasoning problems that present a conflict between heuristic-based and more deliberate answers and, somewhat more surprisingly, they increased participants reliance on the recognition heuristic in the pairwise comparison task.

Our results resonate to what Gigerenzer (2008) refers to as a solution to a misconception related to people's cognitive abilities. According to Gigerenzer, people with higher cognitive

abilities do not rely less on heuristics, rather they are better at adaptively select the appropriate heuristics. In a similar vein, instructions to be more deliberate/rational, may be "linked to the adaptive selection of heuristics and less linked to the execution of a heuristic" (Gigerenzer, 2008, p.21, see also Michalkiewicz, et al.,2018). Such account could explain our results by proposing that participants in the rational condition were better able to regulate their decision behavior, relying on their intuitions or gut-feelings when it was useful to do so (pairwise task) and more often second-guess their intuitive responses to the when reliance on heuristics would led them biases and errors (conflict reasoning problems).

Alternatively, from a dual-process perspective, our results could be seen as suggesting that the recognition heuristic is not purely Type 1 processing but involves Type 2 processing. Kahneman and Frederick (2002) already advanced that possibility. They argued that the recognition heuristic "draws on a "natural assessment" of recognition or familiarity that may be endorsed as a deliberate strategy" (Kahneman & Frederick, 2002, p.8). These authors further argue that this heuristic can be better labeled as a Type 2 process since it is sensitive to instructions, while Type 1 processes would not be (Kahneman & Frederik, 2002).

It is also worth mentioning that although instructions decreased the reliance on heuristic-based responses in conflict reasoning tasks and increased the use of the recognition heuristic on the pairwise comparison task, there was no correlation between the two. In other words, participants who used more the recognition heuristic are not necessarily those who avoid heuristic-based responses in the reasoning problems. More research (with larger samples and stimuli, and alternative ways to manipulate deliberation) is needed to explore these correlations within each condition and across conditions. As for the time being our preliminary conclusion is that instructions to be rational versus intuitive may affect different individuals' reliance on heuristics in more complex ways than initially predicted.

More research is also needed to a) confirm our initial results while overcoming limitations of the current Study; and b) disentangle between competing explanations for the results. Next I will portray some limitations to our study and describe a follow up, ending with some ideas for future studies.

Limitations

One limitation of the present Study concerns the number of the cities used. We used 8 cities (4 large Spanish cities and 4 small Spanish cities), which gave us 56 comparison pairs whereas most studies typically use around 70-140 pairs (e.g. Pohl, 2006). On future studies we should add a few more cities. Also, most studies (e.g. Gigerenzer, 2008; Pohl, 2006) use a homogeneous set of cities (e.g., the largest cities) and not a set of large and small cities of the same country, as we did. As a result, the recognition validity of our study was particularly high. This may have led participants to rely more on the recognition heuristic than usual making the recognition results less comparable to previous studies. Future research should try to replicate the current results while more closely following the procedure of classic recognition heuristic studies.

Follow up

A study made by Michalkiewicz et al. (2018) showed that intelligence (measured using Raven matrixes) moderates participants' tendency to use the recognition heuristic: more intelligent participants made a more adapted use of the recognition heuristic, relying more on the heuristic when recognition validity was higher and less when the recognition validity was lower. In our case, we did not measure intelligence, but we used instructions to manipulate participants tendency to use their gut feelings (intuition) or to more carefully deliberate. In a follow up study, we will explore whether the same kind of instructions will differentially affect the reliance on the recognition heuristic when its ecological validity varies (e.g., is high vs.

low). This, we believe, will be an important test to confirm that more deliberate participants compared to more intuitive participants make a more adapted use of the recognition heuristic while more often avoiding errors and biases in classic conflict reasoning problems.

For that we will add to the questionnaire used in this thesis two more cities so that our total is 10 Spanish cities, 5 most known cities and 5 less known cities (taken from a pre-test already conducted).

To create a low ecological validity condition, a new pairwise comparison task will be added in which participants will be shown several pairs of cities and will have to answer which one is closer to a third city. The distance to the third city (Portuguese city Porto) does not correlate with the right answer (r=0,01; p =.977). Thus, in contrast to the "which city is larger" task participants will perform a "which city is closer". The recognition heuristic has a high ecological validity. In the first case but a close to zero validity in the second case. The rest of the procedure of the experiment will be the same as the one described in this thesis.

We expect to replicate the results of the current study in the already presented tasks. However, in the new added task, we expect a) participants to choose less often the recognized city (compared to the "which city is larger" task), independently of instructions; b) participants in the rational condition to use even less the heuristic on this task since the recognition cue is not useful or related to the criterion. That is, participants in the rational condition would better determine when the recognition cue is useful and when it is not.

Besides the aforementioned follow up, future studies should be made to generalize the results obtained so far.

We could manipulate the cognitive load to extend the current results obtained with the instructions manipulation. For example, by using a cognitive load concurrent task or by adding a limit to response time. In terms of cognitive load, a possible task would be to instruct participants to memorize a number (with two digits compared to seven digits) to tax their

working memory. Just like previous studies in which cognitive load (e.g., Ferreira et al., 2006) and response time (e.g., Ferreira et al., 2016) affected Type 2 processing but not Type 1 processing; we predict that both these options would conceptually replicate our initial results using instructions.

We could also extend the number and variety of the conflict problems used. We could include other classic reasoning problems such as conjunction problems (e.g., the Linda problem) or base-rates problems (e.g., the lawyer-engineer problem). Moreover, instead of the relatively simple syllogism like the one used (based on Modus Ponens), we could use more difficult ones (based on l Modus Pollens). All of these problems create a conflict between an appealing intuitive answer and a cognitively more costly rational answer.

We could also include tasks to study other heuristics of the fast and frugal approach. More specifically, we could put under test the Take-The-Best heuristic (Gigerenzer & Goldstein 1999). This heuristic has been studied using pairwise comparisons tasks. Participants search for cues that distinguish the two options in each pair, starting from the most valid cue to the least valid cue and stopping the search when the first cue that is present in one option and absent in the other is found. for example, when participants have to pick which of two cities have the larger population, if both cities are recognized, participants are supposed to look for other cues (e.g., "has an international airport") and choose the city based on the first, most valid, cue that discriminates between the two cities (e.g., City A has an airport but City B not).

Even though this thesis started by presenting an apparent paradox stemming from the views of heuristics advanced by two perspective (Kahneman and Tversky's Heuristic and Biases approach and Gigerenzer's fast and frugal approach), we would like to end up by highlighting the potential of our experimental approach to search for a novel integration of both points of view. This would help advance our understanding of human judgment and of how people manage heuristics.

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Appendixes

Appendix I. Different instructions given to the participants

Manipulation of instructions	
1. De seguida, vai ser-lhe apresentado um conjunto de problemas e questões.	Neutral
2. De seguida, vai ser-lhe apresentado um conjunto de problemas e questões que são normalmente utilizadas para testar as nossas intuições. Assim, pedimos-lhe que responda com base na sua intuição, dando a primeira resposta em que pensar.	Intuitive
3. De seguida, vai ser-lhe apresentado um conjunto de problemas e questões que são normalmente utilizadas para testar a nossa atenção e capacidade de reflexão. Assim, pondere cuidadosamente antes de dar as suas respostas finais. A primeira resposta que nos ocorre nem sempre é a correta.	Rational

Appendix II. CRT problems used in the study

1. Um computador está infectado com um vírus. A cada minuto, o vírus afecta o dobro dos ficheiros. Se demora 100 minutos para o vírus infectar os ficheiros todos do computador, quanto tempo demoraria para o vírus afectar metade dos ficheiros do computador?	C
2. A Ana e a Sofia foram apanhar conchas à praia. Juntas elas apanharam 12 conchas. A Ana apanhou mais 10 conchas do que a Sofia. Quantas conchas é que a Sofia apanhou?	C
3. Um montanhista ata uma corda grande a uma corda pequena. Juntas, as cordas medem 88 metros. A corda grande mede mais 80 metros do que a corda pequena. Quanto mede a corda pequena?	C
4. Uma televisão e um DVD estão em promoção. Juntos, o DVD e a televisão custam 110€. A televisão custa 100€. Quanto custa o DVD?	NC

Note: c: conflict; nc: non-conflict

Appendix III. Syllogisms used in the study

1. Todas as flores precisam de água. As rosas precisam de água. Logo, rosas são flores. A conclusão é válida?	C
2. Todas as estrelas brilham. O sol brilha. Logo, o sol é uma estrela. A conclusão é válida?	C
3. Tudo o que tem um motor precisa de óleo. Os carros precisam de óleo. Logo, os carros têm um motor. A conclusão é válida?	C
4. Todos os animais precisam de comer. Os gatos são animais. Logo, os gatos precisam de comer. A conclusão é válida?	NC

Note: c: conflict; nc: non-conflict

Appendix IV. Semantic Illusions used in the study

1. A água congela quando o termóstato marca zero graus Celsius.	C
2. É no museu do Louvre que está o retrato de Mona Lisa que Miguel Ângelo pintou.	C
3. A cabra é um animal do campo que dá leite, queijo e lã.	C
4. Foi Pitágoras que estabeleceu o teorema sobre a relação entre os lados de um triângulo.	NC

Note: c: conflict; nc: non-conflict

Appendix V. Spanish Cities used for the Recognition Heuristic

1. L'Hospitalet de Lonbregat
2. Vitoria-Gasteiz
3. Elche
4. Gijon
5. Granada
6. Valencia
7. Madrid
8. Barcelona

Appendix VI.

Table 5. *Overall Correlations between heuristics, beta and composite problems*

	CRTPORP	SilogismoPROP	IlusõesSeMPORP	HRec_PROP	Beta	perf PairWise	CompositProp
CRTPORP	1	0,29*	-0,12	0,06	0,12	-0,11	0,49***
SilogismoPROP		1	-0,05	0,08	0,1	-0,05	0,84***
IlusõesSeMPORP			1	0	0,15	0,02	0,40***
HRec_PROP				1	0,11	0,45***	0,08
Beta					1	0,21*	0,19*
perfPairWise						1	-0,06
CompositProp							1

**p<.05; **p<.01; ***p<.001*

Table 6. *Correlations between heuristics, beta and composite problems in the rational condition*

	CRTPORP	SilogismoPROP	IlusõesSeMPORP	HRec_PROP	Beta	perf PairWise	CompositProp
CRTPORP	1	0,34*	0,28	-0,05	-0,18	-0,27	0,63***
SilogismoPROP		1	0,25	0,02	0,03	-0,08	0,87***
IlusõesSeMPORP			1	-0,24	0,1	-0,15	0,62***
HRec_PROP				1	-0,02	-0,16	-0,09
Beta					1	0,39**	0
perf PairWise						1	-0,19
CompositProp							1

**p<.05; **p<.01; ***p<.001*

Table 7. *Correlations between heuristics, beta and composite problems in the neutral condition*

	CRTPORP	SilogismoPROP	IlusõesSeMPORP	HRec_PROP	Beta	perf PairWise	CompositProp
CRTPORP	1	0,04	-0,35*	0,04	0,17	-0,11	0,21
SilogismoPROP		1	-0,11	0,02	0,18	-0,17	0,84***
IlusõesSeMPORP			1	-0,06	0,02	0,24	0,31*
HRec_PROP				1	0,28	0,24	0
Beta					1	0,22	0,24
perf PairWise						1	-0,06
CompositProp							1

**p<.05; **p<.01; ***p<.001*

Table 8. *Correlations between heuristics, beta and composite problems in the intuitive condition*

	CRTPORP	**SilogismoPROP**	**IlusõesSeMPORP**	**HRec_PROP**	**Beta**	**perf PairWise**	**CompositProp**
CRTPORP	1	0,47**	-0,29	0,07	0,18	-0,02	0,55***
SilogismoPROP		1	-0,26	0,1	0,03	0,03	0,82***
IlusõesSeMPORP			1	0,02	0,19	-0,09	0,26
HRec_PROP				1	0,02	0,72***	0,12
Beta					1	0,08	0,19
perf PairWise						1	-0,04
CompositProp							1

**p<.05; **p<.01; ***p<.001*